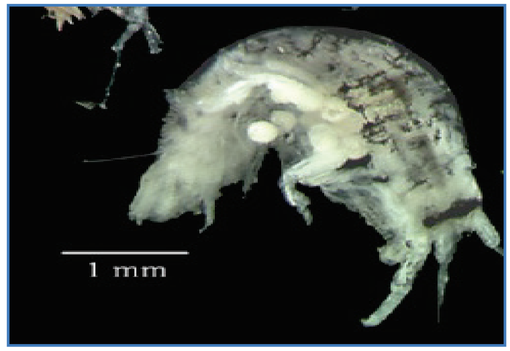
E.7 Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone

E.7.1 ANS Potentially Invading the Great Lakes Basin

E.7.1.1 Crustaceans

E.7.1.1.1 Scud (*Apocorophium lacustre*)

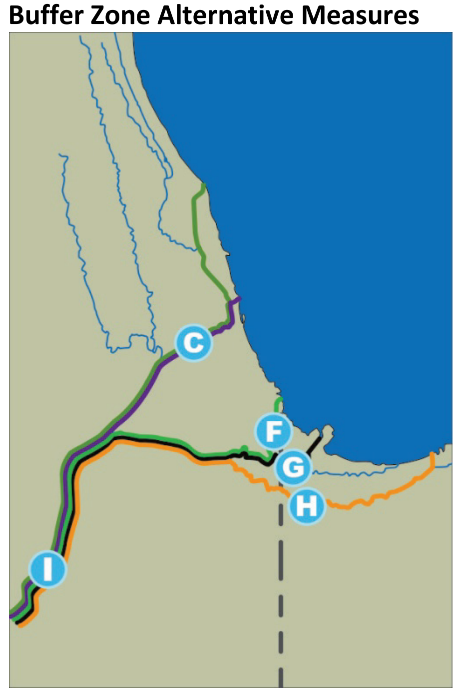


MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures	
	Brandon Road Lock and Dam (I)	Electric Barrier[a]
		GLMRIS Lock
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant[b]
Chicago River Controlling Works	Nonstructural Measures	
	Brandon Road Lock and Dam (I)	Electric Barrier[a]
		GLMRIS Lock
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant[b]
Calumet Harbor	Nonstructural Measures	
	Brandon Road Lock and Dam (I)	Electric Barrier[a]
		GLMRIS Lock
	T.J. O'Brien Lock and Dam (F)[c]	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures	
	Brandon Road Lock and Dam (I)	Electric Barrier[a]
		GLMRIS Lock



	State Line, IL/IN (G)	Physical Barrier
Burns Small Boat Harbor	Nonstructural Measures	
	Brandon Road Lock and Dam (I)	Electric Barrier[a]
		GLMRIS Lock
	Hammond, IN (H)	Physical Barrier

[a] The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an electric barrier at Control Point (I), which is ineffective for the *A. lacustre* and does not impact its probability rating.
[b] Control Point (C) includes 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 *A. lacustre's* probability ratings.
[c] Control Point (F) 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 the Calumet River.

PATHWAY 1

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

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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|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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a Great Lakes and Mississippi River Interbasin Study (GLMRIS) Lock and electric barrier at Brandon Road Lock and Dam in Illinois. The alternative also includes a physical barrier in the channel at Stickney, Illinois. Overall, none of these structural measures are expected to control the arrival of *A. lacustre* to Brandon Road Lock and Dam by human-mediated transport or natural dispersion. 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). Hence, the species is likely at or close to 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways 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 the 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways 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 the 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, 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 Cal-Sag 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 Cal-Sag 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 Stickney, Illinois. At the Brandon Road Lock and Dam control point, the current lock and dam would be retrofitted 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.

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 treatment plants whose treatment addresses ANS, and/or (4) other discharges that originate from drinking or rainwater sources. As the lock travels up the 34-ft 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.

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*. At the Stickney, Illinois, control point a physical barrier and ANSTP would be constructed.

The physical barrier would be constructed in the channel at Stickney, 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 Stickney control point is to remove ANS in CSSC water prior to discharge into the Mississippi River Basin side of the control point. The ANSTP only treats water from the Great Lakes Basin side of the physical barrier, not water from the Mississippi River Basin side. *A. lacustre* is located in the Mississippi River Basin.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 *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 Cal-Sag 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 GLMRIS Lock at the Brandon Road Lock and Dam control point is not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway due to the species being capable of attaching to vessel hulls. The GLMRIS Lock does not dislodge attached organisms from vessel hulls. However, the physical barrier at the Stickney control point 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, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

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 that the locks are not a barrier.

The Mid-system Separation Cal-Sag 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 or 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Overall, structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. Although the species is expected to be able to pass through the Brandon Road Lock and Dam control point by attaching to vessel hulls, the species is expected to be unable to pass through the control point at Stickney, Illinois. 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.

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 Cal-Sag 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 Cal-Sag 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 elements.

Evidence for Probability Rating (Considering All Life Stages)

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which 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 Cal-Sag 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 Cal-Sag 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 a physical barrier and ANSTP at Stickney, Illinois.

The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, human-mediated transport 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, and *A. lacustre* has been documented as a hull fouler (Grigorovich et al. 2008; Johnson et al. 2007). The electric barrier would have no effect on the passage of *A. lacustre*.

At the Stickney, Illinois, control point the physical barrier 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 CSSC water prior to discharge into the Mississippi River Basin side of the control point; therefore the ANSTP would not be an effective control for *A. lacustre* since it is located in the Mississippi River Basin, and water from this basin would not be treated by the ANSTP.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *A. lacustre* 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 Cal-Sag 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 Cal-Sag 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 aquatic pathway 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 2

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

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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|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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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. The alternative also includes a physical barrier in the channel at Stickney, Illinois. Overall, none of these structural measures are expected to control the arrival of *A. lacustre* to the Brandon Road Lock and Dam by human-mediated transport or natural dispersion. 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). 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways 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 the 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways 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 the 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, 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 Cal-Sag 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 Cal-Sag 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 Stickney, Illinois. At the Brandon Road Lock and Dam control point, the current lock and dam would be retrofitted 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.

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 treatment plants whose treatment addresses ANS, and/or (4) other discharges that originate from drinking or rainwater sources. As the lock travels up the 34-ft 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.

This alternative also includes an electric barrier constructed downstream of the lock. The electric barrier is not an effective control measure for *A. lacustre*.

At the Stickney, 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 at the Stickney, Illinois, control point is to remove ANS in CSSC water prior to discharge into the Mississippi River Basin side of the control point. Since *A. lacustre* is located in the Mississippi River Basin, the ANSTP would not be an effective control for this species.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 *A. lacustre* through the aquatic pathway.

T_{10}: See T_{25}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 GLMRIS Lock at the Brandon Road Lock and Dam control point is not expected to address the human-mediated transport of *A. lacustre* through the aquatic pathway due to the species being capable of attaching to vessel hulls. The GLMRIS Lock does not dislodge attached organisms from vessel hulls. However, the physical barrier at the Stickney control point 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, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

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 that the locks are not a barrier. The Mid-system Separation Cal-Sag 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 the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Overall, structural measures as part of this alternative are expected to control the natural dispersion and human-mediated transport of *A. lacustre* through the aquatic pathway. Although the species is expected to be able to pass through the Brandon Road Lock and Dam control point by attaching to vessel hulls, the species is expected to be unable to pass through the control point at Stickney, Illinois. 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.
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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which 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 Cal-Sag Open Control Technologies with a Buffer Zone 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 Cal-Sag 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 a physical barrier and ANSTP at Stickney, Illinois.

The GLMRIS Lock at the Brandon Road Lock and Dam control point is expected to control the natural dispersion of *A. lacustre* through the aquatic pathway; however, human-mediated transport 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, and *A. lacustre* has been documented as a hull fouler (Grigorovich et al. 2008; Johnson et al. 2007). The electric barrier would have no effect on the passage of *A. lacustre*.

At the Stickney, Illinois, control point the physical barrier 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 CSSC water prior to discharge into the Mississippi River Basin side of the control point; therefore the ANSTP would not be an effective control for *A. lacustre* since it is located in the Mississippi River Basin.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *A. lacustre* 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 Cal-Sag 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 Cal-Sag 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* 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, 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)	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 Cal-Sag 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 Calumet Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Brandon Road Lock and Dam.

b. Human-Mediated Transport through Aquatic Pathways

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 arrival of *A. lacustre* from human-mediated transport through aquatic pathways to Brandon Road Lock and Dam.

c. Current Abundance and Reproductive Capacity

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 *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: T.J. O'Brien Lock and Dam are between the current location of *A. lacustre* and 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 Cal-Sag 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 addition, a GLMRIS Lock, electric barrier, ANSTP, and screened sluice gates would be constructed at Calumet Harbor. Overall, none of these structural measures are expected to act as physical barriers to 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 Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways to the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Island 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways 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. 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 Cal-Sag 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 Cal-Sag 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 T.J. O'Brien Lock and Dam. At the Brandon Road Lock and Dam control point, the current lock and dam would be retrofitted 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, flow conditions during a storm with a 0.2% ACE event would not bypass the Brandon Road Lock and Dam 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* organisms that passively drift, and upstream water is buffer zone water and would be controlled for Great Lakes aquatic nuisance species. The buffer zone water originates from (1) this alternative's lakefront ANSTPs, (2) rainwater, (3) discharge from wastewater treatment plants whose treatment addresses aquatic nuisance species, and/or (4) other discharges that originate from drinking or rainwater sources. As the lock travels up the 34-ft 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 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 T.J. O'Brien Lock and Dam with the construction of an ANSTP, electric barrier, GLMRIS Lock, and screened sluice gates. The T.J. O'Brien Lock and Dam control point does not target controlling the passage of Mississippi River Basin ANS. It is designed to control Great Lakes Basin ANS. *A. lacustre* is located in the Mississippi River Basin.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 *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 Cal-Sag 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: 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 that the locks are not a barrier.

The Mid-system Separation Cal-Sag 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}: 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 Cal-Sag 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 Cal-Sag 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 Alternative Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the Brandon Road Lock and Dam and a second at T.J. O'Brien Lock and Dam, which 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 T.J. O'Brien Lock and Dam control point, it does not target controlling the passage of Mississippi River Basin ANS. It is designed to control Great Lakes Basin ANS. *A. lacustre* is located in the Mississippi River Basin.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to 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 Cal-Sag 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 Cal-Sag 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 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, and Physical 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

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

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

Evidence for Probability Rating

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 addition, a physical barrier would be constructed in the channel at the Illinois-Indiana state line. Overall, none of these structural measures are expected to control the arrival of *A. lacustre* to 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). 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 Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways 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. 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways 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. 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, 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 Cal-Sag 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 Cal-Sag 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 the Illinois-Indiana state line. The Brandon Road Lock and Dam control point would retrofit the Brandon Road Lock and Dam 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, flow conditions during a storm with a 0.2% ACE event would not bypass the Brandon Road Lock and Dam 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* organisms that passively drift, and upstream water is buffer zone water and would be controlled for Great Lakes aquatic nuisance species. The buffer zone water originates from (1) this alternative's lakefront ANSTP, (2) rainwater, (3) discharge from wastewater treatment plants whose treatment addresses aquatic nuisance species, and/or (4) other discharges that originate from drinking or rainwater sources. As the lock travels up the 34-ft 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 at the Illinois-Indiana state line would include the construction of a physical barrier. 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 *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 Cal-Sag 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 Illinois-Indiana state line control point is expected to 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 Cal-Sag 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 the Mid-system Separation Cal-Sag 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, this control point is not expected to control the human-mediated transport of the species via hull fouling through the aquatic pathway. The second control point at the Illinois-Indiana state line 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	Medium	***Low***	***Low***

[a] The highlighted 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which 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 Cal-Sag 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 Cal-Sag 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 the Illinois–Indiana state line.

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.

The second control point at the Illinois–Indiana state line would include the construction of a physical barrier. 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 and bilge water or attached to vessel hulls would be unable to traverse the barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 this species through the aquatic pathway up to an extreme storm event, a 0.2% ACE event. 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, and Physical 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 addition, a physical barrier in the channel at Hammond, Indiana, is expected to separate the Great Lakes and Mississippi River basins. Overall, none of these structural measures are expected to control the arrival of *A. lacustre* to 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). 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 Brandon Road Lock and Dam in the Illinois River (USGS 2011).

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways to the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Island 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *A. lacustre* through aquatic pathways to the Brandon Road Lock and Dam. In 2005, *A. lacustre* was found in the Illinois River just above the Dresden Island 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, 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana. The Brandon Road Lock and Dam control point would retrofit the Brandon Road Lock and Dam 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, flow conditions during a storm with a 0.2% ACE event would not bypass the Brandon Road Lock and Dam 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* organisms that passively drift, and upstream water is buffer zone water and would be controlled for Great Lakes aquatic nuisance species. The buffer zone water originates from (1) this alternative's lakefront ANSTP, (2) rainwater, (3) discharge from wastewater treatment plants whose treatment addresses aquatic nuisance species, and/or

(4) other discharges that originate from drinking or rainwater sources. As the lock travels up the 34-ft 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 at Hammond, Indiana, would include the construction of a physical barrier. 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 *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 Cal-Sag 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 Hammond, Indiana, control point is expected to 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 Cal-Sag 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 the Mid-system Separation Cal-Sag 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 the natural dispersion of *A. lacustre* through the aquatic pathway; however, this control point is not expected to control the human-mediated transport of the species via hull fouling through the aquatic pathway. The second control point at Hammond, Indiana, 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana.

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.

The second control point at Hammond, Indiana, would include the construction of a physical barrier. 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 and bilge water or attached to vessel hulls would be unable to traverse the barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of the species through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *A. lacustre* and vessels potentially transporting it in ballast and bilge water or via hull fouling 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 Cal-Sag 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 Cal-Sag 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* up to an extreme storm event, a 0.2% ACE event. 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

Grigorovich, I.A., T.R. Angradi, E.B. Emery, and M.S. Wooten. 2008. Invasion of the Upper Mississippi River system by saltwater amphipods. *Fundamental and Applied Limnology/Archiv für Hydrobiologie*, vol. 173(1), pp. 67–77.

Johnson, L., J. Gonzalez, C. Alvarez, M. Takada, & A. Himes. 2007. Managing Hull-Borne Invasive Species and Coastal Water Quality for California and Baja California Boats Kept in Saltwater. University of California ANR Publication 8359, California Sea Grant College Program Report Number T-061.

USGS (U.S. Geological Survey). 2011. NAS–Nonindigenous Aquatic Species. *Apocorophium lacustre*. http://nas.er.usgs.gov/queries/SpecimenViewer.aspx?SpecimenID=237724. Accessed April 20, 2012.

E.7.1.2 Fish

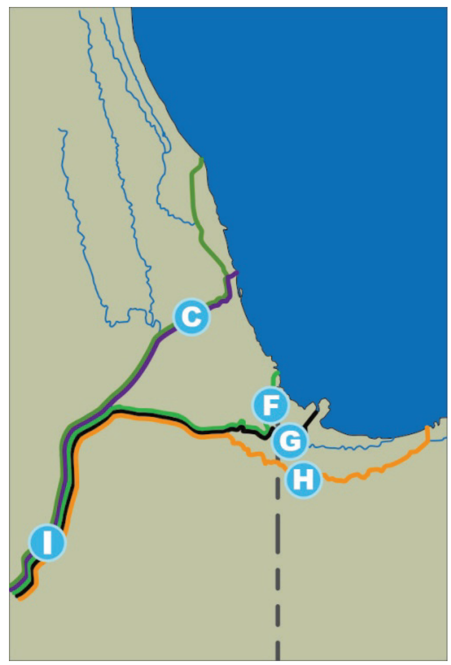
E.7.1.2.1 Bighead Carp (*Hypophthalmichthys nobilis*)

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measure

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant[b]
Chicago River Controlling Works	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant[b]
Calumet Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	T.J. O'Brien Lock and Dam (F)[c]	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	State Line, IL/IN (G)	Physical Barrier



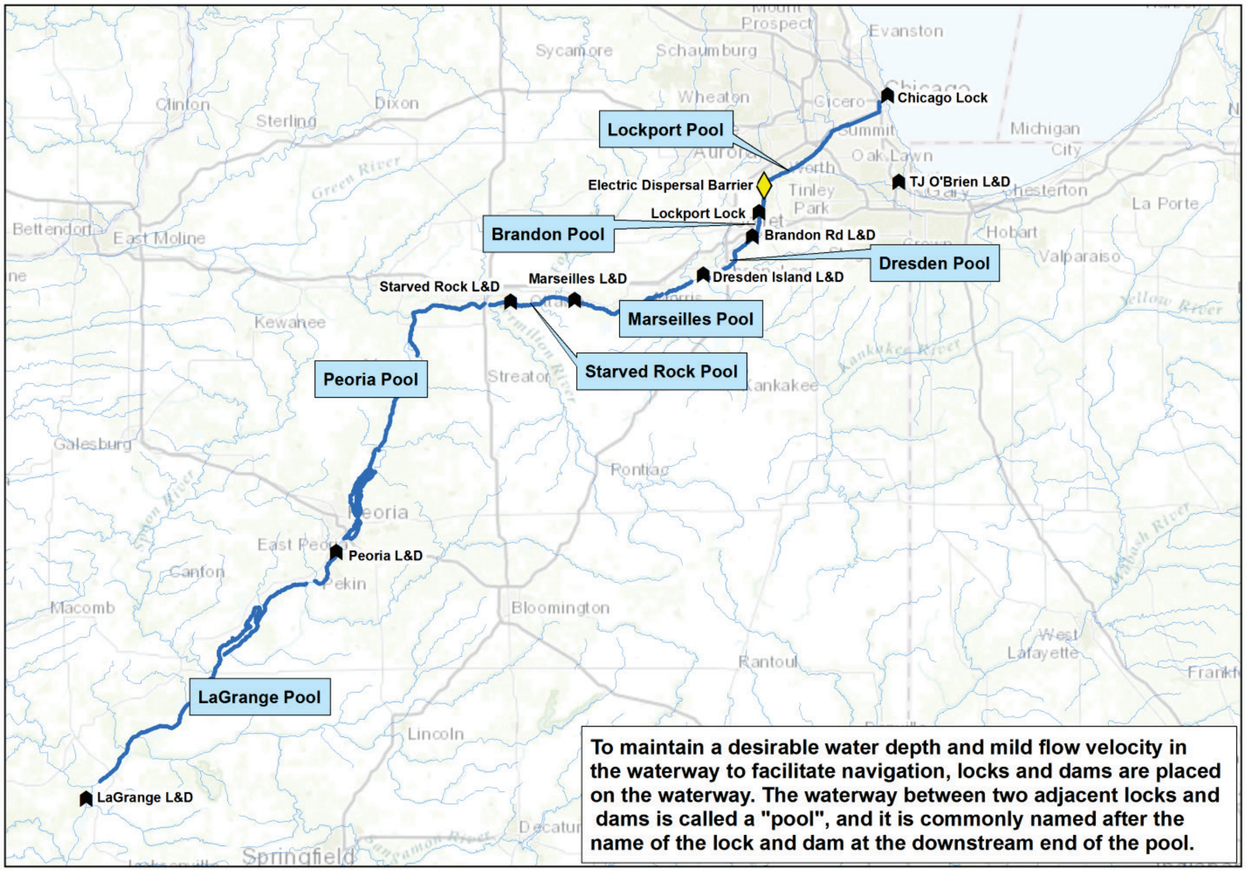
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Hammond, IN (H)	Physical Barrier

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

[b] Control Point (C) includes an ANS Treatment Plant (ANSTP) that removes aquatic nuisance species 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 the bigheads carp's probability ratings.

[c] Control Point (F) is not effective for Mississippi River Basin species because it contains no measures to restrict aquatic nuisance species transfer to Lake Michigan during storm events requiring backflows, when water from the CAWS may be discharged into the Calumet River.

Risk Assessment Reference Map



The current Electric Dispersal Barrier System located approximately 5 mimi 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 CAL-SAG 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 Cal-Sag 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of the bighead carp 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp from human-mediated transport through this aquatic pathway.

c. 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 and reproductive capacity for the bighead carp through this aquatic pathway.

T_{10}: 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 and potential abundance and reproductive capacity of the bighead carp.

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 its current position and the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the Brandon Road Lock and Dam and one at Stickney, Illinois. The control point at the Brandon Road Lock and Dam would include the construction of a Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock and electric barrier, while the Stickney, Illinois, control point would include the construction of a physical barrier and ANSTP. 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% annual chance of exceedance (ACE) event. However, these structural measures are not expected to affect the arrival of the bighead carp at the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp has been detected in the Dresden Island Pool, where 706 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 Chicago Area Water System (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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp has been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of the Brandon Road Lock and Dam.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp has been detected in the Dresden Island Pool, where 706 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 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at the pathway. The bighead carp has arrived at the pathway. Bighead carp has been detected in the Dresden Island Pool, where 706 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 Cal-Sag 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 Cal-Sag 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 the Brandon Road Lock and Dam and a second at Stickney, Illinois. 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 the lock being operated after a power outage, fish within the engineered channel would be removed by 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 treated for ANS or discharges originating from treatment plants and stormwater 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 Stickney, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Stickney, 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 CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney 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 Cal-Sag 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 bighead carp 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 Cal-Sag 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 Stickney 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 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 availability of suitable habitat within the CAWS for 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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 an electric barrier at Brandon Road Lock and Dam as well as the construction of a physical barrier and ANSTP at Stickney, 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.

In addition, a second control point would be created at Stickney, Illinois, with the construction of a physical barrier and an 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 CSSC water prior to discharge into the Mississippi River Basin side of the control point. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	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 4 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 miles 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 Cal-Sag 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 physical barrier is expected to control the passage of this species up to an extreme storm event, a 0.2% ACE event. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 2

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

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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 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 CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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
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 natural dispersion of bighead carp through aquatic pathways to the Brandon Road Lock and Dam.

b. Human-Mediated Transport through Aquatic Pathways
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 arrival of the bighead carp from human-mediated transport through this aquatic pathway.

c. 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 and reproductive capacity for the bighead carp through this aquatic pathway.
T_{10}: See 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 and potential abundance and reproductive capacity of bighead carp.
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 existing barriers to movement of the bighead carp from its current position and the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the Brandon Road Lock and Dam and one at Stickney, Illinois. The control point at the Brandon Road Lock and Dam would include the construction of a GLMRIS Lock and an electric barrier, while the Stickney, Illinois, control point would include the construction of a physical barrier and an ANSTP. 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. However, these structural measures are not expected to affect the arrival of the bighead carp 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 706 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the distance of the bighead carp 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 Cal-Sag 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 Cal-Sag 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 the Lockport Pool upstream of the Brandon Road Lock and Dam.
The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 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). Overall, 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at the pathway. The bighead carp has arrived at the pathway. Bighead carp have been detected in the Dresden Island Pool, where 706 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 Cal-Sag 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 bighead carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag 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 the Brandon Road Lock and Dam and a second at Stickney, Illinois. 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 the lock being operated after a power outage, fish within the engineered channel would be removed by 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 it with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges originating from treatment plants and stormwater 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 Stickney, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Stickney, 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 CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney 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 Cal-Sag 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 bighead carp 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 Cal-Sag 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 Stickney, 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 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 suitability of the habitat within the CAWS 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 Cal-Sag 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 Cal-Sag 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 passage of the bighead carp through this aquatic pathway. Therefore, the 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 Cal-Sag 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 an electric barrier at the Brandon Road Lock and Dam as well as the construction of a physical barrier and an ANSTP at Stickney, 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.

In addition, a second control point would be created at Stickney, Illinois, with the construction of a physical barrier and an 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 CSSC water prior to discharge into the Mississippi River Basin side of the control point. Bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	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 4 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 mimi 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 Cal-Sag 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 physical barrier is expected to control the passage of this species up to an extreme storm event, a 0.2% ACE event. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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 Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of bighead carp.

b. Human-Mediated Transport through Aquatic Pathways

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 arrival of the bighead carp from human-mediated transport through this aquatic pathway.

c. 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 and reproductive capacity for the bighead carp through this aquatic pathway.

T_{10}: See 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 and potential abundance and reproductive capacity of the bighead carp.

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 existing barriers to movement of bighead carp from its current position and the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a GLMRIS Lock and electric barrier at the Brandon Road Lock and Dam. In addition, a GLMRIS lock, electric barrier, ANSTP, and screened sluice gates would be constructed at the T.J. O'Brien Lock and Dam. However, none of these structural measures are expected to act as physical barriers to the arrival

of the bighead carp at Brandon Road Lock and Dam since the bighead carp has arrived at the pathway. One bighead carp was observed in the 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

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 distance from the pathway.

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

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 suitability of habitat.

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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp has been documented at the Brandon Road Lock and Dam and the Lockport Pool upstream of the Brandon Road Lock and Dam.
The Mid-system Separation Cal-Sag 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. The bighead carp has arrived at the pathway. One bighead carp was observed in the 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 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the pathway. The bighead carp has arrived at the pathway. One bighead carp was observed in the 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). Overall, 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 Cal-Sag 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 Cal-Sag 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 the Brandon Road Lock and Dam and a second at the WPS. At the 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 the lock being operated after a power outage, fish within the engineered channel would be removed by 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 it with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges originating from treatment plants and stormwater 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 the T.J. O'Brien Lock and Dam; however, this control point controls the passage of Great Lakes Basin ANS, and bighead carp are in the Mississippi River Basin.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of bighead carp 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 passage of the bighead carp through this aquatic pathway. Therefore, the 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 Cal-Sag 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 the Brandon Road Lock and Dam and includes the construction of a GLMRIS Lock and an 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 the T.J. O'Brien Lock and Dam; however, it controls Great Lakes Basin ANS, and bighead carp are in the Mississippi River Basin.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 4 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 mimi 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 Cal-Sag 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 by 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 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, and Physical 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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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 PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

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

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of a pathway is low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The physical barrier, implemented as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, 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. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of bighead carp.

b. *Human-Mediated Transport through Aquatic Pathways*

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 arrival of the bighead carp from human-mediated transport through this aquatic pathway.

c. *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 and reproductive capacity for the bighead carp through this aquatic pathway.

T_{10}: See 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 and potential abundance or reproductive capacity of the bighead carp.

