



Chicago Area Waterway System Habitat Enhancement Study



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Executive Summary:

Bioengineering Group was tasked with the identification of six measures for enhancing the physical condition of fish habitat on the Chicago Area Waterway System (CAWS). For much of its history the CAWS has experienced heavy commercial vessel traffic producing high energy water movements, a hard/non-living and vertical bank, an unconsolidated sediment bottom, stormwater discharges, sluggish flows and other water quality and ecological challenges. It is believed that establishment of structures within and near the banks to more closely replicate the physical form of a natural river will improve the possibility of fish using and reproducing within the system.

Presented below are four sites and six innovative fish enhancement techniques to achieve a more “natural” and functional habitat for fish within the CAWS. The Appendices attached to this report provide further development of proposed enhancement methods, the application locations within the CAWS, and a detailed Bibliography to directly and indirectly support the methods’ reported successes. Finally, the last Appendix includes a cost estimate for comparison purposes.

Sample Site 43

Habitat Enhancement Constraints and Opportunities

The area for enhancement is located along a reach downstream of Sampling Site 43. The heavily navigated but mostly undeveloped location provides an opportunity to improve aquatic habitat within the waterway and to create additional water areas for fish and their food sources adjacent to the waterway. MWRDGC owns significant portions of land adjacent to this reach. Forested lands, as well as vegetated and unvegetated shallow and deep water habitats, currently exist alongside the banks, both on and off MWRDC property. These areas offer proximal variety and diversity of habitats, although linkage and connectivity is currently poor between the waterway and uplands, especially along the north bank. Land surrounding the immediate project site has been used intensively for quarrying, industrial, residential, and storage stockpiling. Barge traffic levels are high and few opportunities exist for public viewing. Restricted access and limited visibility allow for measures that might otherwise be susceptible to vandalism in more accessible locations. Routine dredging maintains navigable depths and passage and the mooring of large barges occurs often within this reach. Habitat enhancement measures must avoid encroaching into navigational channels, and must be highly resistant to intensive boat wake and potential collision.

Site Conditions

This reach of the waterway is characterized by vertical concrete walls in deteriorating conditions on the North bank, with gently sloping vegetated banks, underlain by outcropping limestone, on the South bank. A small building with access stairs exists along the North bank quite near the location of a pond set back roughly 70 feet from the canal. Bathymetric data shows water depths up to 20 feet near the North bank, with a sloping bottom tapering up to the South bank. A wide zone of shallow water insufficient for boat traffic exists along the south bank. This cross section remains fairly constant throughout the reach. Boat traffic has been described as heavy and with frequent barge access and barge docking, making the reach one of the most trafficked segments of the waterways system. Dense bank vegetation exists on both sides of the river, with wide areas of forested land adjacent to banks.

The south bank features a relatively uniform condition of shallow water with overhanging vegetation and unconsolidated sediments. The water's edge features some rough broken stone, some areas of active bank erosion, and some exposed limestone bedrock. The north bank features a concrete wall roughly 10 feet high from the normal water line, with a soil embankment rising an additional height, up to 15 feet in some areas. Many portions of the bank are well vegetated, but some portions show active bank erosion. Due to the height of the bank and the south-facing exposure, little shade is provided and the only overhanging bank conditions are created by gaps in the deteriorating concrete wall. Based on existing information, limiting factors are recognized as frequent very high energy impacts due to navigational barge traffic, riparian vegetation disconnected from north bank, unconsolidated and undifferentiated sediments, poor overhanging bank and shade conditions, and lack of aquatic structure for shelter and other functions.

Concept Habitat Enhancement Elements

Recommended enhancement measures include those that would cause sediment stabilization and consolidation as well as dissipation of wave/wake energy. Artificial Seaweed along the south bank with Linear Shallows and Chamber Revetment along the north bank have been shown to provide these functions. The mats for seaweed will be placed along the existing 6' contour elevation, parallel to the south bank approximately 50 feet from the bank waterline. In this manner the units should be set back from future dredging and navigational activity, while forming a wide protected zone behind them. A 330-foot-long reach of sheltered shallow shoreline will be created due to the energy dissipation effect of the seaweed. Sediment consolidation, stabilization, and sorting will result, and the overall energy level within the reach will be reduced by placing this element near the middle zone of the channel where it can reduce wave reflection and promote rapid stilling of wake after boats pass by.

