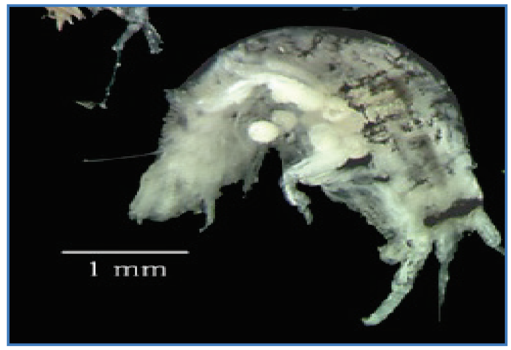
E.8 Mid-system Separation CSSC Open Control Technologies with a Buffer Zone

E.8.1 ANS Potentially Invading the Great Lakes Basin

E.8.1.1 Crustaceans

E.8.1.1.1 Scud (*Apocorophium lacustre*)

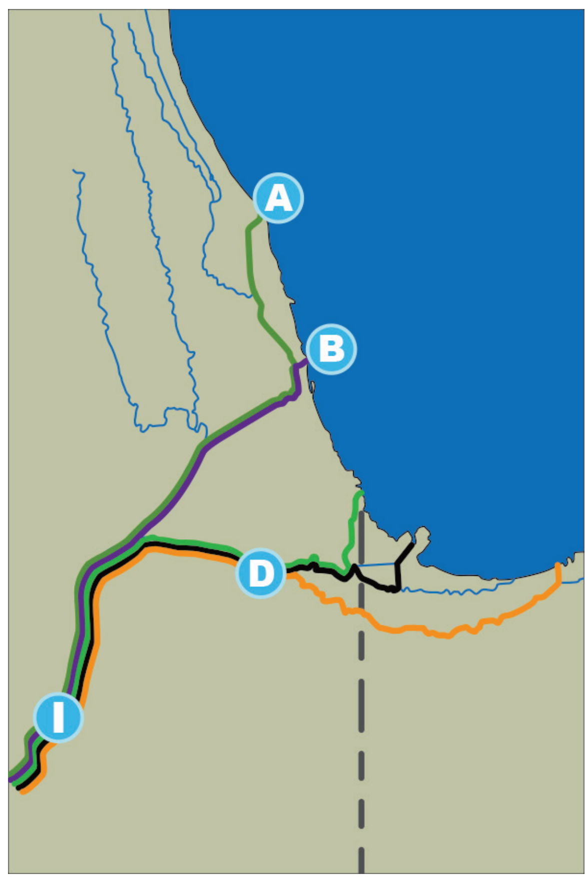


MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier[b]
		GLMRIS Lock
	Wilmette Pumping Station (A)	ANS Treatment Plant[c]
		Screened Sluice Gates
Chicago River Controlling Works	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier[b]
		GLMRIS Lock
	Chicago River Controlling Works (B)[d]	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
		Screened Sluice Gates



Calumet Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier[b]
		GLMRIS Lock
	Alsip, IL (D)	ANS Treatment Plant[c]
		Physical Barrier
Indiana Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier[b]
		GLMRIS Lock
	Alsip, IL (D)	ANS Treatment Plant[c]
		Physical Barrier
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier[b]
		GLMRIS Lock
	Alsip, IL (D)	ANS Treatment Plant[c]
		Physical Barrier

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the *Apocorophium lacustre*.

[b] The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an electric barrier at control point (I), which is ineffective for *A. lacustre* and does not impact its probability rating.

[c] Control Point (D) includes an ANS Treatment Plant that removes ANS from water on the Lake Michigan side of the physical barrier prior to its discharge to the Mississippi River side. The ANS Treatment Plant is not designed to treat Mississippi River Basin water and, therefore, has no impact on *A. lacustre*'s probability ratings.

[d] Control Point (B) is not effective for Mississippi River Basin species because it contains no measures to restrict ANS transfer to Lake Michigan during storm events requiring backflows; when water from the CAWS may be discharged into Lake Michigan.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, ANS Treatment Plant, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	**T_0**		**T_{10}**		**T_{25}**		**T_{50}**	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation Chicago Sanitary and Ship Canal (CSSC) Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* from natural dispersion through aquatic pathways to the Brandon Road Lock and Dam.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* from human-mediated transport through aquatic pathways to the Brandon Road Lock and Dam.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.

T_{10}: See T_0. Abundance is expected to increase beyond T_0 levels.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers. This species is at or close to the pathway and moved through several locks as it moved northward from the lower Mississippi River Basin.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of a Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock and electric barrier at Brandon Road Lock and Dam in Illinois. In addition, an aquatic nuisance species treatment plant (ANSTP) and screened sluice gates would be constructed at Wilmette Pumping Station. Overall, these structural measures are not expected to affect the probability of arrival of *A. lacustre* at Brandon Road Lock and Dam by human-mediated transport or natural dispersion because the species has likely already arrived at the pathway. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.

T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways at the Brandon Road Lock and Dam. The species has likely already arrived at the pathway. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways at the Brandon Road Lock and Dam. The species has likely already arrived at the pathway. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for *A. lacustre* at Brandon Road Lock and Dam by the retrofitting of Brandon Road Lock and Dam into a GLMRIS Lock, and by construction of an electric barrier and engineered approach channel on the downstream side of the lock. At this location, flow conditions during a storm with a 0.2% annual chance of exceedance (ACE) event would not bypass the Brandon Road control point.

The GLMRIS Lock at the Brandon Road Lock and Dam control point addresses the passive drift of *A. lacustre* that may travel against the current toward the Great Lakes Basin and into the lock. If left uncontrolled, the lock could then transport this species upstream.

In the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, the channel downstream of the lock would be uncontrolled against the passive drift of *A. lacustre*; the channel upstream of the lock is buffer zone water, which is controlled for Great Lakes aquatic nuisance species (ANS). The buffer zone water originates from (1) this alternative's lakefront ANSTPs, (2) rainwater, (3) discharge from wastewater treatment plants whose treatment addresses ANS, and/or (4) other discharges that originate from drinking or rain water sources. As the lock travels up the 34-foot lift, a filling and emptying system would remove the contained water from one end and flush and fill the lock with buffer zone water on the opposite end. The current lock would be retrofitted with a pump-driven filling and emptying system to achieve this purpose of plug flow through the lock. However, the GLMRIS Lock would not be an effective control for hull fouling species, such as this.

The Brandon Road Lock and Dam control point also includes an electric barrier constructed downstream of the lock. The electric barrier is not an effective control measure for *A. lacustre*.

In addition, a second control point would be created at WPS with the construction of an ANSTP and screened sluice gates. The WPS control point, designed to control Great Lakes Basin ANS, does not target controlling the passage of Mississippi River Basin ANS, such as *A. lacustre*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: The sluice gate at the WPS is a barrier that could retard dispersion by boat transport. The scud moved through several locks as it moved northward from the lower Mississippi River Basin, suggesting locks are not a barrier.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural

measures would include the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam.

The electric barrier is not effective at controlling the passage of *A. lacustre*. The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway. However, the GLMRIS Lock is not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

In addition, a second control point would be created at the WPS with the construction of an ANSTP and screened sluice gates. The WPS control point, which is designed to control Great Lakes Basin ANS, does not target controlling the passage of Mississippi River Basin ANS, such as *A. lacustre*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would not reduce the likelihood of *A. lacustre* passing through the aquatic pathway; therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *A. lacustre* via hull fouling on vessels. Therefore, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, ANS Treatment Plant, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.

T_{10}: Abundance is expected to increase beyond T_0 levels.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers. This species is at or close to the pathway and moved through several locks as it moved northward from the lower Mississippi River Basin.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam in Illinois. In addition, a GLMRIS Lock, electric barrier, ANSTP, and screened sluice gates would be constructed at the CRCW. However, none of these structural measures are expected to control the arrival of *A. lacustre* at the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32 km (20 mi) from the Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.

T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways at the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways at the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: HIGH**

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at Brandon Road Lock and Dam, and a second at CRCW. At the Brandon Road Lock and Dam control point, the current lock would be retrofitted into a GLMRIS Lock, and an electric barrier and engineered approach channel on the downstream side of the lock would be constructed. At this location, flow conditions during a storm with a 0.2% ACE event would not bypass the Brandon Road control point.

The GLMRIS Lock addresses the passive drift of *A. lacustre* that may travel against the current toward the Great Lakes Basin and into the lock. If left uncontrolled, the lock could then transport this species upstream. In this alternative, the channel downstream of the lock would be uncontrolled for *A. lacustre* that passively drift; upstream water is buffer zone water and would be controlled for Great Lakes ANS. The buffer zone water originates from (1) this alternative's lakefront ANSTPs, (2) rainwater, (3) discharge from wastewater treatment plants whose treatment addresses ANS, and/or (4) other discharges that originate from drinking or rain water sources. As the lock travels up the 34-foot lift, a filling and emptying system would remove the contained water from one end and flush and fill the lock with buffer zone water on the opposite end. The current lock at Brandon Road Lock and Dam would be retrofitted with a pump-driven filling and emptying system to achieve this purpose of plug flow through the lock. However, the GLMRIS Lock would not be an effective control for hull fouling species, such as this.

The Brandon Road Lock and Dam control point also includes an electric barrier constructed downstream of the GLMRIS Lock. The electric barrier is not an effective control measure for *A. lacustre*.

In addition, a second control point would be created at the CRCW with the construction of an ANSTP, electric barrier, GLMRIS Lock, and screened sluice gates. The CRCW control point, which is designed to control Great Lakes Basin ANS, does not target controlling the passage of Mississippi River Basin ANS, such as *A. lacustre*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are not expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway via hull fouling. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: *A. lacustre* moved through several locks as it moved northward from the lower Mississippi River Basin, suggesting locks are not a barrier.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to

address the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, the species is expected to still be able to pass through the aquatic pathway via hull fouling on vessels. This species is known to foul hulls of vessels (Grigorovich et al. 2008). The GLMRIS Lock does not address hull fouling species because the lock does not dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points: one at the Brandon Road Lock and Dam, and a second at CRCW, that would be implemented at T_{25}. At the Brandon Road Lock and Dam control point, structural measures would include an electric barrier and GLMRIS Lock. The electric barrier would have no effect on the passage of *A. lacustre*. The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway.

However, the GLMRIS Lock is not expected to control the human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

As for the CRCW control point, designed to control Great Lakes Basin ANS, it does not target controlling the passage of Mississippi River Basin ANS, such as *A. lacustre*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would not reduce the likelihood of *A. lacustre* passing through the aquatic pathway; therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *A. lacustre* via hull fouling on vessels. Therefore, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *A. lacustre*.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.
T_{10}: Abundance is expected to increase beyond T_0 levels.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: The T.J. O'Brien Lock and Dam is between the current location of *A. lacustre* and the Calumet Harbor. However, this species is at or close to the pathway and moved through several locks as it moved northward from the lower Mississippi River Basin.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam, as well as the construction of a physical barrier and ANSTP at Alsip, Illinois. Overall, none of these structural measures are expected to control the arrival of *A. lacustre* to the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32 km (20 mi) from the Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.
T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River just

above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH–LOW

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.
T_{10}: See T_{25}.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Brandon Road Lock and Dam by the retrofitting of Brandon Road Lock and Dam into a GLMRIS Lock, and construction of an

electric barrier and engineered approach channel on the downstream side of the lock. At this location, flow conditions during a storm with a 0.2% ACE event would not bypass the Brandon Road control point.

The GLMRIS Lock addresses the passive drift of *A. lacustre* that may travel against the current toward the Great Lakes Basin and into the lock. If left uncontrolled, the lock could then transport this species upstream. In this alternative, the channel downstream of the lock would be uncontrolled for *A. lacustre* that passively drift; upstream water is buffer zone water and would be controlled for Great Lakes ANS. The buffer zone water originates from (1) this alternative's lakefront ANSTPs, (2) rainwater, (3) discharge from wastewater treatment plants whose treatment addresses ANS, and/or (4) other discharges that originate from drinking or rain water sources. As the lock travels up the 34-foot lift, a filling and emptying system would remove the contained water from one end and flush and fill the lock with buffer zone water on the opposite end. The current lock would be retrofitted with a pump-driven filling and emptying system to achieve this purpose of plug flow through the lock. However, the GLMRIS Lock would not be an effective control for hull fouling species, such as this.

The Brandon Road Lock and Dam control point also includes an electric barrier constructed downstream of the GLMRIS Lock. The electric barrier is not an effective control measure for *A. lacustre*.

A second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* because the species originates in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-

mediated transport of *A. lacustre* through the aquatic pathway. The Brandon Road Lock and Dam control point would not be effective at controlling the human-mediated transport of *A. lacustre* via hull fouling; however, the physical barrier at the Alsip, Illinois, control point would control the human-mediated transport of the species through the aquatic pathway. Vessels potentially transporting the species in ballast and bilge water, or via hull-fouling, would be unable to traverse the physical barrier.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: Existing potential barriers include the three lock and dam structures along the pathway. *A. lacustre* moved through several locks as it moved northward from the lower Mississippi River Basin, suggesting locks are not a barrier.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The Brandon Road Lock and Dam control point is expected to control natural dispersion of *A. lacustre* through the aquatic pathway; however, it is not expected to control the human-mediated transport of the species via hull fouling through the aquatic pathway. The second control point at Alsip, Illinois, is expected to control both natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species, as well as the natural dispersion of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water, or via hull fouling, would be unable to traverse the barrier.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at Brandon Road Lock and Dam, and a second at Alsip, Illinois.

The Brandon Road Lock and Dam control point would include the construction of a GLMRIS Lock and electric barrier. The GLMRIS Lock would control the natural dispersion of *A. lacustre* through the CAWS; however, human-mediated transport would not be addressed at this control point. The GLMRIS Lock does not address the passage of *A. lacustre* via hull fouling because the lock does not dislodge attached organisms from vessel hulls. The electric barrier would have no effect on the passage of *A. lacustre*.

At the Alsip, Illinois, control point, the physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *A. lacustre* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* because the species originates in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *A. lacustre* passing through the aquatic pathway; therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the passage of *A. lacustre* through the CAWS up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Medium	Medium	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Medium	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Medium	Medium	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. *Low|NPE* means low, given no prior establishment in previous time steps.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Indiana Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *A. lacustre*.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**

In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. ***Current Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. ***Existing Physical Human/Natural Barriers***
T_0: There are no existing barriers; the species is likely already at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a GLMRIS Lock and electric barrier at Brandon

Road Lock and Dam, as well as the construction of a physical barrier and ANSTP at Alsip, Illinois. However, these structural measures are not expected to control the arrival of *A. lacustre* to the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from the Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.
T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam through aquatic pathways. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: MEDIUM–LOW

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for *A. lacustre* at Brandon Road Lock and Dam by the retrofitting of Brandon Road Lock and Dam into a GLMRIS Lock, and by construction of an electric barrier and engineered approach channel on the downstream side of the lock. At this location, flow conditions during a storm with a 0.2% ACE event would not

bypass the Brandon Road control point. In addition, a physical barrier would be constructed at Alsip, Illinois, creating a control point at this location.

In the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, the channel downstream of the lock would be uncontrolled against the passive drift of *A. lacustre*; the channel upstream of the lock is buffer zone water, which is controlled for Great Lakes ANS. The buffer zone water originates from (1) this alternative's lakefront ANSTPs, (2) rainwater, (3) discharge from wastewater treatment plants whose treatment addresses ANS, and/or (4) other discharges that originate from drinking or rain water sources. As the lock travels up the 34-foot lift, a filling and emptying system would remove the contained water from one end and flush and fill the lock with buffer zone water on the opposite end. The current lock would be retrofitted with a pump-driven filling and emptying system to achieve this purpose of plug flow through the lock. However, the GLMRIS Lock would not be an effective control for hull fouling species, such as this. The Brandon Road Lock and Dam control point also includes an electric barrier constructed downstream of the lock at the Brandon Road Lock and Dam. The electric barrier is not an effective control measure for *A. lacustre*. A second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* since the species originates in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the passage of *A. lacustre* through the CAWS to Indiana Harbor by human-mediated transport. The Brandon Road Lock and Dam control point would not be effective at controlling the

human-mediated transport of *A. lacustre* via hull fouling; however, the physical barrier at the Alsip, Illinois, control point would control the human-mediated transport of the species through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway to Indiana Harbor. The Brandon Road Lock and Dam control point is expected to control natural dispersion of *A. lacustre* through the aquatic pathway; however, it is not expected to control the human-mediated transport of the species via hull fouling through the aquatic pathway. The second control point at Alsip, Illinois, is expected to control both natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species, as well as the natural dispersion of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water, or via hull fouling, would be unable to traverse the barrier.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's medium rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at Brandon Road Lock and Dam, and a second at Alsip, Illinois. The Brandon Road Lock and Dam control point would include the construction of a GLMRIS Lock and electric barrier.

The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the CAWS; however, human-mediated transport would not be addressed at this control point. The GLMRIS Lock does not address the passage of *A. lacustre* via hull fouling because the lock does not dislodge attached organisms from vessel hulls. The electric barrier would have no effect on the passage of *A. lacustre*.

At the Alsip, Illinois, control point, the physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *A. lacustre* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *A. lacustre* passing through the aquatic pathway; therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the passage of *A. lacustre* through the CAWS up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Medium	Medium	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Medium	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Medium	Medium	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *A. lacustre*.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* at the Brandon Road Lock and Dam from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of *A. lacustre*.
T_{10}: See T_0. Abundance is expected to increase beyond T_0 levels.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers. This species is at or close to the pathway and moved through several locks as it moved northward from the lower Mississippi River Basin.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam, as well as the construction of a physical barrier and ANSTP at Alsip, Illinois. However, these structural measures are not expected to control the arrival of *A. lacustre* to the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32 km (20 mi) from the Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of *A. lacustre* outside of its current distribution.
T_{10}: See T_0. The species may be closer to the pathway or at the pathway entrance.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for *A. lacustre* in the Mississippi River Basin.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways at the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and

Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways at the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Lock and Dam, less than 32.2 km (20 mi) from Brandon Road Lock and Dam in the Illinois River (USGS 2011). Hence, the species is likely at or close to the pathway. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: MEDIUM–LOW

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at the Brandon Road Lock and Dam, and a second at Alsip, Illinois. The Brandon Road Lock and Dam would be retrofitted into a GLMRIS Lock, and an electric barrier and engineered approach channel on the

downstream side of the lock would be constructed. At this location, flow conditions during a storm with a 0.2% ACE event would not bypass the Brandon Road control point.

In the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, the channel downstream of the lock would be uncontrolled against the passive drift of *A. lacustre*; the channel upstream of the lock is buffer zone water, which is controlled for Great Lakes ANS. The buffer zone water originates from (1) this alternative's lakefront ANSTPs, (2) rainwater, (3) discharge from wastewater treatment plants whose treatment addresses ANS, and/or (4) other discharges that originate from drinking or rain water sources. As the lock travels up the 34-foot lift, a filling and emptying system would remove the contained water from one end and flush and fill the lock with buffer zone water on the opposite end. The current lock would be retrofitted with a pump-driven filling and emptying system to achieve this purpose of plug flow through the lock. However, the GLMRIS Lock would not be an effective control for hull fouling species, such as this species. The Brandon Road Lock and Dam control point also includes an electric barrier constructed downstream of the lock at the Brandon Road Lock and Dam. The electric barrier is not an effective control measure for *A. lacustre*.

The second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP. The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre* because the species originates in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming, crawling, and passive drift) of *A. lacustre* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of *A. lacustre* through the aquatic pathway. The Brandon Road Lock and Dam control point would not be effective at controlling the human-mediated transport of *A. lacustre* via hull fouling; however, the physical barrier at the Alsip, Illinois, control point would control the human-mediated transport of the species

through the aquatic pathway. Vessels potentially transporting the species in ballast and bilge water, or via hull-fouling, would be unable to traverse the physical barrier.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of *A. lacustre* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The Brandon Road Lock and Dam control point is expected to control natural dispersion of *A. lacustre* through the aquatic pathway; however, it is not expected to control the human-mediated transport of the species via hull fouling through the aquatic pathway. The second control point at Alsip, Illinois, is expected to control both natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the vessel-mediated transport of the species, as well as the natural dispersion of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water, or via hull fouling, would be unable to traverse the barrier.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for *A. lacustre* in the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's medium rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}.

This alternative creates two control points: one at Brandon Road Lock and Dam, and a second at Alsip, Illinois. The Brandon Road Lock and Dam control point would include the construction of an electric barrier and GLMRIS Lock. The electric barrier would have no effect on the passage of *A. lacustre*. The GLMRIS Lock is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, human-mediated transport of the species via hull fouling would not be addressed. The GLMRIS Lock does not address the passage of *A. lacustre* due to hull-fouling, because the lock does not dislodge attached organisms from vessel hulls.

At the Alsip, Illinois, control point, the physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that *A. lacustre* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The purpose of the ANSTP is to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP would not be designed to treat Mississippi River Basin water for ANS; therefore, the ANSTP would not be an effective control for *A. lacustre*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *A. lacustre* passing through the aquatic pathway; therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *A. lacustre* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. The physical barrier is expected to control the passage of *A. lacustre* through the CAWS up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Therefore, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

References

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E.8.1.2 Fish

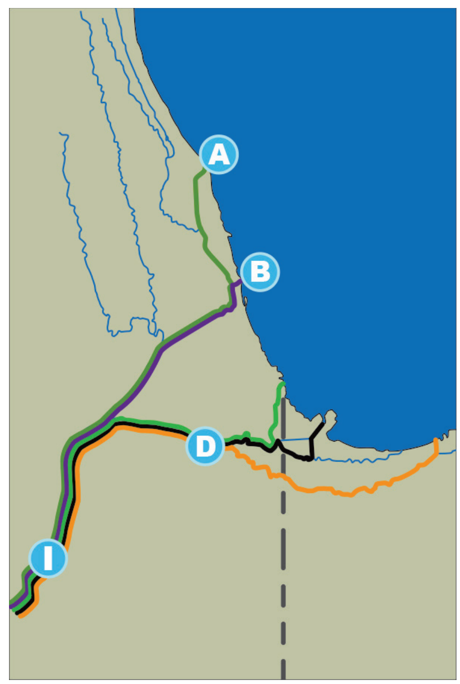
E.8.1.2.1 Bighead Carp (Hypophthalmichthys nobilis)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Wilmette Pumping Station (A)	ANS Treatment Plant[b]
		Screened Sluice Gates
Chicago River Controlling Works	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Chicago River Controlling Works (B)[c]	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
		Screened Sluice Gates
Calumet Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Alsip, IL (D)	ANS Treatment Plant[b]
		Physical Barrier
Indiana Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Alsip, IL (D)	ANS Treatment Plant[b]
		Physical Barrier



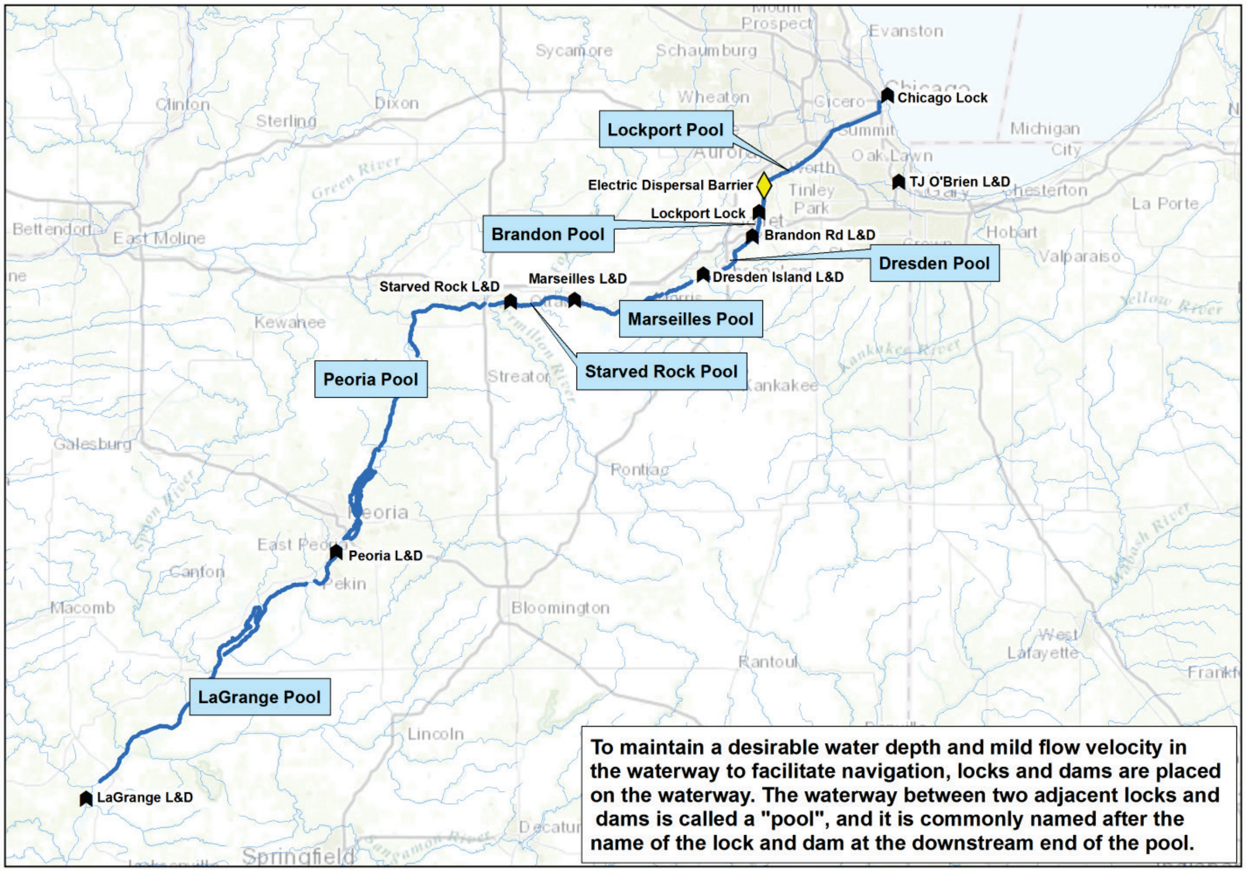
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Alsip, IL (D)	ANS Treatment Plant[b]
		Physical Barrier

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for bighead carp.

[b] Control Points (A) and (D) include an ANSTP that removes ANS from water on the Lake Michigan side of the physical barrier prior to its discharge to the Mississippi River side. The ANSTP is not designed to treat Mississippi River Basin water and therefore has no impact on Bighead carp's probability ratings.

[c] Control Point (B) is not effective for Mississippi River Basin species because they contain no measures to restrict ANS transfer to Lake Michigan during storm events requiring backflows; when water from the CAWS may be discharged into Lake Michigan.