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 its current position to the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would include the construction of a GLMRIS Lock and an electric barrier at the Brandon Road Lock and Dam in Illinois. In addition, a physical barrier constructed in the channel at the Illinois-Indiana state line is expected to separate the Great Lakes and Mississippi River basins. However, these structural measures are not expected to affect the arrival of bighead carp at the 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 the 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_{25}: See T_0

T_{50}: See T_0.

e. *Distance from Pathway*

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 distance of the bighead carp 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 Cal-Sag 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_{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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: Bighead carp has been documented at the Brandon Road Lock and Dam and Lockport Pool upstream of the Brandon Road Lock and Dam.
The Mid-system Separation Cal-Sag 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. The bighead carp has arrived at the pathway. One bighead carp was observed in the 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 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bighead carp at the pathway. The bighead carp has arrived at the pathway. One bighead carp was observed in the 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 Cal-Sag 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 Cal-Sag 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 the Brandon Road Lock and Dam and a second at the Illinois-Indiana state line. At the 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 electric barrier is expected 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 and 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 by 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 it with buffer zone water. Buffer zone water originates from sources that have been treated for ANS or discharges originating from treatment plants and stormwater sources. The flushing action of the GLMRIS Lock is expected to address bighead carp eggs, larvae, and fry that may passively drift through the electric barrier and enter the lock.

In addition, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates a second control point at the Illinois-Indiana state line with the construction of a physical barrier. The physical barrier would be constructed in the channel at the Illinois-Indiana state line 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 Mid-system Separation Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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. In addition, the physical barrier at the Illinois-Indiana state line 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 Cal-Sag 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 Cal-Sag 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 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. The physical barrier at the Illinois-Indiana state line control point is expected to control the vessel-mediated transport of the species as well as the natural dispersion of the species through this 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 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 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 Cal-Sag 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 Cal-Sag 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 Lock is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect passage of bighead carp through this aquatic pathway. Therefore, the 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 Cal-Sag 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 a GLMRIS Lock and an 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 it with buffer zone water. The flushing action of the GLMRIS Lock is expected to address bighead carp eggs, larvae, and fry that may passively drift through the electric barrier and enter the lock.

In addition, a second control point is located at Illinois-Indiana state line that includes the construction of a physical barrier. 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of bighead carp 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	High	High	High
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating	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 4 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 mimi 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 Cal-Sag Open Control Technologies with a Buffer Zone is 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. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier upstream and downstream of the GLMRIS Lock. 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 is expected to control the passage of bighead carp up to an extreme storm event, a 0.2% ACE event. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 5

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

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, GLMRIS Lock, Electric Barrier, and Physical 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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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 PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

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

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of a pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The physical barrier, implemented as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, 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. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the type of mobility or invasion speed of bighead carp.

b. Human-Mediated Transport through Aquatic Pathways

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 arrival of the bighead carp from human-mediated transport through this aquatic pathway.

c. 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 and reproductive capacity for the bighead carp through this aquatic pathway.

T_{10}: See 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 and potential abundance or reproductive capacity of bighead carp.

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 existing barriers to movement of bighead carp from its current position and the Brandon Road Lock and Dam. The bighead carp has arrived at the pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would include the construction of a GLMRIS Lock and an electric barrier at the Brandon Road Lock and Dam in Illinois. In addition, a physical barrier constructed in the channel at Hammond, Indiana, is expected to separate the Great Lakes and Mississippi River basins. However, these structural measures are not expected to affect the arrival of bighead carp at the Brandon Road Lock and Dam by human-mediated transport or natural dispersion. Bighead carp have arrived at the pathway. One bighead carp was observed in the 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 the Lockport Pool upstream of Brandon Road Lock and Dam.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at Brandon Road Lock and Dam. The bighead carp has arrived at the pathway. One bighead carp was observed in the 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 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of bighead carp at the pathway. Bighead carp have arrived at the pathway. One bighead carp was observed in the 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 Cal-Sag 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 Cal-Sag 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 the Brandon Road Lock and Dam and a second at Hammond, Indiana. At the 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 electric barrier is expected 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 the lock being operated after a power outage, fish within the engineered channel would be removed by 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 originating from treatment plants and stormwater sources. The flushing action of the

GLMRIS Lock is expected to address bighead carp eggs, larvae, and fry that may passively drift through the electric barrier and enter the lock.

In addition, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would create a second control point at Hammond, Indiana, with the construction of a physical barrier. The physical barrier would be constructed in the channel at Hammond, Indiana, and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features are expected to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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, which 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. In addition, the physical barrier at the Hammond, Indiana, control point is expected to control the vessel-mediated transport of the species through the aquatic pathway, since 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 Cal-Sag 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 Cal-Sag 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 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. The physical barrier at the Hammond, Indiana, control point is expected to control the vessel-mediated transport of the species as well as the natural dispersion of the species through this 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 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 availability of suitable habitat for the 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 Cal-Sag 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 Cal-Sag 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 Lock is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect passage of bighead carp through this aquatic pathway. Therefore, the 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 Cal-Sag 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 the pathway. One control point is located at the Brandon Road Lock and Dam and includes a GLMRIS Lock and an 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 it with buffer zone water. The flushing action of the GLMRIS Lock is expected to address bighead carp eggs, larvae, and fry that may passively drift through the electric barrier and enter the lock.

In addition, a second control point is located at Hammond, Indiana, that includes the construction of a physical barrier. 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 Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	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 4 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 mimi 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is 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. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier upstream and downstream of the GLMRIS Lock. 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 by using nets, electrofishing, and/or piscicides. The physical barrier is expected to control the passage of bighead carp up to an extreme storm event, a 0.2% ACE event. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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

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. 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.

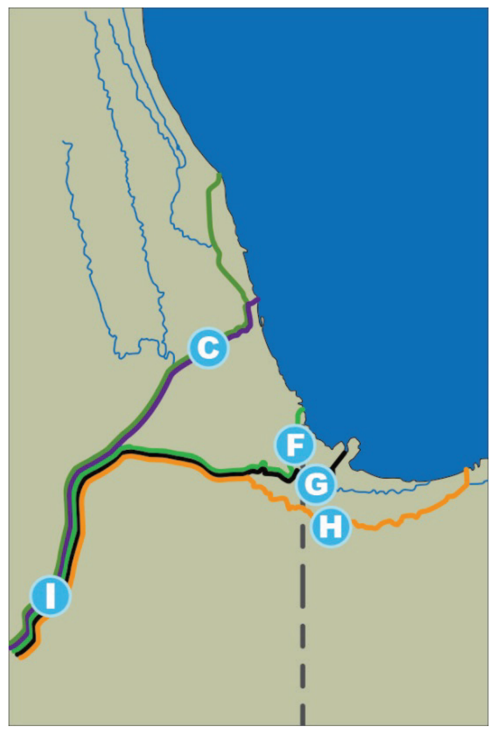
E.7.1.2 2 Silver Carp (Hypophthalmichthys nobilis)

MID-SYSTEM SEPARATION CAL-SAG 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}).

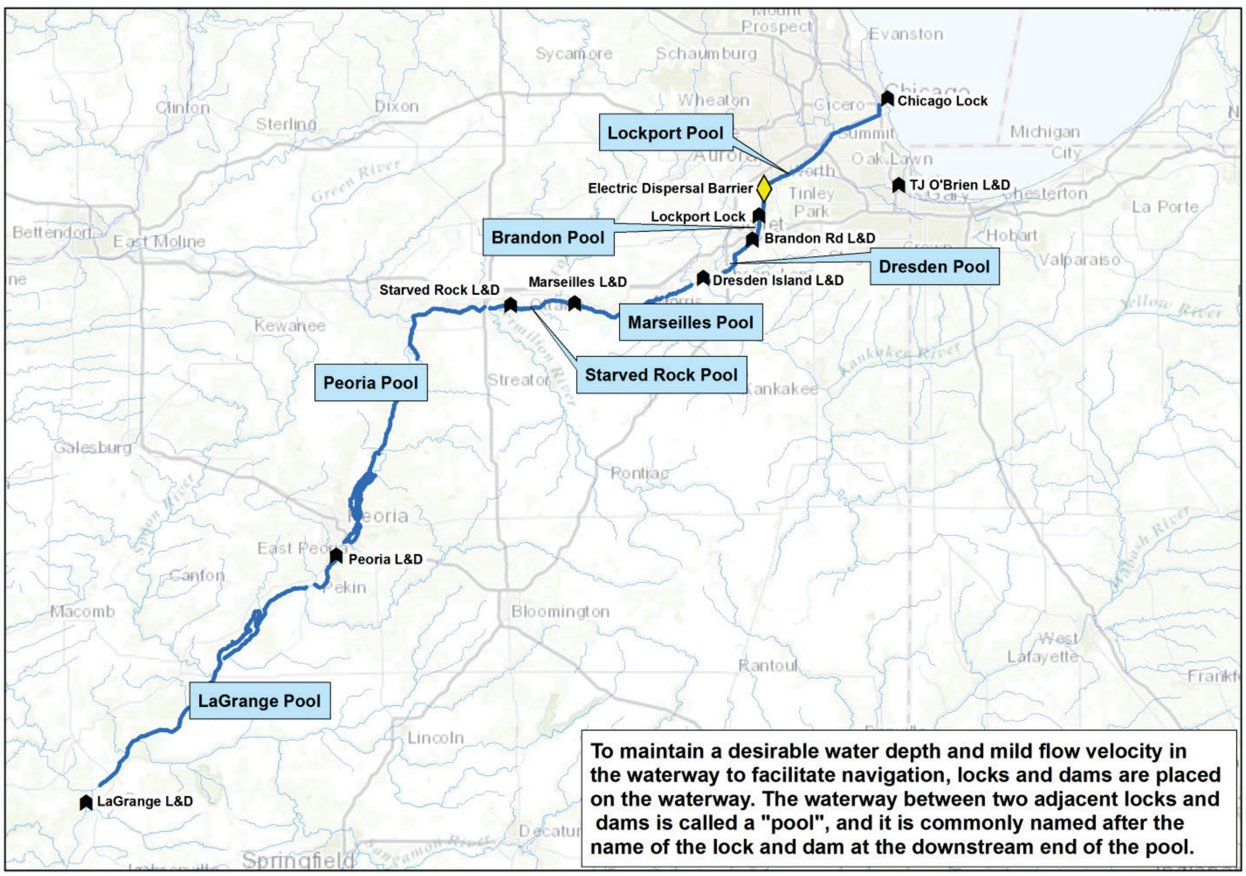
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant[b]
Chicago River Controlling Works	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant[b]
Calumet Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	T.J. O'Brien Lock and Dam (F)[c]	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	State Line, IL/IN (G)	Physical Barrier
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Brandon Road Lock and Dam (I)	Electric Barrier
		GLMRIS Lock
	Hammond, IN (H)	Physical Barrier



[a] For more information regarding nonstructural measures for this species, please refer to the Nonstructural Risk Assessment for the silver carp.
[b] Control Point (C) 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 the silver carp's probability ratings.
[c] Control Point (F) 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 the Calumet River.

Risk Assessment Reference Map



The current Electric Dispersal Barrier System, located approximately 5 mimi 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT SUMMARY

New Federal Action Rating Summary

Probability	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 Cal-Sag 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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 Alternative 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 natural dispersion of silver carp through aquatic pathway to the Brandon Road Lock and Dam.

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Alternative 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 silver carp's arrival at 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 Alternative 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 silver carp's current and potential abundance or reproductive capacity in this aquatic pathway.
T_{10}: 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 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: None. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points, one at Brandon Road Lock and Dam and one at Stickney, Illinois. The control point at Brandon Road Lock and Dam includes the construction of a Great Lakes and Mississippi River Interbasin Study (GLMRIS) lock and electric barrier while the Stickney, Illinois control point would include the construction of a physical barrier and ANSTP.Overall, none of these structural measures are expected to control the silver carp's arrival at Brandon Road Lock and Dam via human-mediated transport or natural dispersion since 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 the 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 Alternative 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 silver 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 Alternative 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 suitability of habitat for the silver carp.
T_{10}: See T_0. See the Nonstructural Alternative Risk Assessment for this species.
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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's arrival at Brandon Road Lock and Dam. The species has likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 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	None	None	None	None
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: See Nonstructural Alternative 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 silver carp's arrival at the pathway. The species has likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 Cal-Sag 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 Cal-Sag 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 Stickney, Illinois. 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, 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 to fill it 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 Stickney, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Stickney, 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 CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney 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 Cal-Sag 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 silver carp 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 Cal-Sag 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 Stickney 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 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 availability of suitable habitat within the CAWS for silver carp.
T_{10}: See T_0. See the Nonstructural Risk Assessment for this species.
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	Low	Low	Medium	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 Stickney, 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 CSSC 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 Cal-Sag 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 Cal-Sag 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 4 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 mimi 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 Cal-Sag 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 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. 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 2

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

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the natural dispersion of silver carp 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points, one at Brandon Road Lock and Dam and one at Stickney, Illinois. The control point at Brandon Road Lock and Dam would include the construction of a GLMRIS Lock and electric barrier while the Stickney, 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 at Brandon Road Lock and Dam, since the species has likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat for the silver 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's arrival at Brandon Road Lock and Dam. The species has likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's arrival at the pathway. The species has likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 Cal-Sag 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 silver carp through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag 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 Stickney, Illinois. 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, 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 to fill it 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 Stickney, Illinois, with the construction of a physical barrier and an ANSTP. The physical barrier would be constructed in the channel at Stickney, 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 CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney 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 Cal-Sag 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 silver carp 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 Cal-Sag 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 Stickney 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of the habitat within the CAWS 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 Cal-Sag 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 Cal-Sag 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 passage through this aquatic pathway. Therefore, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Stickney, 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 Stickney, 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 CSSC 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 Cal-Sag 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 Cal-Sag 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 4 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 mimi 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 Cal-Sag 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 were removed from the approach channel/electric barrier area using nonstructural measures such as nets, electrofishing, or piscicides. The physical barrier is expected to control the passage of this species up to an extreme storm event, a 0.2% ACE event. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 Calumet Harbor over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's type of mobility or invasion speed.

b. Human-Mediated Transport through Aquatic Pathways
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 silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance or reproductive capacity in this aquatic pathway.
T_{10}: 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 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 and Brandon Road Lock and Dam. The silver carp has arrived at the pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag 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. In addition, a GLMRIS Lock, electric barrier, ANSTP and screened sluice gates would be constructed at T.J. O'Brien Lock and Dam. 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 the 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat for the silver 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's arrival at 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 the 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 arrival 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	Low	Low	Low	Low
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's arrival at 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 the 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 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 Cal-Sag 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 Cal-Sag 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, 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 anticipated 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 T.J. O'Brien Lock and Dam; however, this control point controls the passage of Great Lakes Basin ANS, and silver carp are in the Mississippi River Basin.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of silver carp 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 Cal-Sag 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 Cal-Sag 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 Alternative Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 passage through this aquatic pathway. Therefore, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 it 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 T.J. O'Brien Lock and Dam; however, it controls Great Lakes Basin ANS, and silver carp are in the Mississippi River Basin.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 4 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 mimi 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 Cal-Sag 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 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 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 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, and Physical 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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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*(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 PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

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

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of a pathway is low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating.

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's type of mobility or invasion speed.

b. Human-Mediated Transport through Aquatic Pathways

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 silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance or 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 Mid-system Separation Cal-Sag 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. In addition, a physical barrier constructed in the channel at the Illinois-Indiana state line is expected to separate the Great Lakes and Mississippi River basins. 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, since the silver carp has arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 Alternative 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 silver 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 Alternative 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 suitability of habitat for the silver carp.

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	High	High	High	High
Mid-system Separation Cal-Sag 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. he Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's arrival at Brandon Road Lock and Dam, since 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 the 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 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's arrival at the pathway since 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 the 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 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 Cal-Sag 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 Cal-Sag 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 Illinois-Indiana state line. 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, 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 electrica barrier within an engineered channel downstream of the lock. The electric barrier is expected 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 and 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 to fill it 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 silver carp eggs, larvae, and fry that may passively drift through the electric barrier and enter the lock.

In addition, with the construction of a physical barrier, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates a second control point at the Illinois-Indiana state line. The physical barrier would be constructed in the channel at the Illinois-Indiana state line 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 Mid-system Separation Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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. In addition, the physical barrier at the Illinois-Indiana state line 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 Alternative Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 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 Cal-Sag 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 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. The physical barrier at the Illinois-Indiana state line control point is expected to control the vessel-mediated transport of the species as well as the natural dispersion of the species through this 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Lock is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's passage through this aquatic pathway. Therefore, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 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 it with buffer zone water. The flushing action of the GLMRIS Lock is expected to address silver carp eggs, larvae, and fry that may passively drift through the electric barrier and enter the lock.

In addition, a second control point is located at Illinois-Indiana state line that includes the construction of a physical barrier. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basin. 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of silver carp 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	High	High	High
Mid-system Separation Cal-Sag 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 4 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 mimi 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 Cal-Sag Open Control Technologies with a Buffer Zone is 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. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier upstream and downstream of the GLMRIS Lock. 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 is expected to control the passage of silver carp up to an extreme storm event, a 0.2% ACE event. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 (BSBH) TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Electric Barrier, GLMRIS Lock, and Physical 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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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 PROBABILITY OF ESTABLISHMENT/UNCERTAINTY

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

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Hammond, IN, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of a pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating.

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's type of mobility or invasion speed.

b. Human-Mediated Transport through Aquatic Pathways

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 silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's current and potential abundance or 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 Mid-system Separation Cal-Sag 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. In addition, a physical barrier constructed in the channel at Hammond, Indiana, is expected to separate the Great Lakes and Mississippi River basins. 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 since the species has arrived at the pathway Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the suitability of habitat for the silver 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative would not affect the silver carp's arrival at Brandon Road Lock and Dam, since the species has likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's arrival at the pathway, since the species has likely already arrived at the pathway. Adult silver carp are abundant in the Illinois Waterway from the Marseilles Pool downstream to the confluence with the 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana. 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, 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 electric barrier is expected 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 and 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 to fill it 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 silver carp eggs, larvae, and fry that may passively drift through the electric barrier and enter the lock.

In addition, with the construction of a physical barrier, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would create a second control point at Hammond, Indiana. The physical barrier would be constructed in the channel at Hammond, Indiana and is expected to separate the Great Lakes and Mississippi River basins. The barrier and associated flood risk management features are expected to control overtopping of the banks up to an extreme storm event, a 0.2% ACE event.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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. In addition, the physical barrier at the Hammond, Indiana, control point is expected to control the vessel-mediated transport of the species through the aquatic pathway, since 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 Alternative Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 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 Cal-Sag 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 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. The physical barrier at the Hammond, Indiana control point is expected to control the vessel-mediated transport of the species as well as the natural dispersion of the species through this 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the silver carp's availability of suitable habitat 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 Cal-Sag 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 Cal-Sag 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 Lock is expected to address human-mediated transport through aquatic pathways, these measures alone are not expected to affect the silver carp's passage through this aquatic pathway. Therefore, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 the pathway. One control point is located at Brandon Road Lock and Dam and includes 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 it with buffer zone water. The flushing action of the GLMRIS Lock is expected to address silver carp eggs, larvae, and fry that may passively drift through the electric barrier and enter the lock.

In addition, a second control point is located at Hammond, Indiana that includes the construction of a physical barrier. The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basin. 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 Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone 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 Cal-Sag 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 4 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 mimi 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is 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. In addition, further studies would be needed to determine the optimal operating parameters for the electric barrier upstream and downstream of the GLMRIS Lock. 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 is expected to control the passage of silver carp up to an extreme storm event, a 0.2% ACE event. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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

References

Chick, J.H., and M.A. Pegg. 2001. Invasive carp in the Mississippi River basin. Science. Vol. 22, pp. 2250-2251.

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.

Garvey, J.E., D.C. Glover, M.K. Brey, W. Bouska, and G. Whitledge. 2013. Monitoring Asian carp population metrics and control efforts: preventing upstream movement in the Illinois River. Pages 64-68 91 *in* 2012 Asian Carp Monitoring and Rapid Response Plan Interim Summary Reports. Monitoring and Rapid Response Working Group (MRRWG). 162 pp. http://asiancarp.us/documents/MRRP_Interim_Summary_Reports5-6-13.pdf. Accessed June 21, 2013.

Irons, K.S., S.A. DeLain, E. Gittinger, B.S. Ickes, C.S. Kolar, D. Ostendorf, E.N. Ratcliff & A.J. Benson. 2009. Nonnative fishes in the Upper Mississippi River System. U.S. Geological Survey Scientific Investigations Report 2009-5176, 68 pp.

Ruebush, B.C., J.M. Zeigler, D. Wyffels, M.A. McClelland, T. Widloe, B. Caputo, V. Santucci, and K. Irons. 2013. Fixed site monitoring downstream of the dispersal barrier. Pages 36-45 *in* 2012 Asian Carp Monitoring and Rapid Response Plan Interim Summary Reports. Monitoring and Rapid Response Working Group (MRRWG). 162 pp. http://asiancarp.us/documents/MRRP_Interim_Summary_Reports5-6-13.pdf. Accessed June 21, 2013.

Wyffels, D., M. McClelland, V. Santucci, K. Irons, T. Widloe, B. Caputo, B. Ruebush, J. Zeigler, and M. O'Hara. 2013. Barrier defense Asian carp removal project. Pages 56–63 *in* 2012 Asian Carp Monitoring and Rapid Response Plan Interim Summary Reports. Monitoring and Rapid Response Working Group (MRRWG). http://asiancarp.us/documents/ MRRP_Interim_Summary_Reports5-6-13.pdf. Accessed June 21, 2013.

E.7.2 ANS Potentially Invading the Mississippi River Basin

E.7.2.1 Algae

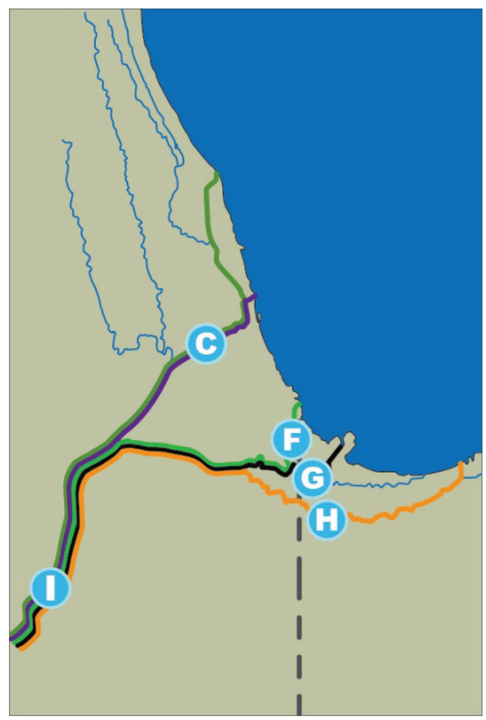
E.7.2.1.1 Grass Kelp (*Enteromorpha flexuosa*)

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock



<table>
<tr><td rowspan="4">Indiana Harbor</td><td colspan="2">Nonstructural Measures</td></tr>
<tr><td>State Line, IL/IN (G)</td><td>Physical Barrier</td></tr>
<tr><td rowspan="2">Brandon Road Lock and Dam (I)[a]</td><td>Electric Barrier</td></tr>
<tr><td>GLMRIS Lock</td></tr>
<tr><td rowspan="4">Burns Small Boat Harbor</td><td colspan="2">Nonstructural Measures</td></tr>
<tr><td>Hammond, IN (H)</td><td>Physical Barrier</td></tr>
<tr><td rowspan="2">Brandon Road Lock and Dam (I)[a]</td><td>Electric Barrier</td></tr>
<tr><td>GLMRIS Lock</td></tr>
<tr><td colspan="3">[a] The Mid-system Separation Cal-Sag 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 E. flexuosa's probability ratings.
[b] The Mid-system Separation Cal-Sag Open Control Technologies Alternative includes an electric barrier at Control Point (F), which is ineffective for E. flexuosa and does not impact its probability rating.</td></tr>
</table>

PATHWAY 1

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

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to affect *E. flexuosa*'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 a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation Cal-Sag 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 as a result of 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 focus nonstructural control measures, in particular algaecides. 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 *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. flexuos*a.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa*'s arrival at the CAWS as a result of natural dispersion through aquatic pathways. Nonstructural measures would include agency monitoring 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 *E. flexuosa*'s ability to establish near the CAWS.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. 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 address ANS originating in the Mississippi River Basin and would not impact the passage of *E. flexuosa* through the CAWS. Overall, none of these structural measures are expected to control *E. flexuosa*'s arrival at the CAWS. The closest that *E. flexuosa* has been recorded to the WPS was 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 a description of how nonstructural measures may impact the distance from the pathway.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may limit *E. flexuosa*'s movement 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways. This may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake.

T_{10}: See T_0.

T_{25}: See T_{10}.

T_{50}: See T_0. The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa*'s arrival at the CAWS via natural dispersion and human-mediated transport through aquatic pathways. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would also include agency monitoring 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to manage *E. flexuosa* populations where they exist; therefore, its 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 Cal-Sag 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 Cal-Sag 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 locations 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 that are 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 are 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}: 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. This alternative includes two control points; one at Stickney, Illinois, and a second at Brandon Road Lock and Dam.

At the Stickney, 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 Stickney, Illinois, control point is to remove ANS from Chicago Sanitary and Ship Canal (CSSC) 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 ultraviolet radiation (UV) 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). *E. flexuosa* filaments and reproductive spores that typically range in size from 0.16 µm to 3.6 mm (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 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 CSSC at the Stickney control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, pre-filtration would be 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. *E. flexuosa* is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag 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 Cal-Sag 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 CSSC 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, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

T_{50}: See T_{25}.

b. *Existing Physical Human/Natural Barriers*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 CSSC 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 *E. flexuosa* through the aquatic pathway.

The physical barrier constructed in the channel at the Stickney, 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 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 Stickney, Illinois, control point would treat CSSC water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. 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 others 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 are 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 Cal-Sag 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. 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 on *E. flexuosa*, and whether an additional treatment process would be 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 2

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

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 elements. (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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier at Stickney, 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 a discussion on how nonstructural measures may impact the invasion speed of *E. flexuosa*.
The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to affect *E. flexuosa*'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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa*'s arrival at the CAWS as a result of 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 focus nonstructural control measures, in particular algaecides. 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 *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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa*'s arrival at the CAWS as a result of natural dispersion through aquatic pathways. Nonstructural measures would also include agency monitoring 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 its ability to establish near CAWS.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 passage of *E. flexuosa* through the CAWS. Overall, none of these structural measures are expected to control the arrival of *E. flexuosa* at the CAWS. The closest *E. flexuosa* has been recorded to the WPS was 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 the pathway.