Other enhancement measures would include the provision of refugia and shallow water zones for fish fry and possible fish and herptile reproduction areas. Linear Shallows will be excavated in one location at the north bank in proximity to an existing pond, approximately 200 feet long and 40 feet wide at the normal water elevation. The target depth of the Linear Shallows is a range from 3 to 8 feet in order to promote cool heavily shaded low wave energy water conditions with soft, but consolidated, soils and increase particulate organic carbon sources in the form of forest detritus. Due to the high presence of forest vegetation and canopy producing shade, primary producing vegetation is not prioritized, though it may colonize spontaneously. The intent is to protect existing trees adjacent to the concrete wall to conserve canopy cover especially from the southern sun exposure. One water opening with a baffle structure to limit wave impact will be created by removal and modification of concrete wall material. This approach will provide access for fish, herptiles, and invertebrates between the waterway, the Linear Shallows, and/or the nearby pond and forest area.

Upstream and downstream of the opening to the Linear Shallows, Chamber Revetment containing scoria type rock will be attached by bolting to the existing concrete walls in two segments, each approximately 100 linear feet and 18" in diameter encased in vinyl coated galvanized wire mesh. The purpose of the sack gabion type Chamber Revetment is to add a biologically active porous stone medium in the form of an overhanging bank, at and slightly above the typical summer water elevation, but within the wake splash zone. Signage or buoys may be used to indicate the position of Artificial Seaweed and Chamber Revetment elements to navigational users in order to avoid damage to enhancement measures and interference with boat operation.

Habitat Enhancement Outcomes

Selected measures will create reduced energy level zones for fish and related organisms to use as sheltered habitat for various life stages. Measures are located in parallel position in order to attain a protected zone with a high level of boat wake energy reduction, within an active, navigable waterway with harsh wave conditions. The key measures complement each other by providing diverse shallow

water and deeper, sheltered water conditions that are accessibly linked for use by not only fish and related aquatic species, but also amphibious and terrestrial animals in order to foster a more complete food web. The main objective is to establish suitable physical conditions in terms of sediment suited for diverse benthic organisms, surface area for algae, microbes, and invertebrates, and sheltered water conditions for varied fish life stages and species. Existing high levels of allochthonous material from adjacent forest leaf litter will then become available for use by a web of aquatic organisms that previously lacked physical habitat. The bank area partially protected by Artificial Seaweed is expected to spontaneously generate some aquatic emergent and/or submerged vegetation due to wave attenuation, which will in turn promote juvenile fish populations and provide well oxygenated daytime refugia for fish during hot weather. In addition, foraging of these artificial seaweed beds by Carp will be less of an issue as would be a living, rooted submerged aquatic plant bed. Measures are concentrated within one continuously treated reach 330 feet in length.

Sample Site 46

Habitat Enhancement Constraints and Opportunities

The urbanized, downtown location of Sample Site 46 provides opportunity to improve fish habitat while also promoting local recognition and understanding for future potential fish habitat measures and outcomes throughout the system. The presence of publicly accessible park areas, residential neighborhoods with focal point water access, and high vehicle traffic on bridges all foster viewing opportunities for visible and appealing improvements as well as fish habitat enhancement measures. Combined with signage to explain and document fish habitat elements, these improvement measures have the ability to not only upgrade the habitat productivity of the channel reach, but also to build support and appreciation for doing so. This level of public involvement often correlates strongly with improved land use management, which in turn contributes to water quality improvements as people become more conscious of personal activities such as car washing, lawn fertilizing, oil dumping, and also larger actions such as conversion of industrial sites to residential or park uses.

Site Conditions

This reach of the waterway is upstream of the actual sampling station. The banks of this reach are characterized by steel sheet pile walls interrupted by short segments of concrete or timber bank structures related to existing bridges or past structures and uses. Stormwater discharge pipes occur at frequent intervals. Although no detailed bathymetry has been provided, depths are understood to be typically 17 feet throughout the reach. Boat traffic has been described as recreational boating, with minor barge access and no barge docking. This makes the reach one of the least trafficked segments of the waterways system, though occasionally used by larger vessels and therefore subject to associated greater wave energies.

