Conceptual Design for a Wetland Treatment and Habitat Improvement Cap at the Solvay Site Car Ferry Slip

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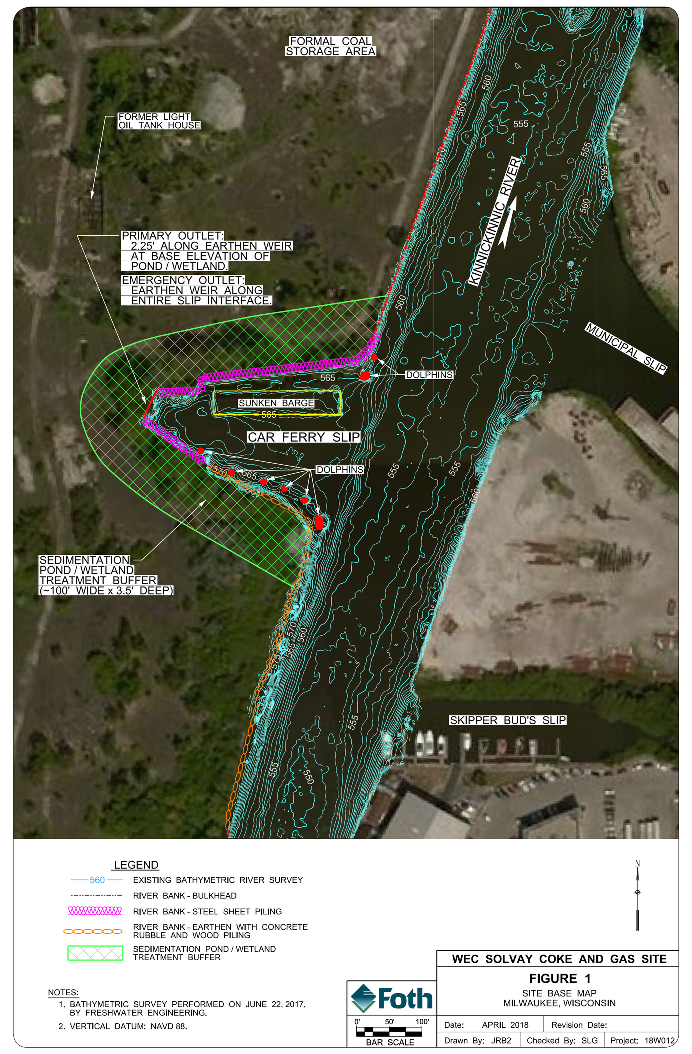
Introduction

We Energy Group Business Services (WE) has environmental liabilities associated with the Former Milwaukee Solvay Coke and Gas Plant Site (Site) that include the possible remediation of sediments within an area of the Site known as the Solvay Car Ferry Slip (Slip) (see **Figure 1**).

WE asked Foth to generate a conceptual-level understanding of how the sediments in the Slip could be capped in place to isolate them from the aquatic environment. The approach being considered would include the construction of a sheet pile wall at the mouth of the Slip to retain several feet of cap material and limit lateral movement of underlying in-situ sediments during consolidation (due to the weight of the cap materials). In addition, the riparian component of the cap surface will be enhanced to include soils and wetland plants to support habitat restoration elements that would address concerns from natural resource agencies and trustees.