The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways. This 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that would be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa*'s arrival at the CAWS via natural dispersion and human-mediated transport through aquatic pathways. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would also include agency monitoring 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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 are 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}: 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 Cal-Sag 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 Cal-Sag 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 Stickney, Illinois, and a second at Brandon Road Lock and Dam.

At the Stickney, 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 at the Stickney, Illinois, control point is to remove ANS from CSSC 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). *E. flexuosa* filaments and reproductive spores that typically range in size from 0.16 µm to 3.6 mm (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 species, such as iron, nitrate, and natural organic matter. Based on water quality data collected by the MWRDGC between 2007 and 2011, the CSSC at the Stickney control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, pre-filtration would be 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 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented immediately. 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 Cal-Sag 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 CSSC 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: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 physical barrier. The ANSTP would treat CSSC 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, thereby reducing 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. See the Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}.

Probability of Passage

Time Step	**T_{10}**	**T_0**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 *E. flexuosa* through the aquatic pathway.

The physical barrier in the channel at the Stickney, 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 Stickney, Illinois, control point would treat CSSC water for *E. flexuosa* prior to its discharge into the Mississippi River Basin side of the control point. 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* passing through the aquatic

pathway 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	Medium	Medium	Medium	Medium
Mid-system Separation Cal-Sag 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 are 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 that are 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 Cal-Sag 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. 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 on *E. flexuosa*, and whether an additional treatment process would be 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 Calumet Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would not affect the existence of 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect *E. flexuosa* 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa*'s arrival at the CAWS as a result of 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 focus nonstructural control measures, in particular algaecides. 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 *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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa*'s arrival at the CAWS as a result of natural dispersion through aquatic pathways. Nonstructural measures such as agency monitoring could 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 its ability to establish near the CAWS.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at T.J. O'Brien Lock and Dam in 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 *E. flexuosa* at the CAWS. Overall, none of these structural measures are expected to act as physical barriers to *E. flexuosa*'s arrival at the CAWS. The closest that *E. flexuosa* has been recorded to the WPS was 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 this species for a description of how nonstructural measures may impact the distance from the pathway.

The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways. This 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 via 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 Cal-Sag 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 Cal-Sag 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 Technology Alternative with a Buffer Zone Alternative includes measures that are expected to manage *E. flexuosa* populations where they exist; 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 Cal-Sag 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 Cal-Sag 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 are 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}: MEDIUM-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 Alternative Risk Assessment.

The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{10}. This alternative creates two control points, one at T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam. At the T.J. O'Brien Lock and Dam control point, the current lock would be replaced with a GLMRIS Lock and an electric barrier, ANSTP, and screened sluice gates would be constructed.

The GLMRIS Lock at the T.J. O'Brien Lock and Dam control point would be designed to minimize the creation of *E. flexuosa* habitat surrounding the lock. 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 on the northern entrance to the T.J. O'Brien GLMRIS Lock would be an ineffective control for *E. flexuosa*, since 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 it with water from an ANSTP. Without the lock flushing, the lock could transport *E. flexuosa* into the CAWS Buffer Zone. After the lock gates are closed, the lock's emptying system would remove lock water from the northern end of the lock, and its filling system would flush and fill the lock from the southern 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 species that foul vessel hulls or temporarily attach to vessels, such as this species. The purpose of the ANSTP is to remove ANS from Calumet River 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 Lock 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 forms 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) in size. Filaments and reproductive spores (spore size: 0.16 µm [Hill 2001]) of *E. flexuosa* are expected to be able 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. Water quality data indicates that the Calumet River at the T.J. O'Brien control point 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; EPA 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 the water, such as turbidity, salinity, and the size and type of organism.

Sluice gates would also be constructed at the T.J. O'Brien Lock and Dam in 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 Calumet River 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 Little Calumet River would be diverted into the Calumet River through the screened gates to reduce flood risk. When water from the Little Calumet River is diverted to the Calumet River during a storm event, *E. flexuosa* is expected to be unable to pass through the control point and into the Little Calumet River because of the species' 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 the Calumet River through the Lock. Again, the passive drifting *E. flexuosa* seeds and plant fragments are expected to be unable to drift through the GLMRIS Lock while water is flowing from the CAWS through the lock into the Calumet River.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag 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 Cal-Sag 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 *E. flexuosa* through the aquatic pathway to the Brandon Road Lock and Dam.

These measures are not expected to control the human-mediated transport of *E. flexuosa* through the GLMRIS Lock via hull fouling. This species has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock would not address the human-mediated transport of this species via hull fouling because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of *E. flexuosa* 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 hull fouling on vessels. *E. flexuosa* has been found to attach to vessel hulls (Lougheed and Stevenson 2004). The GLMRIS Lock would not address the passage of this species via hull fouling 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, and thereby reducing 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. 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points; one at the current T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam. At the T.J. O'Brien Lock and Dam control point, structural measures would include the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates.

The electric barrier would have no effect on 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 human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to 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 Cal-Sag 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 are 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 implemented as part of the Mid-system Separation Cal-Sag 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. Therefore, 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 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(3)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) and (3) designate 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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_0.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to affect *E. flexuosa* 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa* arrival at the CAWS as a result of 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 focus nonstructural control measures, in particular algaecides. 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 *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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa* arrival at the CAWS as a result of 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 its ability to establish near the CAWS.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0.

d. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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 *E*. flexuosa at the CAWS. Overall, these structural measures are not expected to control the arrival of *E. flexuosa* at the CAWS. The closest that *E. flexuosa* has been recorded to the WPS was 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 the pathway.

The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways. This may reduce habitat suitability for *E. flexuosa* at its current location at Muskegon Lake

T_{10}: See T_0. The habitat of Lake Michigan is expected to remain suitable for *E. flexuosa* during this time step.
T_{25}: See T_{10}.
T_{50}: See T_{10}. The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa* arrival at the CAWs as a result of natural dispersion and human-mediated transport through aquatic pathways. Nonstructural measures such as agency monitoring could 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 Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to manage the spread of *E. flexuosa* through aquatic pathways to the CAWS; therefore, the probability of arrival is reduced to low.

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	Medium	Medium	Medium	Medium
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	Medium	***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.

The Mid-system Separation Cal-Sag 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 are 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 Cal-Sag 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_{10}.

T_{25}: The Mid-system Separation Cal-Sag 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 Illinois-Indiana state line and a second at the Brandon Road Lock and Dam.

The Illinois-Indiana state line control point would include the construction of a physical barrier in the channel that 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag 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_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, and thereby reducing 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 due to 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures. This alternative would create a control point at the Illinois-Indiana state line with the construction of a physical barrier. Additionally, 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 impact the passage of *E. flexuosa* through the CAWS.

The physical barrier constructed in the channel at the Illinois-Indiana state line 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 attached 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* and vessels potentially transporting it in ballast and bilge water or via hull fouling 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	High	High	High	High
Mid-system Separation Cal-Sag 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 through the aquatic pathway is 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 are 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 Cal-Sag 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 the passage of *E. flexuosa* through the CAWS up to an extreme storm event, a 0.2% ACE event. 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}: 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(3)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) and (3) designate 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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round. Therefore, the probability of pathway remains high.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty. Therefore, the uncertainty remains none.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to affect *E. flexuosa* 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa* arrival at the CAWS as a result of 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 focus nonstructural control measures, in particular algaecides In addition, the implementation of a ballast/bilge water exchange program, education and outreach and laws and regulations may reduce the probability of 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa* arrival at the CAWS as a result of 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 its ability to establish near the CAWS.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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

E. flexuosa at the CAWS. Overall, none of these structural measures are expected to control the arrival of *E. flexuosa* at the pathway. The closest that *E. flexuosa* has been recorded to the WPS was 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 the pathway.

The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways. This 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are expected to affect *E. flexuosa* arrival at the CAWS as a result of 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 Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to manage the spread of *E. flexuosa* through aquatic pathways to the CAWS; 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 Cal-Sag 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 Cal-Sag 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 are 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana and a second at the Brandon Road Lock and Dam. 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 passage of *E. flexuosa* through the CAWS.

The Hammond, Indiana control point would include the construction of a physical barrier in the channel and it 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of *E. flexuosa* through the aquatic pathway to Brandon Road Lock and Dam.

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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as managing nutrient loads to waterways, which may reduce the probability of *E. flexuosa* establishing in the CAWS, and thereby reducing 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 due to 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 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	Low	Low	Medium	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana for *E. flexuosa* with the construction of a physical barrier. Additionally, 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 impact the natural dispersion or human-mediated transport of *E. flexuosa* 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 *E. flexuosa* and vessels potentially transporting the species in ballast and bilge water or attached 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *E. flexuosa* and vessels potentially transporting it in ballast and bilge water or via hull fouling, 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	High	High	High	High
Mid-system Separation Cal-Sag 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 through the aquatic pathway is 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 are 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 Cal-Sag 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 the passage of *E. flexuosa* through the CAWS up to an extreme storm event, a 0.2% ACE event. 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}: 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

References

Agrawal, S.C. 2009. Factors affecting spore germination in algae – review. *Folia Microbiology*, vol. 54, no. 4, pp. 273–302.

Cordi, B., M.E. Donkin, J. Peloquin, D.N. Price, and M.H. Depledge. 2001. The influence of UV-B radiation on the reproductive cells of the intertidal macroalga, *Enteromorpha intestinalis*. *Aquatic Toxicology*, vol. 56, pp. 1–11.

EPA (U.S. Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule. Office of Water (4601), EPA 815-R-06–007. http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

Hill, K. 2001. Smithsonian Marine Station. *Enteromorpha flexuosa*. http://www.sms.si.edu/irlspec/entero_flexuo.htm.

Illinois Pollution Control Board. 2012. Water Quality Standards and Effluent Limitations for the Chicago Area Waterway System and Lower Des Plaines River: Proposed Amendments to 35 ILL. ADM. CODE 301, 302, 303, and 304. Illinois Pollution Control Board, Chicago, IL.

Kazumi, J. 2007. Ballast water treatment technologies and their application for vessels entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

Lougheed, V.L., and R.J. Stevenson. 2004. Exotic marine macroalgae (*Enteromorpha flexuosa*) reaches bloom proportions in a coastal lake of Lake Michigan. *Journal of Great Lakes Research*, vol. 30(4), pp. 538–544.

Raber, J. 2012. Personal communication from Raber (U.S. Army Corps of Engineers) to J. Pothoff (U.S. Army Corps of Engineers), May 7.

Sutherland, T. F., C. D. Levings, C. C. Elliott, and W. W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139–148.

USACE (U.S. Army Corps of Engineers). 2011. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System Great Lakes and Mississippi River Interbasin Study (GLMRIS). Chicago District, Chicago, IL. 32 pp. http://glmris.anl.gov/documents/docs/ GLMRIS_Baseline_Cargo.pdf.

Viitasalo, S. J. Sassi, J. Rytkönen, and E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35–55.

Waite, T.D., J. Kazumi, P.V.Z. Lane, L.L. Farmer, S.G. Smith, S.L. Smith, G. Hitchcock, and T.R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system, *Marine Ecology Progress Series*, vol. 258, pp. 51–63.

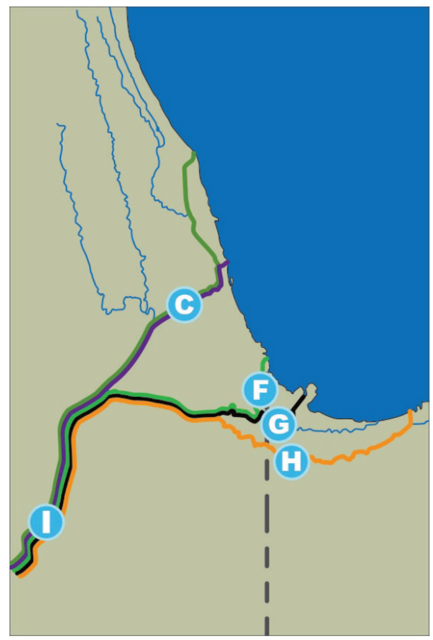
Wuebbles, D.J., K. Hayhoe, and J. Parzen. 2010. Introduction: assessing the effects of climate change on Chicago and the Great Lakes. *Journal of Great Lakes Research*, vol. 36, pp. 1–6.

Xiong, F., F. Lederer, J. Lukavsky, and L. Nedbal. 1996. Screening of freshwater algae (*Chlorophyta, Chromophyta*) for ultraviolet-B sensitivity of the photosynthetic apparatus. *Journal of Plant Physiology*, vol. 148, pp. 42–48.

E.7.2.1.2 Red Algae (Bangia atropurpurea)

MID-SYSTEM SEPARATION CAL-SAG 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 by the public. Technology measures would include combinations of control structures that would be implemented by time step 25 (T_{25}).



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

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures	
	State Line, IL/IN (G)	Physical Barrier
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock

Burns Small Boat Harbor	Nonstructural Measures	
	Hammond, IN (H)	Physical Barrier
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock

[a] The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a GLMRIS Lock and electric barrier at Control Point (I) that is designed to control Mississippi River Basin species and does not impact this species' probability ratings.

[b] The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an electric barrier at Control Point (F), 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 CAL-SAG 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)	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 Cal-Sag 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***	–	***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 WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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}: 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae 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 Cal-Sag 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.
The Mid-system Separation Cal-Sag 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. The distribution and abundance of red algae in the Great Lakes could decrease due to 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; this species has been found in southern Lake Michigan (Lin and Blum 1977).
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. 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 aquatic nuisance species (ANS) originating in the Mississippi River Basin and would not control the arrival of red algae at the CAWS. Overall, none of these structural measures are expected to control the arrival of red algae at the CAWS through the aquatic pathway. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect where red algae 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect the habitat suitability of southern Lake Michigan for red algae.

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_{25}. 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	Medium	Medium	Medium	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag 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 already 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: Although historically present in southern Lake Michigan, recent surveys do not indicate the presence of red algae.

The Mid-system Separation Cal-Sag 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 already be present at the WPS. Therefore, the uncertainty remains high.

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, 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 Cal-Sag 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 Cal-Sag 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 for red algae at Stickney, 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 control ANS originating in the Mississippi River Basin and would not impact the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

The physical barrier would be constructed in the channel at Stickney, 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 CSSC 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 condition.

The treatment technologies employed at the ANSTP would include screening, filtration, 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). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, respectively, 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, the water in the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration would be 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC 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, there is no commercial vessel traffic into the North Shore Channel (USACE 2011a, b).

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 Cal-Sag 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 Separation with Cal-Sag Channel 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 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 CSSC 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 Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 control 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 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 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, an ANSTP would treat CSSC water for red algae prior to 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-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 UV-B or UV-C radiation at any dose showed 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 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 Cal-Sag 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 Cal-Sag 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 implemented as part of the Mid-system Separation Cal-Sag 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, further investigation and bench-scale studies would be needed prior to design and construction 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 2

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

MID-SYSTEM SEPARATION CAL-SAG 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)	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 Cal-Sag 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***	–	***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 Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for red algae.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae 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 Cal-Sag 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.
The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterway which could affect the current abundance or reproductive capacity of red algae.
T_{10}: See the Nonstructural Risk Assessment for this species.
T_{25}: See T_{10}.
T_{50}: See T_{10}.

d. ***Existing Physical Human/Natural Barriers***
T_0: None; this species has been found in southern Lake Michigan (Lin and Blum 1977).
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 passage of red algae to the CAWS. Overall, these structural measures are not expected to control the arrival of red algae at the CAWS because 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 Cal-Sag 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 location 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect the habitat suitability of southern Lake Michigan for red algae.

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_0. Future climate change or new environmental regulations may alter 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 2–26°C (35.6–78°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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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.
T_{50}: See T_0.

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 Cal-Sag 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 Cal-Sag 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 for red algae at Stickney, 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 control ANS originating in the Mississippi River Basin and would not impact the natural dispersion (i.e., current-driven passage) of red algae through the aquatic pathway.

The physical barrier would be constructed in the channel at Stickney, 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 CSSC 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 condition.

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 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). Red algae filaments and reproductive spores, which are approximately 75 µm and 15.5 µm in diameter, respectively, 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 MWRDGC between 2007 and 2011, water in the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration would be 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 red algae through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC 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: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Separation Cal-Sag 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 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 it in ballast and bilge water or via hull fouling would be unable to traverse the physical barrier. The ANSTP would treat CSSC 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 Cal-Sag 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 and 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 control 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 in the channel 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 would treat CSSC water for red algae prior to 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-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 UV-B or UV-C radiation at any dose showed 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 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 Cal-Sag 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 Cal-Sag 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 implemented as part of the Mid-system Separation Cal-Sag 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, further investigation and bench-scale studies would be needed prior to design and construction 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. 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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)	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 Cal-Sag 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)[a]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(spreads)[a]	Medium	High	High	Medium	High	Medium	High	Medium
P(establishment)	Medium	–[b]	Medium	–	Medium	–	Medium	–

[a] The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to impact *P(colonizes)* or *P(spreads).*

[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 Calumet Harbor and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would not affect the existence of the pathway for red algae.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae 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 Cal-Sag 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.
The Mid-system Separation Cal-Sag 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. The distribution and abundance of red algae in the Great Lakes could decrease due to improvements in the water quality of southern Lake Michigan which could reduce the anthropogenic inputs into Lake Michigan that are 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}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at T.J. O'Brien Lock and Dam in 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 red algae at the CAWS. Overall, none of these structural measures are expected to act as physical barriers to the arrival of red algae at the CAWS because the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may already be present at Calumet Harbor.

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 location 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect the habitat suitability of southern Lake Michigan for red algae.

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_{25}. 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	Medium	Medium	Medium	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag 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 already be present at Calumet Harbor. 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 Cal-Sag 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 Cal-Sag 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 already be present at Calumet Harbor. Therefore, the uncertainty remains high.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_0.

3. **P(passage) T_0-T_{50}: 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 Cal-Sag 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 Cal-Sag 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 T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam. At the T.J. O'Brien Lock and Dam, 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.

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 Calumet River side entrance to the T.J. O'Brien GLMRIS Lock would be an ineffective control for red algae. 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 red algae into the CAWS buffer zone. After the lock gates are closed, the lock's emptying system would remove lock water from the Calumet River 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 aquatic nuisance species. Therefore, aquatic nuisance species 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 this species.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet River 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 condition. The ANSTP would also supply the GLMRIS Locks with water treated for aquatic nuisance species for lock flushing.

The treatment technologies included in the ANSTP would be screening 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 aquatic nuisance species and other organic matter larger than 0.75 in. (19.05 mm). Red algae filaments (filament size, 75 µm) (Kipp 2011) and reproductive spores (spore size, 15.5 µm) (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. 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 aquatic nuisance species (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.

Sluice gates would also be constructed at the T.J. O'Brien Lock and Dam in 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 Calumet River water potentially containing aquatic nuisance species 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 Little Calumet River would be diverted into the Calumet River through the screened gates in order to reduce flood risk. When water from the Little Calumet River is diverted to the Calumet River during a storm event, red algae is expected to be unable to pass through the control point and into the Little Calumet 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 the Calumet River 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 the Calumet River.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) 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 Cal-Sag 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 description of the Mid-system Separation Cal-Sag 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 red algae through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of red algae through the GLMRIS Lock via hull fouling. This species is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock would not address the human-mediated transport of this species via hull-fouling because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation Cal-Sag 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 description of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of red algae 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 hull fouling on vessels. Red algae is known to foul hulls of vessels (Kipp 2011; Lin and Blum 1977). The GLMRIS Lock would not address the human-mediated transport of this species via hull-fouling 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 Cal-Sag 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 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. 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the current T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam, that would be implemented at T_{25}. At the T.J. O'Brien Lock and Dam, structural measures would include an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates. The electric barrier would have no effect on 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 human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois–Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_0.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae 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 Cal-Sag 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. Existing Physical Human/Natural Barriers

T_0: See the Nonstructural Risk Assessment for this species.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois–Indiana state line. 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 red algae at the CAWS. Overall, none of these structural measures are expected to control the arrival of red algae at the CAWS because the species has already been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may already be present at Indiana Harbor.

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 Cal-Sag 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 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect where red algae is able to establish; and hence, its location 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect the habitat suitability of southern Lake Michigan for red algae.
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_{25}. 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	Medium	Medium	Medium	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag 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 already be present at Indiana Harbor. Therefore, the probability of arrival remains medium.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See the Nonstructural Risk Assessment for this species.

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 Cal-Sag 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 Cal-Sag 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 already be present at Indiana Harbor. Therefore, the uncertainty remains high.

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 Cal-Sag 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 Cal-Sag 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 Illinois–Indiana state line and a second at the Brandon Road Lock and Dam.

The Illinois–Indiana state line control point would include the construction of a physical barrier in the channel that 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag 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 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 Cal-Sag 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 red algae through the aquatic pathway to the Brandon Road Lock and Dam. 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 Cal-Sag 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}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 red algae 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 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 Cal-Sag 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 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 due to the adoption of water quality standards and effluent discharge limitations that are currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012).

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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures which 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 Cal-Sag 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 Cal-Sag 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 Illinois–Indiana state line with the construction of a physical barrier. 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 aquatic nuisance species originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of red algae through the aquatic pathway. Red algae are found in the Great Lakes Basin.

The physical barrier constructed in the channel at the Illinois–Indiana state line 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 attached 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of red algae and vessels potentially transporting it in ballast and bilge water or via hull fouling 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	High	High	High	High
Mid-system Separation Cal-Sag 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 implemented as part of the Mid-system Separation Cal-Sag 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 the passage of red algae through the CAWS up to an extreme storm event, a 0.2% ACE event. 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}: 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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:

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating:

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae 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 Cal-Sag 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. Existing Physical Human/Natural Barriers

T_0: None; this species has been found in southern Lake Michigan (Lin and Blum 1977).
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 red algae at the CAWS. Overall, none of these structural measures are expected to control the arrival of red algae at the pathway because the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may already be present at BSBH.
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 Cal-Sag 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 and reproductive capacity of red algae.
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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect where red algae is able to establish, and hence its location in relation to the CAWS.
T_{10}: The species may be present at BSBH. Alternatively, its range could contract, which would increase its distance from the 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures such as restrictions on nutrient loads to waterways which could affect the habitat suitability of southern Lake Michigan for red algae.
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 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	Medium	Medium	Medium	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways because the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may already be present at BSBH. 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of red algae at the CAWS through aquatic pathways because the species has been observed in southern Lake Michigan, including offshore of Wilmette, Illinois (Lin and Blum 1977). Red algae may already be present at BSBH. Therefore, the uncertainty remains high.

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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana, and a second at the Brandon Road Lock and Dam.

The Hammond, Indiana, control point would include the construction of a physical barrier 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of red algae through the aquatic pathway to Brandon Road Lock and Dam.

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 Cal-Sag 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 Cal-Sag 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 red algae through the aquatic pathway to the Brandon Road Lock and Dam. 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 Cal-Sag 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}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 red algae 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 red algae 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 Cal-Sag 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 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 due to the adoption of water quality standards and effluent discharge limitations that are currently proposed for the CAWS (Raber 2012; Illinois Pollution Control Board 2012).

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 Cal-Sag 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 Cal-Sag 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 and human-mediated transport. Therefore, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Hammond, Indiana, for red algae with the construction of a physical barrier. 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 aquatic nuisance species originating in the Mississippi River Basin and would not affect the natural dispersion or human-mediated transport of red algae through the aquatic pathway.

The physical barrier constructed in the channel at the Hammond, Indiana, 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 attached 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of red algae and vessels potentially transporting the species in ballast and bilge water or via hull fouling 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	High	High	High	High
Mid-system Separation Cal-Sag 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 implemented as part of the Mid-system Separation Cal-Sag 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 the passage of red algae through the aquatic pathway up to an extreme storm event, a 0.2% ACE event. 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}: 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

References

Agrawal, S. C. 2009. Factors affecting spore germination in algae – review. *Folia Microbiology*, vol. 54, no. 4, pp. 273-302.

EPA (U.S. Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule. Office of Water (4601), EPA 815-R-06–007. http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

Garwood, P.E. 1982. Ecological interactions among *Bangia*, *Cladophora*, and *Ulothrix* along the Lake Erie shoreline. Journal of Great Lakes Research, vol. 8(1), pp. 54–60.

Grippo, M., L. Fox, J. Hayse, I. Hlohowskyj, and T. Allison. 2013. Risks of Adverse Impacts from the Movement and Establishment of Aquatic Nuisance Species between the Great Lakes and Mississippi River Basins, prepared by Argonne National Laboratory for U.S. Army Corps of Engineers, Chicago District, GLMRIS Risk Assessment Team.

Guiry, M.D., & G.M. Guiry. 2012. AlgaeBase. National University of Ireland, Galway. http://www.algaebase.org/search/species/detail/?species_id=1436.

Illinois Pollution Control Board. 2012. Water Quality Standards and Effluent Limitations for the Chicago Area Waterway System and Lower Des Plaines River: Proposed Amendments to 35 ILL. ADM. CODE 301, 302, 303, and 304. Illinois Pollution Control Board, Chicago, IL.

Kazumi, J. 2007. Ballast water treatment technologies and their application for vessels entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

Kipp, R.M. 2011. *Bangia atropurpurea*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1700.

Lin, C. K., and J.L. Blum. 1977. Recent invasion of Red Alga (*Bangia atropurpurea*) in Lake Michigan. *Journal of the Fisheries Research Board of Canada*, vol. 34(12), pp. 2413-2416.

Poppe, F., R. A. M. Schmidt, D. Hanelt, and C. Wiencke. 2003. Effects of UV radiation on the ultrastructure of several red algae. *Phycological Research*, vol. 51, pp. 11-19.

Raber, J. 2012. Personal communication from Raber (U.S. Army Corps of Engineers) to J. Pothoff (U.S. Army Corps of Engineers), May 7.

Sutherland, T. F., C. D. Levings, C. C. Elliott, and W. W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139-148.

USACE (U.S. Army Corps of Engineers). 2011a. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System.