Some bank vegetation exists in narrow strips characterized by opportunistic trees, shrubs, and herbs. The resulting plant community is limited in a real extent, lacks structure, and is physically homogeneous providing only small areas of poor quality habitat. The water surface is highly exposed to solar radiation as there is little overhanging vegetation, with bridge decks providing the only significant shade. Based on existing information, limiting habitat factors are recognized as little riparian vegetation of poor quality, limited shade, lack of structure for shelter of various types, unconsolidated and undifferentiated sediments, and infrequent, but high energy, impacts due to boat traffic.

Concept Habitat Enhancement Elements

Recommended enhancement measures include Floating Vegetation and Sunken Structure adjacent to both banks. Elements will be positioned near bridge abutments and within coves, which will serve to provide shelter from boat traffic and which will not impinge on currently observed traffic patterns. Floating Vegetation is to be established using triangular, fabricated modules designed to be highly

resistant to ice, boat wake, vandalism, and other impacts expected within the reach. Anchor systems will be designed to address site specific conditions. Specific site conditions, and resulting design requirements, will be more fully investigated and documented during the final design project phase. Floating Vegetation treatments will be assembled in lengths from 18 to 36 feet, positioned in close proximity to the bank, well secured to the bank and bed using tension relief systems such as buoys to minimize stress at anchors. Vegetation shall feature low maintenance species that are tolerant of saturated hydrology and hydroponic type growing conditions, and that create significant underwater root systems for fish shelter, as well as attractive foliage and flowers to enhance public acceptance. The key plant species typically incorporated are *Iris versicolor* (blue flag iris), *Scirpus validus* (soft stem bulrush), and *Juncus effusus* (soft rush).

Sunken Structure will be established at the toe of the sheet pile wall, in areas between floating vegetation zones. Rather than using salvaged materials that may easily be misinterpreted by the public as trash and debris (and hence potentially promote illicit dumping), Sunken Structure will consist of concrete box culvert type units resting on an apron of riprap to lift them above the depths of unconsolidated sediment. The top of the concrete structure will be positioned to allow a minimum 9-foot clearance for boat traffic. Signage or buoys may be used to indicate the location of structures to boaters. The concrete units may be off-spec or damaged materials, making them more affordable, with sizes varying within the range of 2'x3'x4' to 6'x6'x10' according to availability and location. Sunken Structure need not be placed precisely in order to function by providing large shaded and sheltered cavities for fish. Additionally, coarse gravel may be placed on top to offer benthic substrate and/or spawning substrate elevated above the zone of flocculated materials and bedload sediments.

Habitat Enhancement Outcomes

The recommended measures will complement each other by providing a diversity of shallow water and deeper water structural conditions to be used by a variety of organisms. The floating vegetation will also provide additional shade offered by the floating elements themselves as well as the overhanging vegetation. Physical and biological conditions will be improved for a variety of fish species at various life stages, as well as for the benthic invertebrates they depend on as a food source. The presence of underwater root zone shelter and daytime oxygenation will significantly enhance conditions necessary for survival and development of juvenile fish. It is expected that this enhanced reach will also attract mature fish as it becomes a refuge during poor water quality and high boat traffic periods in other reaches. This will thereby help to improve survival and hence quantity and diversity of fish in the waterway system, in general. By treating roughly a third of both banks, a high degree of habitat diversity and productivity will be established, while boat mooring spaces and existing infrastructure will be accommodated. A visually attractive pattern of Floating Vegetation will be established using materials that are compatible with boat traffic. Sunken Structure will be largely hidden, due to poor water clarity. A proposed 1000 linear feet of both banks will be treated, using roughly 300 linear feet of treatment elements on each bank.

Sample Site 59

Habitat Enhancement Constraints and Opportunities

The heavily navigated, mixed industrial and residential area near Sample Site 59 with MWRDGC owned adjacent land provides for an opportunity to improve fish habitat both within and alongside the waterway. Barge traffic levels are high and some visibility exists from bridge and roadways near the site. A pipe with evidence of a steady base flow discharges immediately west of the bridge-crossing on the south bank, providing some potential for capturing cool base flow water for use in water temperature mitigation. Due to its restricted access and visibility, the site offers the potential for measures that might otherwise be susceptible to vandalism if located in a more central location. Dredging occurs routinely to maintain navigable depths and commercial vessel traffic is heavy. Enhancement measures must avoid encroaching into navigational channels, and must be highly resistant to intensive boat wake and potential collision. Much forested land exists alongside both banks, both on and off MWRDC property. These areas offer proximal variety and diversity of habitats, although linkage and connectivity is currently poor between the waterway and especially the south bank, which has steep vertical banks in many locations.