Risk Assessment Reference Map




The current Electric Dispersal Barrier System located approximately 5 mi upstream of the Lockport Lock and Dam is assumed to continue operation through T_{50}.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, ANS Treatment Plant, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	**–**	***Low***	**–**

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Brandon Road Lock and Dam and the WPS over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist. Arrival of an individual specimen is examined here and drives the risk rating at all time steps.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival to the Brandon Road Lock and Dam as a result of human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance or reproductive capacity in this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to movement of bighead carp from their current position to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of a Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock and electric barrier at Brandon Road Lock and Dam in Illinois. Additionally, an aquatic nuisance species (ANS) treatment plant (ANSTP) and screened sluice gates would be constructed at Wilmette Pumping Station. Overall, none of these structural measures are expected to affect the arrival of bighead carp at

Brandon Road Lock and Dam by human-mediated transport or natural dispersion since the bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's distance from the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat for the bighead carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the CAWS through aquatic pathways. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).Therefore, the probability of passage remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the pathway. The bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these nonstructural measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{10}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at WPS. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% annual chance of exceedance (ACE) event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address: electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and storm water sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of bighead carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at WPS; however, this control point controls the passage of Great Lakes Basin ANS, and bighead carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through this aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of bighead carp eggs, larvae, and fry, while the electric barrier is expected to control the passage of swimming bighead carp.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures, but implementation of the structural measures would not take place until T_{25}. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Nonstructural and structural measures, including the construction of the Brandon Road Lock and Dam Control Point, as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The Brandon Road Lock and Dam control point includes an electric barrier adjacent to the GLMRIS Lock which is expected to control the passage of swimming bighead carp upstream through the lock, and a GLMRIS Lock which is expected to control the passage of bighead carp eggs, larvae, and fry. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the human-mediated transport of the species through the aquatic pathway.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for bighead carp within this aquatic pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the bighead carp's probability of passage through this aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points along this pathway. One control point is located at Brandon Road Lock and Dam and includes the construction of a GLMRIS Lock and electric barrier. The electric barrier is expected to control the upstream passage of swimming bighead carp through this pathway. The GLMRIS Lock is expected to address the passage of bighead carp eggs, larvae, and fry by flushing water from the lock and filling with buffer zone water. The flushing action of the GLMRIS Lock is expected to address the passive drift of bighead carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at WPS; however, it controls Great Lakes Basin ANS, and bighead carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of the bighead carp through this aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electric barrier area using nonstructural measures such as nets, electrofishing, or piscicides. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming bighead carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, ANS Treatment Plant, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	**–**	***Low***	**–**

[a] The highlighted table cells indicate a rating change in the probability element.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Brandon Road Lock and Dam and the Chicago River Controlling Works over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival via human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance or reproductive capacity in this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The nonstructural measures of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are not expected to affect the bighead carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to the movement of bighead carp from their current position to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam in Illinois. Additionally, a GLMRIS Lock, electric barrier, ANSTP, and screened sluice gates would be constructed at CRCW. However, none of these structural measures are expected to affect the arrival of bighead carp at Brandon

Road Lock and Dam by human-mediated transport or natural dispersion since the bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's distance from the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat for the bighead carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the CAWS through aquatic pathways. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of passage remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the pathway since the bighead carp has arrived at the pathway. One bighead carp was observed in Brandon Road Lock and Dam Pool (ACRCC 2012). There have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these nonstructural measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at CRCW. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% ACE event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address: electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and storm water sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of bighead carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at CRCW; however, it controls the passage of Great Lakes Basin ANS. Bighead carp are in the Mississippi River basin, and therefore, it does not impact the passage of bighead carp.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through this aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of bighead carp eggs, larvae, and fry, while the electric barrier is expected to control the passage of swimming bighead carp.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures, but implementation of the structural measures would not take place until T_{25}. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Nonstructural and structural measures, including the construction of the Brandon Road Lock and Dam Control Point, as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through this aquatic pathway. The Brandon Road Lock and Dam control point includes an electric barrier adjacent to the GLMRIS Lock which is expected to control the passage of swimming bighead carp upstream through the lock, and a GLMRIS Lock which is expected to control the passage of bighead carp eggs, larvae, and fry. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the human-mediated transport of the species through the aquatic pathway.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for bighead carp within the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the bighead carp's

probability of passage through this aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points along this pathway. One control point is located at Brandon Road Lock and Dam and includes the construction of a GLMRIS Lock and electric barrier. The electric barrier is expected to control the upstream passage of swimming bighead carp through this pathway. The GLMRIS Lock is expected to address the passage of bighead carp eggs, larvae, and fry by flushing water from the lock and filling with buffer zone water. The flushing action of the GLMRIS Lock is expected to address the passive drift of bighead carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at CRCW; however, it controls Great Lakes Basin ANS, and bighead carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.
T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current

Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: Nonstructural measures and the Brandon Road Control Point as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the bighead carp through this aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electric barrier area using nonstructural measures such as nets, electrofishing, or piscicides. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming bighead carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, Physical Barrier, and ANS Treatment Plant

RISK ASSESSMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	**–**	***Low***	**–**

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for bighead carp.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival through this aquatic pathway via human-mediated transport.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance or reproductive capacity in this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance and reproductive capacity.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to the movement of bighead carp from their current position to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at Brandon Road Lock and Dam and one at Alsip, Illinois. The control point at Brandon Road Lock and Dam would include the construction of a GLMRIS Lock and electric barrier while the Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP. Overall, none of these structural measures are expected to control the arrival of the bighead carp to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's distance from the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat for the bighead carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the CAWS through aquatic pathways. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of passage remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the pathway. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at WPS. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% ACE event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address: electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and storm water sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of bighead carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and

passive drift) of bighead carp through the aquatic pathway. The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. Bighead carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through this aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to control the human-mediated transport of bighead carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming bighead carp. The physical barrier at the Alsip, Illinois, control point is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of bighead carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming bighead carp. The Alsip, Illinois, control point includes a physical barrier that is expected to control the natural

dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Alternative Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of the habitat for the bighead carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of bighead carp through the aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam as well as the construction of a physical barrier and ANSTP at Alsip, Illinois.

The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to address the passage of bighead carp eggs, larvae, and fry by passive drift against the current and into the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with buffer zone water.

The electric barrier is expected to control the upstream passage of swimming bighead carp through the aquatic pathway.

Additionally, a second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that bighead carp and vessels potentially transporting bighead carp eggs, larvae, and fry in ballast and bilge water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the bighead carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. Additionally, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electric barrier area using nets, electrofishing, and/or piscicides. The physical barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming bighead carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for bighead carp.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating.

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**

In determining the probability of arrival, the pathway is assumed to exist. Arrival of an individual specimen is examined here and drives the risk rating at all time steps.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of thebighead carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the CAWS as a result of human-mediated transport through this aquatic pathway.

c. ***Current and Potential Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current and potential abundance or reproductive capacity of the bighead carp in this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance and reproductive capacity.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to the movement of bighead carp from their current position to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at Brandon Road Lock and Dam and one at Alsip, Illinois. The control point at Brandon Road Lock and Dam would include the construction of a GLMRIS Lock and electric barrier while the Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP. Overall, none of these structural measures are expected to control the arrival of the bighead carp to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's distance from the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat for the bighead carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the CAWS. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of passage remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the pathway. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at WPS. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% ACE event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address: electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and storm water sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of bighead carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and

passive drift) of bighead carp through the aquatic pathway. The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. Bighead carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through this aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to control the human-mediated transport of bighead carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming bighead carp. The physical barrier at the Alsip, Illinois, control point is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of bighead carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming bighead carp. The Alsip, Illinois, control point includes a physical barrier that is expected to control the natural

dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Alternative Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of the habitat for the bighead carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of bighead carp through the aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam as well as the construction of a physical barrier and ANSTP at Alsip, Illinois.

The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to address the passage of bighead carp eggs, larvae, and fry by passive drift against the current and into the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with buffer zone water.

The electric barrier is expected to control the upstream passage of swimming bighead carp through the aquatic pathway.

Additionally, a second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that bighead carp and vessels potentially transporting bighead carp eggs, larvae, and fry in ballast and bilge water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the bighead carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. Additionally, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electric barrier area using nets, electrofishing, and/or piscicides. The physical barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming bighead carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, Physical Barrier, and ANS Treatment Plant

RISK ASSESSMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	**–**	***Low***	**–**

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for bighead carp.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist. Arrival of an individual specimen is examined here and drives the risk rating at all time steps.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival as a result of human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current and potential abundance or reproductive capacity of the bighead carp in this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's current and potential abundance and reproductive capacity.
T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to the movement of bighead carp from their current position to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at Brandon Road Lock and Dam and one at Alsip, Illinois. The Brandon Road Lock and Dam control point would include the construction of a GLMRIS Lock and electric barrier while the Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP. However, these structural measures are not expected to control the arrival of the bighead carp to Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's distance from the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat for the bighead carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp have been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of Brandon Road Lock and Dam. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the bighead carp's arrival at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the probability of passage remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would not affect the bighead carp's arrival at the pathway. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island pool, where significant numbers of adult bighead carp were captured approximately 4 mi downstream of the Brandon Road Lock and Dam in the spring of 2013 (MRWG 2013). In addition, there have been two recorded captures of bighead carp in the CAWS upstream of the Brandon Road Lock and Dam (ACRCC 2009, 2012). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at WPS. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% ACE event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address: electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and storm water sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of bighead carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and

passive drift) of bighead carp through the aquatic pathway. The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. Bighead carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of bighead carp through this aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of bighead carp through the aquatic pathway. The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to control the human-mediated transport of bighead carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming bighead carp. The physical barrier at the Alsip, Illinois, control point is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of bighead carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of bighead carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of bighead carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming bighead carp. The Alsip, Illinois, control point includes a physical barrier that is expected to control the natural

dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.
T_{50}: See T_{25}.

d. ***Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)***

T_0: See the Nonstructural Alternative Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of the habitat for the bighead carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of bighead carp through the aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam as well as the construction of a physical barrier and ANSTP at Alsip, Illinois.

The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to address the passage of bighead carp eggs, larvae, and fry by passive drift against the current and into the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with buffer zone water.

The electric barrier is expected to control the upstream passage of swimming bighead carp through the aquatic pathway.

Additionally, a second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that bighead carp and vessels potentially transporting bighead carp eggs, larvae, and fry in ballast and bilge water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of bighead carp through this pathway. The ANSTP is designed to remove ANS in Lake Michigan water prior to discharge into the CAWS. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of bighead carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of bighead carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming bighead carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the bighead carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of bighead carp. Additionally, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock were removed from the approach channel/electric barrier area using nets, electrofishing, and/or piscicides. The physical barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming bighead carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming bighead carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

References

ACRCC (Asian Carp Regional Coordinating Committee). 2009. Asian carp rapid response workgroup wraps up main operation on Chicago Sanitary Ship Canal – Illinois DNR. Press Release Dated December 6, 2009. http://www.asiancarp.us/news/acrccwrapupildnr.htm. Accessed June, 27, 2013.

ACRCC. 2012. FY 2012 Asian carp control strategy framework. http://asiancarp.us/documents/2012Framework.pdf. Accessed June 21, 2013.

ACRCC (Asian Carp Regional Coordinating Committee). 2013. FY 2013 Asian Carp Control Strategy Framework. http://asiancarp.us/documents/2013Framework.pdf. Accessed August 1, 2013.

Cudmore, B., N.E. Mandrak, J. Dettmers, D.C. Chapman, and C.S. Kolar. 2012. Binational ecological risk assessment of bigheaded carps (Hypophthalmichthys spp.) for the Great Lakes Basin. Department of Fisheries and Oceans, Canadian Science Advisory Secretariat Research Document 2011/114. vi + 57 p.

MRWG (Monitoring and Response Working Group). 2013. May summary. Asian Carp Regional Coordinating Committee. http://www.asiancarp.us/sampling/2013/May2013.pdf. Accessed June 24, 2013.

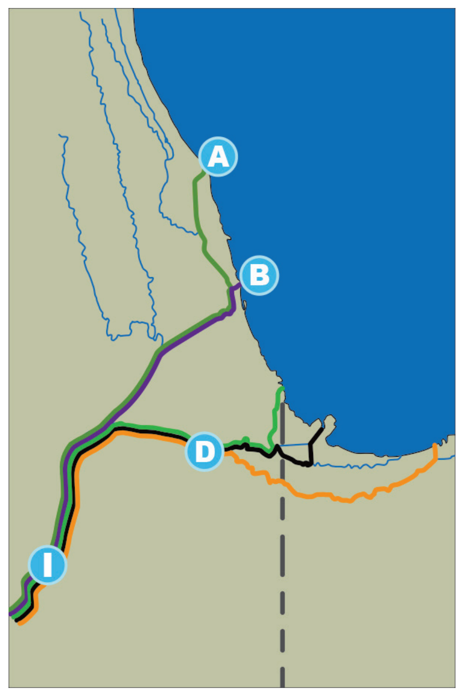
E.8.1.2.2 Silver Carp (*Hypophthalmichthys molitrix*)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

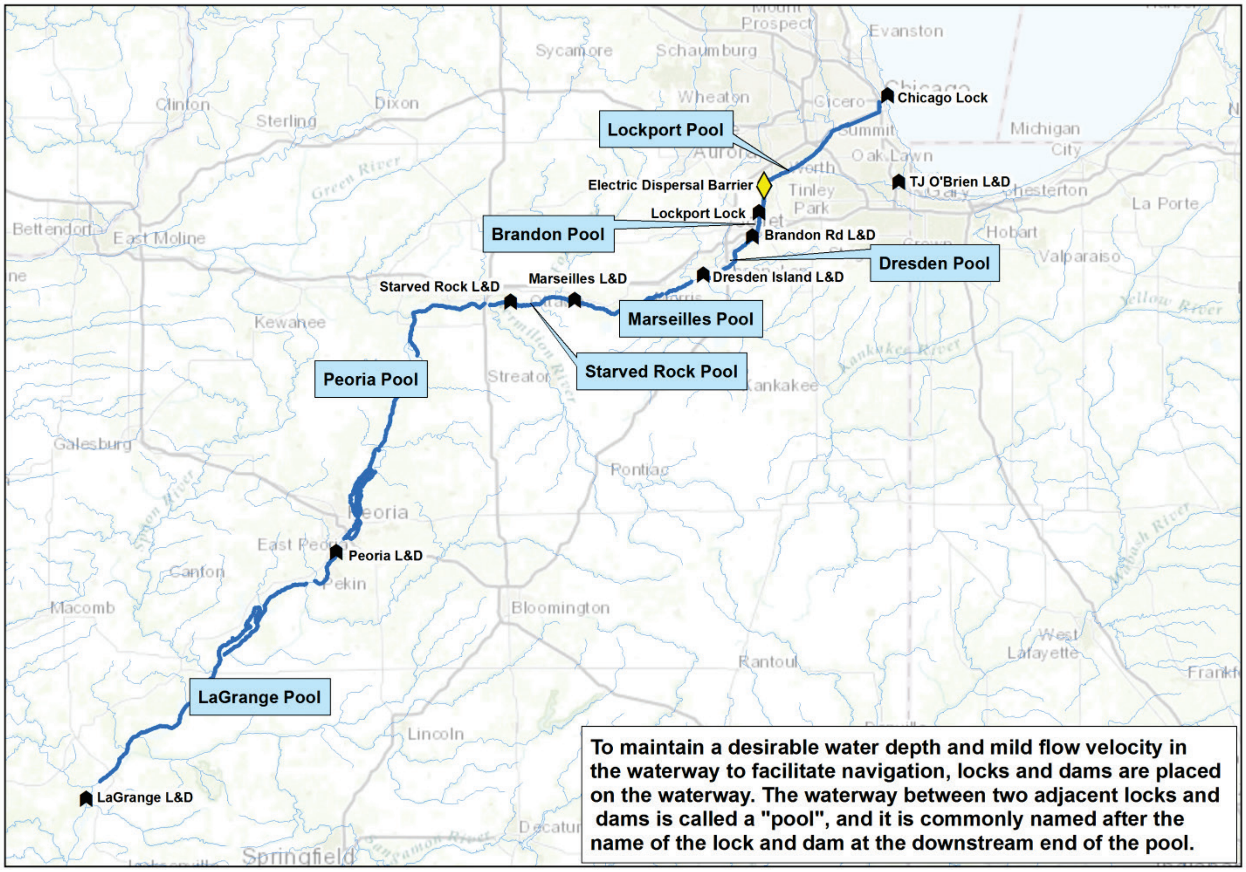
Mid-system Separation Chicago Sanitary and Ship Canal (CSSC) Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Wilmette Pumping Station (A)	ANS Treatment Plant[b]
		Screened Sluice Gates
Chicago River Controlling Works	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Chicago River Controlling Works (B)[c]	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
		Screened Sluice Gates
Calumet Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Alsip, IL (D)	ANS Treatment Plant[b]
		Physical Barrier
Indiana Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Alsip, IL (D)	ANS Treatment Plant[b]
		Physical Barrier



<table>
<tr><td rowspan="5">Burns Small Boat Harbor</td><td colspan="2">Nonstructural Measures[a]</td></tr>
<tr><td rowspan="2">Brandon Road Lock and Dam (I)</td><td>Electric Barrier</td></tr>
<tr><td>GLMRIS Lock</td></tr>
<tr><td rowspan="2">Alsip, IL (D)</td><td>ANS Treatment Plant[b]</td></tr>
<tr><td>Physical Barrier</td></tr>
<tr><td colspan="3">[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the silver carp.
[b] Control Points (A) and (D) include an ANS Treatment Plant that removes ANS from water on the Lake Michigan side of the physical barrier prior to its discharge to the Mississippi River side. The ANS Treatment Plant is not designed to treat Mississippi River Basin water and therefore has no impact on the silver carp's probability ratings.
[c] Control Point (B) is not effective for Mississippi River Basin species because it contains no measures to restrict ANS transfer to Lake Michigan during storm events requiring backflows, when water from the CAWS may be discharged into Lake Michigan.</td></tr>
</table>

Risk Assessment Reference Map



◊ The current Electric Dispersal Barrier System located approximately 5 mi upstream of the Lockport Lock and Dam is assumed to continue operation through T_{50}.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, ANS Treatment Plant, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Brandon Road Lock and Dam and the Wilmette Pumping Station (WPS) over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to movement of silver carp from their current position to Brandon Road Lock and Dam. The silver carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Technology with a Buffer Zone Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of a Great Lakes and Mississippi River Interbasin Study (GLMRIS) Lock and electric barrier at Brandon Road Lock and Dam in Illinois. Additionally, an aquatic nuisance species treatment plant (ANSTP) and screened sluice gates would be constructed at Wilmette

Pumping Station. Overall, none of these structural measures are expected to affect the arrival of silver carp at Brandon Road Lock and Dam by human-mediated transport or natural dispersion. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented in the pool below Brandon Road Lock and Dam. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the Brandon Road Lock and Dam. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of passage remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these nonstructural measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{10}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at the WPS. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% annual chance of exceedance (ACE) event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and stormwater sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of silver carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at the WPS; however, this control point controls the passage of Great Lakes Basin ANS, and silver carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through this aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of silver carp eggs, larvae, and fry, while the electric barrier is expected to control the passage of swimming silver carp.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures; however, implementation of the structural measures would not take place until T_{25}. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Nonstructural and structural measures, including the construction of the Brandon Road Lock and Dam Control Point, as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The Brandon Road Lock and Dam control point includes an electric barrier adjacent to the GLMRIS Lock which is expected to control the passage of swimming silver carp upstream through the lock, and a GLMRIS Lock which is expected to control the passage of silver carp eggs, larvae, and fry. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the human-mediated transport of the species through the aquatic pathway.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for silver carp within this aquatic pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at $T_{0.}$ Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's probability of passage through this aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points along this pathway. One control point is located at Brandon Road Lock and Dam and includes the construction of a GLMRIS Lock and electric barrier. The electric barrier is expected to control the upstream passage of swimming silver carp through this pathway. The GLMRIS Lock is expected to address the passage of silver carp eggs, larvae, and fry by flushing water from the lock and filling with buffer zone water. The flushing action of the GLMRIS Lock is expected to address the passive drift of silver carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at the WPS; however, it controls Great Lakes Basin ANS, and silver carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion and human-mediated transport of the silver carp through this aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock would be removed from the approach channel/electric barrier area using nonstructural measures such as nets, electrofishing, or piscicides. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming silver carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Screened Sluice Gates, ANS Treatment Plant, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–-	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Brandon Road Lock and Dam and the Chicago River Controlling Works (CRCW) over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The nonstructural measures of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are not expected to affect the silver carp's current and potential abundance and reproductive capacity.

T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to movement of silver carp from their current position and Brandon Road Lock and Dam. The silver carp has arrived at the pathway. Mid-system Separation CSSC Open Control Technologies with a Buffer Zone

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of a Great Lakes Mississippi River Interbasin

Study (GLMRIS) Lock and electric barrier at Brandon Road Lock and Dam in Illinois. Additionally, a GLMRIS Lock, electric barrier, ANSTP, and screened sluice gates would be constructed at CRCW. Overall, none of these structural measures are expected to affect the arrival of silver carp at Brandon Road Lock and Dam by human-mediated transport or natural dispersion. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented in the pool below Brandon Road Lock and Dam. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the Brandon Road Lock and Dam. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of passage remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these nonstructural measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at CRCW. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered

approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% ACE event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and stormwater sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of silver carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at CRCW; however, it controls the passage of Great Lakes Basin ANS. Silver carp are in the Mississippi River Basin, and therefore, it does not impact the passage of silver carp.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through this aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of silver carp eggs, larvae, and fry, while the electric barrier is expected to control the passage of swimming silver carp.

T_{50}: See T_{25}.

c. ***Existing Physical Human/Natural Barriers***

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures, but implementation of the structural measures would not take place until T_{10}. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Nonstructural and structural measures, including the construction of the Brandon Road Lock and Dam Control Point, as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through this aquatic pathway. The Brandon Road Lock and Dam control point includes an electric barrier adjacent to the GLMRIS Lock which is expected to control the passage of swimming silver carp upstream through the lock, and a GLMRIS Lock which is expected to control the passage of silver carp eggs, larvae, and fry. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the human-mediated transport of the species through the aquatic pathway.

T_{50}: See T_{25}.

d. ***Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)***

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for silver carp within the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's probability of passage through this aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points along this pathway. One control point is located at Brandon Road Lock and Dam and includes the construction of a GLMRIS Lock and electric barrier. The electric barrier is expected to control the upstream passage of swimming silver carp through this pathway. The GLMRIS Lock is expected to address the passage of silver carp eggs, larvae, and fry by flushing water from the lock and filling with buffer zone water. The flushing action of the GLMRIS Lock is expected to address the passive drift of silver carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at CRCW; however, it controls Great Lakes Basin ANS, and silver carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: Nonstructural measures and the Brandon Road Control Point as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the silver carp through this aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock would be removed from the approach channel/electric barrier area using nonstructural measures such as nets, electrofishing, or piscicides. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming silver carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to the movement of silver carp from their current position to Brandon Road Lock and Dam. The silver carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at Brandon Road Lock and Dam and one at Alsip, Illinois. The control point at Brandon Road Lock and Dam would include the construction of a GLMRIS Lock and electric barrier while the Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP. Overall, none of these structural measures are expected to control the arrival of the silver carp to Brandon Road Lock and Dam. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented in the pool below Brandon Road Lock and Dam. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the Brandon Road Lock and Dam. Silver carp have likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of passage remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. Silver carp have likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at the WPS. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% ACE event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address: electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and stormwater sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of silver carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. Silver carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through this aquatic pathway.
T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to control the human-mediated transport of silver carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming silver carp. The physical barrier at the Alsip control point is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of silver carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming silver carp. The Alsip control point includes a physical barrier that is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Alternative Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of the habitat for the silver carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of silver carp through the aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam as well as the construction of a physical barrier and ANSTP at Alsip, Illinois.

The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to address the passage of silver carp eggs, larvae, and fry by passive drift against the current and into the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with buffer zone water.

The electric barrier is expected to control the upstream passage of swimming silver carp through the aquatic pathway.

Additionally, a second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that silver carp and vessels potentially transporting silver carp eggs, larvae, and fry in ballast and bilge water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the silver carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. Additionally, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock would be removed from the approach channel/electric barrier area using nets, electrofishing, and/or piscicides. The physical barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming silver carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.
T_{25}: See T_{10}. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to the movement of silver carp from their current position to Brandon Road Lock and Dam. The silver carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at Brandon Road Lock and Dam and one at Alsip, Illinois. The control point at Brandon Road Lock and Dam would include the construction of a GLMRIS Lock and electric barrier while the Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP. Overall, none of these structural measures are expected to control the arrival of the silver carp to Brandon Road Lock and Dam. The species has likely arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented in the pool below Brandon Road Lock and Dam.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp at the Brandon Road Lock and Dam. The species has likely arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of passage remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. The species has likely arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at the WPS. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% ACE event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address: electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and storm water sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of silver carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. Silver carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through this aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to control the human-mediated transport of silver carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming silver carp. The physical barrier at the Alsip control point is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of silver carp eggs, larvae, and fry while the electric barrier is

expected to control the passage of swimming silver carp. The Alsip control point includes a physical barrier that is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Alternative Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of the habitat for the silver carp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of silver carp through the aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam as well as the construction of a physical barrier and ANSTP at Alsip, Illinois.
The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to address the passage of silver carp eggs, larvae, and fry by passive drift against the current

and into the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with buffer zone water.

The electric barrier is expected to control the upstream passage of swimming silver carp through the aquatic pathway.

Additionally, a second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that silver carp and vessels potentially transporting silver carp eggs, larvae, and fry in ballast and bilge water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric

Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the silver carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. Additionally, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock would be removed from the approach channel/electric barrier area using nets, electrofishing, and/or piscicides. The physical barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming silver carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	Medium	High	Medium	High
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	Low	Medium	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Medium	High	Medium	High	Medium	High	Medium
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Burns Small Boat Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for silver carp.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp at the Brandon Road Lock and Dam through aquatic pathways by natural dispersion.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the silver carp from human-mediated transport through this aquatic pathway.

c. Current and Potential Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current and potential abundance and reproductive capacity for the silver carp through this aquatic pathway.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance and reproductive capacity.
T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: There are no barriers to the movement of silver carp from their current position to Brandon Road Lock and Dam. The silver carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at Brandon Road Lock and Dam and one at Alsip, Illinois. The control point at Brandon Road Lock and Dam would include the construction of a GLMRIS Lock and electric barrier, while the Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP. Overall, none of these structural measures are expected to control the arrival of the silver carp to Brandon Road Lock and Dam. The silver carp has likely arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the distance from the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Silver carp have been documented in the pool below Brandon Road Lock and Dam.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would not affect the arrival of the silver carp at the Brandon Road Lock and Dam. The silver carp has likely arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the probability of passage remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of silver carp to the pathway. The silver carp has likely arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with Mississippi River (Garvey et al. 2013; Wyffels et al. 2013; Irons et al. 2009; Chick and Pegg 2001). Fewer silver carp have been captured upstream in the Dresden Pool, and none have been captured in the Lockport Pool (Ruebush et al. 2013). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however,

these measures alone are not expected to affect the natural dispersion (i.e., swimming and passive drift) of the silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points on this pathway: one at Brandon Road Lock and Dam and a second at the WPS. At Brandon Road Lock and Dam, the current lock would be rehabilitated into a GLMRIS Lock, and an electric barrier and engineered approach channel would be constructed on the downstream side of the lock. At this location, flood flows for a 0.2% ACE event would not bypass the Brandon Road control point. Nonstructural measures would include monitoring and overfishing and other population reduction measures in the Dresden Island Pool to minimize propagule pressure. These measures also include ballast and bilge water discharge prior to entering the Brandon Road control point from the downstream direction.

The Brandon Road Lock and Dam control point includes an electric barrier within an engineered channel downstream of the lock. The purpose of the electric barrier would be to deter swimming fish from moving into the lock chamber, thus reducing the potential for fish to pass upstream through the Brandon Road control point. To minimize opportunities for bypass through the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

The existing Brandon Road Lock would be rehabilitated to include a pump driven filling and emptying system to flush water from the lock and fill with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges that originate from treatment plants and stormwater sources. The flushing action of the GLMRIS Lock is expected to address the passive drift of silver carp eggs, larvae, and fry that may pass through the electric barrier and enter the lock.

A second control point would be created at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. Silver carp are in the Mississippi River Basin.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of silver carp through this aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Ballast and bilge water discharge prior to entering the Brandon Road Lock is expected to address the human-mediated transport of silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of silver carp through the aquatic pathway. The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to control the human-mediated transport of silver carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming silver carp. The physical barrier at the Alsip control point is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of silver carp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of silver carp through the aquatic pathway. The Brandon Road Lock and Dam control point includes a GLMRIS Lock that is expected to control the passage of silver carp eggs, larvae, and fry while the electric barrier is expected to control the passage of swimming silver carp. The Alsip control point includes a physical barrier that is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Alternative Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of the habitat for the silver carp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast and bilge water discharge that could be implemented at T_0. Though ballast and bilge water discharge prior to entering the Brandon Road Control Point is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the passage of silver carp through the aquatic pathway. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating at this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a GLMRIS Lock and electric barrier at Brandon Road Lock and Dam as well as the construction of a physical barrier and ANSTP at Alsip, Illinois.

The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to address the passage of silver carp eggs, larvae, and fry by passive drift against the current and into the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with buffer zone water.

The electric barrier is expected to control the upstream passage of swimming silver carp through the aquatic pathway.

Additionally, a second control point would be created at Alsip, Illinois, with the construction of a physical barrier and ANSTP. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that silver carp and vessels potentially transporting silver carp eggs, larvae, and fry in ballast and bilge water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP does not target controlling the passage of silver carp through this pathway. The ANSTP is designed to remove ANS in Cal-Sag Channel water prior to discharge into the CAWS. Silver carp are in the Mississippi River Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of silver carp passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of silver carp through the aquatic pathway by natural dispersion or human-mediated transport. As fully described in the Nonstructural Alternative Risk Assessment, the current Electric Dispersal Barrier System, located upstream of the Brandon Road Lock and Dam, is approximately 5 mi upstream of the Lockport Lock and Dam. This Electric Dispersal Barrier System provides a control point in this aquatic pathway and is expected to control the passage of swimming silver carp. Further testing on this system is focused on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty remains high.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion

and human-mediated transport of the silver carp through the aquatic pathway. The GLMRIS Lock is a novel technology and would need to be calibrated to control passage of silver carp. Additionally, further studies would be needed to determine the optimal operating parameters for the electric barrier downstream of the GLMRIS Lock. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the power goes down, the GLMRIS Lock would remain closed until power was restored to the electric barrier, and the fish below the lock would be removed from the approach channel/electric barrier area using nets, electrofishing, and/or piscicides. The physical barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. The current Electric Dispersal Barrier System provides an additional control point in this pathway to control the passage of swimming silver carp. In addition to the structural measures provided in this alternative, the current Electric Dispersal Barrier System is assumed to provide an additional control point in this aquatic pathway to control the passage of swimming silver carp. Optimization of the design and operation of the current Electric Dispersal Barrier System is assumed to continue to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents and very small fish. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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E.8.2 ANS Potentially Invading the Mississippi River Basin

E.8.2.1 Algae

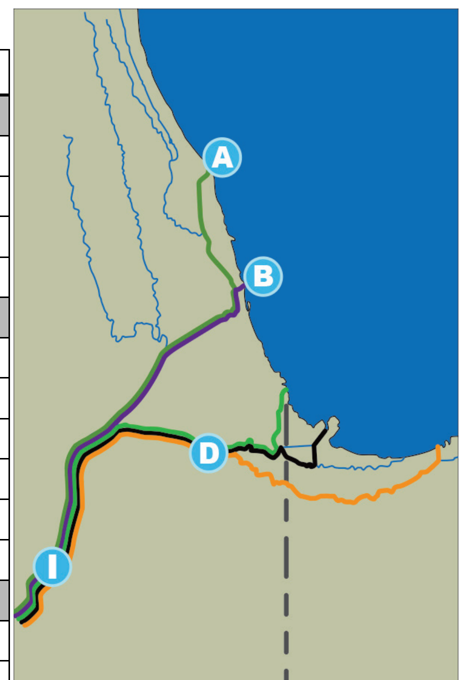
E.8.2.1.1 Grass Kelp (*Enteromorpha flexuosa*)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier[c]
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for *Enteromorpha flexuosa.*

[b] The Mid-system Separation CSSC Open Control Technologies Alternative includes a GLMRIS Lock and electric barrier at Control Point (I), which is designed to control Mississippi River Basin species and does not impact this species' probability ratings.