Preliminary Isolation Cap Evaluation

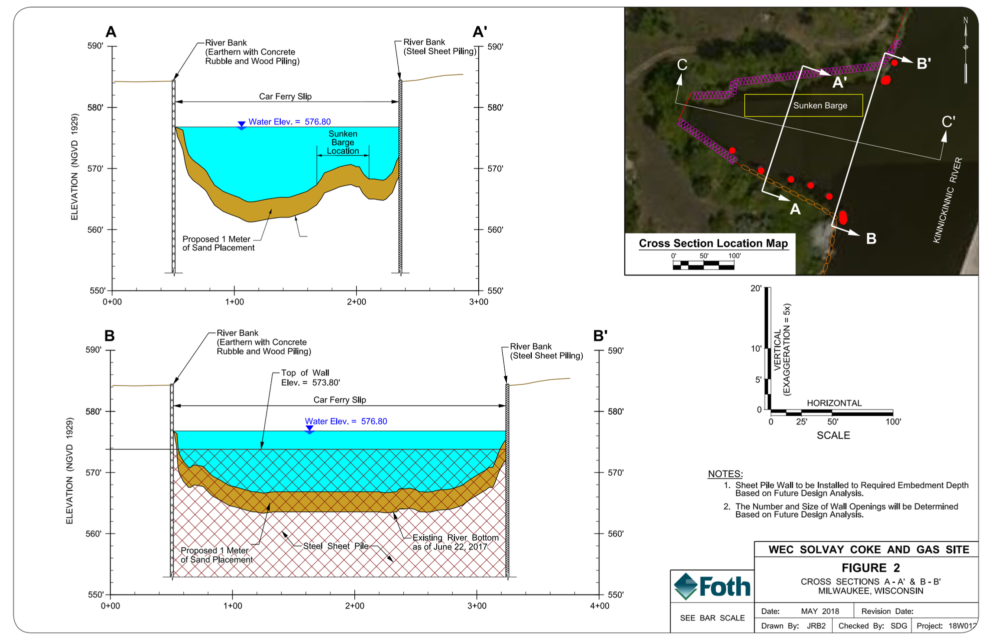
Isolation of the contaminated sediments, located within the Slip, may be achieved through the use of an isolation cap. Based on review of the data presented in the *RI Report* (Arcadis, 2016), a 1 meter sand cap should provide adequate protection from the in situ contaminated sediments. A 1 meter sand cap design was developed utilizing the CapSim model, a numerical model developed by Texas Tech University for evaluating fate and transport of contaminants through sediment layers and sand caps. The model provides the ability to complete analyses ranging from simple caps to complex caps with multiple layers and filter types. It provides the ability to account for activities such as bioturbation, groundwater upwelling, sediment consolidation and deposition, and chemical decay. For this effort, only decay and porewater diffusion were modeled, since little evidence is available to demonstrate significant groundwater upwelling. Consolidation of the underlying sediments and the expression of porewater upwards through the cap is not included in the conceptual evaluation. It would be a component of a future detailed design.