Site Conditions

Near the sample site, the waterway features well vegetated conditions on the north bank, with relatively stable shoreline conditions in most areas. Heavy navigational traffic is concentrated near the north bank where water depths average roughly 20 feet in the main channel. Bathymetric data shows water depths up to 20 feet near the north bank, with a sloping bottom tapering up to the south bank. A wide zone of shallow water insufficient for boat traffic exists along the south bank. This cross section is typical throughout the reach. On the south bank, conditions are marked as concrete, but appear in images to be natural limestone of relatively low height, ranging up to 5 feet, with a wide shallow zone sloping toward the main navigation channel. Along the south bank riparian vegetation occupies a narrow strip, behind which poor soil conditions support a sparse growth of grass and weeds. However, some emergent wetlands exist in patches near the waterline. In some areas, cavities that formed in the limestone banks appear to provide small lunger-type cavities and overhangs on the south bank. The bottom conditions throughout the reach consist of poorly consolidated sediments and flocculated materials frequently disturbed by boat traffic. The water surface is highly exposed to solar radiation with sparse overhanging vegetation. Based on existing information, limiting factors are recognized as frequent very high energy impacts due to navigational barge traffic, unconsolidated and undifferentiated sediments, minimal overhanging bank and shade conditions, and lack of structure for shelter and other functions.

Concept Enhancement Elements

Recommended enhancement measures include Sunken Structure, Artificial Seaweed, and Linear Shallows enhanced by a stormwater management wetland designed to intercept and utilize base flow and treat the first flush of stormwater, plus added riparian reforestation. Sunken Structure can be created in at least three possible ways, and the exact method will require further site investigation and assessment of other issues tied to water usage and maintenance patterns, as well as owner preferences. One method would involve improving existing bank cavities or to create new ones. This could be accomplished by divers, possibly in conjunction with a barge, to access the submerged portions of the south bank. Improvement of existing cavities can be accomplished by enlarging them with various tools and potentially reinforcing and stabilizing them with underwater grout. New additional cavities could be created by using a jackhammer to carve cavities into the bank material in new locations. Existing banks of limestone exhibit hard properties capable of holding cavity forms for long periods. A second method is to create aprons of riprap to elevate structures above the zone of unconsolidated sediment and to apply reclaimed material such as toilet bowls and tanks atop the apron to serve as a cluster of cavities for fish shelter. Given the poor public visibility of the site, this measure would not be likely to instigate any illicit dumping and could represent an inexpensive and resourceful solution. A third method is to apply concrete box culverts or pipes atop riprap aprons to create lunker structures along the steepest and deepest sections of the south bank, or alternately positioned a short distance from shore within the wide shallow zone.

On the south bank at both sides of bridge, away from the stormwater outfalls, Artificial Seaweed will be applied on a total of 330 linear feet of bank. The mats for seaweed will be placed along the existing 6' contour elevation parallel to the south bank approximately 50 feet from the bank waterline. In this manner the units should be set back from future dredging and navigational activity, while forming a wide protected zone behind them. Two reaches totaling 330 feet in length of sheltered shallow shoreline will be created due to the energy dissipation effect of the seaweed. Placing Artificial Seaweed elements near the middle zone of the channel where they serve to reduce wave reflection and promote rapid stilling of a wake after boats pass by will initiate additional sediment consolidation, stabilization, and sorting. Overall energy levels within the reach will be reduced.

Linear Shallows and a constructed wetland will provide shallow aquatic habitat and enhance physical characteristics of incoming stormwater. Linear Shallows will be excavated in one location at the south bank in proximity to a stormwater outfall that exhibits base flow, presumably from groundwater discharge along a culverted stream-course. A stormwater management basin will be constructed in order to manage floatables and sediment that are typically carried by urban streams, and also to capitalize on a source of base flow to provide moisture to support hydric soil conditions and percolating flow to the Linear Shallows. The existing culverted stream will be outfitted with a box forebay equipped with a trash screen and a baffle that diverts low flows through an excavated basin planted with wetland species. High flows will continue down the culvert and will discharge to the waterway using the existing apron at the outfall. The constructed wetland will be sized and planted to provide first flush treatment and to infiltrate a significant portion of the base flow that enters it. It is highly likely that the infiltrated

water is significantly cleaner than the waterway, and it will serve to flush and maintain cool temperatures within the Linear Shallows.