[c] The Mid-system Separation CSSC Open Control Technologies Alternative includes an electric barrier at Control Point (B), which is ineffective for *E. flexuosa* and does not impact its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, Electric Barrier, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	High	Medium	High	Medium	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low (2)***	–	***Low (2)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: LOW**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the Chicago Area Waterway System (CAWS) from natural dispersion through aquatic pathways.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, algaecides. Additionally, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport *of E. flexuosa* to the CAWS pathway.

c. ***Current Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas

where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and reduce ability of establishment near the CAWS. Overall, the Mid-system Separation CSSC Open Alternative may reduce the current abundance and distribution of *E. flexuosa*.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: None.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes construction of an aquatic nuisance species treatment plant (ANSTP) and screened sluice gates at the WPS. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of *E. flexuosa* through the CAWS. Overall, these structural measures are not expected to control the arrival of *E. flexuosa* at the CAWS. *E. flexuosa's* closest proximity to the WPS occurred on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes Basin for *E. flexuosa*. In particular, mean water temperature is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* is found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, temperature is expected to remain suitable. However, changes in nutrients and conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Separation

CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0. The current of the lake may transport the species away from the pathway entrance; however, transport by boat is possible. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage *E. flexuosa* populations where they exist; therefore, the probability of arrival is low.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*.

However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered to be a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.
Therefore, the uncertainty is medium.
T_{10}: See T_0.
T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. **P(passage) T_0-T_{50}: HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at the Wilmette Pumping Station (WPS) with the construction of an ANSTP and screened sluice gates. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *E. flexuosa* filaments and reproductive spores (spore size, 0.16 µm) (Hill 2001) are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the Wilmette Pumping Station control point is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999,

2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

In addition to the ANSTP, sluice gates would also be constructed at WPS in Wilmette, Illinois. The sluice gates would be comprised of two components: solid gates and self-cleaning screened gates with 0.4 in. (10.2 mm) openings. During dry weather conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened and water from the North Shore Channel would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the North Shore Channel is diverted to Lake Michigan during a storm event, *E. flexuosa* is expected to be unable to pass through the control point and into the North Shore Channel due to the species' inability to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{10} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for *E. flexuosa* prior to discharge into the CAWS. Additionally, the sluice gates are expected to control passage of *E. flexuosa* through the aquatic pathway during dry weather events when they are closed. During large storm events requiring backflows to Lake Michigan, *E. flexuosa* is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is

not possible for any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.
T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for *E. flexuosa* prior to discharge into the CAWS. Additionally, the sluice gates are expected to control passage of *E. flexuosa* through the aquatic pathway during dry weather events when they are closed. During large storm events requiring backflows to Lake Michigan, *E. flexuosa* is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is not possible for any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, and this may reduce the probability of *E. flexuosa* establishing in the CAWS, thereby reducing the abundance of spores and filaments in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and physical barrier at Wilmette, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway.

The purpose of the ANSTP is to treat Lake Michigan water for ANS prior to discharge into the CAWS. There are reports on other green algal species (Chlorophyta) that show their susceptibility to UV radiation. Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis*, and found that a 1-hr exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50% and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies, and damage to spores was irreversible. Xiong et al. (1996) screened 67 species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to UV-B radiation (2 W m^{-2} administered for 2 hr) and found that freshwater algae exhibited variable sensitivities to UV exposure that ranged from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller-sized and filamentous algae) lost 30% to 50% of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose, delayed or decreased germination.

Based on the damage or irregular growth found in similar species from UV-C and UV-B radiation, UV-C treatment typically found in wastewater disinfection facilities is expected to be effective at inactivating *E. flexuosa*. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate target species and determine the influence of local water quality. Pilot-scale testing would be required to evaluate dose requirements, possible interferences, and other design questions.

During dry weather conditions and non-backflow conditions, the sluice gates would remain closed and would block the aquatic pathway between Lake Michigan and the CAWS. Sluice gates would be opened only during flood events requiring backflows to Lake Michigan, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, *E. flexuosa* is expected to be unable to passively drift against the velocity of the current exiting the screened sluice gates to enter the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.

T_{10}: See T_0.
T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. Prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure and whether an additional treatment process is needed to control passage of *E. flexuosa* through the ANSTP. Additionally, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, Electric Barrier, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: LOW**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, algaecides. Additionally, the implementation of a ballast/bilge-water exchange program, education and outreach and laws and regulations may reduce the human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. ***Current Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence

reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and its current abundance and distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at the CRCW. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the arrival of *E. flexuosa* at the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of *E. flexuosa* at the CAWS. *E. flexuosa*'s closest proximity to the WPS occurred on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).
T_{50}: See T_0.

e. Distance from Pathway
T_0: See the Nonstructural Risk Assessment for a description of how nonstructural measures may impact the distance from pathway for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to

manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for *E. flexuosa*. In particular, mean water temperature is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* can be found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, water temperature is expected to remain suitable. However, changes in nutrients and conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa*; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*. However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered to be a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.

Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. P(passage) T_0-T_{50}: HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative include structural measures that would be implemented at T_{25}. This alternative creates two control points, one at the current CRCW and a second at Brandon Road Lock and Dam. At the CRCW control point, the current lock would be replaced with two GLMRIS Locks, one shallow and one deep, and an electric barrier, ANSTP, and screened sluice gates would be constructed.

At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS Lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to reduce the likelihood of waves from overtopping and bypassing this control point. These structures would be designed to minimize the creation of habitat surrounding the lock for *E. flexuosa*. Nonstructural measures would be used to monitor for the presence of *E. flexuosa* and, if required, to control the population surrounding the lock.

The electric barrier at the Lakeside entrance to the Chicago GLMRIS Lock would be an ineffective control for *E. flexuosa*. This species is not impacted by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport this species into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lake side of the lock, and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with ANS treated water. Therefore, ANS that rely on passive drift, including *E. flexuosa* would be removed from the lock chamber; however, the GLMRIS Lock would not be an effective control for hull fouling species, such as this species.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge into the CAWS buffer zone. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS-treated water for lock flushing.

The treatment technologies included in the ANSTP would be screening and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Filaments and reproductive spores (spore size, 0.16 µm)

(Hill 2001) of *E. flexuosa* are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and control the UV light from reaching them. Lake Michigan water quality data indicates that Lake Michigan is sufficiently clear to allow for effective UV treatment. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

Additionally, sluice gates would also be constructed at CRCW. The sluice gates would be comprised of two components: solid gates and self-cleaning screened gates with 0.4 in. (10.2 mm) openings. During dry weather conditions and non-backflow conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened and water from the Chicago River would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the Chicago River is diverted to Lake Michigan during a backflow event, *E. flexuosa* is expected to be unable to pass through the control point and into the Chicago River due to its inability to passively drift against the velocity of the exiting current.

For storms that require the passage of an even greater volume than the sluice gates can divert, the gates on a GLMRIS Lock would be opened. Water from the CAWS would be diverted to Lake Michigan through the lock. Again, *E. flexuosa* is expected to be unable to drift through the GLMRIS Lock while water is flowing from the CAWS through the lock into Lake Michigan.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. *E. flexuosa* is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0.

Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.**T_{10}:** See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling on vessels. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock does not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce the probability of *E. flexuosa* establishing in the CAWS, thereby reducing the abundance of spores and filaments in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the current CRCW and a second at Brandon Road Lock and Dam that would be implemented at T_{25}. At the CRCW control point, structural measures would include the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates.

The electric barrier is not effective at controlling the passage of *E. flexuosa*. The GLMRIS Lock, ANSTP and screened sluice gates are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. *E. flexuosa* is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would not reduce the likelihood of *E. flexuosa* passing through the aquatic pathway. Therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *E. flexuosa* via hull fouling on vessels. Overall, the uncertainty remains medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Medium	High	Medium
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	High	Medium	High	Medium	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low(2)***	–	***Low(2)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *E. flexuosa*.

T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier. Consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, algaecides. Additionally, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and reduce ability of establishment near the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative may reduce the current abundance and distribution of *E. flexuosa*.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: None.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of *E. flexuosa* at the CAWS. Overall, none of these structural measures are expected to control the arrival of *E. flexuosa* at the CAWS. *E. flexuosa's* closest proximity to the WPS occurred on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce habitat suitability at its current location at Muskegon Lake.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes basin *for E. flexuosa*. In particular, mean water temperature is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* is found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, temperature is expected to remain suitable. However, changes in nutrients and conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. *E. flexuosa* is highly invasive, and suitable physical habitat is present in the vicinity of Calumet Harbor. The current of the lake may transport the species away from the pathway entrance; however, transport by boat is also possible.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa*; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*.

However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered to be a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*.

Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and an ANSTP.

The physical barrier at the Alsip, Illinois, control point would be constructed in the channel, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *E. flexuosa* filaments and reproductive spores, which typically range in size from 0.16 µm to 3.6mm (Hill 2001), are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. *E. flexuosa* is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (Type of Mobility/Invasion Speed) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures

could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce the probability of *E. flexuosa* establishing in the CAWS and thereby reduce the abundance of spores and filaments in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0. The discharge of common municipal contaminants such as nutrients, metals, total dissolved solids, and sewage may decrease because of the adoption of water quality standards and effluent discharge limitations currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012). These changes may reduce habitat suitability in the CAWS.
T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a physical barrier and ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, the Brandon Road Lock and Dam control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that *E. flexuosa* and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP constructed also at the Alsip, Illinois, control point, would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature documenting the effectiveness of UV radiation on grass kelp. However, there are reports on other algal species including other species of green algae (Chlorophyta). Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis*, and found that a 1-hr exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50 and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies, and damage to spores was irreversible. Xiong et al. (1996) screened 67 species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to UV-B radiation (2 W m^{-2} administered for 2 hr) and found that freshwater algae exhibited variable sensitivities to UV exposure, ranging from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller-sized and filamentous algae) lost 30 to 50% of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination.

The studies cited above examined UV-B and UV-C exposure to algae and demonstrated its impacts on photosynthetic capacity and germination. Based on the findings of delayed and decreased germination, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *E. flexuosa*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier.

Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control the passage of *E. flexuosa* through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Physical Barrier, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	Low	High	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low(2)***	–	***Low(2)***	–	***Low(2)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system

Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, algaecides. Additionally, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of *E. flexuosa* to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and reduce ability of establishment near the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative may reduce the current abundance and distribution of *E. flexuosa*.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of *E. flexuosa* at the CAWS. Overall, none of these structural measures are expected to control the arrival *E. flexuosa* at the CAWS. *E. flexuosa's* closest proximity to the WPS occurred on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).

T_{50}: See T_{10}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.

T_{10}: See T_0. There are no predicted significant differences in habitat components along Lake Michigan in the near or foreseeable future that would affect the arrival of this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for *E. flexuosa*. In particular, mean water temperature is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* is found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, temperature is expected to remain suitable. However, changes in nutrients and conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and to implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. *E. flexuosa* is highly invasive, and suitable physical habitat is present in the vicinity of Indiana Harbor.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa*; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*.

However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered to be a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *E. flexuosa* filaments and reproductive spores, which typically range in size from 0.16 µm to 3.6mm (Hill 2001), are expected to pass through the screens, they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. *E. flexuosa* is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of

the species through the aquatic pathway, because vessels would be unable to traverse the barrier. However, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.**T_{10}:** See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce the probability *of E. flexuosa* establishing in the CAWS and thereby reduce the abundance of spores and filaments in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. The discharge of common municipal contaminants such as nutrients, metals, total dissolved solids, and sewage may decrease because of the adoption of water quality standards and effluent discharge limitations currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012). These changes may reduce habitat suitability in the CAWS

T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Alternative Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0. However, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a physical barrier and ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that *E. flexuosa* and vessels potentially transporting the species in ballast water or via hull fouling would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP constructed at the Alsip, Illinois, control point would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature documenting the effectiveness of UV radiation on grass kelp; however, there are reports on other algal species including other species of green algae (Chlorophyta). Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis*, and found that a one-hour exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50% and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies, and damage to spores was irreversible. Xiong et al. (1996) screened sixty-seven species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to

UV-B radiation (2 W m^{-2} administered for two hours) and found that freshwater algae exhibited variable sensitivities to UV exposure, ranging from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller-sized and filamentous algae) lost 30 to 50% of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination.

The studies cited above examined UV-B and UV-C exposure to algae and demonstrated impacts on photosynthetic capacity and germination. Based on the findings of delayed and decreased germination, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *E. flexuosa*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty is high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier.

Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of *E. flexuosa* through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Physical Barrier, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Medium	***Low***	Medium	***Low***	Medium	***Low***	***High***
P(passage)	Low	High	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Lo(2)***	–	***Low(2)***	–	***Low(2)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation

CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *E. flexuosa*.
T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier. Consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: LOW**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures, in particular, algaecides. Additionally, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of *E. flexuosa* at the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion on how nonstructural measures may impact current abundance and reproductive capacity of *E. flexuosa*.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where *E. flexuosa* is abundant. Managing nutrient loads to waterways may reduce habitat suitability for this species at current infestations and reduce ability of establishment near CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative may reduce the current abundance and distribution of *E. flexuosa*.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: None.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of *E. flexuosa* at the CAWS. Overall, none of these structural measures are expected to control the arrival *E. flexuosa* at the CAWS. *E. flexuosa's* closest proximity to the WPS occurred on the beaches of Muskegon Lake in 2003 (Lougheed and Stevenson 2004). Muskegon Lake is a coastal lake on the eastern shore of, and hydrologically connected to, Lake Michigan (Lougheed and Stevenson 2004).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a description of how nonstructural measures may impact the distance from pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may limit the movement of *E. flexuosa* outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage nutrient loads to waterways where *E. flexuosa* is currently located. In addition, future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes Basin for *E. flexuosa*. Mean water temperature, in particular, is expected to increase (Wuebbles et al. 2010). However, *E. flexuosa* is found in a wide range of water temperatures and is globally distributed (Hill 2001). Therefore, temperature is expected to remain suitable. However, changes in nutrients and conductivity related to future climate change or new environmental regulations may affect the suitability of southern Lake Michigan for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of *E. flexuosa* at the CAWS from natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring may be used to locate areas where *E. flexuosa* is established. In addition, outreach and education can be used to inform the public of *E. flexuosa* management efforts, and voluntary occurrence reporting can supplement agency monitoring. Informed by monitoring information, management efforts may be directed at controlling *E. flexuosa* abundance. Data information collected through agency monitoring and voluntary occurrence reporting can be used to target dense populations of *E. flexuosa* and implement algaecide treatments to reduce biomass and population density. In addition, managing nutrient loads to waterways may reduce habitat suitability for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* arriving at the pathway by reducing the current abundance and distribution of *E. flexuosa*. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. The current of the lake may transport the species away from the pathway entrance; however, transport by boat is possible. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread of *E. flexuosa*; therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	Medium	***High***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage the spread and distribution of *E. flexuosa*. However, surveys to identify the current location of this species would be necessary before ANS control measures (algaecides, dredging, desiccation, and alteration of water quality) could be successfully implemented.

While *E. flexuosa* is considered to be a rapid invader, the most recent report of this species was recorded in 2003 in Lake Muskegon (Lougheed and Stevenson 2004). Therefore, the current location of this species is unknown. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species approaching the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. The future effects of climate change and other conditions that may impact distribution of and habitat suitability for *E. flexuosa* in Lake Michigan are unknown. Therefore the uncertainty is high.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ASNTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *E. flexuosa* filaments and reproductive spores, which typically range in size from 0.16 µm to 3.6mm (Hill 2001), are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. *E. flexuosa* is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *E. flexuosa* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *E. flexuosa* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting

the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.
T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*
T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *E. flexuosa* prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, which includes nonstructural measures such as managing nutrient loads to waterways, may reduce the probability of *E. flexuosa* establishing in the CAWS and thereby reduce the abundance of spores and filaments in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0. The discharge of common municipal contaminants such as nutrients, metals, total dissolved solids, and sewage may decrease because of the adoption of water quality standards and effluent discharge limitations currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012). These changes may reduce habitat suitability in the CAWS.
T_{50}: See T_{25}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, these measures alone are not expected to affect the passage of *E. flexuosa* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a physical barrier and ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam. However, the Brandon Road Lock and Dam control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of *E. flexuosa* through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that *E. flexuosa* and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for *E. flexuosa* prior to discharge into the Mississippi River Basin side of the control point. There is no published information in the literature documenting the effectiveness of UV radiation on grass kelp. However, there are reports on other algal species including other species of green algae (Chlorophyta). Cordi et al. (2001) examined different life stage sensitivities to UV-B radiation (280–315 nm; 0.5–2.2 W m^{-2} supplied by UV-A and UV-B tubes) in *Enteromorpha intestinalis*, and found that a 1-hr exposure inhibited spore germination success and growth rates of settled gametes and zoospores by 50% and 16%, respectively. Zoospores (asexual reproductive spores) were six times more sensitive to UV-B exposure than mature thalli (adult algae) in these studies and damage to spores was irreversible. Xiong et al. (1996) screened 67 species of freshwater algae (Chlorophyta and Chromophyta) for sensitivity to UV-B radiation (2 W m^{-2} administered for 2 hr) and found that freshwater algae exhibited variable sensitivities to UV exposure ranging from reduction to stimulation of photosynthesis (measured as O_2 evolution). The most sensitive species (often the smaller-sized and filamentous algae) lost 30% to 50%of their photosynthetic capacity during UV exposure. The studies by Xiong et al. (1996) concluded that some algal species are extremely sensitive to UV-B radiation while other species are resistant or even stimulated by UV exposure. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination.

The studies cited above examined UV-B and UV-C exposure to algae and demonstrated impacts to photosynthetic capacity and germination. Based on the findings of delayed and decreased germination, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *E. flexuosa*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures may reduce the spread and distribution of *E. flexuosa*; however, these measures alone are not expected to control the passage of this species through the aquatic pathway. *E. flexuosa* is considered to be a marine species but it can tolerate freshwater habitats where industrial activities have created increased nutrient loads and salinity levels in associated waters. Water quality and suitable habitat conditions conducive to the growth of this species in the pathway are unknown and may be seasonally variable. The effectiveness of nutrient management on *E. flexuosa's* abundance and its natural rate of spread is unknown.

In addition, the use of algaecides can reduce population densities of similar algal species in the genus *Enteromorpha*; however, there are no published reports in the literature specific to the effectiveness of algaecides against *E. flexuosa*. Therefore, the uncertainty remains high.**T_{10}:** See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *E. flexuosa* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier..

Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of *E. flexuosa* through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

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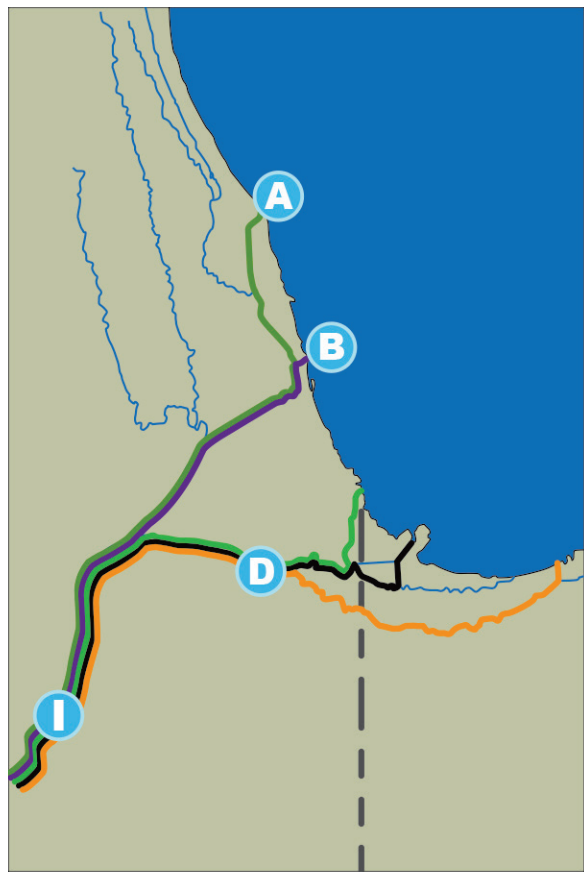
E.8.2.1.2 Red Algae (*Bangia atropurpurea*)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier[c]
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for red algae.

[b] The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes a GLMRIS Lock and electric barrier at Control Point (I), which is designed to control Mississippi River Basin species and does not impact this species' probability ratings.

[c] The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an electric barrier at Control Point (B), which is ineffective for red algae and does not impact its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Screened Sluice Gates, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC

Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the Chicago Area Waterway System (CAWS) from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.
T_{10}: See T_0. The distribution and abundance of red algae in the Great Lakes could decrease as a result of improvements in the water quality of southern Lake Michigan, which could reduce the anthropogenic inputs into Lake Michigan preferred by this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: None.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes construction of an aquatic nuisance species treatment plant (ANSTP) and screened sluice gates at the WPS. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and

it would not impact the arrival of red algae through the CAWS. Overall, these structural measures are not expected to control the arrival of red algae at the CAWS since the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the WPS.
T_{50}: See T_{25}.

*e. **Distance from Pathway***

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect where it is able to establish, and hence its locations in relation to the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

*f. **Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)***

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect habitat suitability for red algae in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways that may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the WPS. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.

T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: Although red algae are historically present in southern Lake Michigan, recent surveys do not indicate their presence. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the WPS. Therefore, the uncertainty remains high.
T_{10}: See T_0.
T_{25}: The future population trends and rate of spread for red algae are uncertain. The effects on red algae of nutrient restrictions to improve water quality in Lake Michigan are uncertain.
T_{50}: The future effects of climate change on red algae and habitat suitability in Lake Michigan are uncertain.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gates located at the WPS. In addition, a GLMRIS Lock and an electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed

to control ANS originating in the Mississippi River Basin and it would not impact the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages that are currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments, which are typically 75 µm in size (Kipp 2011), and reproductive spores, 15.5 µm in size (Kipp 2011), are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the Wilmette Pumping Station project location is anticipated to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition to the ANSTP, sluice gates would be constructed at WPS in Wilmette, Illinois. The sluice gates would be comprised of two components; solid gates and self-cleaning screened gates, with 0.4 in. (10.2 mm) openings. During dry weather conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened and water from the North Shore Channel would be diverted into Lake Michigan through the screened gates to reduce flood risk. When water from the North Shore Channel is diverted to Lake Michigan during a storm event, red algae is expected to be unable to pass through the control point and into the North Shore Channel due to the species being unable to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. However, the nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See T_0. See Section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for red algae prior to discharge into the CAWS. In addition, the sluice gates are expected to control passage of red algae during dry weather events when they are closed. During large storm events requiring backflows to Lake Michigan, red algae is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is not possible for any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for red algae prior to discharge into the CAWS. In addition, the sluice gates are expected to control natural dispersion of red algae during dry weather events when they are closed. During large storm events requiring backflows to Lake Michigan, red algae is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is not possible for

any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae establishing in the CAWS, thereby reducing the abundance and potential passage of red algae spores and filaments through the CAWS to the Brandon Road Lock and Dam.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gate at the Wilmette Pumping Station. In addition, a GLMRIS Lock and an electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and it would not impact the natural dispersion or human-mediated transport of red algae through the aquatic pathway.

The purpose of the ANSTP is to treat Lake Michigan water for ANS prior to discharge into the CAWS. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae, including *B. atropurpurea*, and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-h UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae, and found that spores subjected to any dose of UV-B or UV-C radiation showed delayed or decreased germination. There are no specific reports in the literature that identify the effect or dose-response relationship of UV radiation with respect to *B. atropurpurea* spore viability. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

During dry weather conditions and non-backflow conditions the sluice gates would remain closed and would block the aquatic pathway between Lake Michigan and the CAWS. Sluice gates would be opened only during flood events requiring backflows to Lake Michigan, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, red algae is expected to be unable to passively drift against the velocity of the current exiting the screened sluice gates to enter the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of red algae passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length

of UV radiation exposure and whether an additional treatment process is needed to control the passage of red algae through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, GLMRIS Lock, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS via human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.
T_{10}: See T_0. The distribution and abundance of red algae in the Great Lakes could decrease as a result of improvements in the water quality of southern Lake Michigan, which could reduce the anthropogenic inputs into Lake Michigan preferred by this species.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gate at the CRCW. Additionally, a GLMRIS Lock and an electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and it would not impact the arrival of red algae to the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of red algae at the CAWS since the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the CRCW.

T_{50}: See T_{25}.

*e. **Distance from Pathway***

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of red algae outside of their current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

*f. **Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)***

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect habitat suitability for red algae in southern Lake Michigan. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae to the CAWS.

T_{10}: See T_0.

T_{25}: See T_{10}.

T_{50}: Future climate change or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for red algae. Mean temperature, in particular, is expected to increase (Wuebbles et al. 2010). However, red algae can tolerate a wide range of temperatures, from 2 to 26°C (35.6 to 78°F) (Kipp 2011; Garwood 1982), and they are globally distributed across wide latitudes, from boreal to tropical (Guiry and Guiry 2012).

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including

offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the CRCW. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: Red algae are tolerant of a wide range of temperatures (see section 2f, T_{50} of the Nonstructural Risk Assessment). Red algae have been found in southern Lake Michigan in the vicinity of the CRCW, and appropriate habitat conditions are expected to continue to be present along the shoreline of Lake Michigan, even considering impacts on habitat related to future climate change.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the CRCW. Therefore, the uncertainty remains high.
T_{10}: See T_0.
T_{25}: See T_0. The future population trends and rate of spread for red algae are uncertain. The effects on red algae of measures to improve water quality in Lake Michigan are uncertain.
T_{50}: The future effects of climate change on red algae and habitat suitability in Lake Michigan are uncertain.

3. P(passage) T_0-T_{50} : HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at the current CRCW and a second at Brandon Road Lock and Dam. At the CRCW control point, the current lock would be replaced with two GLMRIS Locks, one shallow and one deep, and an electric barrier, ANSTP, and screened sluice gates would be constructed.

At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS Lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to reduce the likelihood of waves from overtopping and bypassing this control point. These structures would be designed to minimize the creation of habitat surrounding the lock for red algae. Nonstructural measures would be used to monitor for the presence of red algae and if required, to control the population surrounding the lock.

The electric barrier at the Lakeside entrance to the Chicago GLMRIS Lock would be an ineffective control for red algae. This species is not impacted by an electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport red algae into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lakeside of the lock, and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with ANS treated water. Therefore, ANS that rely on passive drift, including red algae would be removed from the lock chamber; however, the GLMRIS Lock would not be an effective control for hull-fouling species, such as red algae.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge into the CAWS buffer zone. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water for lock flushing.

The treatment technologies included in the ANSTP would be screening and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages that are currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments, which are typically 75 µm in size (Kipp 2011), and reproductive spores, which are typically 15.5 µm in size (Kipp 2011), are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at CRCW is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

Additionally, sluice gates would also be constructed at CRCW. The sluice gates would be comprised of two components; solid gates and self-cleaning screened gates with 0.4 in. (10.2 mm) openings. During dry weather conditions and non-backflow conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened and water from the Chicago River would be diverted into Lake Michigan through the screened gates to reduce flood risk. When water from the Chicago River is diverted to Lake Michigan during a backflow event, red algae are expected to be unable to pass through the control point and into the Chicago River due to the species being unable to passively drift against the velocity of the exiting current.

For storms that require the passage of an even greater volume than the sluice gates can divert, the gates on a GLMRIS Lock would be opened. Water from the CAWS would be diverted to Lake Michigan through the lock. Again, the passive drifting red algae is expected to be unable to drift through the GLMRIS Lock while water is flowing from the CAWS through the lock into Lake Michigan.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Red algae is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are not expected to control the human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. This species is known to foul hulls of vessels (Kipp

2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.
T_{10}: None.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to control the natural dispersion of red algae through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling on vessels. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock does not address hull-fouling species since the lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of the red algae's entering and establishing in the CAWS and thereby reduce the abundance of spores and filaments in the CAWS. However, the transport of spores and filaments through the CAWS would not be affected.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points — one at the current CRCW and a second at Brandon Road Lock and Dam — that would be implemented at T_{25}. At the CRCW control point, structural measures would include the construction of an ANSTP, a GLMRIS Lock, an electric barrier, and screened sluice gates. The electric barrier is not effective at controlling the passage of red algae. The GLMRIS Lock, ANSTP, and screened sluice gates are expected to control the natural dispersion of red algae through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Red algae is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the likelihood of red algae passing through the aquatic pathway. Therefore, probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that are expected to control the natural

dispersion of red algae through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of red algae via hull fouling on vessels. Overall, the uncertainty remains high.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	High	Medium	High	Medium	High	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	High	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Medium	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for red algae.

T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS via human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
This species of red algae has been found in southern Lake Michigan (Lin and Blum 1977).
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect the current abundance or reproductive capacity of red algae.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity, which can be very high during certain times of the year and with certain nutrient conditions, is predicted to remain the same.