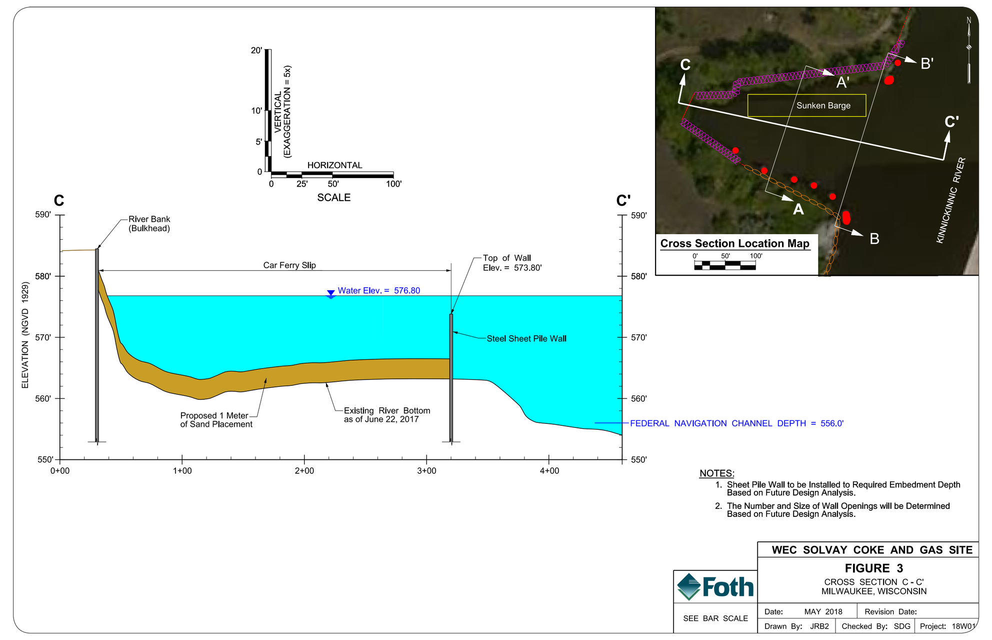
Conceptual Cap Design

The conceptual cap design consists of 1 meter of sand placed across the entire Slip area. At the entrance from the Slip to the Kinnickinnic River, a sheet pile wall would be placed to retain the cap material and prevent sliding into the main navigational channel within the river. Foth assumes that the sand cap will be placed directly on top of the sunken barge that is located in the northern portion of the Slip. **Figures 2 and 3** present the extent of the conceptual cap placement.

Model Setup

Based on the data available and the nature of this evaluation, a simple two layer cap model was chosen. The two layers would consist of a 1 meter sand cap on top of two meters of sediment. In keeping the model simple, it was chosen to model one chemical constituent using an average concentration based on data from the *RI Report*. Based on the sediment boring data, naphthalene was modeled as the contaminant of concern. Physical property data for the fine clay and silt sediments in the Slip were estimated using data from the 2008 Kinnickinnic River Dredging Feasibility Study (Barr Engineering Company, 2006). The chemistry and physical property data for each material layer in the model are provided in **Table 1**.





CapSim Model Sediment Inputs

	Material Type	Layer Thickness [m]	Porosity	Bulk Density [g/cm^3]	Organic Carbon Fraction	Naphthalene Initial Concentration [micrograms/liter]
Layer 1-Cap	Sand	1	0.5	1.65	0.1	0.01
Layer 2-Underlying Sediment	Sediment	2	0.566	1.25	0.001	0

Table 1. *CapSim Model Sediments Inputs*

Cap Model Results

The cap model looked at the evolution of pore water chemical concentration over a 100-year time period. Porewater concentration of naphthalene was computed across the vertical cross section at various time periods, based on diffusion and decay. **Figure 4** shows the evolution through time of the porewater concentrations within the sediments and the sand cap. Concentrations of naphthalene within the sand cap remain relatively low with the concentration being near zero in the surficial portion of the sand cap. While further detailed evaluation is needed for design, it appears that a 1 meter sand cap will provide adequate protection for benthic and aquatic receptors.

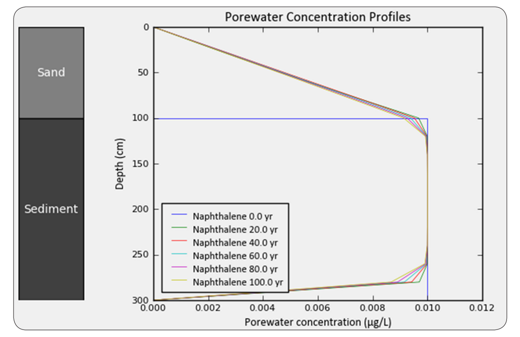


Figure 4. *Model output showing porewater concentration for naphthalene through time.*

Preliminary Sheet Pile Wall Design

To isolate the contaminated sediments to be contained within the Slip from the navigation channel of the Kinnickinnic River, a sheet pile wall may be placed at the mouth of the Slip. It was further assumed that the total retained height of the wall must consider removal of contaminated material within and along the navigable channel just outside the footprint of the capped area on the river side of the wall.

Foth reviewed available technical information to develop an understanding of existing conditions in the Slip, including locations of anticipated obstructions, site bathymetry, and subsurface conditions and used that information to conduct a preliminary engineering analysis of anticipated sheet pile requirements by developing input parameters and running computer simulations of shoring stress/strain conditions.