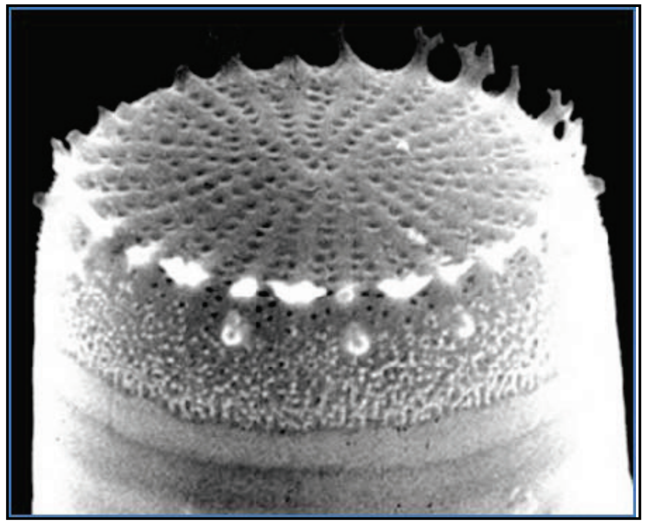
USACE (U.S. Army Corps of Engineers). 2011b. Baseline Assessment of Non-Cargo CAWS Traffic.

Viitasalo, S., J. Sassi, J. Rytkönen, E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35-55.

Waite, T.D., J. Kazumi, P.V. Z. Lane, L.L. Farmer, S.G. Smith, S.L. Smith, G. Hitchcock, and T.R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system, *Marine Ecology Progress Series*, vol. 258, pp. 51-63.

Wuebbles, D.J., K. Hayhoe, & J. Parzen. 2010. Introduction: assessing the effects of climate change on Chicago and the Great Lakes. *Journal of Great Lakes Research*, vol. 36, pp. 1–6.

E.7.2.1.3 Diatom (Stephanodiscus binderanus)

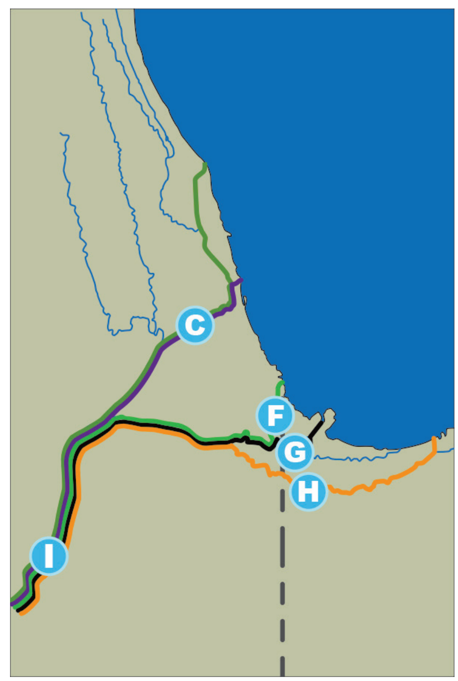


MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier[c]
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	State Line, IL/IN (G)	Physical Barrier
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier
	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 *S. binderanus*.

[b] The Mid-system Separation Cal-Sag Open Control Technologies Alternative includes a GLMRIS Lock and electric barrier at Control Point (I) that is designed to control Mississippi River Basin species and does not impact this species' probability ratings.

[c] The Mid-system Separation Cal-Sag Open Control Technologies Alternative includes an electric barrier at Control Point (F) that 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 CAL-SAG 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)	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 Cal-Sag 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 the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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

c. Type of Mobility/Invasion Speed
See 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 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 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 arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag 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 *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 for this species).

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 aquatic nuisance species (ANS) originating in the Mississippi River Basin and would not impact the arrival of *S. binderanus* at the CAWS. *S. binderanus* is located in the Great Lakes Basin. Overall, these structural measures are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.

As part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes restrictions on nutrient loads to waterways that may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.
T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus* although abundance may continue to decrease.
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	Low	Low	Low	Low
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur 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. See Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Stickney, Illinois. This alternative includes 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 control 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. *S. binderanus* is located in the Great Lakes Basin.

The physical barrier would be constructed in the channel at Stickney, 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 the CSSC 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 employed at the ANSTP would include screening, filtration, and ultraviolet (UV) radiation to deactivate high- and medium-risk Great Lakes and Mississippi River Interbasin Study (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). *S. binderanus* filaments and reproductive spores, which typically have a volume of 830 μm^3 (Kipp 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 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, the water at the CSSC control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, pre-filtration is included in the ANS treatment process at Stickney, Illinois, 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.

Overall, the Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC 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 would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control 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 *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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 aquatic pathway to Brandon Road Lock and Dam.

T_{10}: See T_0.

T_{25}: See T_0. See 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 Cal-Sag 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 control 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. *S. binderanus* is located in the Great Lakes Basin.

The physical barrier constructed in the channel at the Stickney, 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 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 Stickney, Illinois, control point would treat CSSC 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 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.

Based on the damage or irregular growth found in these species from UV-C and UV-B radiation, UV-C treatment typically found in wastewater disinfection facilities is expected to be effective at inactivating *S. binderanus*. 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, identify possible interferences, and address other design questions.

Overall, the Mid-system Separation Cal-Sag 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_0.

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 Cal-Sag 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 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 medium.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that 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. In regard to the ANSTP, further investigation and bench-scale studies would be needed prior to design and construction 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

PATHWAY 2

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

MID-SYSTEM SEPARATION CAL-SAG 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)	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 Cal-Sag 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 the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 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 arrival of *S. binderanus* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways
See 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 arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity
T_0: See Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag 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 *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 for this species).

d. Existing Physical Human/Natural Barriers

T_0: None.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 *S. binderanus* at the CAWS. *S. binderanus* is located in the Great Lakes Basin. Overall, these structural measures are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).
T_{50}: See T_{25}.

e. Distance from Pathway

T_0: See Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.
As part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.
T_{10}: See T_0.
T_{25}: See T_0.
T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus*, although abundance may continue to decrease.

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	Low	Low	Low	Low
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur 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. *S. binderanus* is documented to have declined significantly in Lake Michigan, and this species is not consistently found in phytoplankton surveys. Future improvements in water quality in southern Lake Michigan may continue to reduce the

abundance of *S. binderanus* near the CRCW. However, the species is not expected to be eliminated.
T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag 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 Stickney, Illinois, and a second at Brandon Road Lock and Dam.

At the Stickney, 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 at the Stickney, Illinois, control point is to remove ANS from the CSSC 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 employed at 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). *S. binderanus* filaments and reproductive spores, which typically have a volume of 830 μm^3 (Kipp 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 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 MWRDGC between 2007 and 2011, water at the CSSC control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, 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. *S. binderanus* is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC 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. Surface water is present year-round, and water depth is adequate throughout the CAWS (LimnoTech 2010).

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 *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 or via hull fouling would be unable to traverse the physical barrier. The ANSTP would treat CSSC 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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. See 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 Cal-Sag 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 control 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. *S. binderanus* is located in the Great Lakes Basin.

The physical barrier in the channel at the Stickney, 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 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 Stickney, Illinois, control point would treat CSSC 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 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. Both the physical barrier and ANSTP are expected to control the passage of *S. binderanus* via natural dispersion and human-mediated transport to Brandon Road Lock and Dam. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure of UV radiation for *S. binderanus*.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 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}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that 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. In regard to the ANSTP, further investigation and bench-scale studies would be needed prior to design and construction 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 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Screened Sluice Gates, ANS Treatment Plant, 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 Cal-Sag 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	–	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 Calumet Harbor and Brandon Road Lock and Dam over the next 50 years.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would not affect the existence of 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 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 arrival of *S. binderanus* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See 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 arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 *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 for this species).

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at T.J. O'Brien Lock and Dam in 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* at the CAWS. *S. binderanus* is located in the Great Lakes Basin. Overall, none of these structural measures are expected to act as physical barriers to the arrival of *S. binderanus* at the CAWS. The species is already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes area (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_0.

e. ***Distance from Pathway***

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.

As part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 but they are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. Therefore, the probability of arrival remains high.

T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus*, although abundance may continue to decrease.
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	Low	Low	Low	Low
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. Therefore, the uncertainty remains low.
T_{10}: See T_0.
T_{25}: See T_0. See Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}.

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 Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag 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 *S. binderanus* through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag 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 T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam. At the T.J. O'Brien Lock and Dam, 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.

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 Calumet River side entrance to the T.J. O'Brien GLMRIS Lock would be an ineffective control for *S. binderanus.* 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 *S. binderanus* 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 *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 Calumet River water prior to discharge into the CAWS Buffer Zone. ANSTP effluent would be used to mitigate water quality impacts and to 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 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) in size. *S. binderanus* is expected to pass through the screens (size of diatom: 830 μm^3; Kipp 2011), 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 thus block the UV light from reaching them. Water quality data indicate that the Calumet River is sufficiently clear to allow for effective UV treatment at the T.J. O'Brien Lock and Dam control point. 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.

Sluice gates would also be constructed at the T.J. O'Brien Lock and Dam in 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 Calumet River water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events requiring backflows, the solid gates would be opened, and water from the Little Calumet River would be diverted toward the Calumet River through the screened gates in order to reduce flood risk. When water is backflowed toward the Calumet River during a storm event, *S. binderanus* is expected to be unable to pass through the control point downstream toward the Mississippi River Basin because the species is expected to be 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 the GLMRIS Lock would be opened. Water from the CAWS would be diverted toward the Calumet River through the lock. Again, the passive drifting *S. binderanus* is expected to be unable to drift through the GLMRIS Lock while water was flowing from the CAWS through the lock into the Calumet River and 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. *S. binderanus* is located in the Great Lakes Basin.

The Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 description of the Mid-system Separation Cal-Sag 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 *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. Specifically, this alternative is not expected to control the human-mediated transport of *S. binderanus* through the GLMRIS Lock via hull fouling on vessels. *S. binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via hull fouling because the lock does not dislodge attached organisms from vessel hulls.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation Cal-Sag 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 description of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Structural measures that are 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 via hull fouling on vessels. *S. binderanus* is small (size of diatom: 830 μm^3; Kipp 2011) and may adhere to vessel hulls. The GLMRIS Lock would not address the human-mediated transport of this species via hull fouling 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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. See 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points — one at the current T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam — that would be implemented at T_{25}. At the T.J. O'Brien Lock and Dam, structural measures would include the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates.

The electric barrier would have no effect on 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 human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

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. *S. binderanus* is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative does 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: See 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 that are part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative are not expected to control the human-mediated transport of *S. binderanus* via hull fouling through the aquatic pathway; therefore, 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 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 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 arrival of *S. binderanus* at the CAWS from natural dispersion through aquatic pathways.

b. *Human-Mediated Transport through Aquatic Pathways*

See 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 arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. *Current Abundance and Reproductive Capacity*

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 *S. binderanus*.

T_{10}: See T_0. Future abundance cannot be predicted with any accuracy; however, reproductive capacity is predicted to remain the same, but 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 for this species).

d. *Existing Physical Human/Natural Barriers*

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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* at the CAWS. *S. binderanus* is located in the Great Lakes Basin. Overall, none of these structural measures are expected to control the arrival of *S. binderanus* at the CAWS through aquatic pathway. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes are (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_0.

e. *Distance from Pathway*

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.

As part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes restrictions on nutrient loads to waterways, which may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes are (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus*, although abundance may continue to decrease.

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	High	High	High	High
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating	High	High	High	High

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area. The Mid-system Separation Cal-Sag Open Control

Technologies with a Buffer Zone Alternative is not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes are (Kipp 2011), but this species historically does occur 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. See Nonstructural Risk Assessment for this species.
T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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_{10}.

T_{25}: The Mid-system Separation Cal-Sag 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 Illinois-Indiana state line and a second at the Brandon Road Lock and Dam.

The Illinois-Indiana state line control point would include the construction of a physical barrier 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.

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. *S. binderanus* is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag 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 to Brandon Road Lock and Dam.

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 Cal-Sag 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_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 *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.

T_{50}: See T_{25}.

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

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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. See 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	Low	Low	Low	Medium
Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 the Illinois-Indiana state line with the construction of a physical barrier. 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 passage of *S. binderanus* through the aquatic pathway. *S. binderanus* is located in the Great Lakes Basin.
The physical barrier constructed in the channel at the Illinois-Indiana state line control point is expected to separate the Great Lakes and Mississippi River basins. Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of *S. binderanus* and vessels potentially transporting the species in ballast and bilge water or via hull fouling passing through the aquatic pathway. 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	Medium	Medium
Mid-system Separation Cal-Sag 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 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 low.

T_{10}: See T_0.

T_{25}: Structural measures that are part of the Mid-system Separation Cal-Sag 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 the passage of *S. binderanus* up to an extreme storm event, a 0.2% ACE event. 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}: 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: See T_0. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 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 arrival of *S. binderanus* at the CAWS from natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See 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 arrival of *S. binderanus* at the CAWS from human-mediated transport through aquatic pathways.

c. Current Abundance and Reproductive Capacity

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 *S. binderanus*.

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

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 for this species).

d. Existing Physical Human/Natural Barriers

T_0: None.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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* at the CAWS. *S. binderanus* is located in the Great Lakes Basin. Overall, these structural measures are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes are (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Nonstructural Risk Assessment for this species.

As part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_0. See Nonstructural Risk Assessment for this species.

Probability of Arrival

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

Evidence for Probability Rating (Considering All Life Stages)

T_0: See Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes restrictions on nutrient loads to waterways, which may reduce the productivity of this species but are not expected to affect the arrival of *S. binderanus* at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes are (Kipp 2011), but this species historically does occur in Lake Michigan offshore of Chicago (Makarewicz and Baybutt 1981). Therefore, the probability of arrival remains high.

T_{10}: See T_0. Southern Lake Michigan may remain suitable for *S. binderanus*, although abundance may continue to decrease.

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	Low	Low	Low	Low
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating	Low	Low	Low	Low

Evidence for Uncertainty Rating

T_0: *S. binderanus* is considered to be established in Lake Michigan and was documented offshore of the Chicago area. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of

S. binderanus at the CAWS through aquatic pathways. The species is likely already at the pathway. There are no data available on the current distribution of *S. binderanus* in the Great Lakes are (Kipp 2011), but this species historically does occur 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. See Nonstructural Risk Assessment for this species.

T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 *S. binderanus* through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag 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 Hammond, Indiana, and a second at the Brandon Road Lock and Dam. 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 passage of *S. binderanus* through the aquatic pathway. *S. binderanus* is located in the Great Lakes Basin.

The Hammond, Indiana, control point would include the construction of a physical barrier 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.

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. *S. binderanus* is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag 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 to Brandon Road Lock and Dam.

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 Cal-Sag 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 *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 Cal-Sag 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 *S. binderanus* through the aquatic pathway to Brandon Road Lock and Dam. 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 Cal-Sag 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 Cal-Sag 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 *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.

T_{50}: See T_{25}.

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

T_0: See Nonstructural Risk Assessment for this species.

As part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, nonstructural measures such as restrictions on nutrient loads to waterways could affect habitat suitability for this species.

T_{10}: See T_0.

T_{25}: See T_0.

T_{50}: See T_{25}. See Nonstructural Risk Assessment for this species.

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 Cal-Sag 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 Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, the 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana, for *S. binderanus* with the construction of a physical barrier. 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 passage of *S. binderanus* through the aquatic pathway. *S. binderanus* is located in the Great Lakes Basin.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood that *S. binderanus* and vessels potentially transporting the species in ballast and bilge water or via hull fouling would pass through the aquatic pathway. 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 Cal-Sag 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 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 low.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Separation Cal-Sag 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 the passage of *S. binderanus* up to an extreme storm event, a 0.2% ACE event. 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}: 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

References

Calkins, J., and T. Thordardottir. 1980. The ecological significance of solar UV radiation on aquatic organisms. *Nature*, vol. 283, pp. 563–566.

EPA (U.S. Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule. Office of Water (4601), EPA 815-R-06–007. http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

Karentz, D. 1994. Ultraviolet tolerance mechanisms in Antarctic marine organisms. In: Weiler, C.S., P.A. Penhale (eds.). Ultraviolet Radiation in Antarctica: Measurements and Biological Effects. American Geophysical Union, Washington, D.C.

Kazumi, J. 2007. Ballast Water Treatment Technologies and Their Application for Vessels Entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

Kipp, R.M. 2011. *Stephanodiscus binderanus*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1687.

LimnoTech. 2010. Chicago Area Waterway System Habitat Evaluation and Improvement study: Habitat Evaluation Report. Prepared for the Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL.

Makarewicz, J.C., and R.I. Baybutt. 1981. Long-term 1927–1978 changes in the phytoplankton community of Lake Michigan at Chicago Illinois, USA. Bulletin of the Torrey Botanical Club, vol. 108(2), pp. 240–254.

Sutherland, T.F., C.D. Levings, C.C. Elliott, and W.W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139–148.

USACE (U.S. Army Corps of Engineers). 2011. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System.

Viitasalo, S., J. Sassi, J. Rytkönen, and E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35–55.

Waite, T.D., J. Kazumi, P.V. Z. Lane, L.L. Farmer, S.G. Smith, S.L. Smith, G. Hitchcock, and T.R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system, *Marine Ecology Progress Series*, vol. 258, pp. 51–63.

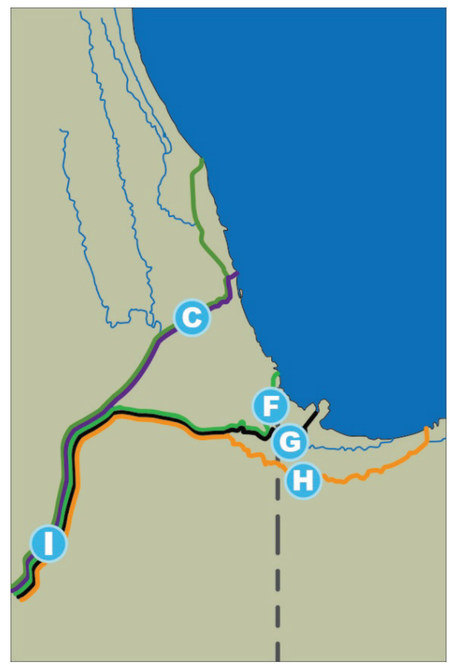
Wuebbles, D.J., K. Hayhoe, and J. Parzen. 2010. Introduction: assessing the effects of climate change on Chicago and the Great Lakes. *Journal of Great Lakes Research*, vol. 36, pp. 1–6.

E.7.2.2 Plants

E.7.2.2.1 Reed Sweetgrass (*Glyceria maxima*)

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures	
	State Line, IL/IN (G)	Physical Barrier
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock

Burns Small Boat Harbor	Nonstructural Measures	
	Hammond, IN (H)	Physical Barrier
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock

[a] The Mid-system Separation Cal-Sag 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.

[b] The Mid-system Separation Cal-Sag Open Control Technologies Alternative includes an electric barrier at Control Point (F) 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 CAL-SAG 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	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 Cal-Sag 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 the Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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

d. Type of Mobility/Invasion Speed
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach may be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. The implementation of a ballast/bilge water exchange program, education and outreach, promoting 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. 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. Nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. Additionally, 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 will 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}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 passage of reed sweetgrass through 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 will 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures as part of this alternative may contain the species and affect 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to reduce 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 Arrival

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	Low	Low	Low	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures as part of this alternative are expected to affect the arrival of reed sweetgrass at the CAWS. Nonstructural measures such as 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 Cal-Sag 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 Hydrologic Separation 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that are expected to affect the arrival of this species at WPS; 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 Cal-Sag 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 Cal-Sag 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 will 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 Cal-Sag 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 Cal-Sag 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 for reed sweetgrass at Stickney, Illinois, with the construction of a physical barrier and 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 (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

The physical barrier would be constructed in the channel at Stickney, 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 aquatic nuisance species from CSSC 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 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). They would also exclude reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments. Seeds of reed sweetgrass, which can typically range in size from 1.5 to 2 mm (Washington State Noxious Weed Control Board 2012), are expected to pass through the screens. Subsequently, they 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 Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration would be 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 CSSC 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, there is no commercial vessel traffic into the North Shore Channel (USACE 2011a).

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 Cal-Sag 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}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 CSSC 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 Cal-Sag 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. See the Nonstructural Risk Assessment for this species.
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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 reed sweetgrass through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Stickney, Illinois, with the construction of a physical barrier and 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 reed sweetgrass through the aquatic pathway.

The physical barrier constructed in the channel at the Stickney, Illinois, control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass 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, the ANSTP would treat CSSC water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point. The 0.4-in. 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 rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that percent 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Medium	Medium	***Low***	***Low***

[a] The highlighted 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 Cal-Sag 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 exposure of UV radiation, 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}: 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 CAL-SAG 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	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 Cal-Sag 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 the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal which are expected to 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach may be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. The implementation of a ballast/bilge water exchange program, education and outreach, promoting 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. 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. Nonstructural

measures would also include agency monitoring to locate areas where reed sweetgrass is established. Additionally, 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 will 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}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 passage of reed sweetgrass through 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 will continue (Howard 2012).

T_{50}: See T_{10}.

e. *Distance from Pathway*

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures as part of this alternative may 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within 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	Low	Low	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures as part of this alternative are expected to affect the arrival of reed sweetgrass at the CAWS. Nonstructural measures such as 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that 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 Cal-Sag 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 Cal-Sag 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, 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 will 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 Cal-Sag 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 Cal-Sag 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 for reed sweetgrass at Stickney, Illinois, with the construction of a physical barrier and 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 (i.e., current-driven passage) of reed sweetgrass through the aquatic pathway.

The physical barrier would be constructed in the channel at Stickney, 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 Chicago Sanitary and Ship Canal 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 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). They would also exclude reed sweetgrass plants, which can reach a height of 2.5 m (Washington State Noxious Weed Control Board 2012), and rhizome fragments. Seeds of reed sweetgrass, which can typically range in size from 1.5 to 2 mm (Washington State Noxious Weed Control Board 2012), are expected to pass through the screens. Subsequently, they 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 MWRDGC between 2007 and 2011, the CSSC at the Stickney, Illinois, control point is expected to have turbidity that may result in particulate interference thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, Illinois, pre-filtration would be 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 CSSC 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: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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}: See T_0.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 it 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 physical barrier. The ANSTP would treat CSSC 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 Cal-Sag 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. See the Nonstructural Risk Assessment for this species.
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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney, Illinois, with the construction of a physical barrier and 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 reed sweetgrass through the aquatic pathway.

The physical barrier in the channel at the Stickney, 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 at the Stickney, Illinois, control point would treat CSSC water for reed sweetgrass prior to discharge into the Mississippi River Basin side of the control point.

The 0.4-in. 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 rate of germination and seedling growth of redbean seeds following exposure to five doses of UV radiation (220–400 nm) and found that percent 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 exposure of UV radiation, and whether an additional treatment process is needed to control passage of reed sweetgrass. 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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)[b]	High	Low	High	Low	High	Low	High	Low
P(spreads)[b]	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 Calumet Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal which are expected to impact the invasion speed of reed sweetgrass by reducing existing populations. Hence, nonstructural measures as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative are expected to impact the invasion speed of reed sweetgrass to the CAWS, by natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach may be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. The implementation of a ballast/bilge water exchange program, education and outreach, promoting 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include ANS control methods such as aquatic herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal that are expected to 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. Additionally, 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 will focus management efforts on locations where reed sweetgrass is abundant. Overall, nonstructural measures as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative are expected to reduce the current abundance and reproductive capacity of reed sweetgrass within its current 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at T.J. O'Brien Lock and Dam in 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 passage 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 the Illinois Beach State Park just north of Waukegan, Illinois. This population was treated with herbicide, and monitoring will 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures as part of this alternative 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within 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	Low	Low	Medium
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures as part of this alternative are expected to affect the arrival of reed sweetgrass at the CAWSthrough aquatic pathways. Nonstructural measures such as 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to affect the arrival of this species at the CAWSthrough aquatic pathways; 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 Cal-Sag 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 Cal-Sag 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 will 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 Cal-Sag 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 Cal-Sag 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 T.J. O'Brien Lock and Dam, and a second at Brandon Road Lock and Dam. At the T.J. O'Brien Lock and Dam 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.

The GLMRIS Locks at the T.J. O'Brien Lock and Dam control point would be designed to minimize the creation of reed sweetgrass habitat surrounding the lock. Nonstructural measures would be used to monitor for the presence of reed sweetgrass and, if required, control the population surrounding the lock.

The electric barrier at the Calumet River side entrance to the T.J. O'Brien 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 Locks would include a pump-driven filling and emptying system to flush water from the lock and fill it with ANSTP water. If the lock is not flushed, it could transport reed sweetgrass seeds and plant fragments into the CAWS Buffer Zone. When the lock gates are closed, the lock is emptied of Calumet River 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 reed sweetgrass, would be removed from the lock chamber; however, the GLMRIS Locks would not be an effective control for hull-fouling species, such as this.

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 ones. The ANTSP would also supply the GLMRIS Locks with ANS-treated water for lock flushing.

ANSTP treatment technologies would include 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). 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. Subsequently, they 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. Water quality data indicates that Calumet River water is sufficiently clear to allow for effective UV treatment. Because UV radiation destroys microorganisms (bacteria, viruses, parasites, and protozoans) (EPA 1999, 2006), it is a well-established technology for disinfecting drinking water and domestic wastewater, 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 sluice gates to be constructed at the T.J. O'Brien Lock and Dam in Illinois, 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 Calumet River water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events requiring backflows, the solid gates would be opened and water from the Little Calumet River would be diverted toward the Calumet River through the screened sluice gates in order to reduce the flood risk. When this occurs, reed sweetgrass plant fragments and seeds are not expected to pass through the control point downstream toward the Mississippi River Basin. This is because the species is unable to passively drift against the velocity of the exiting current.

For storms that require the passage of a volume greater than the sluice gates can divert, GLMRIS Lock gates would be opened and CAWS water would be diverted toward the Calumet River 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 the Calumet River.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 reed sweetgrass seeds and plant fragments through the aquatic pathway to the Brandon Road Lock and Dam.

These measures are not expected to control the human-mediated transport of reed sweetgrass through the GLMRIS Lock by 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 Locks would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from them.

T_{50}: See T_{25}.

c. *Existing Physical Human/Natural Barriers*

T_0: None. The Mid-system Separation Cal-Sag 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}: See T_0.