T_{25}: Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: None
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and it would not impact the arrival of red algae to the CAWS. Overall, these structural measures are not expected to control the arrival of red algae at the pathway since the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Calumet Harbor.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of red algae outside of their current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect habitat suitability for red algae in southern Lake Michigan. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of this species.
T_{10}: See T_0. The habitat of Lake Michigan is expected to remain suitable for red algae during this time step.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Calumet Harbor. Therefore, the probability of arrival remains medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Red algae are tolerant of a wide range of temperatures (section 2f, T_{50} of the Nonstructural Risk Assessment). Red algae have been found in southern Lake Michigan and appropriate habitat conditions are expected to continue to be present along the shoreline of Lake Michigan, even considering impacts on habitat related to future climate change.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0. The future population trends and rate of spread for red algae are uncertain. The effects of measures to improve water quality in Lake Michigan on red algae are uncertain.

T_{50}: See T_{25}.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP at Alsip, Illinois.

The physical barrier at the Alsip, Illinois, control point would be constructed in the channel and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments, typically 75 µm in size (Kipp 2011), and reproductive spores, typically 15.5 µm in size (Kipp 2011), are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Red algae is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. However, the nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: None.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae's establishment in the CAWS and thereby reduce the abundance of red algae spores and filaments in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a physical barrier and ANSTP at Alsip, Illinois.

Additionally, a GLMRIS Lock and an electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of red algae through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that red algae and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP would treat Cal-Sag Channel water for red algae prior to its discharge into the Mississippi River Basin side of the control point. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae, including *B. atropurpurea*, and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-hr UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae, and found that spores subjected to any dose of UV-B or UV-C radiation showed delayed or decreased germination. There are no specific reports in the literature that identify the effect or dose-response relationship of UV radiation with respect to *B. atropurpurea* spore viability.

The studies cited above examined UV-B and UV-C exposure to algae and observed the disruption of chloroplast membranes and impacts on germination. Based on these findings, it is expected that the UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of red algae passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.
T_{10}: See T_0.
T_{25}: Structural measures that are part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of red algae through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for red algae.

T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP, and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS via human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
This species of red algae has been found in southern Lake Michigan (Lin and Blum 1977). The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes restrictions on nutrient loads to waterways, which could affect the current abundance or reproductive capacity of red algae.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity, which can be very high during certain times of the year and with certain nutrient conditions, is predicted to remain the same.
T_{25}: Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: None

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes a physical barrier and ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of red algae to the CAWS. However, these structural measures are not expected to control the arrival of red algae at the pathway since the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Indiana Harbor.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of red algae outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which could affect habitat suitability for red algae in southern Lake Michigan. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of this species.

T_{10}: See T_0.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as restrictions on nutrient loads to waterways, may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Indiana Harbor. Therefore, the probability of arrival remains medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Red algae are tolerant of a wide range of temperatures (section 2f, T_{50}). Red algae have been found in southern Lake Michigan, and appropriate habitat conditions are expected to continue to be present along the shoreline of Lake Michigan, even considering impacts on habitat related to future climate change.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the Indiana Harbor. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0. The future population trends and rate of spread for red algae are uncertain. The effects on red algae of measures to improve water quality in Lake Michigan are uncertain.

T_{50}: See T_{25}.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments, typically 75 µm in size (Kipp 2011), and reproductive spores, typically 15.5 µm in size (Kipp 2011), are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip, Illinois pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al.

2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Red algae is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. However, the nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: None.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to

control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for red algae prior to its discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae's establishment in the CAWS and thereby reduce the abundance of red algae spores and filaments in the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a physical barrier and ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road

Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and it would not impact the natural dispersion or human-mediated transport of red algae through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that red algae and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for red algae prior to its discharge into the Mississippi River Basin side of the control point. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae, including *B. atropurpurea*, and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-hr UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae, and found that spores subjected to any dose of UV-B or UV-C radiation showed delayed or decreased germination. There are no specific reports in the literature that identify the effect or dose-response relationship of UV radiation with respect to *B. atropurpurea* spore viability.

The studies cited above examined UV-B and UV-C exposure to algae and observed disruption of chloroplast membranes and impacts to germination. Based on these findings, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of red algae passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures that are part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. In regard to the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of red algae through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	Medium	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Medium	High	Medium	High	Medium	High	Medium	High
P(passage)	Low	High	Low	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for red algae.

T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: MEDIUM**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS via natural dispersion through aquatic pathways.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS via human-mediated transport through aquatic pathways.

c. ***Current Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for this species.
This species of red algae has been found in southern Lake Michigan (Lin and Blum 1977). The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes restrictions on nutrient loads to waterways, which could affect the current abundance or reproductive capacity of red algae.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity, which can be very high during certain times of the year and with certain nutrient conditions, is predicted to remain the same.
T_{25}: Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species.
T_{50}: See T_{25}.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: None

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes a physical barrier and ANSTP in the channel at Alsip, Illinois. Additionally, a GLMRIS Lock and an electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of red algae to the CAWS. Overall, these structural measures are not expected to control the arrival of red algae at the pathway since the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the BSBH.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of red algae outside of their current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect habitat suitability for red algae in southern Lake Michigan. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of this species.

T_{10}: See T_0. The habitat of Lake Michigan is expected to remain suitable for red algae during this time step.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways, which may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the BSBH. Therefore, the probability of arrival remains medium.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Red algae are tolerant of a wide range of temperatures (section 2f, T_{50}). Red algae have been found in southern Lake Michigan and appropriate habitat conditions are expected to continue to be present along the shoreline of Lake Michigan, even considering impacts on habitat related to future climate change.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways. The species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may be present at the BSBH. Therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: See T_0. The future population trends and rate of spread for red algae are uncertain. The effects of measures to improve water quality in Lake Michigan on red algae are uncertain.

T_{50}: See T_{25}.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at Alsip, Illinois, and a second at Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages that are currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). Red algae filaments, typically 75 µm in size (Kipp 2011), and reproductive spores, typically 15.5 µm in size (Kipp 2011), are expected to pass through the screens, where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Red algae is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. However, the nonstructural measures alone are not expected to address the human-mediated transport of red algae through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to control the human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: None.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures that are part of this alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the

species through the aquatic pathway because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for red algae prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of red algae's establishment in the CAWS and thereby reduce the abundance of red algae spores and filaments in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that could be implemented at T_0. Structural measures would include the construction of a physical barrier and ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and it would not impact the natural dispersion or human-mediated transport of red algae through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that red algae and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for red algae prior to its discharge into the Mississippi River Basin side of the control point. Poppe et al. (2003) examined the effects of UV radiation on four species of red algae including *B. atropurpurea*, and found that all four species showed damage to thylakoid membranes in chloroplasts. Disruption of chloroplast membranes occurred following a 72-hr UV exposure in *B. atropurpurea*. Agrawal (2009) reviewed the literature for reports of environmental factors that affect spore germination in algae and found that spores subjected to UV-B or UV-C radiation of any dose delayed or decreased germination. There are no specific reports in the literature that identify the effectiveness or dose response of UV radiation on *B. atropurpurea* spore viability.

The studies cited above examined UV-B and UV-C exposure to algae and observed disruption of chloroplast membranes and impacts to germination. Based on these findings, it is expected that UV-C treatment typically used in wastewater disinfection facilities could be engineered to inactivate algae and spores. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for red algae.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of red algae passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of red algae through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.
T_{25}: Structural measures that are part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of red algae through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control the passage of red algae through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

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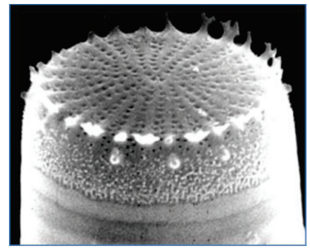
E.8.2.1.3 Diatom (Stephanodiscus binderanus)

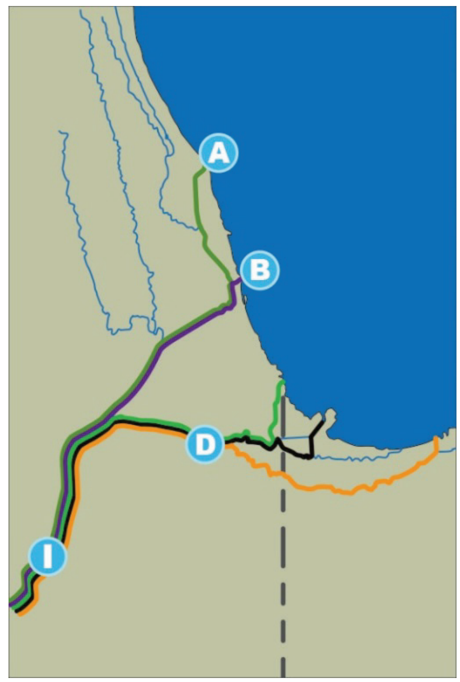


MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by T_{25}.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier[c]
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the diatom.

[b] The Mid-system Separation CSSC Open Control Technologies Alternative includes a GLMRIS Lock and electric barrier at Control Point (I), which are designed to control Mississippi River Basin species and do not impact this species' probability ratings.

[c] The Mid-system Separation CSSC Open Control Technologies Alternative includes an electric barrier at Control Point (B), which is ineffective for *S. binderanus* and does not impact its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Screened Sluice Gates, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. *Low|NPE* means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Wilmette Pumping Station (WPS) and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Chicago Sanitary and Ship Canal (CSSC) Open Control Technologies with a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from natural dispersion through aquatic pathways to the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures, such as restrictions on nutrient loads to waterways, could affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, which can be very high during certain times of the year and with certain nutrient conditions.
T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.
T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes construction of an aquatic nuisance species (ANS) treatment plant (ANSTP) and screened sluice gate at the WPS. In addition, a Great Lakes and Mississippi River Interbasin Study (GLMRIS) Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the arrival of *S. binderanus* to the CAWS. Overall, these structural measures are not expected to control the arrival of *S. binderanus* to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of *S. binderanus* outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could affect habitat suitability for *S. binderanus* in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. In addition, nonstructural measures alone are not expected to affect the arrival of *S. binderanus* to the CAWS via natural dispersion or human-mediated transport. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gate located at the WPS. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current ones.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Stephanodiscus binderanus* is expected to pass through the screens (size of diatom, 830 μm^3; Kipp 2011) where, subsequently, it would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005, Kazumi 2007; Sutherland et al. 2001;, Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition to the ANSTP, sluice gates would also be constructed at the WPS in Wilmette, Illinois. The sluice gates would be composed of two components—solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened, and water from the North Shore Channel would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the North Shore Channel is diverted to Lake Michigan during a storm event, *S. binderanus* is not expected to pass through the control point and into the North Shore Channel, because the species is unable to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, the nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for *S. binderanus* prior to discharge into the CAWS. In addition, the closed sluice gates are expected to control passage of *S. binderanus* during dry weather. During large storm events requiring backflows to Lake Michigan, *S. binderanus* is expected to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is not possible for any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for *S. binderanus* prior to its discharge into the CAWS. In addition, the sluice gates are expected to control passage of *S. binderanus* during dry weather events when they are closed. During large storm events requiring backflows to Lake Michigan, *S. binderanus* is not expected to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is not possible for any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gate at the WPS. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of *S. bindernaus* through the aquatic pathway.

The purpose of the ANSTP at the WPS control point is to treat Lake Michigan water for ANS prior to its discharge into the CAWS. There is no published information documenting the effectiveness of UV radiation on *S. binderanus*; however, there are reports on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an integrated cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *S. binderanus*.

During dry weather conditions and non-backflow conditions, the sluice gates would remain closed and would block the aquatic pathway between Lake Michigan and the CAWS. Sluice gates would be opened only during flood events requiring backflows to Lake Michigan, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, *S. binderanus* is not expected to passively drift against the velocity of the current exiting the screened sluice gates to enter the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *S. binderanus* passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway. Prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of *S. binderanus* through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, GLMRIS Lock, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Chicago River Controlling Works (CRCW) and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would not impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as restrictions on nutrient loads to waterways, could affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0. Further abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, which can be very high during certain times of the year and with certain nutrient conditions.

T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.

T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at the CRCW. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the arrival of *S. binderanus* to the CAWS. Overall, the structural measures are not expected to control the arrival of *S. binderanus* to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of *S. binderanus* outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could affect habitat suitability for *S. binderanus* in southern Lake Michigan. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* to the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes restrictions on nutrient loads to waterways, which may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the

Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50} : HIGH

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at the current CRCW, and a second at Brandon Road Lock and Dam. At the CRCW control point, the current lock would be

replaced with two GLMRIS Locks – one shallow and one deep. Also, an electric barrier, ANSTP, and screened sluice gates would be constructed.

At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS Lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to reduce the likelihood of waves overtopping and bypassing this control point. These structures would be designed to minimize the creation of habitat for *S. binderanus*. Nonstructural measures would be used to monitor for the presence of *S. binderanus,* and, if required, to control the population surrounding the lock.

The electric barrier at the lake side entrance to the Chicago GLMRIS Lock would be an ineffective control for *S. binderanus*. This species is not impacted by electric current. To address the current-driven passage of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and refill it with water from an ANSTP. When the lock gates are closed, the lock is emptied of lake side water, then flushed and filled with ANS-treated water from the CAWS buffer zone side of the lock. Therefore, ANS that rely on passive drift, including *S. binderanus,* would be removed from the lock chamber; however, the GLMRIS Lock would not be an effective control for hull fouling species, such as this species.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge into the CAWS buffer zone. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current ones. The ANSTP also would supply the GLMRIS Locks with ANS-treated water for lock flushing.

The treatment technologies included in the ANSTP would be screening and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life forms currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Stephanodiscus binderanus* is expected to pass through the screens (size of diatom, 830 μm^3; Kipp 2011) where, subsequently, it would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Based on available water quality data, UV treatment of Lake Michigan water at CRCW is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition, sluice gates would also be constructed at the CRCW. The sluice gates would be composed of two components—solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions and non-backflow conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened, and water from the Chicago River would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the Chicago River is diverted to Lake Michigan during a backflow event, *S. binderanus* is not expected to pass through the control point and into the Chicago River, because the species is unable to passively drift against the velocity of the exiting current.

For storms that require the passage of an even greater volume than the sluice gates can divert, the gates on a GLMRIS Lock would be opened. Water from the CAWS would be diverted to Lake Michigan through the lock. Again, the passive, drifting *S. binderanus* is not expected to drift through the GLMRIS Lock while water is flowing from the CAWS through the lock into Lake Michigan.

The Brandon Road Lock and Dam control point, designed to control Mississippi River Basin ANS, does not target controlling the passage of Great Lakes ANS, such as *S. binderanus*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. *Stephanodiscus binderanus* is small (size of diatom, 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull-fouling on vessels. *Stephanodiscus binderanus* is small (size of diatom, 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points: one at the current CRCW, and a second at Brandon

Road Lock and Dam, that would be implemented at T_{25}. At the CRCW control point, structural measures would include the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates. The electric barrier is not effective at controlling the passage of *S. binderanus*. The GLMRIS Lock, ANSTP, and screened sluice gates are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

The Brandon Road Lock and Dam control point, designed to control Mississippi River Basin ANS, does not target controlling the passage of Great Lakes ANS, such as *S. binderanus*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would not reduce the likelihood of *S. binderanus* passing through the aquatic pathway; therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion of *S. binderanus* through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of *S. binderanus* via hull fouling on vessels. Overall, the uncertainty remains high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	High	High	High	High	High	High	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	High	High	High	***Low***	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. *Low|NPE* means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system

Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *S. binderanus*.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.

T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as restrictions on nutrient loads to waterways, could affect the current abundance or reproductive capacity of *S. binderanus*.

T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, which can be very high during certain times of the year and with certain nutrient conditions.

T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.
T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and physical barrier in the channel at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of *S. binderanus* to the CAWS. However, these structural measures are not expected to control the arrival of *S. binderanus* to the pathway. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of S. *binderanus* outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could affect habitat suitability for *S. binderanus* in southern Lake Michigan. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of this species.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty associated with the species' probability of arrival remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH–LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier at the Alsip, Illinois, control point would be constructed in the channel and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current ones.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Stephanodiscus binderanus* is expected to pass through the screens (size of diatom, 830 μm^3; Kipp 2011) where, subsequently, it would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005, Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity, and the size and type of organism.

The Brandon Road Lock and Dam control point, designed to control Mississippi River Basin ANS, does not target controlling the passage of Great Lakes ANS, such as *S. binderanus*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, the nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to its discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water, or via hull fouling, would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water, and via hull fouling, would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to Brandon Road Lock and Dam.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural

measures would include the construction of a physical barrier and ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that *S. binderanus* and vessels potentially transporting the species in ballast and bilge water, or via hull fouling, would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information documenting the effectiveness of UV radiation on *S. binderanus*; however, there are reports on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an integrated cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *S. binderanus*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *S. binderanus* passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Therefore, the probability of passage is low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of *S. binderanus* through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	High	Low	High	Low	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	High	Low	High	Low	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation

CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *S. binderanus*.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as restrictions on nutrient loads to waterways, could affect the current abundance or reproductive capacity of *S. binderanus*.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, which can be very high during certain times of the year and with certain nutrient conditions.
T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.

T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and physical barrier in the channel at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of *S. binderanus* to the CAWS. Overall, these structural measures are not expected to control the arrival of *S. binderanus* to the pathway. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of S*. binderanus* outside of its current distribution
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could affect habitat suitability for *S. binderanus* in southern Lake Michigan. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival for this species.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points: one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current ones.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Stephanodiscus binderanus* is expected to pass through the screens (size of diatom, 830 μm^3; Kipp 2011), where, subsequently, it would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The Brandon Road Lock and Dam control point, designed to control Mississippi River Basin ANS, does not target controlling the passage of Great Lakes ANS, such as *S. binderanus*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, the nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water, or via hull fouling, would be unable to traverse the barrier. However, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic

pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water, or via hull fouling, would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to Brandon Road Lock and Dam.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, with the construction of a physical barrier and ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in

the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that *S. binderanus* and vessels potentially transporting the species in ballast and bilge water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP constructed at the Alsip, Illinois, control point would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. There is no published information in the literature on *S. binderanus*; however, there are reports on the effectiveness of UV radiation on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an Integrated Cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *S. binderanus*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *S. binderanus* passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Therefore, the probability of passage is low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}:

Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway by natural dispersion and human-mediated transport. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control passage of *S. binderanus* through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 5
BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	High	Low	High	Low	High	Medium	High
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	High	Low	High	Low	***Low***	***Low***	***Low***
P(colonizes)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for *S. binderanus*.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* from human-mediated transport through aquatic pathways to the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures such as restrictions on nutrient loads to waterways, could affect the current abundance or reproductive capacity of *S. binderanus*.
T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, which can be very high during certain times of the year and with certain nutrient conditions.
T_{25}: See T_{10}. Further reductions in nutrient levels in Lake Michigan may continue to reduce the abundance of this species in southern Lake Michigan.
T_{50}: See T_{25}. Changes in water temperature and rainfall related to future climate change (Wuebbles et al. 2010) could affect the productivity of this species (see section 2f of the Nonstructural Risk Assessment).

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of *S. binderanus* to the CAWS. However, these structural measures are not expected to control the arrival of *S. binderanus* to the CAWS. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of S*. binderanus* outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which could affect habitat suitability for *S. binderanus* in southern Lake Michigan. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival for this species.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures, such as restrictions on nutrient loads to waterways, which may reduce the productivity of this species; however, nutrient restrictions are not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating
T_0: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* through aquatic pathways to the CAWS. The species is likely already at the pathway. No data are available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011); however, this species has historically occurred in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.
Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This

alternative creates two control points: one at Alsip, Illinois, and a second at Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current ones.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). *Stephanodiscus binderanus* is expected to pass through the screens (size of diatom, 830 μm^3; Kipp 2011), where, subsequently, it would be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip, Illinois, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

The Brandon Road Lock and Dam control point, designed to control Mississippi River Basin ANS, does not target controlling the passage of Great Lakes ANS, such as *S. binderanus*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of *S. binderanus* through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, the nonstructural measures alone are not expected to address the human-mediated transport of *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water, or via hull fouling, would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water, or via hull fouling, would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for *S. binderanus* prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative nonstructural measures, such as managing nutrient loads to waterways, which may reduce the probability of *S. binderanus* entering and establishing in the

CAWS, thereby reducing the abundance and potential passage of *S. binderanus* through the CAWS to Brandon Road Lock and Dam.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, with the construction of a physical barrier and ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of *S. binderanus* through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that *S. binderanus* and vessels potentially transporting the species in ballast and bilge water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for *S. binderanus* prior to its discharge into the Mississippi River Basin side of the control point. There is no published information in the literature on *S. binderanus*; however, there are reports on the effectiveness of UV radiation on other algal species. Ballast water treatment studies by Sutherland et al. (2001) showed that the UV stage of an Integrated Cyclone-UV treatment system (cyclonic separation followed by UV-C sterilization at 253.7 nm and 2.5 kW) was 100% effective in eliminating the ability of a marine diatom, *Skeletonema costatum*, to sexually reproduce and form auxospores. Calkins and Thordardottir (1980) reported a wide range of sensitivities to solar UV-B among marine diatoms. Karentz (1994) reported that cell size in planktonic diatoms is correlated with UV sensitivity; small cells with larger surface area-to-volume ratios exhibited higher rates of DNA damage. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for *S. binderanus*.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *S. binderanus* passing through the aquatic pathway via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Therefore, the probability of passage is low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of *S. binderanus* through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains high.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of *S. binderanus* through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process is needed to control the passage of *S. binderanus* through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

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E.8.2.2 Plants

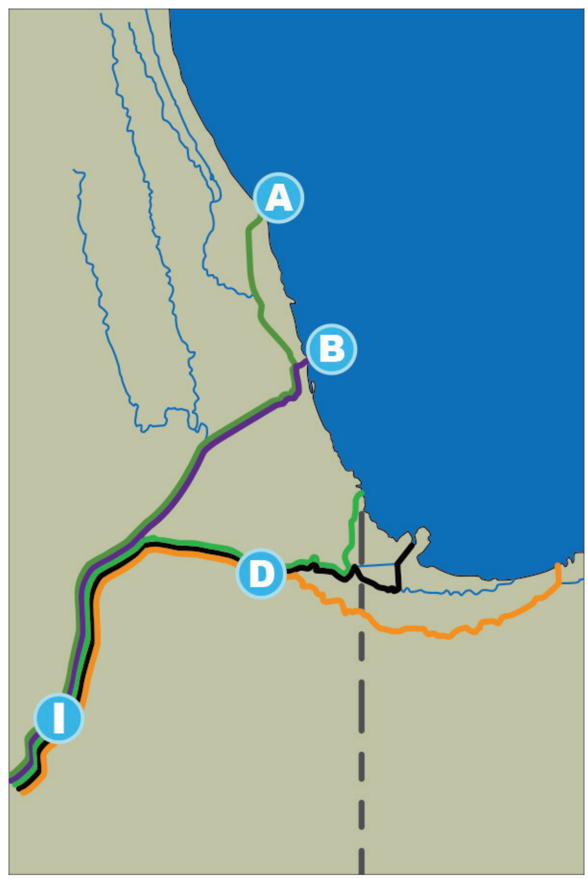
E.8.2.2.1 Reed Sweetgrass (*Glyceria maxima*)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier[c]
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the reed sweetgrass.

[b] The Mid-system Separation CSSC Open Control Technologies Alternative includes a GLMRIS Lock and electric barrier at Control Point (I), which is designed to control Mississippi River Basin species and does not impact this species' probability ratings.

[c] The Mid-system Separation CSSC Open Control Technologies Alternative includes an electric barrier at Control Point (B), which is ineffective for reed sweetgrass and does not impact its probability rating.

PATHWAY 1
WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Screened Sluice Gates, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Medium	Medium	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low(2)***	**–**	***Low(2)***	**–**

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass by natural dispersion through aquatic pathways at the Chicago Area Waterway System (CAWS). Nonstructural measures include aquatic nuisance species (ANS) control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, all of which may impact the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass by human-mediated transport through aquatic pathways at the CAWS. Nonstructural measures such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach, can be used to determine where to target nonstructural control measures — in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach, promotion of the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of reed sweetgrass.

Nonstructural measures include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may impact the current abundance and propagule pressure of the species. In addition, nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform the public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: None.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of an aquatic nuisance species treatment plant (ANSTP) and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a Great Lakes Mississippi River Interbasin Study (GLMRIS) lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the arrival of reed sweetgrass through the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of reed sweetgrass at the CAWS by human-mediated transport or natural dispersion. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to contain the species, thereby affecting its arrival at the CAWS through aquatic pathways.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the Great Lakes Basin.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the WPS pathway by natural dispersion and human-mediated transport. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations followed by rapid implementation of ANS control methods to manage the species. Once managed, education and outreach could control future spread of this species by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Implementation of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the WPS by natural dispersion and human-mediated transport; therefore, the probability of arrival is reduced from medium to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating [a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the WPS pathway by natural dispersion and human-mediated transport. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control) would control spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012, TNC-GIST 2005). Implementing a comprehensive program which expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore the uncertainty is low.

3. P(passage) T_0-T_{50}: MEDIUM-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at the WPS with the construction of an ANSTP and screened sluice gates. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. Reed sweetgrass plants and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically range from 0.06-0.08 in (1.5–2 mm) in size (King County Noxious Weeds 2011), are expected to pass through the screens, they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species and thus block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the Wilmette Pumping Station control point is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition to the ANSTP, sluice gates would also be constructed at the WPS in Wilmette, Illinois. The sluice gates would be composed of two components, solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened and water from the North Shore Channel would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the North Shore Channel is diverted to Lake Michigan during a storm event, reed sweetgrass fragments and seeds are not expected to pass through the control point and into the North Shore Channel because the species would be unable to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for reed sweetgrass prior to discharge into the CAWS. In addition, the sluice gates are expected to control passage of reed sweetgrass during dry weather events when they are closed. During large storm events requiring backflows to Lake Michigan, reed sweetgrass is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern because it is not possible that any vessel can move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: None.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for reed sweetgrass prior to discharge into the CAWS. Additionally, the sluice gates are expected to control passage of reed sweetgrass through the aquatic pathway during dry weather events when they are closed. During large storm events requiring backflows to

Lake Michigan, reed sweetgrass is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is not possible for any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating [a]	Low	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's medium probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural

measures would include the construction of an ANSTP and screened sluice gates at the WPS. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway.

The purpose of the ANSTP is to treat Lake Michigan water for ANS prior to discharge into the CAWS. The 0.4-in.(10.2 mm) screens of the ANSTP would control plant fragments but not seeds from entering UV treatment. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9 x 10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that the percentage of seed germination and rate of seedling growth decreased as irradiation dose increased.

Based on the response to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

During dry weather conditions and non-backflow conditions, the sluice gates would remain closed and would block the aquatic pathway between Lake Michigan and the CAWS. Sluice gates would be opened only during flood events requiring backflows to Lake Michigan, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, reed sweetgrass seeds and fragments are not expected to passively drift against the velocity of the current exiting the screened sluice gates to enter the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. Prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of reed sweetgrass through the ANSTP. In addition, the operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, Electric Barrier, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by natural dispersion through aquatic pathways. Nonstructural measures would include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, all of which may impact the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion of how nonstructural measures may impact this human-mediated transport.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures — in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach, promotion of the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for a discussion of how nonstructural measures may impact current abundance and reproductive capacity of reed sweetgrass.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of reed sweetgrass.

Nonstructural measures include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may impact the current abundance and propagule pressure of the species. In addition, nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform the public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: None.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS lock, electric barrier, and screened sluice gates at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the arrival of reed sweetgrass through the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of reed sweetgrass at the CAWS. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to contain the species, thereby affecting the arrival of reed sweetgrass at the CAWS through aquatic pathways.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the Great Lakes Basin.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS via natural dispersion and human-mediated transport. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations, followed by rapid implementation of ANS control methods to manage the species. Once managed, education and outreach could control future spread of this species by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Implementation of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the aquatic pathway by natural dispersion and human-mediated transport; therefore, the probability of arrival is reduced from medium to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the uncertainty is low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control) would control spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012, TNC-GIST 2005). Implementing a comprehensive program which expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore the uncertainty is low.

3. P(passage) T_0-T_{50}: LOW-MEDIUM

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass seeds and plant fragments through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at the current CRCW and a second at the Brandon Road Lock and Dam. At the CRCW control point, the current lock would be replaced with two GLMRIS locks—one shallow and one deep—and an electric barrier, ANSTP, and screened sluice gate would be constructed. GLMRIS Lock
At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to reduce the likelihood of waves overtopping and bypassing

this control point. These structures would be designed to minimize the creation of habitat surrounding the lock for reed sweetgrass. Nonstructural measures would be used to monitor for the presence of reed sweetgrass and, if required, to control the population surrounding the lock.

The electric barrier at the lake side entrance to the Chicago GLMRIS Lock would be an ineffective control for reed sweetgrass. This species is not impacted by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport reed sweetgrass seeds and plant fragments into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lake side of the lock, and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with ANS treated water. Therefore, ANS that rely on passive drift (including reed sweetgrass) would be removed from the lock chamber; however, the GLMRIS Lock would not be an effective control for hull fouling species, such as this species. GLMRIS Lock

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan water prior to discharge into the CAWS buffer zone. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANTSP would also supply the GLMRIS locks with ANS treated water for lock flushing.