Understanding of Site Conditions

Based on review of the *RI Report* and for purposes of developing a generalized cross section and base set of assumptions for use in the preliminary sheet pile design effort, site conditions can be summarized as follows:

- Cross sections E-E' and F-F' from the *RI report* indicate a surface water elevation of 576.8 feet National Geodetic Vertical Datum ([NGVD], 1929) in the Slip.
- The elevation at the bottom of the Slip, where it meets the river, is approximately 564 feet NGVD, and with the exception of a few localized areas, including a sunken barge in the north half of the Slip, the bottom of the Slip area is generally flat.
- Along the river, bottom elevations drop off into the navigable channel at about a 4:1 (horizontal to vertical) slope to an elevation of 556 feet NGVD and gently slope down to an elevation of 554 feet NGVD nearer to the center of the channel.
- Below the mudline, approximately 7 to 9 feet of sediment is present in the Slip. This material is generally characterized as silt in the sediment core logs, and particle size distribution data indicate silt and clay size particles comprise the majority of the material. The percentage passing the number 200 sieve (P200) ranged from 74 to 97%, and the ratio of silt to clay size particles was noted to vary from 0.4 to 1.6. Larger size particles (sand and fine gravel) appear occasionally but usually only in trace amounts. Based on review of the available information, the sediment would be expected to exhibit geotechnical characteristics similar to a very soft silt. Additionally, this material would be expected to exhibit little to no consolidation near the mudline, however, would be expected to exhibit some degree of shear strength with increasing depth. The existing slope along the navigation channel further supports this as a reasonable assumption since it is evident the material can maintain a 4:1 slope (approximately 14 degrees from horizontal).
- Beneath the sediment layer, a medium stiff layer of silt/clay is described on the sediment core logs. Particle size distribution data for samples collected from sediment cores indicate silt and clay size particles comprise the majority of the material. The P200 percentages ranged from 96 to 98%, and the ratio silt to clay size particles was noted to vary from 0.6 to 2.5. From the perspective of grain size distribution, this material resembles the overlying sediment, however, the degree of consolidation is higher. Accordingly, it would be reasonable to assume this material would exhibit strength characteristics comparable to that of a medium stiff silt.
- Review of Figures 4-26a to 4-26w in the *RI Report* indicate elevated levels of select target contaminants in samples of subsurface sediments collected within the Slip. This includes detections of target contaminants in the sample collected from 6 to 7 feet at sediment core SD-D-08, which is located near the mouth of the Slip. It is understood that material outside the sheet pile wall, along the navigable channel, may be removed as part of future remedial activities which will effectively increase the retained height. Accordingly, for the purposes of the conceptual analysis, it is expected that the removal depth would be 1 foot deeper than the confirmed depth of impacts at 7 feet at core location SD-D-08. Therefore, it is understood that the conceptual wall height should account for 8 feet of removal, plus 3.3 feet of cap material for a total retained height of 11.3 feet.

Preliminary Engineering Analysis of Sheet Pile Requirements

Methodology

Following completion of the information review, the data was used to develop input parameters and assumptions for running computer simulations of shoring stress/strain conditions using ShoringSuite Version 8.3D software by CivilTech Software, USA. The model simulations are intended to approximate lateral earth pressures, shoring stress/strain conditions, and model-predicted deflections and associated factors of safety for overall sheet pile performance. The model also estimates the minimum required section modulus, from which a list of possible sheet pile sections are provided.