T_{25}: See Section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented as part of this alternative are expected to control the natural dispersion of reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam; however, the species is expected to pass through the aquatic pathway 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 Locks would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not dislodge attached organisms from them.

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 Cal-Sag 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. Upgrading wastewater 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 some 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_{25}.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points: one at the current T.J. O'Brien Lock and Dam, and a second at Brandon Road Lock and Dam, that would be implemented at T_{25}. At the

T.J. O'Brien Lock and Dam control point, structural measures would include the construction of an ANSTP, GLMRIS Locks, electric barrier, and screened sluice gates.

The electric barrier would have no effect on the passage of reed sweetgrass. The GLMRIS Locks, 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 human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

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 reed sweetgrass.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the likelihood of reed sweetgrass passing through the aquatic pathway. The species could 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 Cal-Sag 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. Overall, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Separation Cal-Sag 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}: 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(3)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (3) 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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_0.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal which are expected to impact the invasion speed of reed sweetgrass by reducing existing populations. Hence, nonstructural measures as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative are expected to impact the invasion speed of reed sweetgrass to the CAWS by natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach may be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. The implementation of a ballast/bilge water exchange program, education and outreach, promoting 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. 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. Nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. Additionally, 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 will focus management efforts on locations where reed sweetgrass is abundant. Overall, nonstructural measures as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative are expected to reduce the current abundance and reproductive capacity of reed sweetgrass within its current 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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 passage of reed sweetgrass through the CAWS. Overall, none of these structural measures are 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 will continue (Howard 2012).

T_{50}: See T_0.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures as part of this alternative may contain the species, thereby affecting its arrival at the CAWSthrough 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability or suitable habitat for reed sweetgrass within 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	Low	Low	Medium
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures as part of this alternative are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Nonstructural measures such as 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 Cal-Sag 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 Cal-Sag 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}: Implementation of nonstructural measures as part of the Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to affect the arrival of this species at the CAWS through aquatic pathways; 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[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 Cal-Sag 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 will 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 Cal-Sag 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 Cal-Sag 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 Illinois-Indiana state line, and a second at the Brandon Road Lock and Dam.

The Illinois-Indiana state line control point would include the construction of a physical barrier in the channel that 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 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 reed sweetgrass.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 reed sweetgrass through the aquatic pathway to the Brandon Road Lock and Dam. 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: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 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.
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 Cal-Sag 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. Upgrading wastewater treatment plants and closing of two power plants should improve future water quality (Illinois Pollution Control Board 2012). Reed sweetgrass appears to benefit from some 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_{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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 the Illinois-Indiana state line with the construction of a physical barrier. 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 natural dispersion or human-mediated transport of reed sweetgrass through the CAWS.

The physical barrier constructed in the channel at the Illinois-Indiana state line control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass and vessels potentially transporting the species in ballast and bilge water or attached to vessel hulls would be unable to traverse the barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass and vessels potentially transporting it in ballast and bilge water, or via temporary attachment to vessel hulls, 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	High	High
Mid-system Separation Cal-Sag 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. Overall, the uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Separation Cal-Sag 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 by human-mediated transport and natural dispersion. The physical barrier is expected to control the passage of reed sweetgrass through the CAWS up to an extreme storm event, a 0.2% ACE event. 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}: 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(3)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (3) 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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include ANS control methods such as herbicides, cutting, burning, mechanical and/or manual harvesting, and soil removal which are expected to impact the invasion speed of reed sweetgrass by reducing existing populations. Hence, nonstructural measures as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative are expected to impact the invasion speed of reed sweetgrass to the CAWS by natural dispersion through aquatic pathways.

b. Human-Mediated Transport through Aquatic Pathways

See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures such as agency monitoring and voluntary occurrence reporting in combination with education and outreach may be used to determine where to target nonstructural control measures, in particular, aquatic herbicides. The implementation of a ballast/bilge water exchange program, education and outreach, promoting the use of anti-fouling hull paints, and laws and regulations may reduce the probability of 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. 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. Nonstructural measures would also include agency monitoring to locate areas where reed sweetgrass is established. Additionally, 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 will focus management efforts on locations where reed sweetgrass is abundant. Overall, nonstructural measures as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative are expected to affect the current abundance and reproductive capacity of reed sweetgrass within its current 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 passage of reed sweetgrass through the CAWS. Overall, none of these structural measures are 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 will 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures as part of this alternative may contain the species, thereby affecting its arrival at the CAWS through aquatic 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat for reed sweetgrass within 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	Low	Low	Medium
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[a] The highlighted table cell 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures as part of this alternative are expected to affect the arrival of reed sweetgrass at the CAWS through aquatic pathways. Nonstructural measures such as 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to affect the arrival of this species at the CAWS through aquatic pathways; 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	Low	Low	***Low***

[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 Cal-Sag 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, 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), is expected to 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 will 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana, and a second at the Brandon Road Lock and Dam. 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 passage of reed sweetgrass through the CAWS.

The Hammond, Indiana, control point would include the construction of a physical barrier 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 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 reed sweetgrass.

Overall, the Mid-system Separation Cal-Sag 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 to Brandon Road Lock and Dam.

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 Cal-Sag 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 Cal-Sag 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 reed sweetgrass through the aquatic pathway to the

Brandon Road Lock and Dam. 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 Cal-Sag 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}: See T_0.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 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.
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 Cal-Sag 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. Upgrading wastewater treatment plants and closing of two power plants should improve future water quality (Illinois Pollution Control Board 2012). Reed sweetgrass appears to benefit from some 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_{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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana, for reed sweetgrass with the construction of a physical barrier. 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 passage of reed sweetgrass through the CAWS.

The physical barrier constructed in the channel is expected to separate the Great Lakes and Mississippi River basins. It is expected that reed sweetgrass and vessels potentially transporting the species in ballast and bilge water or attached to vessel hulls would be unable to traverse the barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of reed sweetgrass through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of reed sweetgrass and vessels potentially transporting the species in ballast and bilge water, or via temporary attachment to vessel hulls, 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	High	High
Mid-system Separation Cal-Sag 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. Overall, the uncertainty remains medium.

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

T_{25}: Structural measures implemented as part of the Mid-system Separation Cal-Sag 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 the passage of reed sweetgrass up to an extreme storm event, a 0.2% ACE event. 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}: 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

References

EPA (U.S. Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, Office of Water (4601), EPA 815-R-06-007. http://www.epa.gov/ogwdw000/disinfection/lt2/pdfs/ guide_lt2_uvguidance.pdf.

Howard, V.M. 2012. *Glyceria maxima*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=1120.

Illinois Pollution Control Board. 2012. Water Quality Standards and Effluent Limitations for the Chicago Area Waterway System and Lower Des Plaines River: Proposed amendments to 35 ILL. ADM. CODE 301, 302, 303, and 304. Illinois Pollution Control Board, Chicago, IL.

Kazumi, J. 2007. Ballast Water Treatment Technologies and Their Application for Vessels Entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

King County Noxious Weeds. 2011. Reed sweetgrass (*Glyceria maxima*). http://www.kingcounty.gov/environment/animalsAndPlants/noxious-weeds/weed-identification/reed-sweetgrass.aspx.

Krizek, D.T. 1975. Influence of ultraviolet radiation on germination and early seedling growth. *Physiologia Plantarum*, vol. 34, pp. 182–186.

The Nature Conservancy Global Invasive Species Team (TNC-GIST). 2005. Weed Alert! *Glyceria maxima* (C. Hartm.) Holmb. (Reed sweetgrass). http://www.invasive.org/gist/alert/alrtglyc.html.

Peykarestan, B., and M. Seify. 2012. UV irradiation effects on seed germination and growth, protein content, peroxidase and protease activity in redbean. *International Research Journal of Applied and Basic Sciences*, vol. 3, no. 1, pp. 92–102.

Sutherland, T.F., C.D. Levings, C.C. Elliott, and W.W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139–148.

USACE (U.S. Army Corps of Engineers). 2011a. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System. Great Lakes and Mississippi River Interbasin Study (GLMRIS).

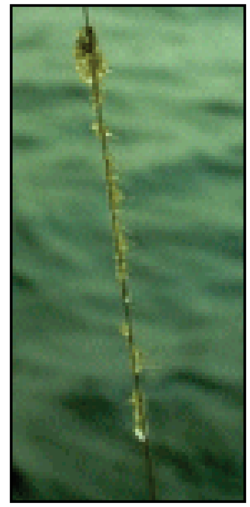
Viitasalo, S., J. Sassi, J. Rytkönen, and E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35–55.

Waite, T.D., J. Kazumi, P.V.Z. Lane, L.L. Farmer, S.G. Smith, S.L. Smith, G. Hitchcock, and T.R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system. *Marine Ecology Progress Series*, vol. 258, pp. 51–63.

Washington State Noxious Weed Control Board. 2012. Reed Sweetgrass Fact Sheet. http://your.kingcounty.gov/dnrp/library/water-and-land/weeds/Brochures/Reed_sweetgrass_fact_sheet.pdf.

E.7.2.3 Crustaceans

E.7.2.3.1 Fishhook Waterflea (*Cercopagis pengoi*)

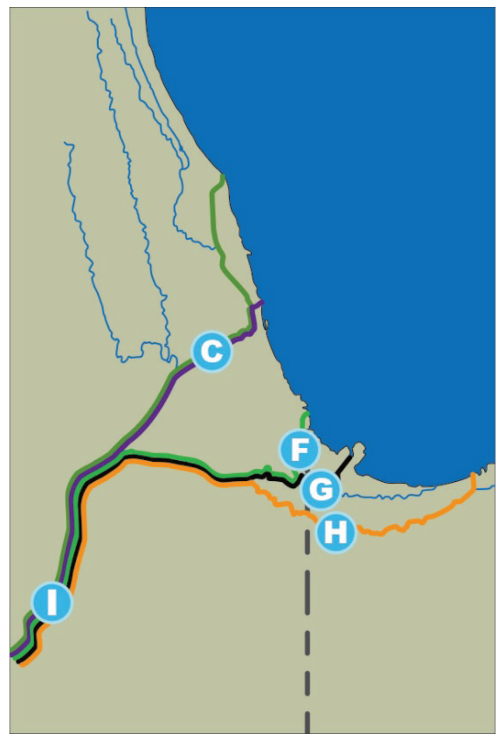


MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE ALTERNATIVE

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures[a]

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier[b]
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures	
	State Line, IL/IN (G)	Physical Barrier
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock



Burns Small Boat Harbor	Nonstructural Measures	
	Hammond, IN (H)	Physical Barrier
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock

[a] The Mid-system Separation Cal-Sag 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.

[b] The Mid-system Separation Cal-Sag Open Control Technologies Alternative includes an electric barrier at Control Point (F), which is ineffective for fishhook waterflea and does not impact its probability rating.

PATHWAY 1

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

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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

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 WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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

e. Type of Mobility/Invasion Speed
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 arrival of the fishhook waterflea from natural dispersion (i.e., passive drift) 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the probability of 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 Cal-Sag 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 (Benson et al. 2012).
T_{10}: See T_0.
T_{25}: The Mid-System Separation Cal-Sag Open Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 fishhook waterflea's arrival. Overall, none of these structural measures are 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 WPS are uncertain, but this species may be 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 Cal-Sag 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 Cal-Sag 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. 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}.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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, 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 Cal-Sag 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., passive drift) of the fishhook waterflea through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-System Separation Cal-Sag 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 fishhook waterflea at Stickney, Illinois with construction of a physical barrier and 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 is not expected to impact the fishhook waterflea, which is located in the Great Lakes basin.

The physical barrier would be constructed in the channel at Stickney, 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 natural dispersion of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from Chicago Sanitary and Ship Canal 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 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). The fishhook waterflea ranges between 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 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 CSSC at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney, 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag 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 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 Cal-Sag 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 fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat CSSC 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 would be unable to traverse the barrier. However, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

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 Cal-Sag 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 control the natural dispersion or human-mediated transport of the fishhook waterflea 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 Cal-Sag 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 fishhook waterflea 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 CSSC 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative would not 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 Cal-Sag 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 Cal-Sag 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 passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative's low 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 Cal-Sag 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 Stickney, Illinois with the construction of a physical barrier and 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 passage of the fishhook waterflea because it is located in the Great Lakes basin.
The physical barrier constructed in the channel 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 CSSC water for the fishhook waterflea prior to discharge into the Mississippi River Basin side of the control point. Vittasalo 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 $mJcm^{-3}$) 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of 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 Cal-Sag 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 Cal-Sag 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 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 2

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

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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

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 CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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, none of these structural measures are 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 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 Cal-Sag 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 Cal-Sag 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. 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}.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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

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 Cal-Sag 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., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-System Separation Cal-Sag 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 for the fishhook waterflea at Stickney, Illinois. This alternative includes the construction of a physical barrier and 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 side and would not impact the passage of the fishhook waterflea through the aquatic pathway because the fishhook waterflea is located in the Great Lakes basin.

The physical barrier would be constructed in the channel at Stickney, 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 passage of the fishhook waterflea by natural dispersion to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from CSSC 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 ranges between 0.02 to 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. 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 CSSC at the Stickney control point is expected to have turbidity that may result in particulate interference, thereby reducing the effectiveness of UV treatment. Consequently, at Stickney, 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag 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 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 Cal-Sag 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 Brandon Road Lock and Dam. The ANSTP would treat CSSC 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 it via ballast water, bilge water, or attached to hulls 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 Cal-Sag 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 control the natural dispersion or human-mediated transport of the fishhook waterflea 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 Cal-Sag 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 Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the fishhook waterflea 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 physical barrier. The ANSTP would treat CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 natural dispersion or human-mediated transport of the fishhook waterflea through the through the aquatic pathway. Therefore, the Mid-System Separation Cal-Sag 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 Cal-Sag 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 Stickney, Illinois by constructing a physical barrier and 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 passage of the fishhook waterflea because it is located in the Great Lakes basin.

The physical barrier constructed in the channel at the Stickney, 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 CSSC water for the fishhook waterflea prior to discharge into the Mississippi River Basin. Vittasalo 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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	–	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 Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the fishhook waterflea 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 Cal-Sag 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 Calumet Harbor pathway entrance (Benson et al. 2012).

T_{10}: See T_0.

T_{25}: The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at T.J. O'Brien Lock and Dam in 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, 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_0.

e. Distance from Pathway

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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Calumet Harbor are uncertain, but this species may be at 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 Cal-Sag 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 Cal-Sag 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 Calumet Harbor are uncertain, but this species may be at 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-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 Cal-Sag 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., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-System Separation Cal-Sag 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 the current T.J. O'Brien Lock and Dam by replacing the current lock with a GLMRIS Lock and constructing an electric barrier, 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 passage of the fishhook waterflea because it is located in the Great Lakes basin.

The GLMRIS Lock at the T.J. O'Brien Lock and Dam control point would be designed to minimize the creation of habitat surrounding the lock 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 Calumet River side entrance to the T.J. O'Brien GLMRIS Lock would be an ineffective control for the fishhook waterflea. 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 the fishhook waterflea, would be removed from the lock chamber. However, the GLMRIS Lock would be an ineffective control for hull fouling species. The fishhook waterflea is known to foul hulls of vessels (Sylvester and MacIsaac 2010) and could be transported through the GLMRIS Lock by this type of human-mediated transport. Therefore, the GLMRIS Lock would not address the passage of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from hulls.

The purpose of the ANSTP is to remove ANS from Calumet River water prior to discharge on the Mississippi River side of the control point. ANSTP effluent would be used to mitigate water quality impacts and maintain hydrologic conditions similar to 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 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. On the basis of water quality data, UV treatment at the T.J. Obrien Lock and Dam 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, salinity, and the size and type of organism.

Sluice gates would also be constructed at the T.J. O'Brien Lock and Dam in 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 Calumet River water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events requiring backflows to the Calumet River, the solid gates would be opened and water from the Little Calumet River would be diverted into the Calumet River through the screened sluice gates in order to reduce flood risk. When water from the Little Calumet River is diverted to the Calumet River during a backflow event, the fishhook waterflea would be unable to pass through the control point and into the Little Calumet River as the species is unable to passively drift against the exiting current.

If the sluice gates are unable to divert a sufficient volume of water during flood events, then the GLMRIS Lock gates would be opened. As with the open screened sluice gates, the fishhook waterflea is expected to be unable to drift into the CAWS against the velocity of the exiting current.

The Mid-System Separation Cal-Sag 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 Cal-Sag 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 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 description of the Mid-System Separation Cal-Sag 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 Brandon Road Lock and Dam. Specifically, this alternative is not expected to control the human-mediated transport of the fishhook waterflea through the GLMRIS Lock 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 the passage of this species via hull fouling because the lock does not 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 Cal-Sag 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 description of the Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the natural dispersion (i.e., passive drift) of the fishhook waterflea 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 via hull-fouling on vessels. The fishhook waterflea is known to foul hulls of vessels (Sylvester and MacIsaac 2010) and could be transported through the GLMRIS Lock by this type of human-mediated transport. The GLMRIS Lock would not address the passage of the fishhook waterflea due to hull fouling because the lock does not dislodge attached organisms from 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that can be implemented at T_0. However, these measures alone are not expected to affect passage of the fishhook waterflea through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative's low probability 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points — one at the current T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam — that would be implemented at T_{25}. At the T.J. O'Brien Lock and Dam, structural measures would include the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates.

The electric barrier would have no effect on 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 human-mediated transport of the species via hull fouling on vessels. Specifically, the GLMRIS Lock does not remove attached organisms.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative does not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway; therefore, the probability of passage remains medium.

T_{50}: See T_{25}. Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative does not reduce the likelihood of the fishhook waterflea passing through the aquatic pathway; therefore, 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 Cal-Sag 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. The uncertainty remains medium.

T_{10}: See T_0.

T_{25}: Structural measures as part of the Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative are not expected to control the human-mediated transport of the fishhook waterflea through the aquatic pathway; 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 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM
MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	None	None	None	None
Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Lakefront Hydrologic Separation Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_0.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Indiana Harbor pathway entrance (Benson et al. 2012).

T_{10}: See T_0.

T_{25}: The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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 fishhook waterflea is in the Great Lakes basin. Overall, 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 Indiana Harbor.

T_{50}: See T_0.

e. *Distance from Pathway*

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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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 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, 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 Cal-Sag 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., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_{10}.

T_{25}: The Mid-System Separation Cal-Sag 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 the Illinois-Indiana state line by constructing a physical barrier. 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 passage of the fishhook waterflea through the aquatic pathway.

The Illinois-Indiana state line control point would include the construction of a physical barrier 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.

Overall, the Mid-system Separation Cal-Sag 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 to Brandon Road Lock and Dam.

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 Cal-Sag 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 fishhook waterflea 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 Cal-Sag 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 Brandon Road Lock and Dam. 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 attached to hulls 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 Cal-Sag 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. 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 Cal-Sag 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 it in ballast or bilge water or attached to hulls 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability within the CAWS for the fishhook waterflea.

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 Cal-Sag 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 Cal-Sag 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 natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Therefore, the probability of passage remains low.

T_{10}: See T_0.

T_{25}: The Mid-System Separation Cal-Sag 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 the Illinois-Indiana state line with the construction of a physical barrier.

The physical barrier constructed in the channel at the Illinois-Indiana state line 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 the fishhook waterflea through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the fishhook waterflea passing through the aquatic pathway. 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 Cal-Sag 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 Cal-Sag 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 physical barrier is expected to control the passage of the fishhook waterflea up to an extreme storm event, a 0.2% ACE event. 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of passage is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	None	None	None	None
Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	None	None	***Low***	***Low***

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 control the arrival of the fishhook waterflea at the pathway. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to limit the movement of the fishhook waterflea 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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, 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 Cal-Sag 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., passive drift) of the fishhook waterflea through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-System Separation Cal-Sag 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 Hammond, Indiana, by constructing a physical barrier. 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 passage of the fishhook waterflea through the aquatic pathway. The fishhook waterflea is in the Great Lakes basin.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the fishhook waterflea through the aquatic pathway to Brandon Road Lock and Dam.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Risk Assessment for this species.

The Technology Alternative with a Buffer Zone includes nonstructural measures that 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 Cal-Sag 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 Brandon Road Lock and Dam. 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 attached to vessel hulls 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 Cal-Sag 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 Cal-Sag 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 fishhook waterflea through the aquatic pathway because the species and vessels potentially transporting it via ballast or bilge water or attached to vessel hulls 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 natural dispersion or human-mediated transport of the fishhook waterflea through the aquatic pathway. Therefore, the Mid-System Separation Cal-Sag 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 Cal-Sag 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 Hammond, Indiana, by constructing a physical barrier. 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 passage of the fishhook waterflea through the aquatic pathway. The fishhook waterflea is in the Great Lakes basin.

The physical barrier constructed in the channel at the Hammond, Indiana, 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the fishhook waterflea passing through the aquatic pathway. 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 Cal-Sag 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 Cal-Sag 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 physical barrier is expected to control the passage of this species up to an extreme storm event, a 0.2% ACE event. 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

Benson, A., E. Maynard, and D. Raikow. 2012. *Cercopagis pengoi*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=163.

Crosier, D.M., and D.P. Molloy. 2007. Fishhook Waterflea – *Cercopagis pengoi*. New York State Museum.

EPA (U.S. Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. EPA 832-F-99-064. Office of Water.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule. Office of Water (4601), EPA 815-R-06–007. http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

Kazumi, J. 2007. Ballast water treatment technologies and their application for vessels entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291.

Sutherland, T.F., C.D. Levings, C.C. Elliott, and W.W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139–148.

Sylvester, F., and H.J. MacIsaac. 2010. Is vessel hull fouling an invasion threat to the Great Lakes? *Diversity and Distributions*, vol. 16, pp. 132–143.

USACE (U.S. Army Corps of Engineers). 2011. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System. GLMRIS.

Viitasalo, S., J. Sassi, J. Rytkönen, and E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35–55.

Waite, T.D., J. Kazumi, P.V.Z. Lane, L.L. Farmer, S.G. Smith, S.L. Smith, G. Hitchcock, and T.R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system. *Marine Ecology Progress Series*, vol. 258, pp. 51–63.

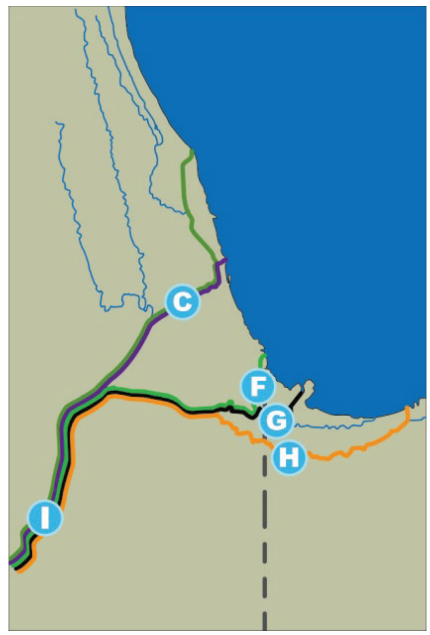
E.7.2.3.2 Bloody Red Shrimp (Hemimysis anomala)

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier[c]
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	State Line, IL/IN (G)	Physical Barrier
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier
	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 bloody red shrimp.

[b] The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies Alternative includes an electric barrier at Control Point (F), which is ineffective for the bloody red shrimp and does not impact its probability rating.

PATHWAY 1

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

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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 the WPS and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone does not affect the pathway for bloody red shrimp.

T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersal (i.e., passive drift) 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and the ANSTP at Stickney, 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 bloody red shrimp at the CAWS. The physical barrier is 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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 at Stickney, Illinois, with the construction of a physical barrier and ANSTP. 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 passage of the bloody red shrimp through the aquatic pathway.

The physical barrier would be constructed in the channel at Stickney, 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 bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from CSSC 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 current conditions.

The treatment technologies included in the ANSTP would include screening, filtration 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). 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 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 CSSC at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., 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 Cal-Sag 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 Cal-Sag 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 CSSC 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 human-mediated transport of the species through the aquatic pathway because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

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 Cal-Sag 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 Cal-Sag 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 bloody red shrimp to Brandon Road Lock and Dam. The physical barrier is expected to control the natural dispersion and human-mediated transport of the bloody red shrimp

through the aquatic pathway, because the species and vessels transporting it would be unable to traverse the barrier. The ANSTP would treat CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures 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 Cal-Sag Open Control Technologies with a Buffer Zone 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 Cal-Sag 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 Stickney, 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 is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.
The physical barrier constructed in the channel at the Stickney, Illinois, control point 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 natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP also constructed at Stickney, Illinois, would treat CSSC 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 the 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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. Further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, and length of exposure and whether an additional treatment process is needed to control passage of the bloody red shrimp 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 2

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

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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 the Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for the bloody red shrimp.
T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion (i.e., 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 bloody red shrimp at the CAWS. Overall, none of these structural measures are 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp at the CAWS through aquatic pathways. 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 Cal-Sag 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 Cal-Sag 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 at Stickney, 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 is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The physical barrier would be constructed in the channel at Stickney, 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 bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove aquatic nuisance species from CSSC 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). 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 constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, the CSSC at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney, 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative. This alternative is expected to control the human-mediated transport of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the vessel-mediated transport of the species through the aquatic pathway because vessels potentially transporting it would be unable to traverse the barrier. The ANSTP would treat CSSC water for the bloody red shrimp prior to discharge into the Mississippi River Basin side of the control point.

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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative. This alternative is expected to control the natural dispersion and human-mediated transport of the bloody red shrimp 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 transporting it would be unable to traverse the physical barrier. The ANSTP would treat CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, these measures are expected to have no effect on the passage of the bloody red shrimp through the CAWS by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures include the construction of a physical barrier and ANSTP. 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 passage of the bloody red shrimp through the aquatic pathway.

The physical barrier constructed in the channel at the Stickney, Illinois, control point 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 natural dispersion and human-mediated transport of this species through the aquatic pathway.

In addition, the ANSTP would treat CSSC 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 the 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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. With regard to the ANSTP, there are no data that specifically measure the effects of UV radiation on bloody red shrimp. Prior to design and construction, further investigation and bench-scale studies would be needed to determine the optimum wavelength, required dose, length of exposure and whether

an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Overall, the uncertainty of passage 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 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 Calumet Harbor and Brandon Road Lock and Dam over the next 50 years.