The treatment technologies included in the ANSTP would be screening and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. Reed sweetgrass plants and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass (seed size 1.5–2 mm; King County 2011) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and thus block the UV light from reaching them. Lake Michigan water quality data indicate that Lake Michigan is sufficiently clear to allow for effective UV treatment. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition, sluice gates would also be constructed at the CRCW control point. The sluice gates would be composed of two components, solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened and water from the Chicago River would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the Chicago River is diverted to Lake Michigan during a backflow event, reed sweetgrass seeds and plant fragments are not expected to pass through the control point and into the Chicago River due to their inability to passively drift against the velocity of the exiting current.

For storms that require the passage of an even greater volume than the sluice gates can divert, the gates on a GLMRIS Lock would be opened. Water from the CAWS would be diverted to Lake Michigan through the lock. Again, the passive drifting reed sweetgrass seeds and plant fragments are not expected to drift through the GLMRIS Lock while water is flowing from the CAWS through the lock into Lake Michigan.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Reed sweetgrass is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See Section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of reed sweetgrass seeds and plant fragments through the aquatic pathway to the Brandon Road Lock and Dam. Reed sweetgrass seeds are small (seed size 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock does not address hull-fouling species because it is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: None.

T_{25}: See Section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of reed sweetgrass plant fragments and seeds through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via temporary attachment to vessel hulls. Reed sweetgrass seeds are small (seed size 1.5–2 mm) (King County 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address hull fouling species because the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's medium rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the current CRCW, and a second at the Brandon Road Lock and Dam, that would be implemented at T_{25}. At the CRCW control point, structural measures would include the construction of an ANSTP, GLMRIS lock, electric barrier, and screened sluice gates.

The electric barrier is not effective at controlling the passage of reed sweetgrass. The GLMRIS Lock, ANSTP and screened sluice gates are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via temporary attachment to vessel hulls. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Reed sweetgrass is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to control the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. The species would still be able to pass into the Mississippi River Basin via temporary attachment to vessel hulls; therefore, the probability of passage remains medium.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway; however, these measures are not

expected to control the human-mediated transport of reed sweetgrass via temporary attachment to vessel hulls. Overall, the uncertainty remains medium.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE: Nonstructural Measures, ANS Treatment Plant, Physical Barrier, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Medium	Medium	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low(2)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC

Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for reed sweetgrass.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to affect the arrival of reed sweetgrass at the CAWS by natural dispersion through aquatic pathways. Nonstructural measures would include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, all of which may impact the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures — in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach, promotion of the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of reed sweetgrass.

Nonstructural measures would include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may all impact the current abundance and propagule pressure of the species. In addition, nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. Furthermore, outreach and education can be used to inform the public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: None.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of reed sweetgrass at the CAWS. Overall, these structural measures are not expected to control the arrival of reed sweetgrass at the CAWS. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to contain the species, thereby affecting the arrival of reed sweetgrass at the CAWS through aquatic pathways.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the Great Lakes Basin.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS via natural dispersion and human-mediated transport. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations followed by rapid implementation of ANS control methods to manage the species. Once managed, education and outreach could control future spread of this species by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Implementation of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect

the arrival of reed sweetgrass via natural dispersion and human-mediated transport; therefore, the probability of arrival is reduced to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control) would control spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012, TNC-GIST 2005). Implementing a comprehensive program which expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore the uncertainty is low.

3. P(passage) T_0-T_{50}: MEDIUM-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, the nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This

alternative creates two control points, one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.GLMRIS Lock

The physical barrier at the Alsip, Illinois, control point would be constructed in the channel and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. Reed sweetgrass plants and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically are 1.5–2 mm in size (King County Noxious Weeds 2011), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the Cal-Sag Channel at the Alsip, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, pre-filtration at Alsip, Illinois, is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Reed sweetgrass is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: None.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. The upgrading of treatment plants and the closing of two power plants should improve future water quality (Illinois Pollution Control Board 2012). Reed sweetgrass appears to benefit from eutrophication; therefore, the suitability of water quality in the CAWS for reed sweetgrass may change. The availability of suitable substrate is not expected to increase.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's medium probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of a physical barrier and ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the

Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass seeds and fragments and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The 0.4-in. (10.2 mm) screens of the ANSTP would control plant fragments but not seeds from entering UV treatment. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9×10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured the rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that the percentage of seed germination and rate of seedling growth decreased as the irradiation dose increased.

Based on the response to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of reed sweetgrass through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE: Nonstructural Measures, ANS Treatment Plant, Physical Barrier, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Low	Medium	Medium	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Low	Medium	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low(2)***	**–**	***Low(2)***	**–**

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for reed sweetgrass.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by natural dispersion through aquatic pathways. Nonstructural measures would include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, all of which may impact the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures — in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach, promotion of the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of the species. Nonstructural measures would include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may all impact the current abundance and propagule pressure of the species. Nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. In addition, outreach and education can be used to inform the public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: None.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of reed sweetgrass at the CAWS. Overall, these structural measures are not expected to control the arrival of reed sweetgrass at the CAWS. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to contain the species, thereby affecting the arrival of reed sweetgrass at the CAWS through aquatic pathways.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the Great Lakes Basin.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathway by natural dispersion and human-mediated transport. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations, followed by rapid implementation of ANS control methods to manage the species. Once managed, education and outreach could control future spread of this species by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: See T_0.

T_{50}: See T_0. Implementation of nonstructural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathway via natural dispersion and human-mediated transport; therefore, the probability of arrival is reduced to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control) would control spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012, TNC-GIST 2005). Implementing a comprehensive program which expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore the uncertainty is low.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. However, the nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP. GLMRIS Lock

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. Reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically range in size from 1.5 to 2 mm (Washington State Noxious Weed Control Board, 2012), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and thus block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Reed sweetgrass is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: None.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. The upgrading of treatment plants and the closing of two power plants should improve future water quality (Illinois Pollution Control Board 2012). Reed sweetgrass appears to benefit from eutrophication; therefore, the suitability of water quality in the CAWS for reed sweetgrass may change. The availability of suitable substrate is not expected to increase.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, with the construction of a physical barrier and ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass plant fragments and seeds and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP constructed at the Alsip, Illinois, control point would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The 0.4-in. (10.2 mm) screens of the ANSTP would control plant fragments but not seeds from entering UV treatment. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9×10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured the rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that the percentage of seed germination and rate of seedling growth decreased as irradiation dose increased.

Based on the response to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of reed sweetgrass through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE: Nonstructural Measures, ANS Treatment Plant, Physical Barrier, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	Medium	Medium
P(passage)	Low	Medium	Low	Medium	Medium	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Low	Low	Low	***Low***	***Low***
P(passage)	Low	Medium	Low	Medium	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low(2)***	**–**	***Low*(2)**	**–**

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating:

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for reed sweetgrass.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by natural dispersion through aquatic pathways. Nonstructural measures would include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, all of which may impact the invasion speed of reed sweetgrass by reducing existing populations.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS by human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach can be used to determine where to target nonstructural control measures — in particular, aquatic herbicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach, promotion of the use of anti-fouling hull paints, and laws and regulations may reduce the human-mediated transport of reed sweetgrass to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the current abundance and propagule pressure of the species. Nonstructural measures include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that may all impact the current abundance and propagule pressure of the species. Nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. In addition, outreach and education can be used to inform to public of reed sweetgrass management efforts, and voluntary occurrence reporting can supplement agency monitoring. Data collected through agency monitoring and voluntary occurrence reporting would focus management efforts on locations where reed sweetgrass is abundant.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: None.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of reed sweetgrass at the CAWS. Overall, structural measures are not expected to control the arrival of reed sweetgrass at the CAWS. The closest established population is in Oak Creek (a tributary of Lake Michigan) in Milwaukee County, Wisconsin (Howard 2012). The population has been established since 1979. In 2006, an isolated established population was discovered growing out of a manhole cover at the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring would continue (Howard 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to contain the species, thereby affecting the arrival of reed sweetgrass at the CAWS through aquatic pathways.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the Great Lakes Basin.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of reed sweetgrass at the CAWS via natural dispersion and human-mediated transport. Agency monitoring could be conducted to determine the current range of existing populations and identify the establishment of new populations, followed by rapid implementation of ANS control methods to manage the species. Once managed, education and outreach could control future spread of this species by recreational boaters as well as other recreational waterway users. Laws and regulations could control the cultivation of this species and subsequent spread by the nursery industry. Voluntary occurrence reports and continued agency monitoring would evaluate the effectiveness of implemented ANS control methods and identify surviving populations requiring further management.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass arriving at the pathway by reducing the current abundance and distribution of reed sweetgrass. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Implementation of nonstructural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to

affect the arrival of this species at the CAWS; therefore, the probability of arrival is reduced to low.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of reed sweetgrass at the CAWS. Therefore, the uncertainty is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Early identification of reed sweetgrass populations through education and outreach and monitoring activities coupled with an aggressive response action (use of aquatic herbicides, manual harvest, or mechanical control) would control spread and transfer of this species. These techniques have been successfully employed in Wisconsin and Massachusetts for effectively reducing reed sweetgrass populations (Howard 2012, TNC-GIST 2005). Implementing a comprehensive program which expands on currently used nonstructural measures would further control the spread of this species into other susceptible areas. Therefore the uncertainty is low.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. However, the nonstructural measures alone are not expected to address the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP. GLMRIS Lock

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm) in size. Reed sweetgrass plants, which typically reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments are expected to be excluded by the screens. Seeds of reed sweetgrass, which typically range in size from 1.5 to 2 mm (Washington State Noxious Weed Control Board 2012), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and thus block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Reed sweetgrass is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of reed sweetgrass through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: None.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within the CAWS.

T_{10}: See T_0.

T_{25}: See T_0. The upgrading of treatment plants and the closing of two power plants should improve future water quality (Illinois Pollution Control Board 2012). Reed sweetgrass appears to benefit from eutrophication; therefore, the suitability of water quality in the CAWS for reed sweetgrass may change. The availability of suitable substrate is not expected to increase. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the probability of passage, owing to the availability of suitable habitat.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois, with the construction of a physical barrier and ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of reed sweetgrass through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass plant fragments and seeds and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, an ANSTP would treat Cal-Sag Channel water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The 0.4-in. (10.2-mm) screens of the ANSTP would control plant fragments but not seeds from entering UV treatment. The following reports pertain to the effects of solar UV on seed viability of higher plant species. Krizek (1975) examined the influence of UV radiation (applied as a 3-day continuous exposure of UV-B in the 280–320 nm range at 26.9×10^{-2} W m^{-2} with a temperature of 25°C) on germination of nine vegetable and field crop plants. The results indicated that seed germination was not adversely affected by continuous exposure to unfiltered UV-B. Krizek (1975) speculated that the seed coat itself provided protection to the plant embryo until emergence. While this testing of UV irradiance did not influence seed germination, further testing by Krizek (1975) showed that exposing plant seedlings to UV radiation for 6 days resulted in abnormal growth in all species but wheat. Later studies by Peykarestan and Seify (2012) measured the rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that the percentage of seed germination and rate of seedling growth decreased as irradiation dose increased.

Based on the response to UV-B, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate reed sweetgrass seeds. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate life stages of reed sweetgrass and to determine whether additional treatment processes are needed to control passage of reed sweetgrass through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Medium	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of reed sweetgrass through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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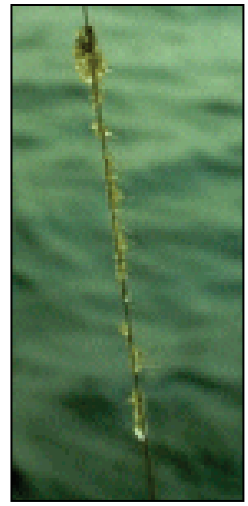
E.8.2.3 Crustaceans

E.8.2.3.1 Fishhook Waterflea (*Cercopagis pengoi*)

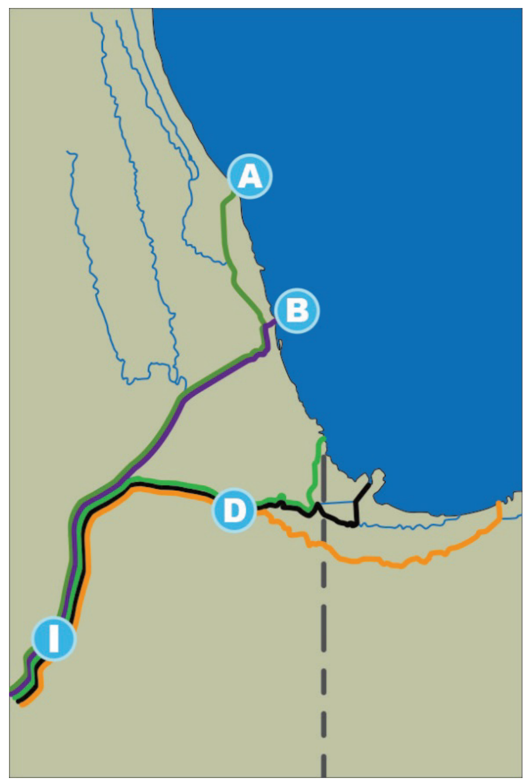


MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier[c]
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
CalumetHarbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for fishhook waterflea.

[b] The Mid-system Separation CSSC Open Control Technologies Alternative includes a GLMRIS Lock and electric barrier at Control Point (I), which is designed to control Mississippi River Basin species and does not impact this species' probability ratings.

[c] The Mid-system Separation CSSC Open Control Technologies Alternative includes an electric barrier at Control Point (B), which is ineffective for the fishhook waterflea and does not impact its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Screened Sluice Gates, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Low	Medium	Medium	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Low	Medium	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between WPS and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**

In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea from natural dispersion through aquatic pathways to the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None; the species is close to or at the WPS pathway entrance (EPA et al. 2012).
T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of an aquatic nuisance species (ANS) treatment plant (ANSTP) and screened sluice gates at the WPS in Wilmette, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point would be designed to address ANS

originating in the Mississippi River Basin and would not impact the arrival of the fishhook waterflea at the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the fishhook waterflea at the CAWS by human-mediated transport or natural dispersion (i.e., passive drift). The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the WPS are uncertain, but this species may be at the WPS.

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance

from the WPS are uncertain, but this species may be at the WPS. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the WPS are uncertain, but this species may be at the WPS. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative creates a control point at Wilmette, Illinois. This alternative includes the construction of an ANSTP and screened sluice gates at Wilmette, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon

Road Lock and Dam; however, this control point would be designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lake Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The fishhook waterflea typically ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007) and is expected to pass through the screens where it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan at the Wilmette Pumping Station control point location is anticipated to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition to the ANSTP, sluice gates would also be constructed at WPS in Wilmette, Illinois. The sluice gates would be comprised of two components, solid gates and self-cleaning screened gates with 0.4 in. (10.2 mm) openings. During dry weather conditions and non-backflow events, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened and water from the North Shore Channel would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the North Shore Channel is diverted to Lake Michigan during a backflow event, the fishhook waterflea is expected to be unable to pass through the control point and into the North Shore Channel due to the species being unable to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for the fishhook waterflea prior to discharge into the CAWS. Additionally, the sluice gates are expected to control passage of the fishhook waterflea during dry weather conditions when they would be closed and during large storm events requiring backflows to Lake Michigan; the fishhook waterflea is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is not possible for any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for the fishhook waterflea prior to discharge into the CAWS. Additionally, the sluice gates are expected to control passage of the fishhook waterflea during dry weather events when they are closed and during large storm events requiring backflows to Lake Michigan; the fishhook waterflea is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern since it is not possible for any vessel to move from Wilmette Harbor to the North Shore Channel. The WPS separates Lake Michigan from the North Shore Channel.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gates at the WPS in Wilmette, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point would be designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway.

The purpose of the ANSTP is to treat Lake Michigan water for ANS prior to discharge into the CAWS. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide—alone and in combination) on a range of zooplankton, including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200 to 800 l h^{-1} flow rates at 562–141 mJ cm^{-3}) ranged from 76% to 77%. Species-specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% kill in all treatments except ultrasound), while cladocerans were the least affected group (>99% kill only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

During dry weather conditions and non-backflow conditions, the sluice gates would remain closed and would control an aquatic pathway between Lake Michigan and the CAWS, as well as control the CAWS and Lake Michigan from mixing. Sluice gates would be opened only during flood events requiring backflows to Lake Michigan, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, the fishhook waterflea is expected to be unable to passively drift against the velocity of the current exiting the screened sluice gates to enter the CAWS.

Overall, the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the fishhook waterflea passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is

needed to control passage of the fishhook waterflea through the ANSTP. Additionally, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, Electric Barrier, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Low	Medium	Medium	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Low	Medium	Medium	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between WPS and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from natural dispersion (i.e., passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: None, the species is close to or at the CRCW pathway entrance (Benson et al. 2012).
T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at CRCW in Chicago, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of the fishhook waterflea at the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the fishhook waterflea at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the CRCW are uncertain, but this species may be at the CRCW.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the CRCW are uncertain, but this species may be at the CRCW. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the CRCW are uncertain, but this species may be at the CRCW. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50} : LOW-HIGH**

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species).

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control point, one at the current CRCW and a second at Brandon Road Lock and Dam. At the CRCW control point, the current lock would be replaced with two GLMRIS Locks, one shallow and one deep, and an electric barrier, ANSTP, and screened sluice gates would be constructed.

At the CRCW control point a breakwater would be constructed southeast of the GLMRIS Lock and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to reduce the likelihood of waves overtopping and bypassing this control point. These structures would be designed to minimize the creation of habitat for the fishhook waterflea. Nonstructural measures would be used to monitor for the presence of the fishhook waterflea and if required, to control the population surrounding the lock.

The electric barrier at the lake side entrance to the Chicago GLMRIS Lock would be an ineffective control for the fishhook waterflea. This species passage through the U-shaped engineered channel is not impacted by electric current. To address passive drift of this species, the Chicago GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. If left uncontrolled, the lock could transport the fishhook waterflea into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lake side of the lock and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with ANS treated water. Therefore, ANS that rely on passive drift, including the fishhook waterflea, would be removed from the lock chamber; however, the GLMRIS Lock would not be an effective control for hull fouling species, such as this species.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge into the CAWS buffer zone. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water for lock flushing.

The treatment technologies included in the ANSTP would be screening and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The fishhook waterflea typically ranges between 0.02 and 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007) and is expected to pass through the screens where it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Lake Michigan water quality data indicates that Lake Michigan is sufficiently clear to allow for effective UV treatment. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition, sluice gates would also be constructed at CRCW in Chicago, Illinois. The sluice gates would be comprised of two components, solid gates and self-cleaning screened gates with 0.4 in. (10.2 mm) openings. During dry weather conditions and non-backflow conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened and water from the North Shore Channel would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the Chicago River is diverted to Lake Michigan during a backflow event, the fishhook waterflea is expected to be unable to pass through the control point into the Chicago River due to the species being unable to passively drift against the velocity of the exiting current.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The fishhook waterflea is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. This species has been found in hull scrapes and is considered a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address hull fouling species since the lock is unable to dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.**T_{10}:** See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to the Brandon Road

Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway by human-mediated transport via hull fouling on vessels. This species has been found in hull scrapes and is considered a hull fouler (Sylvester and MacIsaac 2010). The GLMRIS Lock would not address hull fouling species since the lock is unable to dislodge attached organisms from vessel hulls.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Medium	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the current CRCW and a second at Brandon Road Lock and Dam that would be implemented at T_{25}. At the CRCW control point, structural measures would include the construction of an ANSTP, GLMRIS Lock, and electric barrier. The electric barrier is not effective at controlling the passage of the fishhook waterflea. The GLMRIS Lock, ANSTP, and screened sluice gates are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms from vessel hulls.

The purpose of the ANSTP is to treat Lake Michigan water for ANS prior to discharge into the CAWS. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide—alone and in combination) on a range of zooplankton, including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200 to 800 $l\ h^{-1}$ flow rates at 562–141 $mJ\ cm^{-3}$) ranged from 76% to 77%. Species-specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% kill in all treatments except ultrasound), while cladocerans were the least affected group (>99% kill only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The fishhook waterflea is located in the Great Lakes Basin.

Overall, the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway when compared with the No New Federal Action Alternative. The species is expected to still be able to pass into the Mississippi River Basin via hull fouling. Overall, the probability of passage remains medium.

T_{50}: See T_{25}. The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative would not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway when compared with the No New Federal Action Alternative. The species is expected to still be able to pass into the Mississippi River Basin via hull fouling. Overall, the probability of passage remains high.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway; however, these structural measures are not expected to control the human-mediated transport of the fishhook waterflea via hull fouling on vessels. Overall, the uncertainty remains low.

T_{50}: See T_{25}.

4. **P(colonizes) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. **P(spreads) T_0-T_{50}: HIGH**

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

HYBRID MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Low	Medium	Medium	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rate Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Medium	Low	Medium	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for fishhook waterflea.

T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from natural dispersion (i.e., passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None, the species is close to or at Calumet Harbor pathway entrance (Benson et al. 2012).

T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the arrival of the fishhook waterflea at the CAWS. Overall, these structural measures are not expected to control the arrival of the fishhook waterflea at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the Calumet Harbor are uncertain, but this species may be at the Calumet Harbor.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north

of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the Calumet Harbor are uncertain, but this species may be at the Calumet Harbor. Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the Calumet Harbor are uncertain, but this species may be at the Calumet Harbor. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: LOW**

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to affect the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event. The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The fishhook waterflea, which typically ranges between 0.02 to 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), is expected to pass through the screens where it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The fishhook waterflea is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented immediately. Nonstructural measures alone are not expected to address the human-mediated transport through the aquatic pathway of the fishhook waterflea due to hull fouling.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast or bilge water or via hull fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast or bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois by constructing a physical barrier and an ANSTP. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that the fishhook waterflea and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide – alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200 to 800 $l\ h^{-1}$ flow rates at 562–141 $mJ\ cm^{-3}$) ranged from 76% to 77%. Species specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% kill in all treatments except ultrasound) while cladocerans were the least affected group (>99% kill only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the fishhook waterflea passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. In regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process would be needed to control passage of the fishhook waterflea through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	Low	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	Low	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for fishhook waterflea.

T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH
In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from natural dispersion (i.e., passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None, the species is close to or at Indiana Harbor pathway entrance (Benson et al. 2012).
T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of the fishhook waterflea at the CAWS. Overall, these structural measures are not expected to control the arrival of the fishhook waterflea at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the Indiana Harbor are uncertain, but this species may be at the Indiana Harbor.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the

Indiana Harbor are uncertain, but this species may be at the Indiana Harbor. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the Indiana Harbor are uncertain, but this species may be at the Indiana Harbor. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at the Brandon

Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The fishhook waterflea, which typically ranges between 0.02 to 0.09 (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), is expected to pass through the screens, it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not control the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The fishhook waterflea is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative creates a control point at Alsip, Illinois with the construction of a physical barrier and an ANSTP. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that the fishhook waterflea and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP constructed at the Alsip, Illinois, control point would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide – alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200 to 800 $l\ h^{-1}$ flow rates at 562–141 $mJ\ cm^{-3}$)

ranged from 76% to 77%. Species specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% kill in all treatments except ultrasound) while cladocerans were the least affected group (>99% kill only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the fishhook waterflea passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure and whether an additional treatment process is needed to control passage of the fishhook waterflea through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, GLMRIS Lock, and Electric Barrier

RISK ASSESSMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	Low	High	Medium	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	Low	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	Low	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC

Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for the fishhook waterflea.
T_{10}: See T_0.
T_{25} The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**
In determining the probability of arrival, it is assumed the pathway exists.

Factors that Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from natural dispersion (i.e., passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the fishhook waterflea.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None.

T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point would be designed to control ANS originating in the Mississippi River Basin and would not impact the arrival of the fishhook waterflea at the CAWS. Overall, these structural measures are not expected to control the arrival of the fishhook waterflea at the CAWS. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the BSBH are uncertain, but this species may be at the BSBH.
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the fishhook waterflea in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north

of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the BSBH are uncertain, but this species may be at the BSBH. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea at the CAWS through aquatic pathways. The fishhook waterflea was established in Lake Michigan, north of Chicago, Illinois, in 1999 (Benson et al. 2012). The exact location and distance from the BSBH are uncertain, but this species may be at the BSBH. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, it is assumed the species has arrived at the pathway.

Factors that Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at Brandon

Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). The fishhook waterflea, which typically ranges between 0.02 to 0.09 in. (0.6 and 2.4 mm) in length (Crosier and Molloy 2007), is expected to be able to pass through the screens where it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical and biological properties of water such as turbidity, salinity and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The fishhook waterflea is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water or via hull fouling would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the fishhook waterflea in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create a control point at Alsip, Illinois with the construction of a physical barrier and an ANSTP. Additionally, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that the fishhook waterflea and vessels potentially transporting the species in ballast water or attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Viitasalo et al. (2005) evaluated four potential ballast water treatments (ozonation, UV, ultrasonication, and hydrogen peroxide – alone and in combination) on a range of zooplankton including copepods, cladocerans (including the fishhook water flea), rotifers, a barnacle, and bivalve veligers. Average kill rates for cladocerans following exposure to UV light (200 to 800 l h^{-1} flow rates at 562–141 mJ cm^{-3}) ranged from 76% to

77%. Species specific differences were observed among organisms in these studies; rotifers were the most susceptible to treatment (>99% kill in all treatments except ultrasound) while cladocerans were the least affected group (>99% kill only in ozone treatments). Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the fishhook waterflea.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the fishhook waterflea passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the fishhook waterflea through the aquatic pathway. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure and whether an additional treatment process is needed to control passage of the fishhook waterflea through the ANSTP. Overall, uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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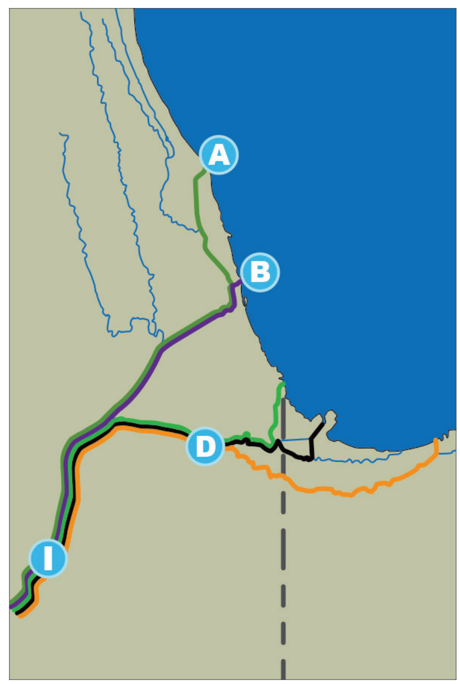
E.8.2.3.2 Bloody Red Shrimp (*Hemimysis anomala*)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier[c]
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information on nonstructural measures for this species, refer to the Nonstructural Risk Assessment for the bloody red shrimp.

[b] The Mid-system Separation CSSC Open Control Technologies Alternative includes a GLMRIS Lock and an electric barrier at Control Point (I) that is designed to control Mississippi River Basin species and does not affect this species probability ratings.

[c] The Mid-system Separation CSSC Open Control Technologies Alternative includes an electric barrier at Control Point (B) that is ineffective for the bloody red shrimp and does not affect its probability rating.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, GLMRIS Lock, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Chicago Sanitary and Ship Canal (CSSC) Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion through aquatic pathways to the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from human-mediated transport through aquatic pathways at the CAWS.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers; the species is likely already at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an aquatic nuisance species (ANS) treatment plant (ANSTP) and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and is not expected to affect the passage of the bloody red shrimp through aquatic pathways to the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the bloody red shrimp's arrival at the CAWS by human-mediated transport or natural dispersion (i.e., swimming and passive drift). The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the U.S. Geological Survey (USGS) one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution or affect its arrival at the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the bloody red shrimp in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the probability of arrival remains high.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival for the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures would not address the natural dispersion (i.e., swimming and passive drift) of bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. The structural measures create a control point for the bloody red shrimp at Wilmette, Illinois, with the construction of an ANSTP and sluice gates. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and is not expected to affect the passage of the bloody red shrimp through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). Self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to pass through the screens; it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

In addition to the ANSTP, sluice gates would be constructed at the WPS in Wilmette, Illinois. The sluice gates would be comprised of two components, solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened, and water from the North Shore Channel would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the North Shore Channel is diverted to Lake Michigan during a storm event, the bloody red shrimp is not expected to pass through the control point and into the North Shore Channel, because the species is expected to be unable to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control natural dispersion (i.e., swimming and passive drift) for the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0.

Nonstructural measures alone are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. This alternative includes structural measures that are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for the bloody red shrimp prior to its discharge into the CAWS. In addition, the sluice gates are expected to control passage of the bloody red shrimp during dry weather when they are closed. During large storm events requiring backflows to Lake Michigan; the bloody red shrimp is expected to be unable to passively drift against the velocity of the current exiting through the screened sluice gates to enter the aquatic pathway.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{10}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for the bloody red shrimp prior to its discharge into the CAWS.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the high rating designated for this time step in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and is not expected to impact the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The purpose of the ANSTP is to treat Lake Michigan water for ANS prior to its discharge into the CAWS. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, the lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of resting eggs of a marine brine shrimp (*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the bloody red shrimp.