The area between the stormwater management wetland and the Linear Shallows will be planted densely with riparian trees to promote shade for maintaining cool water temperature. The linear shallows will be approximately 100 feet long and 40 feet wide at the normal water elevation. The target depth of the Linear Shallows is a range from 3 to 4 feet in order to promote cool heavily shaded low wave energy water conditions with soft but consolidated, organism appropriate soils. The intent is to create a cool water sheltered refuge with access for fish, herptiles, and invertebrates. At one end, a water opening with a baffle structure to limit wave impact will be created by removal and modification of bank edge material. The opening to the Linear Shallows will be sheltered by artificial seaweed to further buffer wave impacts to achieve low energy levels. Signage or buoys may be used to indicate the position of Artificial Seaweed and Sunken Structure elements to navigational users in order to avoid damage to enhancement measures and interference with boat operation.

Habitat Enhancement Outcomes

Measures are selected to create reduced energy level zones for fish and related organisms to use as sheltered habitat for various life stages. Measures are positioned in order to minimize impacts to navigation and to establish quiet water zones within an active navigable waterway with harsh environmental conditions. The main objective is to establish productive physical conditions in terms of littoral sediment suited for diverse benthic organisms, surface area for algae, microbes, and invertebrates, and sheltered water conditions and varied fish life stages and species. Redirecting and infiltrating water flowing through the stormwater culvert will maintain water flow and temperature regimes within the Linear Shallows and will allow the establishment of up to five acres of moist soils, which in turn hosts an array of flora and fauna uncommon along the waterways system. Good existing levels of allochthonous material from existing and new adjacent forest leaf litter will then become available for use by a web of aquatic organisms that previously lacked physical habitat.

The bank area partially protected by Artificial Seaweed is expected to spontaneously generate some aquatic emergent and/or submerged vegetation due to wave attenuation, which in turn will promote juvenile fish populations and provide well oxygenated daytime refugia for fish during hot weather. Sunken Structure will increase diversity and quantity of physical fish habitat for multiple purposes depending on design. Measures are dispersed within a reach approximately 1000 feet in length at locations that are best adapted to their installation and ongoing performance.

Sample Site 99 Bubbly Creek

Habitat Enhancement Constraints and Opportunities

Sample Site 99 is located within a densely urbanized, partially accessible, and somewhat visible area of the city which is undergoing renewal and redevelopment. There is an increased awareness and appreciation of the waterway, which was formerly used for the disposal of slaughterhouse wastewater and other problematic discharges. The site offers opportunity for fish habitat improvement while also contributing to local recognition and understanding for future potential fish habitat measures and outcomes elsewhere in the system. With publicly accessible waterfront areas near old and new industrial and residential areas, combined with very high vehicle traffic on bridges, the site provides viewing opportunities for visible and appealing fish habitat enhancement measures. Signage can be used to explain and document fish habitat elements, thereby not only upgrading local habitat productivity, but also generating support and catalyzing further waterway stewardship in tandem with ongoing development. Bubbly Creek is understood to have high nutrient loading due to its historic use, but is free from commercial navigation owing to its relatively shallow depth. Recreational boat use appears to be on the rise as the area becomes valued as a public waterway.

Site Conditions

The reach of the waterway near the sample site features vertical banks of different materials and in various states of repair. The banks typically have little or no vegetation above the wall structures. There are limited portions of the bank that support vegetation, which is sparse due to erosion at and below the waterline, and these are narrow strips between the waterline and buildings or paved areas. Some newly redeveloped areas of the bank appear to be shallow sloped soil grassy embankments with riprap toe treatment at the waterline. Conditions below the waterline are unknown. Stormwater discharge pipes are located at frequent intervals. Limited bathymetry data has been provided that indicated that depths near the center of the channel are between 9 and 13 feet. Areas along the banks range from 6 to 9 feet. Boat traffic is exclusively recreational and the reach is perhaps the least trafficked segment of the waterways system studied. Aquatic habitat exhibits poor physical diversity and poor productivity. The water surface is highly exposed to solar radiation with little overhanging vegetation, and as with other waterways within the system, bridge decks are the main features that provide shade. Based on existing information, limiting factors are recognized as poor riparian vegetation, poor shade, lack of structure for shelter of various types, unconsolidated and undifferentiated sediments, and infrequent and low-energy impacts from small boats.