The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would not affect the existence of 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion (i.e., 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates near the T.J. O'Brien Lock and Dam in 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 bloody red shrimp through 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_0.

e. Distance from Pathway

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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. The alternative creates a control point at the current T.J. O'Brien Lock and Dam 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 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 passage of the bloody red shrimp through the aquatic pathway.

The GLMRIS Lock 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 Calumet River side entrance to the T.J. O'Brien GLMRIS Lock is not expected to be an effective control for the bloody red shrimp. This species passage through the U-shaped engineered channel 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 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 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 the bloody red shrimp, would be removed from the lock chamber.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet River water prior to its discharge into the Mississippi River Basin side of the control point. ANSTP effluent would be used to mitigate water quality impacts and to maintain hydrologic conditions similar to 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 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 Calumet River water at the T.J. O'Brien Lock and Dam 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.

Sluice gates would also be constructed at T.J. O'Brien Lock and Dam in 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 Calumet River 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 Little Calumet River would be diverted into the Calumet River through the screened gates to reduce flood risk. When water from the Little Calumet River is diverted to the Calumet River during a storm event, the bloody red shrimp is expected to be unable to pass through the control point and into the Little Calumet River due to the species being unable to passively drift against the velocity of the exiting current.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion 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 Cal-Sag 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 Cal-Sag 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 Calumet River water for bloody red shrimp prior to its discharge into the CAWS. The sluice gates are expected to control passage during dry weather conditions when they would be closed. During large storm events requiring backflows to Lake Michigan, the bloody red shrimp would be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the aquatic pathway. Additionally, discharging ballast and bilge water, as part of the nonstructural measures, prior to entering the GLMRIS Lock is expected to help control the human-mediated transport of the bloody red shrimp 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 Cal-Sag 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 Cal-Sag 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 bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Calumet River water for bloody red shrimp prior to its discharge into the CAWS. The sluice gates are expected to control passage during dry weather conditions when they would be closed. During large storm events requiring backflows to Lake Michigan, the bloody red shrimp would be unable to passively drift against the velocity of the exiting current through the screened sluice gates to enter the aquatic pathway. Nonstructural measures, such as discharging ballast and bilge water prior to entering the GLMRIS Lock, are expected to help control the human-mediated transport of the bloody red shrimp 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative's high rating does not differ for this time step from that reported in the No New Federal Action Risk Assessment.
T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag 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 T.J. O'Brien Lock and Dam in 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 is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The GLMRIS Lock at the T.J. O'Brien Lock and Dam control point is expected to address the passage of the bloody red shrimp by natural dispersion (i.e. 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 have no effect on the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The purpose of the ANSTP is to treat Calumet River water for ANS prior to 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 the 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 to discharge water from the CAWS. The discharged water would pass through screened sluice gates prior to discharge into the Calumet River. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp passing through the aquatic pathway. Therefore, the probability of passage is reduced to low.

T_{50}: See T_0.

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 Cal-Sag 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 natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Therefore, the uncertainty remains medium.
T_{10}: See T_0. Nonstructural measures alone are not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Therefore, the uncertainty remains low.
T_{25}: Structural measures, as part of the Mid-system Separation Cal-Sag 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 to control the bloody red shrimp from transferring. Research needs would include modeling, laboratory and field testing to determine the optimal design, and operating parameters. Prior to design and construction, as well, 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 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 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The physical barrier, implemented as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, 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. Overall, the uncertainty is low.
T_{50}: See T_0.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the bloody red shrimp from natural dispersion (i.e., 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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 is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through aquatic pathways to the CAWS. Overall, structural measures are not expected to control the arrival of the bloody red shrimp at the CAWS through aquatic pathways. 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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.

This species' potential rate of spread through the aquatic pathway is uncertain. The lack of vessel traffic and the upstream movement required to move through the aquatic pathway are expected to slow passage to an uncertain degree.

The Mid-System Separation Cal-Sag 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}: 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 Cal-Sag 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_{10}.
T_{25}: The Mid-system Separation Cal-Sag 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 the Illinois-Indiana state line by constructing a physical barrier. 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 is not expected to control the natural dispersion (i.e., passive drift) of the bloody red shrimp through the aquatic pathway.
The physical barrier would be constructed in the channel at the Illinois-Indiana state line 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.
Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., 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 Cal-Sag 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_{10}.
T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam. The physical barrier is expected to control the human-mediated transport of the species through the aquatic pathway, 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: There are no existing barriers; the species is likely already at the pathway. The Mid-system Separation Cal-Sag 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 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 Cal-Sag 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 bloody red shrimp 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 bloody red shrimp 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 Risk Assessment for this species.

The Mid-System Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 passage of the bloody red shrimp through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Technology with a Buffer Zone Alternative's low rating does not differ for this time step 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 Cal-Sag 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 the Illinois-Indiana state line with the construction of a physical barrier. 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 is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The physical barrier constructed in the channel at the Illinois-Indiana state line control point is expected to separate the Great Lakes and Mississippi River basins. Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp 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	High	High
Mid-system Separation Cal-Sag 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 natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The physical barrier is expected to control the passage of the bloody red shrimp through the CAWS up to an extreme storm event, a 0.2% ACE event. 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, Electric Barrier, and GLMRIS Lock

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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The physical barrier, implemented as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the probability of arrival of the bloody red shrimp from natural dispersion (i.e., 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 Cal-Sag 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.

c. 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 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 is not expected affect the natural dispersion or human-mediated transport of the species through aquatic pathways to the CAWS. Overall, structural measures are not expected to control the arrival of the bloody red shrimp at the pathway. 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 Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to control 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 Cal-Sag 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 Cal-Sag 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}: 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 Cal-Sag 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 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures as part of the alternative would create a control point for the bloody red shrimp at Hammond, Indiana, with the construction of a physical barrier. 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 is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., passive drift) of the bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam.

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 Cal-Sag 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_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 bloody red shrimp through the aquatic pathway to Brandon Road Lock and Dam, because vessels potentially transporting the species in ballast and bilge water 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 Cal-Sag 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 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 Cal-Sag 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 bloody red shrimp to Brandon Road Lock and Dam. The physical barrier is expected to control the passage 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 Risk Assessment for this species.

The Mid-System Separation Cal-Sag 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_{25}.

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 Cal-Sag 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 Cal-Sag 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 Technology with a Buffer Zone Alternative's low probability of passage rating does not differ for this time step from that reported in the No New Federal Action Risk Assessment.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{25}. Structural measures, as part of this alternative, create a control point at Hammond, Indiana, with the construction of a physical barrier. 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 is not expected to affect the natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway.

The physical barrier constructed in the channel at Hammond, Indiana, is expected to separate the Great Lakes and Mississippi River basins.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the bloody red shrimp 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	High	High
Mid-system Separation Cal-Sag 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 natural dispersion or human-mediated transport of the bloody red shrimp through the aquatic pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that are expected to control the natural dispersion and human-mediated transport of the bloody red shrimp through the aquatic pathway. The physical barrier is expected to control the passage of this species up to an extreme storm event, a 0.2% ACE event. 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

EPA (Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, Office of Water (4601), EPA 815-R-06-007. http://www.epa.gov/ogwdw000/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

Kazumi, J. 2007. Ballast water treatment technologies and their application for vessels entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

Kipp, R.M., A. Ricciardi, J. Larson, and A. Fusaro. 2011. *Hemimysis anomala*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. Revision date Aug. 8, 2007. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=2627.

Raikow, D.F., D.F. Reid, E.R. Blatchley III, G. Jacobs, and P.F. Landrum. 2007. Effects of proposed physical ballast tank treatments on aquatic invertebrate resting eggs. *Environmental Toxicology and Chemistry*, vol. 26, no. 4, pp. 717–725.

Sutherland, T.F., C.D. Levings, C.C. Elliott, and W.W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139–148.

USACE (U.S. Army Corps of Engineers). 2011. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System. Great Lakes & Mississippi River Interbasin Study GLMRIS.

Viitasalo, S., J. Sassi, J. Rytkönen, and E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35–55.

Waite, T.D., J. Kazumi, P.V.Z. Lane, L.L. Farmer, S.G. Smith, S.L. Smith, G. Hitchcock, and T.R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system, *Marine Ecology Progress Series*, vol. 258, pp. 51–63.

E.7.2.4 Fish

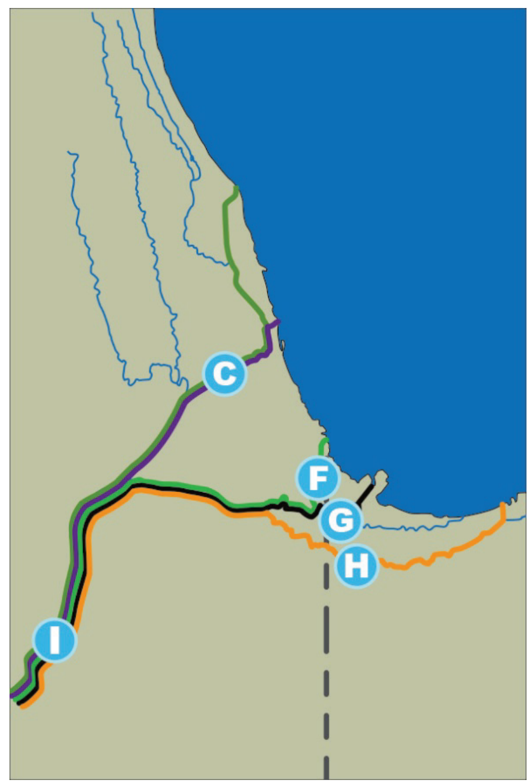
E.7.2.4.1 Threespine Stickleback (Gasterosteus aculeatus)

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



<table>
<tr><td rowspan="4">Indiana Harbor</td><td colspan="2">Nonstructural Measures[a]</td></tr>
<tr><td>State Line, IL/IN (G)</td><td>Physical Barrier</td></tr>
<tr><td rowspan="2">Brandon Road Lock and Dam (I)[b]</td><td>Electric Barrier</td></tr>
<tr><td>GLMRIS Lock</td></tr>
<tr><td rowspan="4">Burns Small Boat Harbor</td><td colspan="2">Nonstructural Measures[a]</td></tr>
<tr><td>Hammond, IN (H)</td><td>Physical Barrier</td></tr>
<tr><td rowspan="2">Brandon Road Lock and Dam (I)[b]</td><td>Electric Barrier</td></tr>
<tr><td>GLMRIS Lock</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 threespine stickleback.
[b] The Mid-system Separation Cal-Sag 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 affect this species probability ratings.</td></tr>
</table>

PATHWAY 1

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

MID-SYSTEM SEPARATION CAL-SAG 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)	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 Cal-Sag 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect arrival of the threespine stickleback at the Chicago Area Waterway System (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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect arrival of the threespine stickleback from human-mediated transport.

c. Current Abundance and Reproductive Capacity
T_0: See the Nonstructural Risk Assessment for this species.
It is uncertain whether nonstructural measures as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative may 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 WPS.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Stickney, 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 affect the arrival of the threespine stickleback to the CAWS. Overall, none of these structural measures are expected to control the arrival of the threespine stickleback at the CAWS since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback in southern Lake Michigan.

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	High	High	High	High
Mid-system Separation Cal-Sag 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 Cal-Sag 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. In addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Overall, 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	None	None	None	None
Mid-system Separation Cal-Sag 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 North Shore Channel, just beyond the entrance to the WPS pathway. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback, which is already present at the pathway. In addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). Overall, 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 Cal-Sag 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 Cal-Sag 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 for the threespine stickleback at Stickney, 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 Stickney, 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 natural dispersion of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from CSSC 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 conditions.

The treatment technologies included in the ANSTP would include screening, filtration, 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 the threespine stickleback, which typically has a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and 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 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, as well as 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 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 CSSC at the Stickney control point may reduce the effectiveness of UV treatment. Consequently, at Stickney, 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for the threespine stickleback prior to discharging it 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, there is no commercial vessel traffic into the North Shore Channel (USACE 2011a, b).

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 Cal-Sag 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 or human-mediated transport of 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 Cal-Sag 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 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 threespine stickleback 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 threespine stickleback prior to discharging it 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 Cal-Sag 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_{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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 Stickney, 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 at the Stickney, Illinois, control point 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, larvae, or 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.

In addition, the ANSTP would treat CSSC 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 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 to embryos (lesions in the liver, kidney, skin, and intestines, as well as gill, eye, and spinal cord malformations) 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 due 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the threespine stickleback passing through the aquatic pathway 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	Low	Low	Low
Mid-system Separation Cal-Sag 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 as part of the Mid-system Separation Cal-Sag 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 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. 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 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 2

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

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISTMENT 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 Cal-Sag 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 CRCW and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative may 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Stickney, 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 affect the arrival of the threespine stickleback at the CAWS. Overall, none of these structural measures are expected to control the arrival of the threespine stickleback at the CAWS, since in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback in southern Lake Michigan.
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	High	High	High	High
Mid-system Separation Cal-Sag 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 Cal-Sag 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. In addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). 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	None	None	None	None
Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species is documented near the CRCW pathway. The Mid-system Separation Cal-Sag 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. In addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 Cal-Sag 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., passive drift) of the threespine stickleback through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag 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 for the threespine stickleback at Stickney, 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 Stickney, 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 natural dispersion of the threespine stickleback through the aquatic pathway.

The purpose of the ANSTP at the Stickney control point is to remove ANS from CSSC 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 inactivate 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 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, as well as 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 constituents, such as iron, nitrate, and natural organic matter. Based on water quality data collected by MWRDGC between 2007 and 2011, it is expected that the turbidity of the CSSC at the Stickney control point may reduce the effectiveness of UV treatment. Consequently, at Stickney, 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 at 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for the threespine stickleback prior to discharging it 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 Cal-Sag 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 threespine stickleback 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 Cal-Sag 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 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 physical barrier. The ANSTP would treat CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 the threespine stickleback through the aquatic pathway. 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 Cal-Sag 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 Stickney, 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 at the Stickney, Illinois, control point 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, 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.

In addition, the ANSTP would treat CSSC 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 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 to embryos (lesions in the liver, kidney, skin, and intestines, and gill, eye, and spinal cord malformations) 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 due 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 Cal-Sag 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 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	Low	Low	Low
Mid-system Separation Cal-Sag 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 threespine stickleback 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 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative are expected to control the passage of the threespine stickleback by human-mediated transport and natural dispersion. 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 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 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag 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 Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from 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 Cal-Sag 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. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative does not include physical human/natural barriers.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag 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 T.J. O'Brien Lock and Dam in 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 at the aquatic pathway. Overall, none of these structural measures are expected to act as physical barriers to the arrival of the threespine stickleback at the CAWS, since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback 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 Cal-Sag 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 Cal-Sag 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. In addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near

Lockport Lock and Dam (INHS undated). The species has already arrived at the pathway. 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 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	None	None	None	None

Evidence for Uncertainty Rating

T_0: The species is documented near the Calumet Harbor pathway. The Mid-system Separation Cal-Sag 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. In addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 Cal-Sag 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 Cal-Sag 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 the current T.J. O'Brien Lock and Dam 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 address ANS originating in the Mississippi River Basin and would not affect the passage of the threespine stickleback through the aquatic pathway.

At the T.J. O'Brien Lock and Dam control point, these structures would be designed to minimize the creation of habitat surrounding the lock 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 through the aquatic pathway. The electrical barrier would be placed within an engineered channel that would extend from the Calumet River side of the GLMRIS Lock into the Calumet River. To minimize opportunities for Great Lakes fish to bypass through 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 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 threespine stickleback eggs, larvae, and fry, would be removed from the lock chamber.

The purpose of the ANSTP is to remove aquatic nuisance species from Calumet River 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 threespine stickleback 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 threespine sticklebacks, which typically have a total length of approximately 4.3 in. (110 mm) (FishBase 2013) and body depth 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, as well as fish with body width 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 Calumet River water at the T.J. O'Brien Lock and Dam 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.

Additionally, sluice gates would also be constructed at the T.J. O'Brien Lock and Dam control point. The sluice gates would be com*pr*ised 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 Calumet River 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 Little Calumet River would be diverted into the Calumet River through the screened gates in order to reduce flood risk. When water from the Little Calumet River is diverted to the Calumet River during a storm event, it is expected that threespine stickleback would be unable to pass through the screened sluice gates and into the Little Calumet River. The 0.4 in. (10.2 mm) openings of the screened sluice gate are equal to or smaller than the body depth of typical threespine stickleback (threespine stickleback body depth, 0.4–0.6 in. or 11.4–14.6 mm; Bergstrom 2002). Threespine stickleback with body depths less than 0.4 in. and eggs, larvae, and fry are not expected to pass through the control point into the Little Calumet 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 the Calumet River through the lock. Again, passive drifting eggs, larvae and fry are expected to be unable to drift through the GLMRIS Lock while water was flowing from the CAWS through the lock into the Calumet River. In addition, it is expected that threespine stickleback trying to swim against the exiting current would be deterred by the electric barrier and unable to pass through the lock.

Overall, the Mid-system Separation Cal-Sag 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 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 Cal-Sag 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 Cal-Sag 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 through the aquatic pathway. Additionally, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to reduce the passage of threespine stickleback through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation Cal-Sag 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 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 Cal-Sag 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 threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. Calumet River water would be treated for threespine stickleback by the ANSTP prior to discharge 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 the threespine stickleback 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 the threespine stickleback through the aquatic pathway. 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 Cal-Sag 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 gate at the T.J. O'Brien Lock and Dam in 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 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.

In addition, the ANSTP would treat Calumet River 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 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 to embryos (lesions in the liver, kidney, skin, as well as intestines, and gill, eye, and spinal cord malformations) 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 due 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 gate is open only during flood events, and water from the CAWS would be diverted through screened sluice gates prior to discharge into the Calumet River. The screen size is 0.4 in (11.4 mm). Body depth of the threespine stickleback is typically 0.4 to 0.6 in (11.4 to 14.6 mm). During these events, it is expected that threespine stickleback would be unable to pass through the screened sluice gates. Fish with body depth 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer[a] Zone Rating	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 of threespine stickleback 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 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 Cal-Sag 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 GLMRIS Lock is a novel technology that would need to be designed, built, and calibrated in order to control the threespine stickleback from transferring. 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, length of UV radiation exposure, and whether an additional treatment process is needed to control passage of the bloody red shrimp through the ANSTP. Additionally, operating parameters for 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 4
INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures and Physical 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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Overall, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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 to the CAWS. Overall, none of these structural measures are expected to control the arrival of the threespine stickleback at the CAWS, since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback at the CAWS, since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 arrival of 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 Cal-Sag 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 Cal-Sag 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. In addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 Cal-Sag 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_{10}.
T_{25}: The Mid-system Separation Cal-Sag 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 for the threespine stickleback at the Illinois-Indiana state line with the construction of a physical barrier. 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 the Illinois-Indiana state line 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam.

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 Cal-Sag 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_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. 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 Cal-Sag 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 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 Cal-Sag 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 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 threespine stickleback through the aquatic pathway, since 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 Risk Assessment for this species.
The Mid-system Separation Cal-Sag 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_{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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that can 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 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 Cal-Sag 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 the Illinois-Indiana state line with the construction of a physical barrier. 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 the species 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 the species through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the 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 Cal-Sag 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}: See T_0. 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 as part of the Mid-system Separation Cal-Sag 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 the passage of threespine stickleback up to an extreme storm event, a 0.2% ACE event. 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures and Physical 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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Overall, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating:

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback from 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 at the CAWS. Overall, none of these structural measures are expected to control the arrival of the threespine stickleback at the pathway, since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to reduce the habitat suitability for the threespine stickleback in southern Lake Michigan.
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	High	High	High	High
Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the threespine stickleback through aquatic pathways at the CAWS, since, in addition to being established in southern Lake Michigan, the threespine stickleback was found in the North Shore Channel in 1988 (Johnston 1991). Furthermore, the Illinois Natural History survey has found the threespine stickleback near Lockport Lock and Dam (INHS undated). The species has 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	None	None	None	None
Mid-system Separation Cal-Sag 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 Cal-Sag 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. 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 Cal-Sag 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 Cal-Sag 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 for the threespine stickleback at Hammond, Indiana, with the construction of a physical barrier. 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 Hammond, Indiana, 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam.

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 Cal-Sag 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_{10} for a description of the Mid-system Separation Cal-Sag 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 threespine stickleback through the aquatic pathway to the Brandon Road Lock and Dam. 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 Cal-Sag 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 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_{10} for a description of the Mid-system Separation Cal-Sag 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 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 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 Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 natural dispersion or human-mediated transport of the threespine stickleback through the aquatic pathway. 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 Cal-Sag 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 Hammond, Indiana, with the construction of a physical barrier. 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. The physical barrier is expected to control the passage of the threespine stickleback by natural dispersion and human-mediated transport, because the species and vessels potentially transporting it in ballast and bilge water would be unable to traverse the barrier.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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}: See T_0. 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 as part of the Mid-system Separation Cal-Sag 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 the passage of the species up to an extreme storm event, a 0.2% ACE event. 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

Bergstrom, C.A. 2002. Fast-start swimming performance and reduction in lateral plate number in threespine stickleback. *Canadian Journal of Zoology* vol. 80, pp. 207–213.

EPA. (U.S. Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule. Office of Water (4601), EPA 815-R-06–007. http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

Fishbase. 2013. *Gasterosteus aculeatus aculeatus* Linnaeus, 1758 Three-spined stickleback. http://www.fishbase.org/Summary/speciesSummary.php?ID=2420&AT=threespine+stickleback. Accessed 12 September 2013.

INHS (Illinois Natural History Survey). Undated. http://www.inhs.uiuc.edu/cbd/ilspecies/fishmaps/ga_aculeat.gif.

Johnston, C.E. 1991. Discovery of the threespine stickleback (*Gasterosteus aculeatus*) (Pisces: Gasterosteidae) in Lake Michigan drainage, Illinois. *Transactions of the Illinois State Academy of Science*, vol. 84, pp. 173.

Jordan, D. Starr and Barton W. Evermann. 1896-1900. The Fishes of North and Middle America: A Descriptive Catalogue of the Species of Fish-Like Vertebrates found in the Waters of North America, North of the Isthmus of Panama (Bulletin of U.S. National Museum, no. 47).

Kazumi, J. 2007. Ballast water treatment technologies and their application for vessels entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

Mahmoud, U. M., I. A. A. Mekkawy, and E. H. Sayed. 2009. Ultraviolet radiation-A (366 nm) induced morphological and histological malformations during embryogenesis of *Clarias gariepinus* (Burchell, 1822). *Journal of Photochemistry and Photobiology B: Biology*, vol. 95, pp. 117-128.

Sutherland, T. F., C. D. Levings, C. C. Elliott, and W. W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139-148.

Swarup, H. 1958. Stages in the Development of the Stickleback *Gasterosteus aculeatus* (L.). *Journal of Embryology and Experimental Morphology* 6(3):373-383.

USACE (U.S. Army Corps of Engineers). 2011a. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System Great Lakes and Mississippi River Interbasin Study (GLMRIS). Chicago District, Chicago, IL. 32 pp. http://glmris.anl.gov/documents/docs/ GLMRIS_Baseline_Cargo.pdf. Accessed June 27, 2013.

USACE (U.S. Army Corps of Engineers). 2011b. Baseline Assessment of Non-Cargo CAWS Traffic. Great Lakes and Mississippi River Interbasin Study (GLMRIS). Chicago District, Chicago, IL. 28 pp. http://glmris.anl.gov/documents/docs/GLMRIS_Baseline_NonCargo.pdf. Accessed June 27, 2013.

Viitasalo, S., J. Sassi, J. Rytkönen, E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35-55.

Waite, T. D., J. Kazumi, P. V. Z. Lane, L. L. Farmer, S. G. Smith, S. L. Smith, G. Hitchcock, and T. R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system, *Marine Ecology Progress Series*, vol. 258, pp. 51-63.

Zagarese, H. E. and C. E. Williamson. 2001. The implications of solar UV radiation exposure for fish and fisheries. *Fish and Fisheries*, vol. 2, no. 3, pp. 250-260.

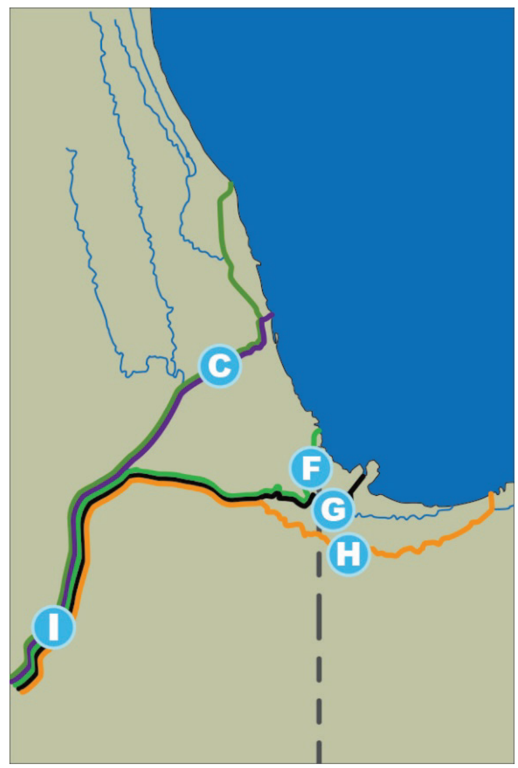
E.7.2.4.2 Ruffe (Gymnocephalus cernuus)

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock
Indiana Harbor	Nonstructural Measures	
	State Line, IL/IN (G)	Physical Barrier
	Brandon Road Lock and Dam (I)[a]	Electric Barrier
		GLMRIS Lock



<table>
<tr><td rowspan="3">Burns Small Boat Harbor</td><td colspan="2">Nonstructural Measures</td></tr>
<tr><td>Hammond, IN (H)</td><td>Physical Barrier</td></tr>
<tr><td rowspan="2">Brandon Road Lock and Dam (I)[a]</td><td>Electric Barrier</td></tr>
<tr><td></td><td>GLMRIS Lock</td></tr>
<tr><td colspan="3">[a] The Mid-system Separation Cal-Sag 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.</td></tr>
</table>

PATHWAY 1

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

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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 Cal-Sag 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 Chicago Area Waterway System (CAWS).

b. Human-Mediated Transport through Aquatic Pathways
See the Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag 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 aquatic 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 affect the arrival of the ruffe to the CAWS. Overall, none of these structural measures are 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 aquatic 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 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 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 Cal-Sag 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 aquatic 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 aquatic pathway.
T_{25}: See T_{10}.
T_{50}: See T_{25}. 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 the ruffe's arrival at the CAWS through aquatic pathways. Nonstructural measures as part of the alternative may increase the time it takes for the species to arrive. 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 aquatic 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 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the ruffe's arrival at the CAWS through aquatic pathways. Nonstructural measures as part of the alternative may increase the time it takes 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 aquatic pathway. Overall, the uncertainty remains low.