Sluice gates would be opened only during flood events, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, the bloody red shrimp is not expected to passively drift against the velocity of the current exiting the screened sluice gates to enter the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures, as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, ANS Treatment Plant, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from human-mediated transport through aquatic pathways at the CAWS.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers; the species is likely already at pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and is not expected to impact the natural dispersion or human-mediated transport of the bloody red shrimp through aquatic pathways to the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the bloody red shrimp at the CAWS. The species

is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution or affect its arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the bloody red shrimp in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50} : HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of bloody red shrimp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that could be implemented at T_{25}. Structural measures include the creation of a control point for the bloody red shrimp at the CRCW by replacing the current lock with two GLMRIS Locks, one shallow and one deep, and constructing an electric barrier, an ANSTP, and a screened sluice gate. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and is not

expected to affect the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS Lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to reduce the likelihood of waves overtopping and bypassing this control point. These structures would be designed to minimize the creation of habitat surrounding the lock for the bloody red shrimp. Nonstructural measures would be used to monitor for the presence of the bloody red shrimp and, if required, to control the population surrounding the lock.

The electric barrier at the lake side entrance to the CRCW GLMRIS Lock is expected to be an ineffective control for the bloody red shrimp. This species passage through the U-shaped engineered channel is not affected by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, it could transport the bloody red shrimp into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lake side of the lock, and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with water treated for ANS. Therefore, species that rely on passive drift, including the bloody red shrimp, are expected to be removed from the lock chamber.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge into the CAWS buffer zone. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with water treated for ANS for lock flushing.

The treatment technologies included in the ANSTP would be screening and ultraviolet (UV) radiation to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to pass through the screens and would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Lake Michigan water quality data indicate that Lake Michigan is sufficiently clear to allow for effective UV treatment. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA

2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

In addition, sluice gates would be constructed at CRCW. The sluice gates would be comprised of two components, solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened and water from the Chicago River would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the Chicago River is diverted to Lake Michigan during a storm event, the bloody red shrimp is not expected to pass through the control point and into the Chicago River, because the species is not expected to be able to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for bloody red shrimp prior to its discharge into the CAWS. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the human-mediated transport of the species through the aquatic pathway.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to the Brandon Road Lock and Dam. Lake Michigan water would be treated for bloody red shrimp by the ANSTP prior to its discharge into the CAWS. In addition, discharging ballast and bilge water prior to entering the GLMRIS Lock is expected to help control the human-mediated transport of this species through the aquatic pathway.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures include an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gate at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The GLMRIS Lock is expected to address the natural dispersion and human-mediated transport of the bloody red shrimp through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The purpose of the ANSTP is to treat Lake Michigan water for ANS prior to its discharge into the CAWS. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of resting eggs of a marine brine shrimp (*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for the bloody red shrimp.

Sluice gates would be opened only during flood events, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, the bloody red shrimp is expected to be unable to passively drift against the velocity of the current exiting the screened sluice gates to enter the aquatic pathway.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Low	**High**	**High**

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage through the aquatic pathway of the bloody red shrimp by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage through the aquatic pathway of the bloody red shrimp by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures, as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the bloody red shrimp from transferring. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Medium	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for bloody red shrimp.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from human-mediated transport through aquatic pathways at the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers; the species is likely already at the pathway.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and the ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through aquatic pathways to the CAWS. Overall, these structural measures are not expected to control the arrival of the bloody red shrimp at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).
T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution or affect its arrival at the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the bloody red shrimp in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic

pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This

alternative creates a control point for the bloody red shrimp at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and is not expected to affect the natural dispersion (i.e., swimming or passive drift) of the bloody red shrimp through the aquatic pathway.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event. The physical barrier is expected to control the passage of the bloody red shrimp by natural dispersion through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to pass through the screens and would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and thus block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Alsip is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. As part of this alternative, structural measures are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species from Lake Michigan to the CAWS, because vessels potentially transporting the species in ballast or bilge water would be unable to traverse the barrier.

T_{50}: See T_0.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. As part of this alternative, structural measures are expected to control natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the Mid-system Hydrologic Separation Alternative's high probability of passage rating designated for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect passage of the bloody red shrimp through the aquatic pathway.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. The bloody red shrimp and vessels potentially transporting the species in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the passage of this species through the aquatic pathway via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Cal-Sag Channel water for bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of resting eggs of a marine brine shrimp

(*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be need to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating Action	Medium	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the CAWS by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0. Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the CAWS by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: As part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, structural measures are expected to control the passage of the bloody red shrimp by natural dispersion and human-mediated transport. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	Medium	High	High	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for bloody red shrimp.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from human-mediated transport through aquatic pathways at the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers; the species is likely already at pathway.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect passage of the bloody red shrimp through the CAWS. Overall, these structural measures are not expected to control the arrival of the bloody red shrimp at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore in 2006 (Kipp et al. 2011).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

This alternative is not expected to reduce the habitat suitability for the bloody red shrimp in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and just south of Waukegan Harbor a half mile (0.8 km) offshore just south of Waukegan Harbor in 2006 (Kipp et al. 2011). Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS 1 one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and a half mile (0.8 km) offshore just south of Waukegan Harbor in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to address the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures create a control point for the bloody red shrimp at Alsip, Illinois. This alternative includes the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the

Mississippi River Basin and would not affect the passage of the bloody red shrimp through the aquatic pathway.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions.

The treatment technologies in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to pass through the screens, where it would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip pre-filtration is included in the treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp by natural dispersion.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to address the human-mediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. As part of this alternative, structural measures are expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting it in ballast or bilge water would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures are part of this alternative and are expected to control the passage of the bloody red shrimp through the aquatic pathway to the Brandon Road Lock and Dam by natural dispersion and human-mediated transport. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_0.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the bloody red shrimp through the aquatic pathway.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the bloody red shrimp and vessels potentially transporting the species in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the passage of this species through the aquatic pathway via human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Cal-Sag Channel water for bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm^2; 254 nm) killed 59% and 91% of resting eggs of a marine brine shrimp (*Artemia* sp.) and a freshwater cladoceran (*Daphnia mendotae*), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic

pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating
T_0: See the Nonstructural Risk Assessment for this species.
This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.
Nonstructural measures alone are not expected to affect the passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: As part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, structural measures are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction, further investigation and bench-scale studies would be need to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether and additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	Medium	High	High	High
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[a]	Low	–	Medium	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	Low	Low	Low	Low	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	Low	–[b]	Low	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating:

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for bloody red shrimp.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating:

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from human-mediated transport through aquatic pathways at the CAWS.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the bloody red shrimp.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers, as it is likely to have already arrived at the pathway.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the bloody red shrimp through the CAWS. Overall, these structural measures are not expected to control the arrival of the bloody red shrimp at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and a half mile (0.8 km) offshore just south of Waukegan Harbor in 2006 (Kipp et al. 2011).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the bloody red shrimp outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the bloody red shrimp in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely

already at the pathway, having been documented by the USGS one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 a half mile (0.8 km) offshore and just south of Waukegan Harbor in 2006 (Kipp et al. 2011). Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp through aquatic pathways at the CAWS. The species is already established in Lake Michigan and is likely already at the pathway, having been documented by the one nautical mile (1.6 km) offshore of Jackson Harbor in 2007 and a half mile (0.8 km) offshore just south of Waukegan Harbor in 2006 (Kipp et al. 2011). Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of bloody red shrimp through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures create a control point for the bloody red shrimp at Alsip, Illinois, with the

construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the bloody red shrimp through the aquatic pathway.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk GLMRIS species of concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). The bloody red shrimp typically ranges between 0.2 and 0.5 in. (6 and 13 mm) (Kipp et al. 2011) and is expected to pass through the screens and would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip pre-filtration is included in the treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the bloody red shrimp through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0.

Nonstructural measures alone are not expected to address the humanmediated transport of the bloody red shrimp through the aquatic pathway.

T_{10}: See T_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measure implemented as part of this alternative, are expected to control the passage of the bloody red shrimp to the Brandon Road Lock and Dam by the Lake Michigan water diversion. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. The physical barrier would control the vessel-mediated transport of the species from Lake Michigan to the CAWS, because vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. As part of this alternative, structural measures are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the bloody red shrimp in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Medium	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage for the bloody red shrimp through the CAWS by natural dispersion and human-mediated transport. . Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the bloody red shrimp through the aquatic pathway.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the bloody red shrimp and vessels potentially transporting it in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the passage of this species through the CAWS by human-mediated transport and natural dispersion.

In addition, the ANSTP would treat Cal-Sag Channel water for bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point. Published data are not available describing the effects of UV radiation on the bloody red shrimp; however, lethal effects of UV radiation have been reported for other planktonic aquatic crustaceans. Studies by Raikow et al. (2007) showed that exposure to high levels of UV radiation (4,000 mJ/cm2; 254 nm) killed 59% and 91% of resting eggs of a marine brine shrimp (Artemia sp.) and a freshwater cladoceran (Daphnia mendotae), respectively. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move the species through the aquatic pathway are expected to slow passage to an uncertain degree.

Nonstructural measures alone are not expected to affect the passage for the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: As part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative, structural measures are expected to control the passage of the bloody red shrimp by natural dispersion and human-mediated transport through the aquatic pathway. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. For the ANSTP, prior to design and construction further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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E.8.2.4 Fish

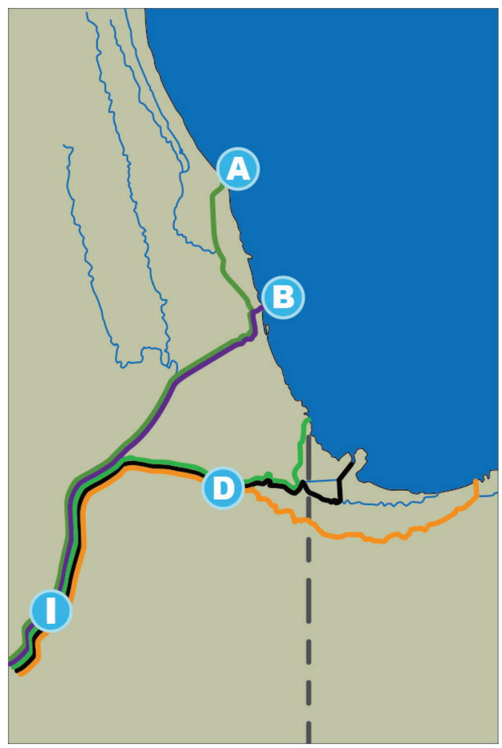
E.8.2.4.1 Threespine Stickleback (*Gasterosteus aculeatus*)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures involve the development of a monitoring and response program that could be implemented at T_0 (in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the threespine stickleback.

[b] The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes a GLMRIS Lock and an electric barrier at Control Point (I) that is designed to control Mississippi River Basin species and does not affect the threespine stickleback's probability ratings.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Screened Sluice Gates, GLMRIS Lock and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	**–**	***Low|NPE***	**–**

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway for the threespine stickleback.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival the threespine stickleback at the Chicago Area Waterway System (CAWS) as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback as a result of human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
It is uncertain whether the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative can reduce the current abundance and reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at the WPS.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of an aquatic nuisance species treatment plant (ANSTP) and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and threespine stickleback are in the Great Lakes basin. Overall, none of these structural measures are expected to act as physical barriers to the arrival

of the threespine stickleback at the CAWS by human-mediated transport or natural dispersion because, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel (NSC) in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not likely to reduce the distance of the threespine stickleback from the pathway. The threespine stickleback is already at the pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the threespine stickleback in southern Lake Michigan.

T_{10}: See T_0. Habitat is expected to remain suitable for the threespine stickleback.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. The species has already arrived at the pathway. The threespine stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.

T_{10}: See T_0. No changes in the habitat of Lake Michigan are expected to alter the probability of arrival of the threespine stickleback at the WPS.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species has been documented in the NSC, just beyond the entrance to the WPS pathway. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the threespine stickleback's arrival, because it is already present at the pathway. The threespine stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at the WPS in Wilmette, Illinois, with the construction of an ANSTP and screened sluice gates. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion of the threespine stickleback through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes Mississippi River Interbasin Study (GLMRIS) aquatic nuisance species (ANS) of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of their size. Larval fish and eggs, which range in size from 0.16 to 0.17 in. (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, and fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the screens They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point is expected to be effective.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006; EPA 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

In addition to the ANSTP, sluice gates would be constructed at the WPS in Wilmette, Illinois. The sluice gates would comprise two components: solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened, and water from the NSC would be diverted into Lake Michigan through the screened gates to reduce flood risk. When water from the NSC is diverted to Lake Michigan during a storm event, it is expected that threespine stickleback would be unable to pass through the screened sluice gates and into the NSC. The 0.4-in. (10.2-mm) openings of the screened sluice gates are equal to or smaller than the body depth of typical threespine stickleback (0.4–0.6 in. or 11.4–14.6 mm [Bergstrom 2002]). Threespine stickleback fish with body depths less than 0.4 in., eggs, larvae, and fry are not expected to pass through the control point into the NSC during backflows because of the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of threespine stickleback through this aquatic pathway.
T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for threespine stickleback eggs and larvae prior to discharge into the CAWS. In addition, the closed sluice gates are expected to control passage of threespine stickleback during dry weather. During large storm events that require backflows to Lake Michigan, threespine sticklebacks are not expected to pass through the screened sluice gates. Furthermore, threespine stickleback eggs, larvae, and fry are not expected to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, nonstructural measures alone are not expected to affect the natural dispersion or human-mediated transport of threespine stickleback through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.
T_{10}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. This alternative includes structural measures that are expected to control the natural dispersion and human-mediated transport of threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for threespine stickleback eggs and juveniles prior to discharge into the CAWS. In addition, the closed sluice gates are expected to control passage during dry weather. During large storm events that require backflows to Lake Michigan, swimming threespine stickleback are not expected to pass through the screened sluice gates. Furthermore, threespine stickleback eggs, larvae, and fry are not expected to passively

drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.
T_{10}: See T_0. Habitat in the CAWS is expected to remain suitable for the threespine stickleback.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to control the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the aquatic pathway.
The ANSTP would treat Lake Michigan water for the threespine stickleback prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced

the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early-life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation towing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The screened sluice gates are open only during flood events, and water from the CAWS would be diverted through screened sluice gates prior to discharge into Lake Michigan. The screen size is 0.4 in. Body depths of the threespine stickleback are typically 0.4–0.6 in. During these events, it is expected that threespine stickleback would be unable to pass through the screened sluice gates. Fish with body depths less than the screen size, eggs, larvae, and fry are not expected to pass through the screen against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of threespine stickleback passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Low	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to control the passage of threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to control the passage of threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures implemented as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the threespine stickleback through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, the uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 2
CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: *Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, Electric Barrier, and Screened Sluice Gates*

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	***High***	***Low***	***High***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	**–**	***Low|NPE***	**–**

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between CRCW and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback via human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species. It is uncertain whether the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative can reduce the current abundance and reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at the CRCW.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, a GLMRIS Lock, an electric barrier, and screened sluice gates at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin threespine stickleback is in the Great Lakes basin. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the threespine stickleback at the CAWS because, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the distance of the threespine stickleback from the pathway. The threespine stickleback is already at the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the threespine stickleback in southern Lake Michigan.

T_{10}: See T_0. Habitat near the CRCW is expected to remain suitable for the threespine stickleback.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. The species has already arrived at the pathway. The threespine stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.

T_{10}: See T_0. No changes in the habitat of Lake Michigan are expected to alter the threespine stickleback's probability of arrival at the CRCW.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species has been documented near the CRCW pathway. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback because it is already present at the pathway. Threespine stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50} : HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the creation of a control point at the current CRCW by replacing the current lock with two GLMRIS Locks, one shallow and one deep, and constructing an electric barrier, an ANSTP, and screened sluice gates. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not affect the natural dispersion of the threespine stickleback through the aquatic pathway.

At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS Lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to reduce the likelihood of waves overtopping and bypassing this control point. These structures would be designed to minimize the creation of habitat for the threespine stickleback. Nonstructural measures would be used to monitor for the presence of the threespine stickleback and, if required, to control the population surrounding the lock.

The electric barrier is expected to address the transfer of swimming threespine stickleback. The electric barrier would be placed within an engineered channel that would extend from the lake side of the GLMRIS Lock into Lake Michigan. To minimize opportunities for Great Lakes fish to bypass the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessels, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

To address passive drift of this species' eggs, larvae, and fry, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill it with water from an ANSTP. Without the lock flushing, the lock could transport these eggs and fry into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lake side of the lock, and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with ANSTP treated water. Therefore, ANS that rely on passive drift, including threespine stickleback eggs and fry, would be removed from the lock chamber.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth ranging from 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of their size. Larval fish and eggs, which range in size from 0.16 to 0.17 in. (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, and fish with body widths less than 0.75 in. (19.05 mm) are expected to be able to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the CRCW control point is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

In addition to the ANSTP, sluice gates would be constructed at the WPS in Wilmette, Illinois. The sluice gates would have two components: solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened, and water from the Chicago River would be diverted into Lake Michigan through the screened gates to reduce flood risk.

When water from the NSC is diverted to Lake Michigan during a storm event, it is expected that threespine stickleback would be unable to pass through the screened sluice gates and into the Chicago River. The 0.4-in. (10.2-mm) openings of the screened sluice gates are equal to or smaller than the body depth of typical threespine stickleback (0.4–0.6 in. or 11.4–14.6 mm) (Bergstrom 2002). Threespine stickleback fish with body depths less than 0.4 in. and eggs, larvae, and fry are not expected to pass through the control point into the Chicago River during backflows because of the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP,GLMRIS Lock, electric barrier, and screened sluice gates are expected to control passage of threespine stickleback. In addition, nonstructural measures, such as discharging ballast and bilge water prior to entering the GLMRIS Lock, are expected to reduce the passage of threespine stickleback caused by vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to affect the natural dispersion or human-mediated transport of threespine stickleback through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. Lake Michigan water would be treated for threespine stickleback by the ANSTP prior to discharge into the CAWS, and the GLMRIS Lock, electric barrier, and screened sluice gates are expected to control its passage. In addition, nonstructural measures, such as discharging ballast and bilge water prior to entering the GLMRIS Lock, are expected to reduce the passage of threespine stickleback caused by vessel-mediated transport.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.

T_{10}: See T_0. Habitat in the CAWS is expected to remain suitable for the threespine stickleback.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, a GLMRIS Lock, an electric barrier, and screened sluice gates at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the aquatic pathway.

The electric barrier is expected to control the downstream passage of the threespine stickleback.

The GLMRIS Lock is expected to address the passage of threespine stickleback eggs, larvae, and fry by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

The ANSTP would treat Lake Michigan water for the threespine stickleback prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early-life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation towing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The screened sluice gates are open only during flood events, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, threespine stickleback are not expected to pass through the screened sluice gates, while threespine stickleback eggs, larvae, and fry are not expected to passively drift against the velocity of the current exiting the screened sluice gates to enter the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Low	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to control the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to control the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The electric barrier upstream and downstream of the GLMRIS Lock would need to be calibrated to be an effective control method for the threespine stickleback. Research needs would include identification of optimal electrical parameters and hydraulic models. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated to control transfer of the threespine stickleback. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the threespine stickleback through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, GLMRIS Lock and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for the threespine stickleback.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback as a result of human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
It is uncertain whether the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative can reduce the current abundance and reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at Calumet Harbor.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the CAWS. Overall, none of these structural measures are expected to control the arrival of the threespine stickleback at the CAWS because, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the distance of the threespine stickleback from the pathway. The threespine stickleback is already at the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the threespine stickleback in southern Lake Michigan.
T_{10}: See T_0. Habitat near Calumet Harbor is expected to remain suitable for the threespine stickleback.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. The species has already arrived at the pathway. The threespine

stickleback is considered established in southern Lake Michigan and was found in the NS C in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.
T_{10}: See T_0. No changes in the habitat of Lake Michigan are expected to the alter probability of arrival of the threespine stickleback at Calumet Harbor.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species has been documented near the Calumet Harbor pathway. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback because it is already present at the pathway. The threespine stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated).Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural

measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the CAWS.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions.

The treatment technologies included in the ANSTP would include screening and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of their size. Larval fish and eggs, which range in size from 0.16 to 0.17 in. (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, and fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1996, 2006) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is

dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water are not expected to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of the threespine stickleback through the aquatic pathway. Implementation of the structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.

T_{10}: See T_0. Habitat in the CAWS is expected to remain suitable for the threespine stickleback.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the aquatic pathway.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the threespine stickleback and vessels potentially transporting threespine stickleback eggs and larvae in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of threespine stickleback through the aquatic pathway.

The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early-life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation towing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{25}: Structural measures implemented as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to the design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process would be needed to control passage of threespine stickleback through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, GLMRIS Lock and Electric Barrier

PROBAILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for threespine stickleback.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWSs as a result of natural dispersion (i.e., swimming and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback as result of human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
It is uncertain whether the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative can reduce the current abundance and reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at Indiana Harbor.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the arrival of the threespine stickleback through the CAWS. Overall, none of these structural measures are expected to control the arrival of the threespine stickleback at the CAWS because, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the distance of the threespine stickleback from the pathway. The threespine stickleback is already at the pathway.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the threespine stickleback in southern Lake Michigan.

T_{10}: See T_0. Habitat near Indiana Harbor is expected to remain suitable for the threespine stickleback.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. The species has already arrived at the pathway. The threespine

stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.
T_{10}: See T_0. No changes in the habitat of Lake Michigan are expected to alter the probability of arrival of the threespine stickleback at Indiana Harbor.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species is documented near the Indiana Harbor pathway. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback because it is already present at the pathway. The threespine stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural

measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the aquatic pathway.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of their size. Larval fish and eggs, which range in size from 0.16 to 0.17 in. (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, and fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1996, 2006) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is

dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of the threespine stickleback through the aquatic pathway. Structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.

T_{10}: See T_0. Habitat in the CAWS is expected to remain suitable for the threespine stickleback.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the aquatic pathway.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the threespine stickleback and vessels potentially transporting threespine stickleback eggs and larvae in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early-life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation towing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.
T_{25}: Structural measures implemented as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process would be needed to control passage of threespine stickleback through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, GLMRIS Lock and Electric Barrier

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[a]	High	–	High	–	High	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	None	High	None	High	None	High	None
P(passage)	High	Medium	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	High	Low	High	Low	High	Low	High	Low
P(establishment)	High	–[b]	High	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating:

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for threespine stickleback.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating:

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS as a result of natural dispersion (i.e., swimming and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback as a result of human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
It is uncertain whether the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative can reduce the current abundance and reproductive capacity of the threespine stickleback in the Great Lakes.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers
T_0: None. The threespine stickleback has arrived at the BSBH.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the CAWS. Overall, none of these structural measures are expected to control the arrival of the threespine stickleback at the CAWS because, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the distance of the threespine stickleback from the pathway. The threespine stickleback is already at the pathway.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the threespine stickleback in southern Lake Michigan.
T_{10}: See T_0. Habitat near the BSBH is expected to remain suitable for the threespine stickleback.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS through aquatic pathways. The species has already arrived at the pathway. The threespine

stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the probability of arrival remains high.
T_{10}: See T_0. No changes in the habitat of Lake Michigan are expected to alter the threespine stickleback's probability of arrival at the BSBH.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species is documented near the BSBH pathway and is established in the CAWS. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback because it is already present at the pathway. The threespine stickleback is considered established in southern Lake Michigan and was found in the NSC in 1988 (Johnston 1991). Furthermore, the Illinois Natural History Survey has found the threespine stickleback near the Lockport Lock and Dam (INHS undated). Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH–LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the threespine stickleback through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural

measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the CAWS.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The physical barrier is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions.

The treatment technologies included in the ANSTP would include screening and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and a body depth of 0.4 to 0.6 in. (11.4 to 14.6 mm) (Bergstrom 2002), would be excluded by the screens because of their size. Larval fish and eggs, which range in size from 0.16 to 0.17 in. (4.3 to 4.5 mm) (Jordan and Evermann 1896) and 0.05 to 0.07 in. (1.2 to 1.7 mm) (Swarup 1958), respectively, and fish with body widths of less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1996, 2006) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is

dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the threespine stickleback through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of threespine stickleback through the aquatic pathway. Structural measures would not be implemented until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the threespine stickleback in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0; however, these measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the aquatic pathway.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the threespine stickleback and vessels potentially transporting threespine stickleback eggs and larvae in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of threespine stickleback through the aquatic pathway.

The ANSTP would treat Cal-Sag Channel water for the threespine stickleback prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early-life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation towing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate threespine stickleback eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate threespine stickleback that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of threespine stickleback and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: Nonstructural measures alone are not expected to affect the passage of the threespine stickleback through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{25}: Structural measures implemented as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the threespine stickleback through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation, and whether an additional treatment process would be needed to control passage of the threespine stickleback and its various life stages through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

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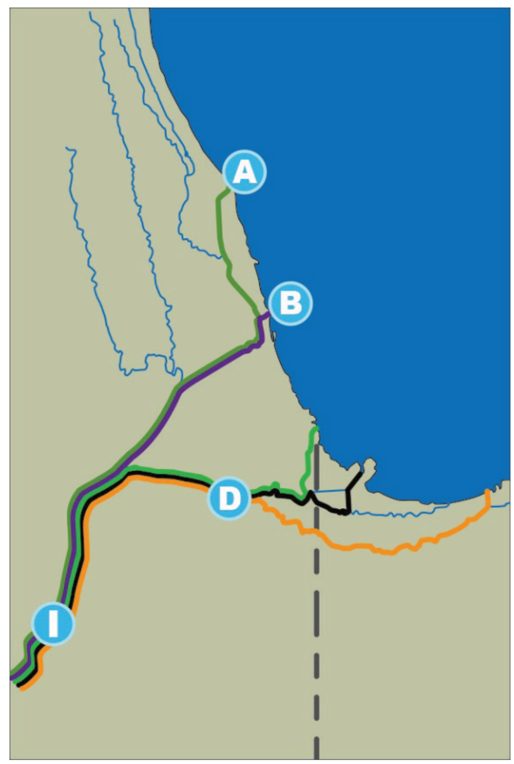
E.8.2.4.2 Ruffe (*Gymnocephalu cernuus*)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the ruffe.

[b] The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes a GLMRIS Lock and an electric barrier at Control Point (I) that is designed to control Mississippi River Basin species and does not affect the ruffe's probability ratings.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Screened Sluice Gates, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating
The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

A. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe from natural dispersion through aquatic pathways at the Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations, may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of an aquatic nuisance species treatment plant (ANSTP) and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a Great Lakes and Mississippi River Interbasin Study (GLMRIS) Lock and electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address aquatic nuisance species (ANS) originating in the Mississippi River Basin, and ruffe is found in the Great Lakes Basin. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the ruffe at the CAWS by human-mediated transport or natural dispersion. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.
T_{50}: See T_0.

d. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.

T_{10}: See T_0.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge-water exchange programs that may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can spread quickly by vessel-mediated transport and can quickly become abundant (FWS 1996; Bauer et al. 2007), having spread across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge-water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could move closer to the WPS by spreading through the suitable habitat along Lake Michigan or by vessel transport to southern Lake Michigan. Nonstructural measures such as ballast/bilge-water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Medium
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe through aquatic pathways at the CAWS. Nonstructural measures as part of the alternative may increase the time for the species to arrive. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Over 50 years, the probability increases that ruffe would have time to spread to the WPS by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the WPS. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe through aquatic pathways at the CAWS. Nonstructural measures as part of the alternative may increase the time for the ruffe to arrive. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The probability increases that ruffe would have time to spread to the WPS by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the WPS. Therefore, the probability of arrival remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe would have time to spread to the WPS by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the WPS. Therefore, the probability of arrival remains high.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at the WPS in Wilmette, Illinois, and a second at the Brandon Road Lock and Dam.

At the WPS control point, the purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some ruffe, which typically have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by these screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can “shade” and “encase” target species, and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point location is expected to be effective.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006: Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

In addition to the ANSTP, sluice gates would also be constructed at the WPS in Wilmette, Illinois. The sluice gates would comprise two components: solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened, and water from the North Shore Channel (NSC) would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the NSC is diverted to Lake Michigan during a storm event, it is expected that ruffe would be unable to pass through the screened sluice gates and into the NSC. The 0.4-in. (10.2-mm) openings of the screened sluice gate are smaller than the body depth of typical ruffe (1.1–1.3 in. or 28.4–31.8 mm) (Fuller et al. 2012). Ruffe with body depths less than 0.4 in. (10.2 mm), eggs, larvae, and fry are expected to be unable to pass through the control point and into the NSC during backflows due to the velocity of the exiting current.

The Brandon Road Lock and Dam control point does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The ruffe is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for ruffe eggs, larvae, and fry prior to discharge into the CAWS. In addition, the closed sluice gates are expected to control passage of ruffe during dry weather events. During large storm events requiring backflows to Lake Michigan, swimming ruffe are not expected to pass through the screened sluice gates. In addition, ruffe eggs,

larvae, and fry are not expected to be able to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS.
T_{50}: See T_{25}.

c. ***Existing Physical Human/Natural Barriers***

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for description of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative. This alternative includes structural measures that are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for ruffe prior to discharge into the CAWS. In addition, the closed sluice gates would control passage of the ruffe during dry weather. .During large storm events that require backflows to Lake Michigan, swimming ruffe are expected to be unable to pass through the screened sluice gates. Ruffe eggs, larvae, and fry are not expected to be able to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS.

T_{50}: See T_{25}.

d. ***Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)***

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gate at the WPS in Wilmette, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway.