Table 2 summarizes input parameters used in the model for sediment and soil conditions on both the active and passive sides of the conceptual sheet pile wall:

Active and Passive Sides of Sheet Pile

Active Side of Sheet Pile

Depth Below Top of Wall (ft)	Layer Name	Saturated Unit Weight (pcf)	Effective Friction Angle (degrees)
0	Sand Cap	119	30
3.3	Sediment	100	14
10.3	Medium Stiff Silt	133	28

Passive Side of Sheet Pile

Depth Below Top of Wall (ft)	Layer Name	Saturated Unit Weight (pcf)	Effective Friction Angle (degrees)
11.3	Medium Stiff Silt	133	28

ft = feet
pcf = pounds per cubic foot

Table 2. *Active and Passive Sides of Sheet Pile*

Additional assumptions incorporated into the model included the following:

- The entire section is assumed to be completely submerged. Water depth over the model section was assumed to be 10 feet.
- An interface friction angle of 9 degrees was assumed for the soil-steel interface.
- A factor of safety of 1.5 was applied.
- Conditions along the passive side of the wall do not account for the possibility of deeper sediment removal below a depth of 11.3 feet below the top of the sand cap.

Results and Discussion

Results of the model indicate that sheet piles with a minimum section modulus of 8 cubic inches per foot of wall (in^3/ft) would be expected to meet performance criteria under the assumed design conditions, and the required minimum embedment depth is estimated to be 16.5 feet below the base of the wall. Hence, the minimum pile length based on the preliminary model results is 27.8 feet. Deflection calculations indicate movement near the top of the sheeting would be expected to be about 1 inch.

The approximate alignment of the wall is shown on **Figures 2 and 3**.

Preliminary Wetland Cap Design

The approximately 46-acre project site is anticipated to be redeveloped and contain an approximately 1,000,000 square foot (23 acre [ac]) building and parking area, with the remaining 23 acres remaining as pervious surface (i.e., grass). Storm water runoff from the redeveloped property will need to be managed according to state and local requirements. For purposes of this evaluation, half of the runoff from the 23 acres of impervious area and runoff from the full 23 acres of pervious area will be directed to the storm water management features to be discussed in this section. It is assumed that runoff from the remaining impervious area will be managed properly.

Chapters NR 151 and NR 216 of the Wisconsin Administrative Code (Wis. Admin. Code) specify the need for the management of post-construction storm water associated with land-disturbing activities larger than 1 acre in size. While the site may become exempt from the infiltration requirement, based on the soil type and depth to groundwater, it will likely need to comply with the peak discharge and TSS removal requirements. The peak discharge requirement is to reduce the post-development peak discharge for the 1-year (yr), 24-hour (hr) and 2-yr, 24-hr storms to that of the pre-development levels. The TSS requirement is to reduce the load from parking areas and roads by 40% compared to pre-development levels.

It is assumed for purposes of this evaluation that an on-land BMP is desired to be used for storm water management. A combination wet detention pond and treatment wetland is proposed surrounding the Slip. The system would serve to collect, temporarily store, and treat runoff storm water from the site prior to being discharged to the Kinnickinnic River. Water would be released to the Slip through a control structure at a rate that would allow the site to comply with the peak discharge control and sediment removal efficiency previously mentioned.

Methodology

Peak Discharge Control

In order to determine peak discharge control and TSS removal efficiency, runoff volume and peak discharge from the property under both existing and proposed conditions must be determined. This was done using the U.S. Department of Agriculture (USDA) hydrologic methodology detailed in *Technical Release No. 55 (TR-55) – Urban Hydrology for Small Watersheds* (USDA, 1986). The calculations were performed using PondPack software (Bentley, 2008).

Rainfall was determined from storm event depths per National Oceanic and Atmospheric Administration (NOAA) *Atlas 14 Rainfall for Midwest and Southeast States* (Merkel and Moody, 2015). Gauge ID: 47-5479 at the General Mitchell International Airport (Milwaukee, Wisconsin) was used. The following storms were analyzed, with precipitation depths shown in parenthesis (inches): 1-yr, 24-hr (2.35), 2-yr, 24-hr (2.65), 100-yr, 24-hr (5.98). The 1-yr, 24-hr and 2-yr, 24-hr storms were analyzed in order to comply with Wis. Admin. Code NR 151 peak discharge requirements. The 100-yr, 24-hr storm was analyzed so that the system features could safely pass the larger storm event.