T_{10}: The probability increases that ruffe will 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 uncertainty remains medium.

T_{25}: See T_{10}.
T_{50}: The probability increases that ruffe will 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 uncertainty 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 Cal-Sag 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 and passive drift) of ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag 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 for ruffe at Stickney, 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 passage of the ruffe through the aquatic pathway. The ruffe is found in the Great Lakes Basin.

The physical barrier would be constructed in the channel at Stickney, 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 natural dispersion (i.e., swimming and passive drift) of the ruffe through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from CSSC water prior to its 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 condition.

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 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 screens because of their size. Larval fish and eggs that 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 widths less than 0.75 in. (19.05 mm), are expected to pass through the 0.75-in. 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 CSSC at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney, 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for the ruffe 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 would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

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 Cal-Sag 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 Cal-Sag 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 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 CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that can be implemented at T_0; however, these measures are not expected to affect the passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone 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 Cal-Sag 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 Stickney, 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 passage of the ruffe through the aquatic pathway. The ruffe is found in the Great Lakes Basin.

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 or larvae in ballast water would be unable to traverse the physical barrier; therefore, this 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 CSSC water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point. There are reports on the effects of UV irradiation on fish eggs, larvae, and fry. 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 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, 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 early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due 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 of fish 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative 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 as part of the Mid-system Separation Cal-Sag 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. 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 would be needed to control passage of 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 2

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

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag 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 Cal-Sag 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 aquatic 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and an ANSTP at Stickney, 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 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 aquatic 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 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. See the Nonstructural Risk Assessment for this species.

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

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures include ballast/bilge water exchange programs, which may increase the time the ruffe takes to arrive at the aquatic 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 thought 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 aquatic 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 Cal-Sag 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.

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 Cal-Sag 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 Cal-Sag 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 the ruffe's arrival 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 aquatic 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 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the ruffe's arrival 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 aquatic pathway. Therefore, the uncertainty remains low.
T_{10}: The probability increases that ruffe will 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 uncertainty remains medium.
T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe will 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 uncertainty 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 Cal-Sag 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 and passive drift) of the ruffe through the aquatic pathway.

T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag 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 for the ruffe at Stickney, 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 passage of the ruffe through the aquatic pathway. The ruffe is in the Great Lakes Basin.

The physical barrier would be constructed in the channel at Stickney, 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 ruffe through the aquatic pathway to the Brandon Road Lock and Dam.

The purpose of the ANSTP is to remove ANS from CSSC water prior to its 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 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 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). 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 screens because of their size. Larval fish and eggs that 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 widths less than 0.75 in. (19.05 mm), are expected to pass through the 0.75-in. 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 MWRDGC between 2007 and 2011, the CSSC at the Stickney project location is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney, 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 ruffe through the aquatic pathway to the Brandon Road Lock and Dam. The ANSTP would treat CSSC water for ruffe 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 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 Cal-Sag 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 Cal-Sag 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 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 physical barrier. The ANSTP would treat CSSC water for ruffe 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Mid-system Hydrologic Separation 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 Cal-Sag 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 Stickney, 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 passage 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, 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 the species through the aquatic pathway.

In addition, the ANSTP would treat CSSC water for the ruffe prior to its discharge into the Mississippi River Basin side of the control point. There is no specific information in the literature documenting the effects of UV radiation on survivability of the eggs and larvae of this fish species; however, there are reports on the effects of UV irradiation on other fishes' 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 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, 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 early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 as part of the Mid-system Separation Cal-Sag 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. 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 would be needed to control passage of 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 3

CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 Calumet Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 aquatic 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 Control Technologies without a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at the T.J. O'Brien Lock and Dam in 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 ruffe are 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. 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 aquatic 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 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures include ballast/bilge water exchange programs, which may increase the time the ruffe takes to arrive at the aquatic 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 thought 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. Ballast/bilge water exchange programs may increase the time the ruffe takes to arrive at the aquatic 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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 to swimming to the aquatic 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 will 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the ruffe's arrival 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 aquatic pathway. Therefore, the uncertainty remains low.
T_{10}: The probability increases that ruffe will 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 uncertainty remains medium.
T_{25}: See T_{10}.
T_{50}: The probability increases that ruffe will 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 uncertainty 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 Alternative Risk Assessment.

The Mid-system Separation Cal-Sag 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 ruffe through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative include structural measures that would be implemented at T_{25}. This alternative would create a control point for ruffe at the current T.J. O'Brien Lock and Dam 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 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 passage of the ruffe through the aquatic pathway.

At the T.J. O'Brien Lock and Dam control point, structures would be designed to minimize the creation of habitat for the ruffe surrounding the lock. 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 that would extend from the Calumet River side of the GLMRIS Lock into the Calumet River. To minimize opportunities for Great Lakes fish to bypass through 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 ruffe 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 ruffe eggs, larvae, and fry, would be removed from the lock chamber.

The purpose of the ANSTP is to remove ANS from Calumet River water prior to its 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 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 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 widths less than 0.75 in. (19.05 mm), are expected to pass through the 0.75-in. 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, thus blocking the UV light from reaching them. Based on water quality data, UV radiation of Calumet River water at the T.J. O'Brien Lock and Dam 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 T.J. O'Brien Lock and Dam control point. 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 Calumet River water potentially containing ANS would be routed through the ANSTP prior to discharge into the Mississippi River Basin side of the control point. However, during large storm events the solid gates would be opened and water from the Little Calumet River would be diverted into the Calumet River through the screened gates in order to reduce flood risk. When water from the Little Calumet River is diverted to the Calumet River during a storm event, it is expected that ruffe would be unable to pass through the screened sluice gates and into the Little Calumet River. The 0.4-in. (10.2-mm) openings of the screened sluice gate are smaller than the typical body depth of ruffe (ruffe body depth is 1.1–1.3 in., or 28.4–31.8 mm [Fuller et al. 2012]). Ruffe 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 Little Calumet River during backflows because of 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 the Calumet River through the lock. Again, passive 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 the Calumet River. In addition, swimming ruffe trying to pass through the open locks while water is being diverted would be deterred by the electric barrier and are not expected to drift against the velocity of the exiting current to enter the lock and potentially the CAWS.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the ruffe through the aquatic pathway.

T_{50}: See T_{25}.

b. Human-Mediated Transport through Aquatic Pathways

T_0: See the Nonstructural Alternative Risk Assessment.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 ruffe through the aquatic pathway to Brandon Road Lock and Dam. The ANSTP would treat Calumet River water for ruffe eggs, larvae, and fry prior to its discharge into the Mississippi River Basin side of the control point. The GLMRIS Lock, electric barrier, and screened sluice gates are expected to control passage of ruffe through the aquatic pathway. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to reduce the passage of the ruffe through the aquatic pathway due to vessel-mediated transport.

T_{50}: See T_{25}.

c. Existing Physical Human/Natural Barriers

T_0: None. The Mid-system Separation Cal-Sag 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 control 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 a description of the Mid-system Separation Cal-Sag 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 ruffe through the aquatic pathway to Brandon Road Lock and Dam. Calumet River water would be treated for ruffe eggs, larvae, and fry by the ANSTP prior to discharge into the Mississippi River Basin side of the control point, and the GLMRIS Lock, electric barrier, and screened sluice gates are expected to control its passage. In addition, nonstructural measures such as requiring vessels to discharge ballast and bilge water prior to entering the GLMRIS Lock are expected to reduce passage of the 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 passage of the ruffe through the aquatic pathway by natural dispersion or human-mediated transport. Therefore, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone 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 Cal-Sag 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 T.J. O'Brien Lock and Dam in 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 passage of the ruffe through the aquatic pathway. The ruffe is located in the Great Lakes Basin.

The electric barrier is expected to control the downstream passage of the ruffe. The GLMRIS Lock is expected to address the natural dispersion (i.e., passive drift) of ruffe eggs, larvae, and fry 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 purpose of the ANSTP is to treat Calumet River water for ANS 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 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, 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 early life stages of fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due 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 pass through screened sluice gates prior to its discharge into the Calumet River. 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 due to the velocity of the exiting current.

Overall, the Mid-system Separation Cal-Sag 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. 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 Cal-Sag 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 as part of the Mid-system Control Technologies without a Buffer Zone Alternative are expected to control the natural dispersion and human-mediated transport of the ruffe 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 transfer of ruffe. Research needs would include modeling, and laboratory and field testing to determine the optimal design and operating parameters. 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 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}: 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(2)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) and (3) designate 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-LOW

Probability of Pathway

Time Step	**T_0**	**T_{10}**	**T_{25}**	**T_{50}**
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Overall, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative 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. Overall, the uncertainty is low.
T_{50}: See T_0.

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 Cal-Sag 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 Cal-Sag 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 aquatic 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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 ruffe is in the Great Lakes basin. Overall, none of these structural measures are 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 aquatic 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 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. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures include ballast/bilge water exchange programs, which may increase the time the ruffe takes to arrive at the aquatic 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 thought 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 aquatic 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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 aquatic 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 will 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 Cal-Sag 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 Cal-Sag 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 aquatic pathway. Therefore, the uncertainty remains low.

T_{10}: See T_0. The probability increases that ruffe will 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 uncertainty remains medium.

T_{25}: See T_{10}.

T_{50}: The probability increases that ruffe will 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 uncertainty 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 Cal-Sag 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 ruffe through the aquatic pathway.

T_{10}: See T_{10}.

T_{25}: The Mid-system Separation Cal-Sag 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 the Illinois-Indiana state line with the construction of a physical barrier. 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 passage of the ruffe through the aquatic pathway.

The physical barrier would be constructed in the channel at the Illinois-Indiana state line 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the ruffe through the aquatic pathway to Brandon Road Lock and Dam.

T_{50}: See T_{25}.

b. *Human-Mediated Transport through Aquatic Pathways*

T_0: See Nonstructural Alternative Risk Assessment.

The Mid-system Separation Cal-Sag 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_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Structural measures as part of this alternative are expected to control the human-mediated transport of ruffe through the aquatic pathway to Brandon Road Lock and Dam. 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 Cal-Sag 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 Cal-Sag 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 ruffe 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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone 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 Cal-Sag 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 Illinois-Indiana state line with the construction of a physical barrier. 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 passage of the ruffe through the aquatic pathway.

The physical barrier constructed in the channel at the Illinois-Indiana state line is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe 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 natural dispersion and human-mediated transport of this species through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the ruffe 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: See 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 as part of the Mid-system Separation Cal-Sag 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 the passage of the ruffe through the aquatic pathway up to an extreme storm event, a 0.2% ACE event. 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}: 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(3)***	–	***Low(2)***	–

[a] The highlighted table cells indicate a rating change in the probability element. (2) and (3) designate 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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Overall, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag 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 Cal-Sag 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 aquatic 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 ruffe are in the Great Lakes Basin. Overall, these structural measures are not expected to control the arrival of the ruffe at the pathway. 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 aquatic 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 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. See the Nonstructural Risk Assessment for this species.

T_{25}: See T_{10}.

T_{50}: See T_{10}. See Nonstructural Risk Assessment for this species.

e. Distance from Pathway

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures include ballast/bilge water exchange programs, which may increase the time the ruffe takes to arrive at the aquatic 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 thought to assist the ruffe's dispersion in the Great Lakes.

T_{10}: See T_0. Ruffe could become closer to 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 aquatic 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 Cal-Sag 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. Climate change may alter the physical, hydraulic, chemical, and climatological suitability of the Great Lakes and its tributaries for ruffe. Water temperatures, streamflows, and water depth, in particular, may be altered, potentially affecting the distribution of 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 Cal-Sag 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 Cal-Sag 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 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 aquatic 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 will have time to spread to the BSBH by natural dispersion alone or 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 Cal-Sag 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 Cal-Sag 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 aquatic pathway. Therefore, the uncertainty remains low.
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 uncertainty remains medium.
T_{25}: See T_{10}.
T_{50}: 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 uncertainty 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 Cal-Sag 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 ruffe through the aquatic pathway.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag 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 for the ruffe at Hammond, Indiana, with the construction of a physical barrier. 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 passage of the ruffe through the aquatic pathway.

The physical barrier would be constructed in the channel at Hammond, Indiana, 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.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion of the ruffe through the aquatic pathway to Brandon Road Lock and Dam.

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 Cal-Sag 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 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 Cal-Sag 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 ruffe through the aquatic pathway to the Brandon Road Lock and Dam. 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 Alternative Risk Assessment.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability of the CAWS for the ruffe.

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 Cal-Sag 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 Cal-Sag 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 Technology 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 Cal-Sag 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 Hammond, Indiana, with the construction of a physical barrier. 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 ruffe through the aquatic pathway.

The physical barrier constructed in the channel at Hammond, Indiana, is expected to separate the Great Lakes and Mississippi River basins. It is expected that the ruffe 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 natural dispersion and human-mediated transport of this species through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	Medium	Medium	Low	Low

Evidence for Uncertainty Rating

T_0: The effectiveness of the electric barrier on ruffe is not well understood. The potential speed of natural dispersion through the CAWS is uncertain.

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 as part of the Mid-system Separation Cal-Sag 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 the passage of the ruffe through the aquatic pathway up to an extreme storm event, a 0.2% ACE event. 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}: 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

References

Bauer, C.R., A.M. Bobeldyk, and G.A. Lamberti. 2007. Predicting habitat use and trophic interactions of Eurasian ruffe, round gobies, and zebra mussels in nearshore areas of the Great Lakes. *Biological Invasions*, vol. 9, pp. 667–678.

Bowen, A.K., and M.A. Goehle. 2011. Surveillance for Ruffe in the Great Lakes, 2011. http://www.fws.gov/midwest/alpena/documents/2011-GL-Ruffe-Report.pdf.

EPA (Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule. Office of Water (4601), EPA 815-R-06–007.
http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

Fuller, P., G. Jacobs, J. Larson, and A. Fusaro. 2012. Gymnocephalus cernua. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=7.

FWS (U.S. Fish and Wildlife Service). 1996. Ruffe Control Plan. Submitted to the Aquatic Nuisance Species Task Force by the Ruffe Control Committee. U.S. Fish and Wildlife Service, Fishery Resources Office, Ashland, WI. 30 pp. http://www.fws.gov/midwest/ashland/ruf_cont.html

Kazumi, J. 2007. Ballast water treatment technologies and their application for vessels entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

Mahmoud, U.M., I.A.A. Mekkawy, and E.H. Sayed. 2009. Ultraviolet radiation-A (366 nm) induced morphological and histological malformations during embryogenesis of *Clarias gariepinus* (Burchell, 1822). *Journal of Photochemistry and Photobiology B: Biology*, vol. 95, pp. 117–128.

Sutherland, T. F., C.D. Levings, C.C. Elliott, and W.W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139–148.

USACE (U.S. Army Corps of Engineers). 2011. Dispersal barrier efficacy study. Efficacy study interim report IIA, Chicago Sanitary and Ship Canal Dispersal Barriers-Optimal operating parameters laboratory research and safety tests. Chicago District, Chicago, Illinois. 140 pp.

Viitasalo, S., J. Sassi, J. Rytkönen, and E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35–55.

Waite, T.D., J. Kazumi, P.V.Z. Lane, L.L. Farmer, S.G. Smith, S.L. Smith, G. Hitchcock, and T.R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system, *Marine Ecology Progress Series*, vol. 258, pp. 51–63.

Zagarese, H.E., and C.E. Williamson. 2001. The implications of solar UV radiation exposure for fish and fisheries. *Fish and Fisheries*, vol. 2, no. 3, pp. 250–260.

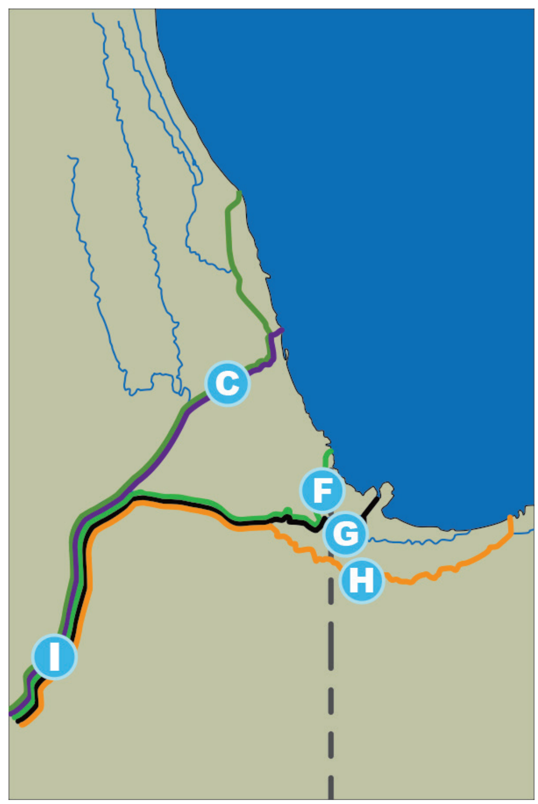
E.7.2.4.3 Tubenose Goby - (Proterorhinus semilunaris)

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock



Indiana Harbor	Nonstructural Measures[a]	
	State Line, IL/IN (G)	Physical Barrier
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier
	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 tubenose goby.

[b] The Mid-system Separation Cal-Sag 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.

PATHWAY 1

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

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for the tubenose goby.
T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby 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 for a discussion on how nonstructural measures may impact human-mediated transport.
The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include agency monitoring and voluntary occurrence reporting, which, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include agency monitoring and voluntary occurrence reporting, which, in combination with education and outreach, can be used to

determine where to target nonstructural control measures, in particular, piscicides However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation is not expected to be an effective control measure for the tubenose goby because the species is currently established in deep-water environments, where implementation of such a control is not feasible. Because of the small size and widespread distribution of the tubenose goby, controlled harvest and overfishing are not expected to be effective control measures to affect arrival of 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 aquatic nuisance species (ANS) originating in the Mississippi River Basin and would not impact the passage of the tubenose goby to 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that may be implemented at T_0. Nonstructural measures include ballast/bilge-water exchange programs, which may increase the time for the tubenose goby 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 believed to assist the dispersion of the tubenose goby in the Great Lakes.

T_{10}: See T_0. The tubenose goby could become closer to the WPS by 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the availability of suitable habitat 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 Cal-Sag 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 Cal-Sag 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 is expected to increase the time for the tubenose goby to arrive at the pathway.
The Mid-system Separation Cal-Sag 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 Hydrologic Separation 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. Nonstructural measures implemented as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, 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 for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced to low.

T_{25}: There is no commercial vessel transport to the WPS, and the implementation of nonstructural measures such as a ballast/bilge water exchange program, implemented as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative, are expected to increase the time 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating
T_0: See the Nonstructural Risk Assessment for this species.

Nonstructural measures implemented as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.
T_{10}: See T_0. Nonstructural measures as part of the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative 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. Therefore, the uncertainty is medium.
T_{25}: The Mid-system Separation Cal-Sag 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. 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 Cal-Sag 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 Cal-Sag 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 for the tubenose goby at Stickney, 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 (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

The physical barrier would be constructed in the channel at Stickney, 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 CSSC 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 Great Lakes Mississippi River Interbasin Study (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 length of approximately 5.0 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) (Pallas 1811), as well as 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 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 Metropolitan Water Reclamation District of Greater

Chicago (MWRDGC) between 2007 and 2011, the CSSC water at the Stickney project location is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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 would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011a,b).

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 Cal-Sag 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 Cal-Sag 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 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 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone A 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0; however, the 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 at the Stickney, Illinois, control point would be constructed in the channel 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 or 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 Stickney, Illinois, control point would treat CSSC 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, 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 fishes (developing embryos in eggs and early larvae) are highly sensitive to UV-B radiation due 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 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. 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 Cal-Sag 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 Cal-Sag 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 remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Separation Cal-Sag 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, further investigation and bench-scale studies would be needed prior to design and construction 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 the 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 2

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

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, Physical Barrier, and ANS Treatment Plant

PROBABILITY OF ESTABLISHMENT

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 Cal-Sag 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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for the tubenose goby.
T_{10}: See T_0.

T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures include agency monitoring and voluntary occurrence reporting, which, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular, piscicides. 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 at the CAWS pathway.

c. 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 includes nonstructural measures that could be implemented at T_0. Nonstructural measures include agency monitoring and voluntary occurrence reporting, which, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular, piscicides.

However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation is not expected to be an effective control measure for the tubenose goby because the species is currently established in deep-water 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 increase the time it takes for the tubenose goby to arrive 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures include ballast/bilge-water exchange programs that may increase the time for the tubenose goby 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 believed to assist the dispersion of the tubenose goby in the Great Lakes.

T_{10}: See T_0. Tubenose goby could become closer to the CRCW by 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). Ballast/bilge-water exchange

programs may increase the time for the tubenose goby 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 is expected to increase the time for the tubenose goby to arrive at the pathway.
The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag 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 for the tubenose goby to arrive at the pathway.

The Mid-system Separation Cal-Sag 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. Therefore, the probability of arrival is reduced to low.

T_{25}: The Mid-system Separation Cal-Sag 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. 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, the 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

T_{10}: See T_0. The Mid-system Separation Cal-Sag 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.

T_{25}: The Mid-system Separation Cal-Sag 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. However, over time, trends in future populations and spread rates become less certain. Therefore, uncertainty remains medium.

T_{50}: See T_0. See the Nonstructural Risk Assessment for this species.

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 Cal-Sag 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 Cal-Sag 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 for the tubenose goby at Stickney, 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 (i.e., swimming and passive drift) of the tubenose goby through the aquatic pathway.

The physical barrier would be constructed in the channel at Stickney, 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 CSSC 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 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 length of approximately 5.0 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) (Pallas 1811), as well as 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 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 CSSC water at the Stickney project location is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, pre-filtration at Stickney 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.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 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 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 Cal-Sag 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 Cal-Sag 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 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 physical barrier. The ANSTP would treat CSSC water for the tubenose goby prior to discharging it 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Stickney, 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 Stickney, 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 at the Stickney, Illinois, control point would treat CSSC 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, 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 due 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 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. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of the tubenose goby and to determine whether additional treatment processes are needed to control its passage through the ANSTP.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 remains medium.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Separation Cal-Sag 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, further investigation and bench-scale studies would be needed prior to design and construction 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 the 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 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG 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	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 Cal-Sag 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 Calumet Harbor and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative would not affect the existence of 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby to 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that can be implemented at T_0. Nonstructural measures include agency monitoring and voluntary occurrence reporting, which, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular, piscicides. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures include agency monitoring and voluntary occurrence reporting, which, in combination with education and outreach, can be used to determine where to target nonstructural control measures, in particular, piscicides. However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.
If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation is not expected to be an effective control measure for the tubenose goby because the species is currently established in deep-water environments where implementation of such a control is not feasible. Because of the small size and widespread distribution of the tubenose goby, controlled harvest and overfishing are also not expected to be effective control measures to increase the time it takes for the tubenose goby to arrive 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at the T.J. O'Brien Lock and Dam in 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. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures include ballast/bilge-water exchange programs, which may increase the time for the tubenose goby 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 dispersion of the tubenose goby in the Great Lakes.

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

Ballast/bilge-water exchange programs may increase the time for the tubenose goby 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	***Low***	Medium	Medium

[a] The highlighted table cell 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 Cal-Sag 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 is expected to increase the time for the tubenose goby to arrive at the pathway.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 for the tubenose goby to arrive at the pathway. Therefore, the probability of arrival is reduced to low.

T_{25}: The Mid-system Separation Cal-Sag 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. 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 Calumet Harbor. Therefore, the 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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.
T_{25}: The Mid-system Separation Cal-Sag 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}. See the Nonstructural Risk Assessment for this species.

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 Cal-Sag 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 Cal-Sag 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 tubenose goby at the current T.J. O'Brien Lock and Dam 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 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.

At the T.J. O'Brien Lock and Dam control point, structures would be designed to minimize the creation of habitat surrounding the lock 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 tubenose goby. The electric barrier would be placed within an engineered channel that would extend from the lake side of the GLMRIS Lock into the Calumet River. 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 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 Calumet River 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 ANS from Calumet River water prior to discharge into 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 condition. 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 Calumet River water at the T.J. O'Brien Lock and Dam 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 T.J. O'Brien Lock and Dam 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 Calumet River 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 Little Calumet River would be diverted into the Calumet River through the screened gates to reduce flood risk. When water from the Little Calumet River is diverted to the Calumet River during a storm event, it is expected that tubenose goby would be unable to pass through the screened sluice gates and into the Little Calumet River. Tubenose goby 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 Little Calumet 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 the Calumet River through the lock. Again, passively drifting eggs, larvae and fry would be unable to drift through the GLMRIS Lock while water was flowing from the CAWS through the lock into the Calumet River. In addition, it is expected that tubenose goby trying to swim against the exiting current would be deterred by the electric barrier and unable to pass through the lock.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 human-mediated transport of the tubenose goby through the aquatic pathway. In addition, nonstructural measures such as discharging ballast and bilge water prior to entering the GLMRIS Lock are expected to help control 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: None. The Mid-system Separation Cal-Sag 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 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 Cal-Sag 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 tubenose goby through the aquatic pathway to the Brandon Road Lock and Dam. Calumet River water would be treated for tubenose goby eggs and larvae by the ANSTP prior to discharge 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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that can 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 Cal-Sag 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 Cal-Sag 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 T.J. O'Brien Lock and Dam in 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.

The GLMRIS Lock would address the passage of tubenose goby 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 electric barrier is expected to control the downstream passage of the tubenose goby.