The ANSTP would treat Lake Michigan water for the ruffe prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation owing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to assess whether additional treatment processes are needed to control its passage through the ANSTP.

The screened sluice gate is open only during flood events, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, it is expected that ruffe would be unable to pass through the screened sluice gates. Fish with body depths less than the screen size, eggs, larvae, and fry are not expected to pass through the screen because of the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the ruffe through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, Electric Barrier, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	***Low***	***High***	***Low***	***High***
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating
The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations, may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, a GLMRIS Lock, an electric barrier, and screened sluice gates at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River and ruffe is in the Great Lakes basins. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the ruffe at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.
T_{50}: See T_{25}.

d. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge-water exchange programs that may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can spread quickly by vessel-mediated transport and can quickly become abundant (FWS 1996; Bauer et al. 2007), having spread across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge-water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could move closer to the CRCW by spreading through the suitable habitat along Lake Michigan or by vessel transport to southern Lake Michigan. Nonstructural measures such as ballast/bilge-water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Medium
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe through aquatic pathways at the CAWS. Nonstructural measures as part of the alternative may increase the time for the species to arrive. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: Over 50 years, the probability increases that ruffe would have time to spread to the CRCW by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the CRCW. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe through aquatic pathways at the CAWS. Nonstructural measures as part of the alternative may increase the time for the ruffe to arrive. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The probability increases that ruffe would have time to spread to the CRCW by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the CRCW. Therefore, the probability of arrival remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe would have time to spread to the CRCW by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the CRCW. Therefore, the probability of arrival remains high.

3. P(passage) T_0-T_{50} : HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at the CRCW and a second at the Brandon Road Lock and Dam. At the current CRCW, the current lock would be replaced with two GLMRIS Locks, one shallow and one deep, and an electric barrier, an ANSTP, and screened sluice gates would be constructed.

At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS Lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to control waves from overtopping the wall and bypassing this control point. These structures would be designed to minimize the creation of habitat surrounding the lock for the ruffe. Nonstructural measures would be used to monitor for the presence of the ruffe and, if required, to control the population surrounding the lock.

The electric barrier is expected to address the transfer of swimming ruffe. The electric barrier would be placed within an engineered channel extending from the lake side of the GLMRIS Lock into Lake Michigan. To minimize opportunities for Great Lakes fish to bypass the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced, U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to the lock being operated after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

To address passive drift of this species' eggs, larvae, and fry, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport these eggs and fry into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lake side of the lock, and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with ANSTP treated water. Therefore, ANS that rely on passive drift, including ruffe eggs, larvae, and fry, would be removed from the lock chamber.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water for lock flushing. The nonstructural measures of ballast- and bilge-water management prior to entering the GLMRIS Lock are expected to control the passage of the ruffe through ballast- and bilge-water discharge.

The treatment technologies included in the ANSTP would be screening and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some ruffe, which typically have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by these screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), as well as small adult fish with body depths of less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the CRCW control point is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006; 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

In addition, sluice gates would also be constructed at the CRCW control point. The sluice gates would comprise two components: solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened, and water from the Chicago River would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the Chicago River is diverted to Lake

Michigan during a storm event, it is expected that ruffe would be unable to pass through the screened sluice gates and into the Chicago River. The 0.4-in. (10.2 mm) openings of the screened sluice gate are smaller than the body depth of the adult ruffe (1.1–1.3 in. or 28.4–31.8 mm) (Fuller et al. 2012). Ruffe with body depths less than 0.4 in. (10.2 mm), eggs, larvae, and fry are not expected to pass through the control point and into the Chicago River during backflows due to the velocity of the exiting current.

For storms that require the passage of an even greater volume than the sluice gates can divert, the gates on a GLMRIS Lock would be opened. Water from the CAWS would be diverted to Lake Michigan through the lock. Again, passively drifting eggs, larvae, and fry are not expected to drift through the GLMRIS Lock while water is flowing from the CAWS through the lock into Lake Michigan. In addition, swimming ruffe trying to swim against the exiting current would be deterred by the electric barrier and would be unable to pass through the lock.

The Brandon Road Lock and Dam control point does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Ruffe are located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates are expected to control passage of the ruffe through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water from vessels before they enter the GLMRIS Lock are expected to help reduce the passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however these nonstructural measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. Lake Michigan water would be treated for ruffe eggs and larvae by the ANSTP prior to discharge into the CAWS, and the GLMRIS Lock, electric barrier, and screened sluice gates are expected to control its passage. In addition, nonstructural measures such as discharging ballast and bilge water prior to its entering the GLMRIS Lock are expected to reduce passage of ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gate at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway.

The electric barrier is expected to control the downstream passage of the ruffe by natural dispersion, vessels, and diversion of water for flood risk management.

The GLMRIS Lock would address the passage of ruffe eggs by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end and, on the opposite end, flush and fill the lock with water treated by the ANSTP.

The ANSTP would treat Lake Michigan water for the ruffe prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation owing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The screened sluice gate is open only during flood events, and water from the CAWS would be diverted through screened sluice gates prior to discharge into Lake Michigan.

During these events, it is expected that ruffe would be unable to pass through the screened sluice gates. Fish with body depths less than the screen size, eggs, larvae, and fry are not expected to pass through the screen against the velocity of the exiting current.

Overall, the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion, vessels, and the Lake Michigan diversion. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway.

The electric barrier upstream and downstream of the GLMRIS Lock would need to be calibrated in order to be an effective control method for the ruffe. Research needs would include identification of optimal electrical parameters and hydraulic models. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated to control transfer of the ruffe. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the ruffe through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	***Low***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for the ruffe.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS from natural dispersion (i.e., swimming and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations, may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Existing Physical Human/Natural Barriers
T_0: There are no existing physical barriers.
T_{10}: See T_0.
T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the arrival of the ruffe through the CAWS. Overall, these structural measures are not expected to control the arrival of the ruffe at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc

and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.

T_{50}: See T_{25}.

d. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.

T_{10}: See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{25}. See the Nonstructural Risk Assessment for this species.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge-water exchange programs, which may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can spread quickly by vessel-mediated transport and can quickly become abundant (FWS 1996; Bauer et al. 2007), having spread across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge-water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could move closer to Calumet Harbor by spreading through the suitable habitat along Lake Michigan or by vessel transport. Alternatively, its range could contract, decreasing its probability of arriving. Nonstructural measures such as ballast/bilge-water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. See the Nonstructural Risk Assessment for this species.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe through aquatic pathways at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Over 50 years, the probability increases that ruffe would have time to spread to Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to Calumet Harbor. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe through aquatic pathways at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: The probability increases that ruffe would have time to spread to Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to Calumet Harbor. Therefore, the probability of arrival remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe would have time to spread to the Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the Calumet Harbor. Therefore, the probability of arrival remains high.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for the ruffe at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip control point is to remove ANS from Cal-Sag Channel water prior to discharge into the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water for lock flushing. The nonstructural measures of ballast- and bilge-water management prior to entering the GLMRIS Lock are expected to control the passage of the ruffe through ballast- and bilge-water discharge.

The treatment technologies included in the ANSTP would be screening and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some ruffe, which typically have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by these screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), as well as fish with body depth less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Lake Michigan water quality data indicate that Lake Michigan is sufficiently clear to allow for effective UV treatment. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006; 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe and vessels potentially transporting ruffe eggs and larvae in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation owing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to assess whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via

natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation, and whether an additional treatment process would be needed to control passage of the ruffe through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	***Low***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for ruffe.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe from natural dispersion (i.e., swimming and passive drift) through aquatic pathways at the CAWS.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations, may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the arrival of the ruffe through the CAWS. Overall, these structural measures are not expected to control the arrival of the ruffe at the CAWS. The ruffe exists in northern Lake Michigan in

Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.
T_{50}: See T_{25}.

d. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge-water exchange programs, which may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can spread quickly by vessel-mediated transport and can quickly become abundant (FWS 1996; Bauer et al. 2007), having spread across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge-water transport is believed to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could move closer to Indiana Harbor by spreading through the suitable habitat along Lake Michigan or by vessel transport. Alternatively, its range could contract, decreasing its probability of arriving. Nonstructural measures such as ballast/bilge-water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.
T_{25}: See T_{10}.
T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival for the ruffe through aquatic pathways at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival remains low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Over 50 years, the probability increases that ruffe would have time to spread to Calumet Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to Indiana Harbor. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival for the ruffe at the CAWS through aquatic pathways. Nonstructural measures may increase the time for the ruffe to arrive at the CAWS pathway. Currently, the ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0. The probability increases that ruffe would have time to spread to Indiana Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to Indiana Harbor. Therefore, the probability of arrival remains medium.

T_{25}: See T_{10}.
T_{50}: See T_{25}. The probability increases that ruffe would have time to spread to Indiana Harbor by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the Indiana Harbor. Therefore, the probability of arrival remains high.

3. **P(passage) T_0-T_{50}: HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for the ruffe at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some ruffe, which have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by the screens because of their size.

Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip, pre-filtration is included in ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana

Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe and vessels potentially transporting ruffe eggs and larvae in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation owing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs and embryos. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to assess whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process would be needed to control passage of the ruffe through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Low	–	Low	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Low	Medium	Low	Medium	Medium	High
P(passage)	High	Medium	High	Medium	***Low***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	Low	–	***Low(2)***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) designates an increase in the number of low elements.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for the ruffe.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier, creating an aquatic pathway between the basins.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS from natural dispersion (i.e., swimming and passive drift) through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations, may reduce the human-mediated transport of the ruffe to the CAWS pathway.

c. Existing Physical Human/Natural Barriers
T_0: There are no existing barriers.
T_{10}: See T_0.
T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the arrival of the ruffe through the CAWS. Overall, these structural measures are not expected to control the arrival of the ruffe at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay

(Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway.
T_{50}: See T_{25}.

d. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of the ruffe.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. See the Nonstructural Risk Assessment for this species.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge-water exchange programs, which may increase the time the ruffe takes to arrive at the CAWS pathway. Ruffe can spread quickly by vessel-mediated transport and can quickly become abundant (FWS 1996; Bauer et al. 2007), having spread across the northern Great Lakes in a decade (Fuller et al. 2012). Ballast/bilge-water transport is believed to assist the ruffe's dispersion in the Great Lakes.
T_{10}: See T_0. Ruffe could move closer to the BSBH by spreading through the suitable habitat along Lake Michigan or by vessel transport. Alternatively, its range could contract, decreasing its probability of arriving. Nonstructural measures such as ballast/bilge-water exchange programs may increase the time the ruffe takes to arrive at the CAWS pathway.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the ruffe in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0. See the Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Medium

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival for the ruffe through aquatic pathways at the CAWS. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the probability of arrival is low.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Over 50 years, the probability increases that ruffe would have time to spread to the BSBH by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the BSBH. Therefore, the probability of arrival remains medium.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	High

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the ruffe at the CAWS through aquatic pathways. The ruffe exists in northern Lake Michigan in Green Bay/Bay de Noc and has not been detected outside of Green Bay (Bowen and Goehle 2011); however, the species is capable of swimming to the CAWS pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0. The probability increases that ruffe would have time to spread to the BSBH by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the BSBH. Therefore, the probability of arrival remains medium.

T_{25}: See T_{10}.

T_{50}: See T_{10}. The probability increases that ruffe would have time to spread to the BSBH by natural dispersion alone or through a combination of human-mediated transport to the southern Great Lakes and natural dispersion to the BSBH. Therefore, the probability of arrival remains high.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for the ruffe at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event. The purpose of the ANSTP is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). It is expected that some ruffe, which have a total body length ranging from 3.7 to 4.9 in. (94.3 to 124.5 mm), body depth ranging from 1.1 to 1.3 in. (28.4 to 31.8 mm), and body width ranging from 0.6 to 0.8 in. (15.5 to 19.1 mm) (Fuller et al. 2012), would be excluded by the screens because of their size. Larval fish and eggs, which range in size from 0.01 to 0.05 in. (0.34 to 1.3 mm) (Fuller et al. 2012), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity because suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip control point may reduce the effectiveness of UV treatment. Consequently, at Alsip, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the ruffe in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of the ruffe through the aquatic pathway.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe and vessels potentially transporting ruffe eggs and larvae in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for the ruffe prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, dwarfism) and histological (lesions in the liver, kidney, skin and intestines and gill, eye, spinal cord malformations) changes to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fish (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation owing to the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate ruffe eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate ruffe that may pass through the 0.75-in. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of ruffe and to assess whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the ruffe passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: Nonstructural measures alone are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure, and whether an additional treatment process would be needed to control the passage of the ruffe through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

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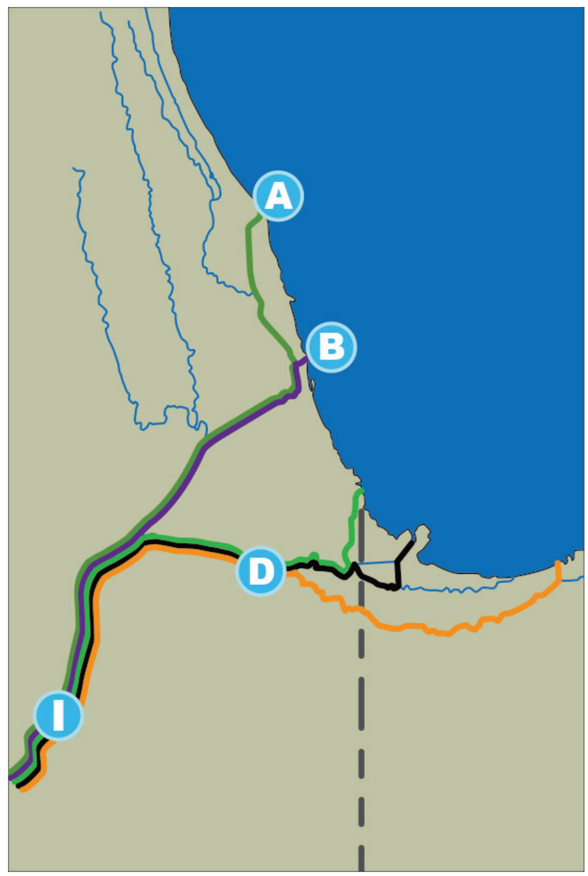
E.8.2.4.3 Tubenose Goby (*Proterorhinus semilunaris*)

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by T_{25}.

Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock

[a] The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes a GLMRIS Lock and electric barrier at Control Point (I), which is designed to control Mississippi River Basin species and does not impact the tubenose goby's probability ratings.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION WITH CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Screened Sluice Gates, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	***Low***	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	***Medium***	***Low***	***Medium***
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system

Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the tubenose goby's arrival at the Chicago Area Waterway System (CAWS) as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with other nonstructural measures such as education and outreach, may be used to determine where to focus nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Agency monitoring and voluntary occurrence reporting, in combination with additional nonstructural measures such as education and outreach, can be used to determine where to focus nonstructural control measures, in particular piscicides. However, the tubenose goby is currently too dispersed to be effectively controlled with the occasional application of piscicides in localized areas.
If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Dessication (water drawdown) is not expected to be

an effective control measure for the tubenose goby, because the species is currently established in deepwater environments where implementation of such a control is not feasible. Because of the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. *Existing Physical Human/Natural Barriers*

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of an aquatic nuisance species (ANS) treatment plant (ANSTP) and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of the tubenose goby at the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the tubenose goby at the CAWS via human-mediated transport or natural dispersion. The tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs that may increase the time the tubenose goby takes to arrive at the CAWS pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes.

T_{10}: See T_0. Tubenose goby could come closer to the WPS via vessel transport or natural dispersion to southern Lake Michigan. The species may be able to occupy shallow waters of all five Great Lakes (EPA 2008). Nonstructural measures such as ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway as a result of implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge-water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. The tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway as a result of implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. There is no commercial vessel transport to the WPS, and the implementation of nonstructural measures such as a ballast/bilge water exchange program are expected to increase the time it takes for the tubenose goby to arrive at the pathway. However, over time, the probability increases that the species would have time to spread to the WPS by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the WPS. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. However, uncertainty associated with the effectiveness of nonstructural measures implemented as part of this alternative to control the arrival of tubenose goby at the CAWS is believed to increase with time. Therefore, the uncertainty is medium.

T_{25}: See T_{10}. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. However, over time, trends in future populations and spread rates become less certain. Therefore, the uncertainty remains medium.

T_{50}: See T_{25}.

3. **P(passage) T_0-T_{50}: HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates a control point for the tubenose goby at the WPS in Wilmette, Illinois, with the construction of an ANSTP and screened sluice gates. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm (Fuller et al. 2012), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens; they would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point location is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al.2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition to the ANSTP, sluice gates would also be constructed at the WPS in Wilmette, Illinois. The sluice gates would be composed of two components—solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened, and water from the North Shore Channel would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the North Shore Channel is diverted to Lake Michigan during a storm event, it is expected that tubenose goby would be unable to pass through the screened sluice gates and into the North Shore Channel. The 0.4-in. (10.2-mm) openings of the screened sluice gate are smaller than the body depth of tubenose goby (0.7–1.0 in. or 17.3–25.5 mm; Fuller et al. 2012). Tubenose goby with body depths less than 0.4 in. (10.2 mm), eggs, larvae, and fry are expected to be unable to pass through the control point and into the North Shore Channel during backflows due to the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSCC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for tubenose goby prior to discharge into the CAWS. In addition, the sluice gates are expected to control passage of tubenose goby during dry weather events when they are closed. During large storm events requiring backflows to Lake Michigan, swimming tubenose goby are not expected to pass through the screened sluice gates. In addition, tubenose

goby eggs, larvae, and fry are not expected to be able to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS.
T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these nonstructural measures would not act as physical human/natural barriers to the passage of tubenose goby. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. This alternative includes structural measures that are expected to control the tubenose goby's passage to Brandon Road Lock and Dam via natural dispersion and human-mediated transport. The ANSTP would treat Lake Michigan water for tubenose goby eggs and larvae prior to discharge into the CAWS. In addition, the closed sluice gates would control passage of tubenose goby during dry weather events. During large storm events requiring backflows to Lake Michigan; swimming tubenose goby are not expected to pass through the screened sluice gates. Tubenose goby eggs, larvae, and fry are expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gate at the WPS in Wilmette, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. Tubenose goby are located in the Great Lakes Basin.

The ANSTP at the WPS control point would treat Lake Michigan water for the tubenose goby prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, and dwarfism) and histological changes (lesions in the liver, kidney, skin, and intestines, as well as gill, eye, and spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that the early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. (19.05-mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The screened sluice gate is open only during flood events, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, it is expected that tubenose goby would be unable to pass through the screened sluice gates. Fish with body depths less than the screen size, eggs, larvae, and fry are not expected to pass through the screen due to the velocity of the exiting current.

Overall, the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that the tubenose goby would pass through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***Medium***	***Medium***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the tubenose goby through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is medium.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION WITH CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, Electric Barrier, GLMRIS Lock, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	***Low***	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	***High***	***Low***	***High***
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Chicago River Controlling Works (CRCW) and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to impact the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the tubenose goby's arrival at the CAWS as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with additional nonstructural measures such as education and outreach, can be used to determine where to focus nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Agency monitoring and voluntary occurrence reporting, in combination with additional nonstructural measures such as education and outreach, can be used to determine where to focus nonstructural control measures, in particular piscicides. However, the tubenose goby is currently too dispersed to be effectively controlled with the occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation (water drawdown) is not expected to be an effective control measure for the tubenose goby, because the species is currently established in deepwater environments where implementation of such a control is not feasible. Because of the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to impact arrival of the tubenose goby at the CAWS pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of the tubenose goby at the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the tubenose goby at the CAWS. The tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs, which may increase the time the tubenose goby takes to arrive at the CAWS pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes.

T_{10}: See T_0. The tubenose goby could come closer to the CRCW via vessel transport or natural dispersion to southern Lake Michigan. The species may be able to occupy shallow waters of all five Great Lakes (EPA 2008). Nonstructural measures such as ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the tubenose goby arriving at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: The Mid-System Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge-water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that the tubenose goby would arrive at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways to the CAWS. However, over time, the probability increases that the species would have time to spread by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the CRCW. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's uncertainty of arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

T_{10}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the uncertainty of arrival for the tubenose goby at the CAWS through aquatic pathways. The implementation of a ballast/bilge-water exchange program is expected to increase the time it takes for the tubenose goby to arrive at the pathway. However, uncertainty associated with the effectiveness of nonstructural measures implemented as part of this alternative to control the arrival of tubenose goby at the CAWS is believed to increase with time. Therefore, the uncertainty is medium.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. However, over time, trends in future populations and spread rates become less certain. Therefore, uncertainty remains medium.

T_{50}: See T_{25}.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at the CRCW and a second at Brandon Road Lock and Dam. At the CRCW, the current lock would be replaced with two GLMRIS Locks, one shallow and one deep, and an electric barrier, an ANSTP, and screened sluice gates would be constructed.

At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS Lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to control waves from overtopping and bypassing this control point. These structures would be designed to minimize the creation of habitat for the tubenose goby. Nonstructural measures would be used to monitor for the presence of the tubenose goby, and, if required, to control the population surrounding the lock.

The electric barrier is expected to address the transfer of swimming tubenose goby. The electric barrier would be placed within an engineered channel that would extend from the lake side of the GLMRIS Lock into Lake Michigan. To minimize opportunities for Great Lakes fish to bypass the barrier due to rough channel walls, the electric barrier would be placed within a constructed, smooth-surfaced, and U-shaped engineered channel. Further testing would focus on determining optimal design and operating parameters to address electric field shielding by steel-hulled vessel, fish entrainment within barge-induced water currents, and very small fish. If the barrier is without power, the GLMRIS Lock would be closed until power is restored. Prior to operating the lock after a power outage, fish within the engineered channel would be removed using nonstructural measures such as netting or piscicides.

To address passive drift of this species' eggs, larvae, and fry, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport these eggs, larvae, and fry into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lake side of the lock, and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with ANS treated water. Therefore, ANS that rely on passive drift, including tubenose goby eggs, larvae, and fry, would be removed from the lock chamber.

The purpose of the ANSTP is to remove aquatic nuisance species from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with ANS treated water for lock flushing. The nonstructural measures of ballast and bilge water management prior to entering the GLMRIS Lock are expected to control the passage of the tubenose goby through ballast and bilge water discharge.

The treatment technologies included in the ANSTP would include screening and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5.0 in. (127 mm) (Fuller et al. 2012), body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 by 1.3 mm) (Pallas 1811) in size, and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the CRCW control point is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

In addition, sluice gates would also be constructed at the CRCW control point. The sluice gates would be composed of two components—solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events, the solid gates would be opened and water from the Chicago River would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the Chicago River is diverted to Lake Michigan during a storm event, it is expected that tubenose goby would be unable to pass through the screened sluice gates and into the Chicago River. The 0.4-in. (10.2-mm) openings of the screened sluice gate are smaller than the body depths of typical tubenose goby (tubenose goby body depth, 0.7–1.0 in. or 17.3–25.5 mm; Fuller et al. 2012). Tubenose goby fish with body depths less than 0.4 in. (10.2 mm), eggs, larvae, and fry are not expected to pass through the control point into the Chicago River during backflows due to the velocity of the exiting current.

For storms that require the passage of an even greater volume than the sluice gates can divert, the gates on a GLMRIS Lock would be opened. Water from the CAWS would be diverted to Lake Michigan through the lock. Again, passive-drifting eggs, larvae, and fry are expected to be unable to drift through the GLMRIS Lock while water is flowing from the CAWS through the lock into Lake Michigan. In addition, swimming tubenose goby trying to swim against the exiting current would be deterred by the electric barrier and are expected to be unable to pass through the lock.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. Tubenose goby are located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway. The ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates are expected to control passage of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water before they enter the GLMRIS Lock are expected to help reduce the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these nonstructural measures alone are not expected to address the natural dispersion or human-mediated transport of tubenose goby through the aquatic pathway. Implementation of structural measures would not occur until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. Lake Michigan water would be treated for tubenose goby eggs, larvae, and fry by the ANSTP prior to discharge into the CAWS. The GLMRIS Lock, electric barrier, and screened sluice gates are expected to control the natural dispersion and human-mediated transport of tubenose goby. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to impact the passage of tubenose goby through the aquatic pathway due to vessel-mediated transport.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural

measures would include the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gate at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. Tubenose goby are located in the Great Lakes Basin.

The GLMRIS Lock would address the passage of tubenose goby eggs by passive drift through the lock chamber. The lock's pump-driven filling and emptying system would remove the contained water from one end, and, on the opposite end, flush and fill the lock with water treated by the ANSTP. The electric barrier is expected to control the downstream passage of the tubenose goby by natural dispersion, vessels, and diversion of water for flood risk management.

The ANSTP would treat Lake Michigan water for the tubenose goby prior to discharge into the CAWS. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, and fin blistering, dwarfism) and histological changes (lesions in the liver, kidney, skin, and intestines, and gill, eye, and spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. (10.05-mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

The screened sluice gate is open only during flood events, and water from the CAWS would be diverted through screened sluice gates prior to discharge into Lake Michigan. During these events, it is expected that tubenose goby would be unable to pass through the screened sluice gates. Fish with body depths less than the screen size, eggs, larvae, and fry are not expected to pass through the screen against the velocity of the exiting current.

Overall, the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that the tubenose goby would pass through the aquatic pathway. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***High***	***High***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the natural dispersion and human-mediated transport of the tubenose goby. Research needs would include modeling and laboratory and field testing to determine the optimal design and operating parameters. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the tubenose goby through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is high.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION WITH CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	***Low***	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system

Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for tubenose goby.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating
The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: LOW-MEDIUM

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the tubenose goby's arrival at the CAWS as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Agency monitoring and voluntary occurrence reporting, in combination with additional nonstructural measures such as education and outreach, can be used to determine where to focus nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge water exchange program education and outreach and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Agency

monitoring and voluntary occurrence reporting, in combination with additional nonstructural measures such as education and outreach, can be used to determine where to focus nonstructural control measures, in particular piscicides. However, the tubenose goby is currently too dispersed to be effectively controlled with the occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Dessication (water drawdown) is not expected to be an effective control measure for the tubenose goby, because the species is currently established in deepwater environments where implementation of such a control is not feasible. Because of the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to impact its arrival at the CAWS pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of the tubenose goby at the CAWS. Overall, these structural measures are not expected to control the arrival of the tubenose goby at the CAWS. The tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the aquatic pathway.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as ballast/bilge water exchange programs, which may increase the time the tubenose goby takes to arrive at the CAWS pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

Nonstructural measures such as ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{25}: See T_{10}.

T_{50}: See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that the tubenose goby would arrive at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced from medium to low.

T_{25}: See T_{10}. The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways to the CAWS. However, over time, the probability increases that the species would have time to spread by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to Calumet Harbor. Therefore, its probability of arrival remains medium.

T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. However, uncertainty associated with the effectiveness of nonstructural measures implemented as part of this alternative to control the arrival of tubenose goby at the CAWS is believed to increase with time. Therefore, the uncertainty is medium.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. However, over time, trends in future populations and spread rates become less certain. Therefore, uncertainty remains medium.

T_{50}: See T_{25}.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative would create two control points, one at Alsip, Illinois, and a second at Brandon Road Lock and Dam.

At the Alsip, Illinois, control point, a physical barrier would be constructed in the channel and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 mm by 1.3 mm) in size (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the

Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1996, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The tubenose goby is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting this species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of tubenose goby through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat CSSC water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See $_{25}$.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. Tubenose goby are located in the Great Lakes Basin.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting tubenose goby eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, and dwarfism) and histological changes (lesions in the liver, kidney, skin, and intestines, and gill, eye, spinal cord, and malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that the early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. (19.05-mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that the tubenose goby would pass through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the tubenose goby through the CAWS by natural dispersion or human-mediated transport; therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process would be needed to control passage of tubenose goby and its various life stages through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION WITH CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	***Low***	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for tubenose goby.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: LOW-MEDIUM**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the tubenose goby's arrival at the CAWS as a result of natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures may reduce the arrival of the tubenose goby from human-mediated transport through aquatic pathways. Agency monitoring and voluntary occurrence reporting, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge-water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach, can be used to determine where to focus

nonstructural control measures, in particular piscicides. However, the tubenose goby is currently too dispersed to be effectively controlled with the occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Dessication (water drawdown) is not expected to be an effective control measure for the tubenose goby, because the species is currently established in deepwater environments where implementation of such a control is not feasible. Because of the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to impact its arrival at the CAWS pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of the tubenose goby at the CAWS. Overall, these structural measures are not expected to control the arrival of the tubenose goby at the CAWS. The tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may affect the tubenose goby's distance from the pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes; consequently, ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that the tubenose goby would arrive at the aquatic pathway via implementation of a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced from medium to low.

T_{25}: See T_{10}. The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. However, over time,

the probability increases that the species would have time to spread by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to Indiana Harbor. Therefore, its probability of arrival remains medium.
T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. However, uncertainty associated with the effectiveness of nonstructural measures implemented as part of this alternative to control the arrival of tubenose goby at the CAWS is believed to increase with time. Therefore, the uncertainty is medium.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. However, over time, trends in future populations and spread rates become less certain. Therefore, uncertainty remains medium.
T_{50}: See T_{25}.

3. P(passage) T_0–T_{50}: HIGH–LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at Brandon Road Lock and Dam.

At the Alsip, Illinois, control point, a physical barrier would be constructed in the channel and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 mm by 1.3 mm) in size (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The tubenose goby is located in the Great Lakes Basin.