Additional inputs and assumptions incorporated into the existing conditions model included the following:

- Watershed size of 34.5 acres. Note that the property is approximately 46 acres in size. However, for purposes of this evaluation, under proposed conditions 11.5 acres of impervious runoff would be managed by a separate method independent from the system discussed in this plan. Therefore for comparison purposes, a watershed size of 34.5 acres was also used under existing conditions.
- A runoff curve number (RCN) of 84.5 (10.0 acres of buildings and roads, and 24.5 acres of green space; assumed hydrologic soil group C).
- A time of concentration (tc) of 0.40 hours (assumed slope of 1%).

Runoff from both the existing and proposed conditions are summarized in **Table 3**. The estimated peak discharge rate increases substantially under proposed conditions due to the increased impervious area. To comply with Wis. Admin. Codes NR 151 and NR 216, BMPs (i.e., wet detention pond, treatment wetland, etc.) would need to be installed so the proposed condition peak discharge is at or below the existing condition peak discharge for the 1-yr, 24-hr and 2-yr, 24-hr storms.

Runoff Volume and Peak Flow
Existing Conditions and Proposed without BMPs

Parameter	1-yr 24-hr Storm	2-yr 24-hr Storm	100-yr 24-hr Storm
Existing Conditions Peak Flow (cfs)	31.7	41.4	137.6
Proposed Conditions (no BMPs)			
Peak Flow (cfs)	45.4	58.71	189.3
Runoff Volume (ac-ft)	3.04	3.72	12.3

ac-ft = acre feet
BMP = best management practice
cfs = cubic feet per second

Table 3. *Runoff Volume and Peak Flow Existing Conditions and Proposed without BMPs*

The combined wet detention pond and treatment wetland proposed for management of runoff from the 34.5 acres of post-development conditions is shown on **Figure 1**. The pond/wetland system was assumed to have 50% of its volume occupied by wetland vegetation. The system was further assumed to surround the entire land/Slip interface, totaling approximately 700 feet in length. The primary system outlet would be an earthen overflow weir located in the center of the Slip. The weir would be approximately 2.25 feet long, set at an elevation equal to the base elevation of the pond/wetland. An emergency overflow earthen weir would be installed along the entire 700-foot length of the land/Slip interface to safely pass the 100-yr, 24-hr storm event.

Using these criteria, an approximate pond/wetland width of 100 feet and depth of 3.5 feet would be required to provide the necessary peak discharge control for the 1-yr, 24-hr and 2-yr, 24-hr storms. Modeling results are summarized in **Table 4**.

Pond/Treatment Wetland Discharge and Storage

Parameter	1-yr 24-hr Storm	2-yr 24-hr Storm	100-yr 24-hr Storm
Maximum Discharge Allowed (cfs) (from Table 3 – Existing Conditions)	31.7	41.4	NA
Modeled Discharge (cfs)	20.2	25.7	NA
Maximum Ponding Depth (ft)	2.17	2.54	NA

NA = not applicable

Table 4. *Pond/Treatment Wetland Discharge and Storage*

Sediment Removal

Wis. Admin. Code NR 151 calls for TSS removal to be calculated with water quality models such as WinSLAMM (PV & Associates, 2017) using established continuous storm rainfall records. Per NR 151, the site will likely classify as a redevelopment site, which carries the requirement to reduce the load from parking areas and roads by 40% compared to pre-development levels. Preliminary calculations were performed in WinSLAMM to estimate sediment removal efficiency of the proposed pond/wetland system. Inputs and assumptions incorporated into the proposed conditions model included the following:

- Continuous rainfall record for Milwaukee, per WinSLAMM database.
- Watershed size of 34.5 acres (parking lot and roofs assumed over 11.5 acres and landscaping assumed over 23 acres). This is a conservative assumption, as NR 151 only requires a reduction in sediment load from parking areas and roads for redevelopment sites.
- No pond/wetland permanent pool depth.
- Pond/wetland area of 1.5 acres at 3.5 foot depth (approximately 700 feet by 100 feet).
- No volume loss assume due to wetland vegetation (while the vegetation would reduce pond volume, it would also aid in sediment removal; it was assumed that these functions would balance each other).
- Outlet structures: 2.25 foot wide earthen weir set at pond/wetland invert.