The ANSTP at the T.J. O'Brien Lock and Dam control point would treat Calumet River water for the tubenose goby prior to discharge into the CAWS. There are reports on the effects of UV irradiation of 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 due 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 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. screen. Site-specific dose-response tests would be required to determine the UV dose necessary to inactivate all life stages of the 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 the Calumet River. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the tubenose goby 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating	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 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}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that 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 transfer of the tubenose goby. Research needs include modeling and laboratory and field testing to determine the optimal design and operating parameters. In regard to the ANSTP, further investigation and bench-scale studies would be needed prior to design and construction 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, the 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 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures and Physical 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_0.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby 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 Cal-Sag 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 from 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, piscicides. 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures are not expected to reduce the current abundance or reproductive capacity of the tubenose goby. 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. However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation is not expected to be an effective control measure for the tubenose goby because the species is currently established in deep-water environments, where implementation of such a control is not feasible. Because of the small size and widespread distribution of the tubenose goby, controlled harvest and overfishing are also not expected to be effective control measures to increase the time it takes for the tubenose goby to arrive 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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 pathway.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures may affect the distance of the tubenose goby 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 dispersion of the tubenose goby in the Great Lakes; consequently, ballast/bilge-water exchange programs may increase the time for the tubenose goby 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 is expected to increase the time for the tubenose goby to arrive at the pathway.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 for the tubenose goby to arrive at the pathway. The Mid-system Separation Cal-Sag 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. Therefore, the probability of arrival is reduced to low.

T_{25}: See T_{10}. The Mid-system Separation Cal-Sag 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. 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, the 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 Cal-Sag Open Control Technologies with a Buffer Zone Rating[a]	Low	Medium	Medium	Medium

Evidence for Uncertainty Rating

T_0: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is low.

T_{10}: The Mid-system Separation Cal-Sag 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.

T_{25}: The Mid-system Separation Cal-Sag 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}. See the Nonstructural Risk Assessment for this species.

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 Cal-Sag 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_{10}.

T_{25}: The Mid-system Separation Cal-Sag 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 Illinois-Indiana state line and a second at the Brandon Road Lock and Dam.

The Illinois-Indiana state line control point would include the construction of a physical barrier in the channel that 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of 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 Cal-Sag 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_{10}.

T_{25}: See section 3a (*Type of Mobility/Invasion Speed*) at T_{25} for a description of the Mid-system Separation Cal-Sag 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 to the Brandon Road Lock and Dam. 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 Cal-Sag 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 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 Cal-Sag 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 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 the species 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 Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 the Illinois-Indiana state line with the construction of a physical barrier. 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 Illinois-Indiana state line control point is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting the species 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 the tubenose goby through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the tubenose goby and vessels potentially transporting it in ballast and bilge water 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 Cal-Sag 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 remains medium.

T_{10}: See T_0.

T_{25}: Structural measures implemented as part of the Mid-system Separation Cal-Sag 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 the passage of the tubenose goby through the CAWS up to an extreme storm event, a 0.2% ACE event. 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}: 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures and Physical 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	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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(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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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:

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating:

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of the tubenose goby 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 Cal-Sag 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 from 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, piscicides. 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 Cal-Sag 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 target nonstructural control measures, in particular, piscicides. However, the current distribution of the tubenose goby is too dispersed to be effectively controlled with occasional application of piscicides in localized areas.

If localized populations are found in shallow localized waters, desiccation (water drawdown) may be implemented. Desiccation is not expected to be an effective control measure for the tubenose goby because the species is currently established in deep-water environments where implementation of such a control is not feasible. Because of the small size and widespread distribution of the tubenose goby, controlled harvest and overfishing are also not expected to be effective control measures to affect the time it takes for the tubenose goby to arrive 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 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).
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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes nonstructural measures that could be implemented at T_0. Nonstructural measures may affect the distance of the tubenose goby 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 dispersion of the tubenose goby in the Great Lakes; consequently, ballast/bilge-water exchange programs may increase the time for the tubenose goby 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 is expected to increase the time for the tubenose goby to arrive at the pathway.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 for the tubenose goby to arrive at the pathway. The Mid-system Separation Cal-Sag 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. Therefore, the probability of arrival is reduced to low.

T_{25}: The Mid-system Separation Cal-Sag 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. 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, the 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 Cal-Sag 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 Cal-Sag 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 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 Cal-Sag 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 for the tubenose goby to arrive at the pathway. Therefore, the uncertainty is medium.

T_{25}: The Mid-system Separation Cal-Sag 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}. See the Nonstructural Risk Assessment for this species.

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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana and a second at the Brandon Road Lock and Dam.

The Hammond, Indiana control point would include the construction of a physical barrier in the channel that 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to control the natural dispersion (i.e., swimming and passive drift) of 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 Cal-Sag 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 Cal-Sag 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 to the Brandon Road Lock and Dam. 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 Cal-Sag 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 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 Cal-Sag 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 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.

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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect habitat suitability of the CAWS for the tubenose goby.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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. See the Nonstructural Risk Assessment for this species.

T_{25}: The Mid-system Separation Cal-Sag 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 Hammond, Indiana with the construction of a physical barrier. 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 is expected to separate the Great Lakes and Mississippi River basins. It is expected that the tubenose goby and vessels potentially transporting the species 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 the tubenose goby through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of the tubenose goby and vessels potentially

transporting it in ballast and bilge water 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 Cal-Sag 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 remains medium.
T_{10}: See T_0.
T_{25}: Structural measures implemented as part of the Mid-system Separation Cal-Sag 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 the passage of tubenose goby through the aquatic pathway up to an extreme storm event, a 0.2% ACE event. 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}: 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

References

Dopazo, S.N., L.D. Corkum, and N.E. Mandrak. 2008. Fish assemblages and environmental variables associated with Gobiids in nearshore areas of the lower Great Lakes. *Journal of Great Lakes Research*, vol. 34, no. 3, pp. 450–460.

EPA (U.S. Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule. Office of Water (4601), EPA 815-R-06–007. http://www.epa.gov/ogwdw/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

EPA (U.S. Environmental Protection Agency). 2008. Predicting Future Introductions of Nonindigenous Species to the Great Lakes. National Center for Environmental Assessment, Washington, DC. EPA/600/R-08/066F. http://www.epa.gov/ncea.

Fuller, P., L. Nico, E. Maynard, and M. Neilson. 2012. *Proterorhinus semilunaris*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=714.

Jude, D.J., R.H. Reider, and G.W. Smith. 1992. Establishment of *Gobiidae* in the Great Lakes Basin. *Canadian Journal of Fisheries and Aquatic Sciences*, vol. 49, pp. 416–421.

Kazumi, J. 2007. Ballast water treatment technologies and their application for vessels entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

Kocovsky, P.M., J.A. Tallman, D.J. Jude, D.M. Murphy, J.E. Brown, and C.A. Stepien. 2011. Expansion of tubenose gobies *Proterorhinus semilunaris* into western Lake Erie and potential effects on native species. *Biological Invasions*, DOI 10.1007/s10530-011-9962-5.

Mahmoud, U. M., I. A. A. Mekkawy, and E. H. Sayed. 2009. Ultraviolet radiation-A (366 nm) induced morphological and histological malformations during embryogenesis of *Clarias gariepinus* (Burchell, 1822). *Journal of Photochemistry and Photobiology B: Biology*, vol. 95, pp. 117–128.

Neilson, M.E., and C.A. Stepien. 2009. Evolution and phylogeography of the tubenose goby genus *Proterorhinus* (Gobiidae: Teleostei): evidence for new cryptic species. *Biological Journal of the Linnean Society*, vol. 96, pp. 664–684.

Pallas. 1811. Fishes of the NE Atlantis and the Mediterranean: Tubenose goby (Proterorhinus marmoratus). Marine Species Identification Portal. http://species-identification.org/species.php?species_group=fnam&id=1655. Accessed August 20, 2013.

Sutherland, T. F., C. D. Levings, C. C. Elliott, and W. W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139–148.

USACE (U.S. Army Corps of Engineers). 2011a. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System Great Lakes & Mississippi River Interbasin Study (GLMRIS). Chicago District, Chicago, IL. 32 pp. http://glmris.anl.gov/documents/docs/GLMRIS_Baseline_Cargo.pdf. Accessed June 27, 2013.

USACE (U.S. Army Corps of Engineers). 2011b. Baseline Assessment of Non-Cargo CAWS Traffic. Great Lakes & Mississippi River Interbasin Study (GLMRIS). Chicago District, Chicago, IL. 28 pp. http://glmris.anl.gov/documents/docs/GLMRIS_Baseline_NonCargo.pdf. Accessed June 27, 2013.

Viitasalo, S., J. Sassi, J. Rytkönen, and E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35–55.

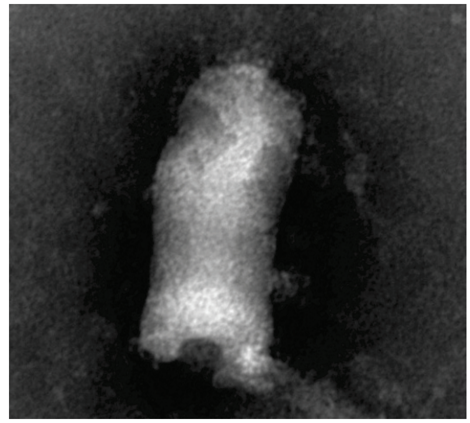
Waite, T. D., J. Kazumi, P. V. Z. Lane, L. L. Farmer, S. G. Smith, S. L. Smith, G. Hitchcock, and T. R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system, *Marine Ecology Progress Series*, vol. 258, pp. 51–63.

Zagarese, H. E., and C. E. Williamson. 2001. The implications of solar UV radiation exposure for fish and fisheries. *Fish and Fisheries*, vol. 2, no. 3, pp. 250–260.

E.7.2.5 Virus

E.7.2.5.1 Viral Hemorrhagic Septicemia (Novirhabdovirus sp.)

MID-SYSTEM SEPARATION CAL-SAG 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative Measures

Pathway	Control Point	Option or Technology
Wilmette Pumping Station	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Chicago River Controlling Works	Nonstructural Measures[a]	
	Stickney, IL (C)	Physical Barrier
		ANS Treatment Plant
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Calumet Harbor	Nonstructural Measures[a]	
	T.J. O'Brien Lock and Dam (F)	Screened Sluice Gates
		ANS Treatment Plant
		Electric Barrier
		GLMRIS Lock
	Brandon Road	Electric Barrier

	Lock and Dam (I)[b]	GLMRIS Lock
Indiana Harbor	Nonstructural Measures[a]	
	State Line, IL/IN (G)	Physical Barrier
	Brandon Road Lock and Dam (I)[b]	Electric Barrier
		GLMRIS Lock
Burns Small Boat Harbor	Nonstructural Measures[a]	
	Hammond, IN (H)	Physical Barrier
	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 VHSv.

[b] The Mid-system Separation Cal-Sag 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.

PATHWAY 1

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

MID-SYSTEM SEPARATION CAL-SAG 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)	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 Cal-Sag 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 Wilmette Pumping Station (WPS) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative does not affect the pathway for viral hemorrhagic septicemia (VHSv).

T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an aquatic nuisance species treatment plant (ANSTP) and a physical barrier in the Chicago Sanitary and Ship Canal (CSSC) at Stickney, 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, Illinois. Additionally, 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 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).

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 Cal-Sag 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 Cal-Sag 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_{25}. 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 Cal-Sag 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 Cal-Sag 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). 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 Cal-Sag 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 of the Nonstructural Alternative Risk Assessment for this species). Its ability to spread rapidly in the Great Lakes has been documented.

The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv at the CAWSthrough 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). 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 Cal-Sag 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 Cal-Sag 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 Stickney, Illinois, and a second at the Brandon Road Lock and Dam. The Stickney, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, 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 Stickney, Illinois, control point is to remove aquatic nuisance species from CSSC water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations.

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). 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 where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

The performance of UV treatment 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 CSSC at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment.

Consequently, at Stickney 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. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Brandon Road Lock and Dam. The ANSTP would treat CSSC water for VHSv prior to discharge into the Mississippi River Basin side of the control point. The physical barrier is expected to control the human-mediated transport of the species through the aquatic pathway, because vessels would be unable to traverse the barrier; however, there is no commercial vessel traffic into the North Shore Channel (USACE 2011).

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 Cal-Sag 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 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 CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag 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 Cal-Sag 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 Stickney, Illinois, with the construction of a physical barrier and 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 VHSv through the aquatic pathway.

The physical barrier constructed in the channel at the Stickney, 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 would treat CSSC water for VHSv prior to discharge into the Mississippi River Basin side of the control point. UV irradiation in the 200–280 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, length of UV radiation exposure, and need for an additional treatment process to control passage of VHSv through the ANSTP.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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. 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 need for an additional treatment process 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 2

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

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

PROBABILITY OF EXTABLISHMENT 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 Cal-Sag 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 Chicago River Controlling Works (CRCW) and the Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes an ANSTP and a physical barrier in the CSSC at Stickney, 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier and ANSTP at Stickney, 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 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).
T_{50}: See T_{25}.

e. *Distance from Pathway*

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 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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). 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 Cal-Sag 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 Cal-Sag 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). 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 Cal-Sag 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 Cal-Sag 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 Stickney, Illinois, and a second at Brandon Road Lock and Dam. The Stickney, Illinois, control point would include the construction of a physical barrier and ANSTP.

The physical barrier would be constructed in the channel at Stickney, 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 CSSC water prior to discharge to the Mississippi River Basin side of a control point. ANSTP effluent would be used to mitigate water quality impacts, such as low flows, stagnant zones, and low dissolved oxygen concentrations.

The treatment technologies included in the ANSTP would include 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). 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 where they would subsequently be pumped through the ANSTP and exposed to UV treatment.

Performance of UV treatment 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 MWRDGC between 2007 and 2011, the CSSC at the Stickney control point is expected to have turbidity that may reduce the effectiveness of UV treatment. Consequently, at Stickney pre-filtration would be included in the ANS treatment process prior to UV treatment.

Ultraviolet 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. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Brandon Road Lock and Dam. The ANSTP would treat CSSC 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 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: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 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 vessel attachment would be unable to traverse the physical barrier. The ANSTP would treat CSSC 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag 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 Cal-Sag 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 Stickney, Illinois, with the construction of a physical barrier and 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 VHSv through the aquatic pathway. VHSv is located in the Great Lakes Basin.

The physical barrier constructed in the channel at the Stickney, 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 would treat CSSC water for VHSv prior to discharge into the CAWS. UV irradiation in the 200–280 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. 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, length of UV radiation exposure, and need for an additional treatment process to control passage of VHSv through the ANSTP.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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. 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 need for an additional treatment process 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 3
CALUMET HARBOR TO BRANDON ROAD LOCK AND DAM

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

PROBABILITY OF EXTABLISHMENT 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 Cal-Sag 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)[a]	High	Low	High	Low	High	Low	High	Low
P(spreads)[a]	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium
P(establishment)	Medium	–[b]	Medium	–	Medium	–	Medium	–

[a] The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to impact *P(colonizes)* or *P(spreads)*.

[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 Calumet Harbor and Brandon Road Lock and Dam over the next 50 years. The Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates at T.J. O'Brien Lock and Dam in 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 VHSv at the CAWS. VHSv is located in the Great Lakes Basin. Overall, none of these structural measures are expected to act as physical barriers to 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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

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 Cal-Sag 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 Cal-Sag 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 T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam. At the T.J. O'Brien Lock and Dam 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.

The electric barrier at the lake side entrance to the T.J. O'Brien GLMRIS Lock would be an ineffective control for VHSv. 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 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 ANS treated water. 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 aquatic nuisance species from Calumet River 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 aquatic nuisance species for lock flushing.

The treatment technologies included in the ANSTP would be screening and UV radiation treatment 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). 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.

The performance of UV treatment is affected by water clarity, as suspended particles can shade and encase target species, and block the UV light from reaching them. Water quality data indicate that Calumet River water is sufficiently clear to allow for effective UV treatment at the T.J. O'Brien Lock and Dam control point. 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.

Sluice gates would also be constructed at the T.J. O'Brien Lock and Dam in Illinois. The sluice gates would consist 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 Calumet River water potentially containing ANS would be routed through the ANSTP prior to discharge into the CAWS. However, during large storm events requiring backflows to the Calumet

River, the solid gates would be opened, and water from the Little Calumet River would be diverted into the Calumet River through the screened sluice gates to reduce flood risk. When water from the Little Calumet River is diverted to the Calumet River during a storm event, VHSv is expected to pass through the control point and into the Little Calumet 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 the Calumet River through the lock. Again, the passive drifting VHSv is expected to be unable to drift through the GLMRIS Lock while water is flowing from the CAWS through the lock into the Calumet River.

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. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 VHSv through the aquatic pathway to the Brandon Road Lock and Dam. These measures are not expected to control the human-mediated transport of VHSv through the GLMRIS Lock by temporary 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 would not address the human-mediated transport of this species via temporary attachment to vessel hulls because the lock does not 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative. Structural measures implemented 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 temporary 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 would not address the human-mediated transport of this species via hull fouling 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative creates two control points, one at the current T.J. O'Brien Lock and Dam and a second at Brandon Road Lock and Dam, that would be implemented at T_{25}. At the

T.J. O'Brien Lock and Dam control point, structural measures would include the construction of an ANSTP, GLMRIS Lock, electric barrier, and screened sluice gates. The electric barrier would have no effect on 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 human-mediated transport of the species via temporary attachment to vessel hulls. Specifically, the GLMRIS Lock does not remove attached organisms.

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. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to 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 Cal-Sag 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 implemented as part of the Mid-system Separation Cal-Sag 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 temporary attachment to vessel hulls. 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 4

INDIANA HARBOR TO BRANDON ROAD LOCK AND DAM

MID-SYSTEM SEPARATION CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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. (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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-system Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel at the Illinois-Indiana state line that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-System Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at the Illinois-Indiana state line. 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 VHSv at the CAWS. VHSv is located in the Great Lakes Basin. 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 is likely to have 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 is likely to have 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 Cal-Sag 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 Cal-Sag 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-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 Cal-Sag 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 Cal-Sag 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 Illinois-Indiana state line and a second at the Brandon Road Lock and Dam.
The Illinois-Indiana state line control point would include the construction of a physical barrier in the channel that 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.
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. VHSv is located in the Great Lakes Basin.
Overall, the Mid-system Separation Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Brandon Road Lock and Dam. 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: See the Nonstructural Risk Assessment for this species.

The Mid-system Separation Cal-Sag 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 Cal-Sag 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 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.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag 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 Cal-Sag 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 the Illinois-Indiana state line with the construction of a physical barrier. 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 VHSv through the aquatic pathway. VHSv is located in the Great Lakes Basin.

The physical barrier constructed in the channel at the Illinois-Indiana state line 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 ballast and bilge water or attached to vessel hulls would be unable to traverse the barrier; therefore, the physical barrier is expected to control the natural dispersion and human-mediated transport of this species through the aquatic pathway.

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of VHSv and vessels potentially transporting it in ballast and bilge water or via temporary attachment to vessel hulls 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}
Without Project Rating	Low	Low	Low	Low
Mid-system Separation Cal-Sag 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 Cal-Sag 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 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. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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 CAL-SAG OPEN CONTROL TECHNOLOGIES WITH A BUFFER ZONE: Nonstructural Measures, 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)	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 Cal-Sag 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	***Low***	***Low***	***Low***	***Low***
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. (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-LOW

Probability of Pathway

Time Step	T_0	T_{10}	T_{25}	T_{50}
No New Federal Action Rating	High	High	High	High
Mid-System Separation Cal-Sag 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

T_0: Pathway is visible, confirmed, and present year-round.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes a physical barrier in the channel near Hammond, Indiana, that is expected to separate the Great Lakes and Mississippi River basins, thereby reducing the likelihood that an aquatic pathway connects the two 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. Therefore, the probability of pathway is reduced to low.
T_{50}: See T_{25}.

Uncertainty of Pathway

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

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

Evidence for Uncertainty Rating

T_0: The existence of the pathway has been confirmed with certainty.
T_{10}: See T_0.
T_{25}: The Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative is expected to separate the Great Lakes and Mississippi River basins. However, 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. Overall, the uncertainty is low.
T_{50}: See T_{25}.

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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes the construction of a physical barrier at Hammond, Indiana. 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 VHSv at the CAWS. VHSv is located in the Great Lakes Basin. Overall, these structural measures are not expected to control the arrival of VHSv to the pathway. 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative is not expected to affect the arrival of VHSv through aquatic pathways to 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. 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 Cal-Sag 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 Cal-Sag 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 Hammond, Indiana, and a second at the Brandon Road Lock and Dam. 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 passage of VHSv through the aquatic pathway. VHSv is located in the Great Lakes Basin.

The Hammond, Indiana, control point would include the construction of a physical barrier 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.

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. VHSv is located in the Great Lakes Basin.

Overall, the Mid-system Separation Cal-Sag 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 to Brandon Road Lock and Dam.
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 Cal-Sag 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 Cal-Sag 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 VHSv through the aquatic pathway to the Brandon Road Lock and Dam. 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: See the Nonstructural Risk Assessment for this species.
The Mid-system Separation Cal-Sag 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 Cal-Sag 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 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 transportingit in ballast and bilge water or via temporary attachment to vessel hulls 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 Cal-Sag 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 Cal-Sag 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 Cal-Sag 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 Mid-system Separation Cal-Sag 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 Cal-Sag Open Control Technologies with a Buffer Zone Alternative includes structural measures that would be implemented at T_{10}. This alternative creates a control point at Hammond, Indiana, for VHSv, with the construction of a physical barrier. 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 aquatic nuisance species originating in the Mississippi River Basin and would not affect the passage of VHSv through the aquatic pathway. VHSv is located in the Great Lakes Basin.

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

Overall, the Mid-system Separation Cal-Sag Open Control Technologies with a Buffer Zone Alternative reduces the likelihood of VHSv and vessels potentially transporting the species in ballast and bilge water or via temporary attachment to vessel hulls 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 Cal-Sag 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 Cal-Sag 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 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. However, a storm event exceeding the 0.2% ACE design event could cause the waterway to overtop the physical barrier. 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

References

Chevrefils, G., E. Caron, H. Wright, G. Sakomoto, P. Payment, B. Barbeau, and B. Cairns. 2006. UV dose required to achieve incremental log inactivation of bacteria, protozoa, and viruses. *International Ultraviolet Association News* 8, pp. 38–45.

Elsayed, E., M. Faisal, M. Thomas, G. Whelan, W. Batts, and J. Winton. 2006. Isolation of viral haemorrhagic septicaemia virus from muskellunge, *Esox masquinongy* (Mitchell), in Lake St. Clair, Michigan, USA, reveals a new sublineage of the North American genotype. *Journal of Fish Diseases*, vol. 29(10), pp. 611–619.

EPA (U.S. Environmental Protection Agency). 1999. Wastewater Technology Fact Sheet: Ultraviolet Disinfection. Office of Water, EPA 832-F-99-064.

EPA (U.S. Environmental Protection Agency). 2006. Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, Office of Water (4601), EPA 815-R-06-007. http://www.epa.gov/ogwdw000/disinfection/lt2/pdfs/guide_lt2_uvguidance.pdf.

Grippo, M., L. Fox, J. Hayse, I. Hlohowskyj, and T. Allison. 2013. Risks of Adverse Impacts from the Movement and Establishment of Aquatic Nuisance Species between the Great Lakes and Mississippi River Basins, prepared by Argonne National Laboratory for U.S. Army Corps of Engineers, Chicago District, GLMRIS Risk Assessment Team.

Huber, P., B. Petri, S. Allen, and J.S. Lumsden. 2010. "Viral Haemorrhagic Septicaemia Virus IVb Inactivation by Ultraviolet Light, and Storage Viability at 4 and −20°C." *Journal of Fish Diseases* 33 (4): 377–380. doi:10.1111/j.1365-2761.2009.01134.x.

Kazumi, J. 2007. Ballast Water Treatment Technologies and Their Application for Vessels Entering the Great Lakes via the St. Lawrence Seaway. Transportation Research Board Special Report 291. 18 pp.

Kipp, R.M., A. Ricciardi, A.K. Bogdanoff, and A. Fusaro. 2013. *Novirhabdovirus sp. genotype IV sublineage b*. USGS Nonindigenous Aquatic Species Database, Gainesville, FL. http://nas.er.usgs.gov/queries/GreatLakes/SpeciesInfo.asp?NoCache=9%2F29%2F2008+2%3A05%3A31+PM&SpeciesID=2656&State=&HUCNumber=DGreatLakes. Revised Sept. 27, 2012.

Kurth, J., R. Waldmann, J. Heith, K. Mausbach, and R. Burian. 1999. Efficient inactivation of viruses and mycoplasma in animal sera using UVC irradiation. *Developments in biological standardization* 99: 111–118.

Oye, A.K., and E. Rimstad. 2001. Inactivation of infectious salmon anaemia virus, viral haemorrhagic septicaemia virus and infectious pancreatic necrosis virus in water using UVC irradiation. *Diseases of aquatic organisms* 48 (1) (December 20): 1–5. doi:10.3354/dao048001.

Skall, H.F., N.J. Olesen, and S. Mellergaard. 2005. Viral Hemorrhagic Septicaemia Virus in marine fish and its implications for fish farming – a review. *Journal of Fish Diseases*, vol. 28, pp. 509–529.

Sutherland, T.F., C.D. Levings, C.C. Elliott, and W.W. Hesse. 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Marine Ecology Progress Series*, vol. 210, pp. 139–148.

USACE (U.S. Army Corps of Engineers). 2011. Baseline Assessment of Cargo Traffic on the Chicago Area Waterway System.

Viitasalo, S., J. Sassi, J. Rytkönen, and E. Leppäkoski. 2005. Ozone, ultraviolet light, ultrasound, and hydrogen peroxide as ballast water treatments – experiments with mesoplankton in low-saline brackish water. *Journal of Marine Environmental Engineering*, vol. 8, pp. 35–55.

Waite, T.D., J. Kazumi, P.V.Z. Lane, L.L. Farmer, S.G. Smith, S.L. Smith, G. Hitchcock, and T.R. Capo. 2003. Removal of natural populations of marine plankton by a large-scale ballast water treatment system. *Marine Ecology Progress Series*, vol. 258, pp. 51–63.

Whelan, G.E. 2009. Viral Hemorrhagic Septicemia (VHSv) Briefing paper. Michigan Department of Natural Resources. http://www.michigan.gov/documents/dnr/Viral-Hemorrhagic-Septicemia-Fact-Sheet-11-9-2006_178081_7.pdf. Accessed June 4, 2013.

Wuebbles, D.J., K. Hayhoe, and J. Parzen. 2010. Introduction: assessing the effects of climate change on Chicago and the Great Lakes. *Journal of Great Lakes Research*, vol. 36, pp. 1–6.