Overall, the Alsip, Illinois, control point is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of tubenose goby through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical

barrier and an ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway. The tubenose goby is located in the Great Lakes Basin.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting tubenose goby eggs, larvae, and fry in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366-nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, and dwarfism) and histological changes (lesions in the liver, kidney, skin, and intestines, and gill, eye, and spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that the early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. (19.05-mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the tubenose goby passing through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty is medium.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process would be needed to control passage of tubenose goby and its various life stages through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION WITH CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	Medium	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	High	Low	High	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	Low	Low	***Low***	Medium	Medium	Medium	Medium	Medium
P(passage)	High	Medium	High	Medium	***Low***	Low	***Low***	Low
P(colonizes)	Medium	High	Medium	High	Medium	High	Medium	High
P(spreads)	Medium	High	Medium	High	Medium	High	Medium	High
P(establishment)	Low	–[b]	***Low***	–	***Low***	–	***Low***	–

[a] The highlighted table cells indicate a rating change in the probability element.

[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating:

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the Burns Small Boat Harbor (BSBH) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for tubenose goby.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Calumet-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating:

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: LOW-MEDIUM**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the tubenose goby's arrival at the CAWS as a result of natural dispersion through aquatic pathways.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures may reduce the tubenose goby's probability of arrival as a result of human-mediated transport through aquatic pathways. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach can be used to determine where to focus nonstructural control measures, in particular piscicides. In addition, the implementation of a ballast/bilge water exchange program, education and outreach, and laws and regulations may reduce the human-mediated transport of the tubenose goby to the CAWS pathway.

c. ***Current Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to affect current abundance or reproductive

capacity of the tubenose goby. Nonstructural measures, such as agency monitoring and voluntary occurrence reporting, in combination with education and outreach, can be used to determine where to focus nonstructural control measures, in particular piscicides. However, the tubenose goby is currently too dispersed to be effectively controlled with the occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Dessication (water drawdown) is not expected to be an effective control measure for the tubenose goby, because the species is currently established in deepwater environments where implementation of such a control is not feasible. Because of the tubenose goby's small size and widespread distribution, controlled harvest and overfishing are also not expected to be effective control measures to impact its arrival at the CAWS pathway.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: There are no existing barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the arrival of the tubenose goby to the CAWS. However, these structural measures are not expected to control the arrival of the tubenose goby at the CAWS. The tubenose goby is established in the western basin of Lake Erie (Kocovsky et al. 2011), Lake St. Clair (Jude et al. 1992), and the St. Louis River, which empties into Lake Superior (Fuller et al. 2012).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species for a discussion on how nonstructural measures may impact the distance of the tubenose goby from the pathway.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may affect the tubenose goby's distance from the pathway. The species invaded the Laurentian Great Lakes in the 1990s, presumably via ballast water from transoceanic cargo ships (Jude et al. 1992). Jump dispersal by the tubenose goby from the lower Great Lakes to Lake Superior can be explained by ship transport (Dopazo et al. 2008). Ballast/bilge water transport is thought to assist the tubenose goby's dispersion in the Great Lakes; consequently, nonstructural measures such as ballast/bilge water exchange programs may increase the time the tubenose goby takes to arrive at the CAWS pathway.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_0.
T_{50}: See T_0. See the Nonstructural Risk Assessment for this species.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the tubenose goby in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell indicates a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that the tubenose goby would arrive at the aquatic pathway by implementing a ballast/bilge-water exchange program that is expected to control the human-mediated transport of this species. However, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's low probability of arrival rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced from medium to low.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. However, over time, the probability increases that the species would have time to spread by human-mediated transport to ports in southern Lake Michigan coupled with natural dispersal to the BSBH. Therefore, its probability of arrival remains medium.
T_{50}: See T_{25}.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Medium	Medium	Medium
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.
T_{10}: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the tubenose goby's arrival at the CAWS through aquatic pathways. The implementation of a ballast/bilge water exchange program, as part of the nonstructural component of this alternative, is expected to increase the time it takes for the tubenose goby to arrive at the pathway. However, uncertainty associated with the effectiveness of nonstructural measures implemented as part of this alternative to control the arrival of tubenose goby at the CAWS is believed to increase with time. Therefore, the uncertainty is medium.
T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of the tubenose goby through aquatic pathways at the CAWS. However, over time, trends in future populations and spread rates become less certain. Therefore, uncertainty remains medium.
T_{50}: See T_{25}.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at Brandon Road Lock and Dam.

At the Alsip, Illinois, control point the physical barrier would be constructed in the channel and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Calumet-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to current conditions.

The treatment technologies included in the ANSTP would include screening, filtration and UV radiation designed to deactivate high- and medium-risk GLMRIS ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter greater than 0.75 in. (19.05 mm). It is expected that some tubenose goby, which typically have a total body length of approximately 5 in. (127 mm) (Fuller et al. 2012), a body depth ranging from 0.7 to 1.0 in. (17.3 to 25.5 mm), and a body width ranging from 0.4 to 0.7 in. (9.9 to 17.1 mm) (Neilson and Stepien 2009), would be excluded by the screens because of their size. Larval fish and eggs, which are approximately 0.10 by 0.05 in. (2.5 mm by 1.3 mm) in size (Pallas 1811), and fish with body widths less than 0.75 in. (19.05 mm) are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the Cal-Sag Channel at the Alsip control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Alsip, pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005, Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast water treatment strategy is dependent upon the chemical, physical, and biological properties of water such as turbidity, salinity, and the size and type of organism.

As for the Brandon Road Lock and Dam control point, it does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. The tubenose goby is located in the Great Lakes Basin.

Overall, the Alsip, Illinois, control point is expected to control the natural dispersion (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of the tubenose goby through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures, as part of this alternative, are expected to control the human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting this species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of tubenose goby through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone

Alternative. Structural measures, as part of this alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting this species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for the tubenose goby in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of the tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and electric barrier would be constructed at Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not impact the natural dispersion or human-mediated transport of the tubenose goby through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting tubenose goby eggs and larvae in ballast water would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat Cal-Sag Channel water for the tubenose goby prior to discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs and larvae. Mahmoud et al. (2009) studied the consequences of UV-A (366 nm) exposure on different developmental stages of African catfish (*Clarius garepinus*) and found that UV exposure caused a time-dependent delay in the hatching rate of fertilized eggs and reduced the percentage of hatched embryos by as much as 40% after a 60-min exposure. Mortality rates of hatched embryos increased with increased exposure to UV-A radiation. UV-induced morphological (abnormal body curvature, fin blistering, and dwarfism) and histological changes (lesions in the liver, kidney, skin, and intestines, and gill, eye, and spinal cord malformations) to embryos were also observed in these studies. The degree of damage was correlated with UV-A dose, organ location, embryonic stage, and pigmentation. Zagarese and Williamson (2001) found that early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation because of the lack of photoprotective pigments and/or extensions of the integument.

Water and wastewater disinfection facilities utilize UV-C treatment to inactivate bacteria, viruses, and protozoa, but its efficacy has not been tested extensively on fish. Based on the response to UV-A and UV-B exposure, it is expected that a UV-C treatment process typically used for water and wastewater disinfection can be engineered to inactivate tubenose goby eggs, larvae, and fry. In addition to UV-C treatment, pumps would be required to route the water through the ANSTP. It is expected that pumping and UV-C treatment would eliminate tubenose goby that may pass through the 0.75-in. (19.05-mm) screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that the tubenose goby would pass through the aquatic pathway via natural dispersion and human-mediated transport to the Brandon Road Lock and Dam. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Medium	Medium	Low	Low
Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of tubenose goby through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures, as part of the Mid-system Separation with CSSC Open Control Technologies with a Buffer Zone Alternative, are expected to control the natural dispersion and human-mediated transport of the tubenose goby through the aquatic pathway.

The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. With regard to the ANSTP, prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure of UV radiation, and whether an additional treatment process would be needed to control passage of tubenose goby and its various life stages through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: HIGH

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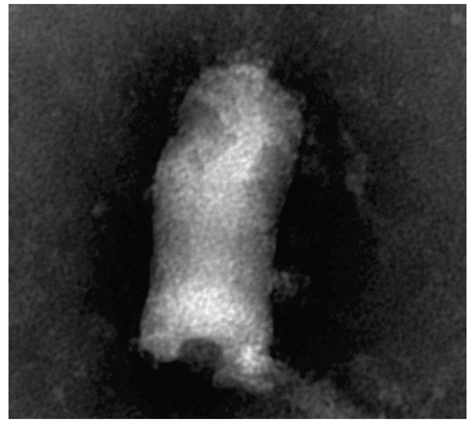
E.8.2.5 Virus

E.8.2.5.1 Viral Hemorrhagic Septicemia Virus (*Novirhabdovirus sp.*)

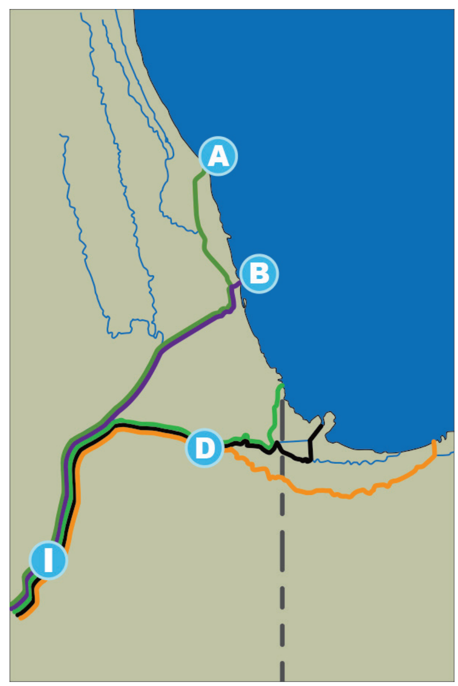


MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

This alternative would include a combination of the following options and technologies. The nonstructural measures would include the development of a monitoring and response program. Nonstructural measures could be implemented at time step 0 (T_0, in units of years) by local, state, and federal agencies and the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Wilmette Pumping Station (A)	Screened Sluice Gates
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Chicago River Controlling Works (B)	ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
		Screened Sluice Gates
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Alsip, IL (D)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock

[a] For more information on nonstructural measures for this species, refer to the Nonstructural Risk Assessment for the VHSv.

[b] The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes a GLMRIS Lock and an electric barrier at Control Point (I) that is designed to control Mississippi River Basin species and does not affect the probability ratings for VHSv.

PATHWAY 1

WILMETTE PUMPING STATION (WPS) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CHICAGO SANITARY AND SHIP CANAL (CSSC) OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, Electric Barrier, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	***Low***	***Low***	***Low***	***Low***
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Chicago Sanitary and Ship Canal (CSSC) Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the viral hemorrhagic septicemia virus (VHSv) at the Chicago Area Waterway System (CAWS) via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would include the construction of an aquatic nuisance species treatment plant (ANSTP) and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a Great Lakes Mississippi River Interbasin Study (GLMRIS) Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not affect the arrival of VHSv at the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of VHSv at the CAWS by human-mediated transport or natural dispersion. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species is already at the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: VHSv was reported in Lake Michigan near Waukegan, Illinois, and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009).

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), which could reduce the productivity of VHSv.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: VHSv has spread throughout the Great Lakes in less than a decade. It has been documented in Lake Michigan as far south as Waukegan.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay,

Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species is already at the pathway. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: VHSv is considered to be established in Lake Michigan and was documented offshore of the Waukegan and Winthrop harbors in Illinois (section 2e). Its ability to spread rapidly in the Great Lakes has been documented.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species is already at the pathway. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.

3. **P(passage) T_0-T_{50}: HIGH-LOW**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point for VHSv at Wilmette, Illinois, with the construction of an ANSTP and screened sluice gates. In addition, a GLMRIS Lock and an

electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not affect the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening and ultraviolet (UV) radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv particles, which typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can “shade” and “encase” target species and block the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the WPS control point location is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

In addition to the ANSTP, sluice gates would be constructed at the WPS in Wilmette, Illinois. The sluice gates would comprise two components, solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions, the solid gates would remain closed, and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events the solid gates would be opened and water from the North Shore Channel (NSC) would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the NSC is diverted to Lake Michigan during a storm event, VHSv particles are expected to be unable to pass through the control point and into the NSC, because the species is unable to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for VHSv prior to discharge into the CAWS. In addition, the sluice gates are expected to control passage of VHSv during dry weather events when they are closed, and during large storm events requiring backflows to Lake Michigan, VHSv particles are expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern, because it is not possible for any vessel to move from Wilmette Harbor to the NSC. The WPS separates Lake Michigan from the NSC.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Lake Michigan water for VHSv prior to discharging it into the CAWS. In addition, the sluice gates are expected to control passage of VHSv during dry weather when they are closed, and during large storm events requiring backflows to Lake Michigan, VHSv is expected to be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the CAWS. Vessel-mediated transport of the species at this pathway is not a concern, because it is not possible for any vessel to move from Wilmette Harbor to the NSC. The WPS separates Lake Michigan from the NSC.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Therefore, the alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would include the construction of an ANSTP and screened sluice gates at the WPS in Wilmette, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of VHSv through the aquatic pathway.

In addition, the ANSTP would treat Lake Michigan water for VHSv prior to discharge into the CAWS. UV irradiation in the 200- to 280-nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2} resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure for VHSv.

During dry weather conditions and non-backflow conditions, the sluice gates would remain closed and would block an aquatic pathway between Lake Michigan and the CAWS. Sluice gates would be opened only during flood events requiring backflows to Lake Michigan, and water from the CAWS would pass through screened sluice gates prior to discharge into Lake Michigan. During these events, VHSv particles are expected to be unable to passively drift against the velocity of the current exiting the screened sluice gates to enter the CAWS.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of VHSv passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway. Prior to the design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV radiation exposure and whether an additional treatment process is needed to control passage of VHSv through the ANSTP. In addition, operating parameters of the sluice gates would have to be developed to address variable flows that may exit the CAWS. Overall, uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 2

CHICAGO RIVER CONTROLLING WORKS (CRCW) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, ANS Treatment Plant, GLMRIS Lock, Electric Barrier, and Screened Sluice Gates

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–-

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the CRCW and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the pathway.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS from human-mediated transport through aquatic pathways

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers
T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, a GLMRIS Lock, an electric barrier, and screened sluice gates at the CRCW in Chicago, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to control ANS originating in the Mississippi River Basin and would not affect the arrival of VHSv at the CAWS. Overall, none of these structural measures are expected to control the arrival of VHSv at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species is likely already arrived at the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), which could reduce the productivity of VHSv.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species is likely already arrived at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species is likely already arrived at the pathway. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50} : HIGH**

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)
a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at the current CRCW and a second at the Brandon Road Lock and Dam. At the CRCW control point, the current lock would be replaced with two GLMRIS Locks, one shallow and one deep, and an electric barrier, an ANSTP, and screened sluice gates would be constructed.
At the CRCW control point, a breakwater would be constructed southeast of the GLMRIS Lock, and a guide wall would extend into the lake to create a calm pool surrounding the lock entrance. Armor stone would be placed along the southwestern side of the GLMRIS Lock to reduce the likelihood of waves overtopping and bypassing this control point.

The electric barrier at the lake side entrance to the Chicago GLMRIS Lock would be an ineffective control for VHSv. This species is not affected by electric current. To address passive drift of this species, the GLMRIS Lock would include a pump-driven filling and emptying system to flush water within the lock and fill with water from an ANSTP. Without the lock flushing, the lock could transport VHSv into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the lake side of the lock, and its filling system would flush and fill the lock from the CAWS buffer zone side of the lock with water treated for ANS. Therefore, ANS that rely on passive drift, including VHSv, would be removed from the lock chamber; however, the GLMRIS Lock would not be an effective control for hull-fouling species, such as this species.

The purpose of the ANSTP is to remove ANS from Lake Michigan water prior to discharge into the CAWS buffer zone. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions. The ANSTP would also supply the GLMRIS Locks with treated water for lock flushing.

The treatment technologies included in the ANSTP would be screening and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv particles, which typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006), are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can "shade" and "encase" target species and control the UV light from reaching them. Based on water quality data, UV treatment of Lake Michigan water at the CRCW control point is expected to be effective. UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity and upon the size and type of organism.

In addition, sluice gates would be constructed at the CRCW. The sluice gates would comprise two components, solid gates and self-cleaning screened gates with 0.4-in. (10.2-mm) openings. During dry weather conditions and non-backflow conditions, the solid gates would remain closed and all Lake Michigan water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events requiring backflows to Lake Michigan, the solid gates would be opened and water from the Chicago River would be diverted into Lake Michigan through the screened gates in order to reduce flood risk. When water from the Chicago River is diverted to Lake Michigan during a backflow event, VHSv particles are expected to be unable to pass through the control point and into the Chicago River, because the species is unable to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are not expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock does not dislodge organisms attached to vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion of VHSv through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to still be able to pass through the aquatic pathway via attachment to vessel hulls. VHSv is small (particles range from 170 to 180 nm in length and 60 to 70 nm in width) (Skall et al. 2005; Elsayed et al. 2006) and may adhere to vessel hulls. The GLMRIS Lock does not dislodge organisms attached to vessel hulls.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the current CRCW and a second at the Brandon Road Lock and Dam, that would be implemented at T_{25}. At the CRCW control point, structural measures would include the construction of an ANSTP, a GLMRIS Lock, an electric barrier, and screened sluice gates. The electric barrier is not effective at controlling the passage of VHSv. The GLMRIS Lock, ANSTP, and screened sluice gates are expected to control the natural dispersion of VHSv through the aquatic pathway. However, these ANS Controls are not expected to control the passage of the species via hull-fouling on vessels. Specifically, the GLMRIS Lock does not remove organisms attached to vessel hulls.

The Brandon Road Lock and Dam control point does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative would not reduce the likelihood of VHSv passing through the aquatic pathway; therefore, the probability of passage remains high.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion of VHSv through the aquatic pathway; however, these measures are not expected to control the human-mediated transport of VHSv via hull-fouling on vessels. Overall, the uncertainty remains low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	**U**	**P**	**U**	**P**	**U**	**P**	**U**
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for VHSv.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS via human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers
T_0: None.

T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the arrival of VHSv at the CAWS. Overall, the structural measures are not expected to control the arrival of VHSv at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway.
T_{50}: See T_{25}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), which could reduce the productivity of VHSv.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the probability of arrival remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0.

Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% annual chance of exceedance (ACE) event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv particles typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006) and are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip, Illinois, control point may reduce the effectiveness of UV treatment. Consequently, at Alsip pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

The Brandon Road Lock and Dam control point does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to address the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels potentially transporting the species in ballast and bilge water would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high probability of passage rating for this time step does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of VHSv through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that VHSv and vessels potentially transporting the species in contaminated ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point.

UV irradiation in the 200- to 280-nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2} resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of UV exposure, and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of VHSv passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the natural dispersion and human-mediated transport of VHSv through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to the design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation and whether an

additional treatment process would be needed to control passage of VHSv through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary [a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between Indiana Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system

Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for VHSv.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.

T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. P(arrival) T_0-T_{50}: HIGH

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. Type of Mobility/Invasion Speed

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS via natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS via human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species in Lake Michigan.

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the arrival of VHSv at the CAWS. Overall, the structural measures are not expected to control the arrival of VHSv at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway.

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

f. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), which could reduce the productivity of VHSv.

Probability of Arrival

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0.

Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv particles typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006) and are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip, Illinois, control point may reduce the effectiveness of UV treatment. Consequently, at Alsip pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001; Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

The Brandon Road Lock and Dam control point does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels would be unable to traverse the barrier; however, most commercial vessel traffic to Indiana Harbor is lakewise, and ballast water is rarely discharged in inland ports of Illinois (NBIC 2012).

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels would be unable to traverse

the barrier. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point.
T_{50}: See T_{25}.

d. Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion and human-mediated transport. Therefore, the alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of VHSv through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that VHSv and vessels potentially transporting the species in contaminated ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. UV irradiation in the 200- to 280-nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2} resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of VHSv passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be

needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP. Overall, the uncertainty is low.
T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

PATHWAY 5

BURNS SMALL BOAT HARBOR (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CSSC OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, ANS Treatment Plant, Electric Barrier, and GLMRIS Lock

PROBABILITY OF ESTABLISHMENT SUMMARY

No New Federal Action Rating Summary

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	High	Low	High	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[a]	Medium	–	Medium	–	Medium	–

[a] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating Summary[a]

Probability Element	T_0		T_{10}		T_{25}		T_{50}	
	P	U	P	U	P	U	P	U
P(pathway)	High	None	High	None	High	None	High	None
P(arrival)	High	Low	High	Low	High	Low	High	Low
P(passage)	High	Low	High	Low	***Low***	Low	***Low***	Low
P(colonizes)	High	Low	High	Low	High	Low	High	Low
P(spreads)	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	***Low|NPE***	–	***Low|NPE***	–

[a] The highlighted table cells indicate a rating change in the probability element. Low|NPE means low, given no prior establishment in previous time steps.
[b] "–" Indicates an uncertainty rating was not assigned to *P(establishment)* because there is no objective way to characterize overall uncertainty for an aggregate rating.

EVIDENCE FOR ESTIMATING THE RISK OF ESTABLISHMENT/UNCERTAINTY

1. P(pathway) T_0-T_{50}: HIGH

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round. No activities or events are expected to reduce or eliminate the hydrologic connection between the BSBH and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for VHSv.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the Cal-Sag Channel at Alsip, Illinois. The ANSTP would treat water collected from the Lake Michigan side of the physical barrier and discharge this treated water to the Mississippi River side of the barrier; consequently, an aquatic pathway between the basins would be present.
T_{50}: See T_{25}.

Uncertainty: NONE

Evidence for Uncertainty Rating

The existence of the pathway has been confirmed with certainty.

2. **P(arrival) T_0-T_{50}: HIGH**

In determining the probability of arrival, the pathway is assumed to exist.

Factors That Influence Arrival of Species

a. ***Type of Mobility/Invasion Speed***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS via natural dispersion through aquatic pathways.

b. ***Human-Mediated Transport through Aquatic Pathways***
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS via human-mediated transport through aquatic pathways.

c. ***Current Abundance and Reproductive Capacity***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the current abundance or reproductive capacity of VHSv.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. Changes in water temperature related to future climate change (Wuebbles et al. 2010) could affect the spread or virulence of this species in Lake Michigan.

d. ***Existing Physical Human/Natural Barriers***
T_0: None.
T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Alsip, Illinois. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the arrival of VHSv at the CAWS. Overall, these structural measures are not expected to control the arrival of VHSv at the CAWS. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway.
T_{50}: See T_{25}.

e. ***Distance from Pathway***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of VHSv outside of its current distribution or reduce its probability of arrival at the CAWS.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

f. ***Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)***
T_0: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for VHSv in southern Lake Michigan.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0. VHSv is sensitive to climatological conditions. Future climate change and/or new environmental regulations may alter the physical, chemical, and climatological suitability of the Great Lakes for VHSv. Future climate change is projected to increase water temperature in the Great Lakes (Wuebbles et al. 2010), and this could affect the virulence, spread, or abundance of VHSv.

Probability of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the probability of arrival remains high.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

Uncertainty of Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species .

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWS through aquatic pathways. VHSv was reported in Lake Michigan near Waukegan in Illinois and at Green Bay, Little Sturgeon Bay, Algoma, and Milwaukee in Wisconsin (Kipp et al. 2013; Whelan 2009). Hence, the species has likely already arrived at the pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. P(passage) T_0-T_{50}: HIGH-LOW

In determining the probability of passage, the species is assumed to have arrived at the pathway.

Factors That Influence Passage of Species (Considering All Life Stages)

a. Type of Mobility/Invasion Speed

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0.

Nonstructural measures alone are not expected to address the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative creates two control points, one at Alsip, Illinois, and a second at the Brandon Road Lock and Dam. The Alsip, Illinois, control point would include the construction of a physical barrier and an ANSTP.

The physical barrier would be constructed in the channel at Alsip, Illinois, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features would be designed to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The purpose of the ANSTP at the Alsip, Illinois, control point is to remove ANS from Cal-Sag Channel water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to the current conditions.

The treatment technologies included in the ANSTP would include screening, filtration, and UV radiation to deactivate high- and medium-risk ANS of Concern and their various life stages currently found in the Great Lakes Basin. In the first treatment step, self-cleaning screens would exclude ANS and other organic matter larger than 0.75 in. (19.05 mm). VHSv particles typically range from 170 to 180 nm in length and 60 to 70 nm in width (Skall et al. 2005; Elsayed et al. 2006) and are expected to pass through the screens. They would subsequently be pumped through the ANSTP and exposed to UV treatment.

UV treatment performance is affected by water clarity, as suspended particles can shade and encase target species and block the UV light from reaching them. Transmittance of UV light can also be inhibited by some dissolved constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, it is expected that the turbidity of the Cal-Sag Channel at the Alsip, Illinois, control point may reduce the effectiveness of UV treatment. Consequently, at Alsip pre-filtration is included in the ANS treatment process prior to UV treatment.

UV radiation is a well-established technology for disinfecting drinking water and domestic wastewater by destroying microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 2006, 1999) and has been investigated as a ballast-water treatment against ANS (Viitasalo et al. 2005; Kazumi 2007; Sutherland et al. 2001, Waite et al. 2003). UV radiation disrupts cellular nucleic acids (DNA, RNA), thereby prohibiting cell replication (EPA 2006; Viitasalo et al. 2005). The response to UV radiation can vary significantly among organisms (EPA 2006; Viitasalo et al. 2005). Viitasalo et al. (2005) stated that the effectiveness of UV irradiation as a ballast-water treatment strategy is dependent upon the chemical, physical, and biological properties of water, such as turbidity and salinity, and upon the size and type of organism.

The Brandon Road Lock and Dam control point does not target controlling the passage of Great Lakes ANS. It is designed to control Mississippi River Basin ANS. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., infected host and passive drift) of VHSv through the aquatic pathway.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures alone are not expected to address the human-mediated transport of VHSv through the aquatic pathway.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway, because vessels would be unable to traverse the barrier.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes nonstructural and structural measures. Nonstructural measures could be implemented at T_0; however, these measures alone are not expected to affect the natural dispersion or human-mediated transport of VHSv through the aquatic pathway. Implementation of structural measures would not take place until T_{25}.

T_{10}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway to the Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway, because the species and vessels would be unable to traverse the barrier. The ANSTP would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point.

T_{50}: See T_{25}.

d. *Suitable Habitat (Physical, Structural, Hydrologic, Hydraulic, Chemical, and Climatological)*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability for VHSv in the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

Probability of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating[a]	High	High	***Low***	***Low***

[a] The highlighted table cells indicate a rating change in the probability element.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that could be implemented at T_0; however, these measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the alternative's high rating does not differ from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures would create a control point at Alsip, Illinois, with the construction of a physical barrier and an ANSTP. In addition, a GLMRIS Lock and an electric barrier would be constructed at the Brandon Road Lock and Dam; however, this control point is designed to address ANS originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of VHSv through the aquatic pathway.

The physical barrier constructed in the channel at the Alsip, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that VHSv and vessels potentially transporting the species in contaminated ballast water and attached to hulls would be unable to traverse the physical barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP at the Alsip, Illinois, control point would treat Cal-Sag Channel water for VHSv prior to discharge into the Mississippi River Basin side of the control point. UV irradiation in the 200- to 280-nm wavelength range has been shown to be an effective method for the inactivation of bacteria and viruses in general (Kurth et al. 1999; Chevrefils et al. 2006). Oye and Rimstad (2001) showed that VHSv is very sensitive to UV-C irradiation, achieving a 3-log reduction of infective virus in freshwater at a UV-C dose of 7.9 ± 1.5 J m^{-2}. Huber et al. (2010) showed that a UV dose of 1.8 mJ cm^{-2}

resulted in a 3-log reduction of VHSv IVb, while a lower UV dose (0.79 mJ cm^{-2}) resulted in a similar reduction in a European strain of VHSv. Huber et al. (2010) conclude that classic design doses (40–120 mJ cm^{-2}) would prove very effective against VHSv and other pathogens in the Great Lakes ecosystems. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP.

Overall, the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of VHSv passing through the aquatic pathway via natural dispersion and human-mediated transport. Therefore, the probability of passage is reduced to low.

T_{50}: See T_{25}.

Uncertainty of Passage

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Low
Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures alone are not expected to affect the passage of VHSv through the aquatic pathway by natural dispersion or human-mediated transport; therefore, the uncertainty remains low.

T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.

T_{25}: Structural measures as part of the Mid-system Separation CSSC Open Control Technologies with a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of VHSv through the aquatic pathway. The physical barrier is expected to control passage up to an extreme storm event, a 0.2% ACE event. Implementation of a physical barrier would require the use of mitigation tunnels and reservoirs. Obstructed screens and inlets or gate problems during a large storm event could result in excessive river stages, overbank flooding, and bypass of the separation structures. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Prior to design and construction of the ANSTP, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation and whether an additional treatment process would be needed to control passage of VHSv through the ANSTP. Overall, the uncertainty is low.

T_{50}: See T_{25}.

4. P(colonizes) T_0-T_{50}: HIGH

The probability and uncertainty ratings for *P(colonizes)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: LOW

5. P(spreads) T_0-T_{50}: MEDIUM

The probability and uncertainty ratings for *P(spreads)* are assumed to remain unchanged from the No New Federal Action Risk Assessment.

Uncertainty: MEDIUM

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