Concept Enhancement Elements

Recommended enhancement measures include Floating Vegetation, Artificial Seaweed, Chamber Revetment, and Vegetated Revetment strategically placed to take advantage of existing structures and adjacent land use. To capitalize on existing potentially positive features habitat elements will be

position near bridge abutments and within coves, which serve to provide shelter from boat traffic and which will not conflict with existing or likely future boating activities.

Floating Vegetation is to be established using two methods, each suited to the specific location where it will be deployed, in order to minimize cost while maximizing useful life. In areas sheltered from direct ice or boat impact, inexpensive, structurally minimal Floating Vegetation will be assembled from geofabric layers with attached sealed foam filled pipes for buoyancy. In locations along the creek banks, triangular fabricated modules designed to be highly resistant to ice, boat wake, and vandalism will be used. Anchor systems will be designed to address site specific conditions. Floating Vegetation treatments will be assembled in lengths from 18 to 36 feet, positioned adjacent to the bank, and well secured to the bank and bed using tension relief systems such as buoys to minimize stress at anchors. Vegetation shall feature low maintenance species that are tolerant of saturated hydrology and hydroponic type growing conditions, and that produce significant underwater root systems for fish shelter, as well as attractive foliage and flowers to enhance public acceptance. The key plant species used are expected to be *Iris versicolor* (blue flag iris), *Scirpus validus* (soft stem bulrush), and *Juncus effusus* (soft rush), with shade-tolerant *Sparganium* and *Carex* species added in the most shady locations. Artificial Seaweed will be placed between existing bridge piers in order to create sheltered shallow zones passable to fish, but with minimal water circulation shared with the main channel. A visually appealing scattering of Floating Vegetation will be established using materials that are consistent with boat traffic and park access and usage, including fishing.

Floating Vegetation geofabric elements as described above will be added to promote aeration, biological filtration, and physical habitat from the underwater root zone within the sheltered zones. Vegetated Revetment will be applied to the eroding banks with good sun access in the vicinity of the bridge decks. Plant species will include *Carex crinita* (fringed sedge), *Iris versicolor* (blue flag iris), *Juncus effusus* (soft rush), and *Carex stricta* (tussock sedge), and *Leersia oryzoides* (rice cutgrass) Chamber Revetment will be used to treat the shorter eroding bank areas most affected by shade from the bridge decks. Both types of revetment will include polymer mesh chambers rather than wire materials, and will be filled with a rock mix featuring a majority of scoria to maximize porosity because high density rock is not required. To supplement coverage by both types of revetment, riprap toe protection will be applied for bank protection of surfaces deeper than 2 feet below normal summer water elevation. Additionally a small scale mechanical aeration system, potentially powered by photovoltaic cells mounted on bridge structures would complement the proposed bank and in-stream elements in order to provide a consistent level of oxygen in the underbridge areas with high oxygen retention capacity due to high shade, which attracts fish and provides for cooler water temperatures.

Habitat Enhancement Outcomes

Habitat element selection and placement for this reach of waterway have been tailored to take advantage of the unique shaded and sheltered refuge area under the bridge decks, which appears to support greater potential for maintaining cool summer water temperatures compared to other studied reaches within the system. With or without mechanical oxygenation, the proposed measures will help

create and maintain shaded, cool water refugia with oxygen levels greater than in surrounding waters. Additional habitat elements have been identified to be placed at intervals on both banks of the creek at dispersed locations in order to promote shelter and physical diversity within the channel upstream of the bridges, and downstream towards the confluence in order to promote migration and access for fish during the various seasons and even throughout the various times of the day. Selected measures serve complementary functions in order to enhance biological and physical diversity for fish and benthic organisms. Within the Floating Vegetation underwater root zones, shelter and oxygenation from photosynthesizing plants greatly enhances survival and development of juvenile fish. The enhancement elements within the reach are also expected to attract mature fish as a refuge during poor water quality and high temperature periods, potentially serving as a crucial resource for fish survival, thereby improving quantity and diversity of fish species. An estimated 200 linear feet of bank in total will receive Floating Vegetation elements of one type or another, approximately 100 linear feet of Chamber Revetment and 200 linear feet of Vegetated Revetment will be applied on the left bank, and an estimated 330 linear feet of Artificial Seaweed will be placed, in a pattern that accommodates boat mooring spaces and existing infrastructure.