Preliminary model results show greater than 40% TSS removal, indicating that the system would comply with NR 151 TSS removal requirements.

Habitat Restoration Elements

The Kinnickinnic River contains 25 miles of streams which have been extensively modified through straightening and stream bed modification by way of concrete lining (Note: many of the concrete-lined sections are now being restored to a more natural state). Comprised mainly of industrial land use and urbanized development, wetlands within the Kinnickinnic River watershed include less than 1% (WDNR, 2001). The habitat restoration of the Solvay Car Ferry Slip will provide great valve to the watershed of the Kinnickinnic River in both water quality, biodiversity and overall aesthetic appeal. With wetlands being limited in the Kinnickinnic watershed, a treatment wetland retention basin along with aquatic habitat improvements of the Slip will provide diverse functionalities that include:

- Increased wildlife habitat
- Nutrient transformation
- Food chain interaction
- Surface water retention
- Increased aquatic habitat
- Increased biodiversity

Habitat Design

Shoreline Restoration

Native vegetation will be established along shoreline areas of the retention wetland with suitable native species found common in the Milwaukee River Basin. The vegetation will provide bank stabilization, prevent erosion, slow storm water flow, remove or break down pollutants in storm water, and create wildlife habitat. Protecting plantings during establishment will be essential for success and will need temporary fencing for protection. Native riparian vegetation species are adapted to local conditions and need little to no maintenance once established.

Storm Water Treatment Wetland

The treatment wetland would be constructed along the land/Slip interface, to provide treatment to storm water before it reaches the Kinnickinnic River. Storm water will be treated through filtration and bioremediation in the wetland by the use of native aquatic vegetation breaking down nutrients. In conjunction with the treatment wetland emergent and submergent plantings within the Slip will be utilized to provide additional filtration of nutrients and aquatic habitat.

Other Habitat Enhancements

With aquatic habitat being limiting within the Kinnickinnic River system any habitat enhancements to the Solvay Slip will provide exceptional benefit to the aquatic community. Habitat enhancements other than riparian restoration and aquatic vegetation (submergent and emergent) within the Slip could include the addition of:

- Island construction
- Tree laydowns
- Rock piles (6-10 inches)
- Clean gravel beds (2-4 inches)
- Artificial habitat (cribs and/or stake beds

Habitat enhancements should coordinate to select target species to provide benefits to the species' life history traits/characteristics that include:

- Spawning
- Refuge
- Resting
- Nesting/nursery
- Foraging
- Ambush

Benefit of Solvay Slip Habitat Restoration (Yellow Perch)

One species to benefit from the restoration of the Solvay Slip would include yellow perch. Once abundant in southwestern Lake Michigan, yellow perch populations have declined dramatically as historical information suggests that an estuarial population existed in the Milwaukee-Kinnickinnic River estuary (WDNR, 2017). With declining near-shore wetlands, recruitment of substantial year classes of yellow perch have caused a decline in recreational fishing opportunities for yellow perch in the Milwaukee area. The habitat restoration of the Solvay Slip would benefit yellow perch populations as the Slip design would allow fish to ingress and egress. Yellow perch are random spawners and require substrates that include sand, gravel, submerged vegetation or brush in sheltered areas (Niebur et al., 2015). Potential habitat improvements to the Slip would provide ample spawning substrates along with foraging opportunities for larval and juvenile yellow perch with the increase in macroinvertebrates found within the aquatic vegetation and with the overall location of the Slip near the estuary.

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