DRAFT DOAN BROOK ESTUARY FEASIBILITY REPORT

The Doan Brook Watershed Partnership

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Authorization for Release

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The undersigned attest, to the best of their knowledge, that this document and the information contained herein is accurate and conforms to EnviroScience's internal Quality Assurance standards.

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EXECUTIVE SUMMARY

The Doan Brook Watershed Partnership (DBWP) contracted EnviroScience, Inc. to prepare a feasibility study for a potential estuary at the confluence of Lake Erie and Doan Brook in Cleveland, Ohio. Pending stakeholder agreement, EnviroScience also sought to create a framework to construct a new coastal estuarine habitat to enhance and increase the fish population, provide bird habitat, promote recreation, and improve water quality. EnviroScience included KS Associates, Inc. on the project team as a subconsultant for coastal engineering services, as well as GPD Group for modeling and geotechnical services.

The feasibility study consisted of an analysis of the following items:

- Environmental Review
- Geotechnical Borings and Analysis
- Hydraulic and Hydrologic Modeling
- Sediment and Turbidity
- Ice Flow & Trash Evaluations
- Camera Monitoring of Ice and Trash Flow Near Future Estuary
- Biological Conditions – Current and Potential
- Water Quality
- Location of Utilities
- Structural Stability of Existing Infrastructure
- Impact of The Doan Valley Interceptor Tunnel
- Navigation/Boating Impacts
- Lessons Learned from Similar Projects
- Regulatory Requirements

The results of these parameters were applied to a feasibility checklist based on feedback from the Technical Advisory Committee. Based on the data collected as part of this study, the project team has deemed the Doan Brook Estuary project feasible. In some cases, EnviroScience recommends additional investigation and collection of new data (water quality, sediment) to better inform future phases of the project.

1.0 INTRODUCTION

The Doan Brook watershed includes approximately 12 square miles in Shaker Heights, Cleveland Heights, and Cleveland, Ohio. Doan Brook currently flows to Lake Erie by way of a 3,300 linear foot box culvert through the Cleveland Lakefront Nature Preserve (CLNP), formerly Dike 14. Construction of the culvert by the U.S. Army Corps of Engineers (USACE) began in 1976. The entrance to the culvert lies south of I-90 and to the east of Martin Luther King Jr. Drive at the intersection of MLK Jr. Drive and Broad Avenue. The Brook enters the 3,300 linear foot culvert at this location and flows under I-90, continuing underneath the CLNP, which was formerly the Dike 14 confined disposal facility designed to accommodate contaminated dredge material and debris from the dredging of the Cuyahoga River. The Dike 14 perimeter containment cell (orange outline in Figure 1.1) denotes the boundary of Dike 14 and the future CLNP. Material placed within this boundary is considered hazardous as its source is from Cuyahoga River dredge spoils in the late 1970's, which is known to contain PAHs, PCBs, and petroleum products. The southern boundary of the Dike 14/CLNP is approximately the midpoint of the 3,300 linear foot culvert. The Doan Brook Watershed Partnership (DBWP) secured a Coastal Management Assistance Grant from the Ohio Department of Natural Resources (ODNR) to perform a study of the feasibility of daylighting portions of Doan Brook and creating a coastal estuary at the at the mouth of the brook.

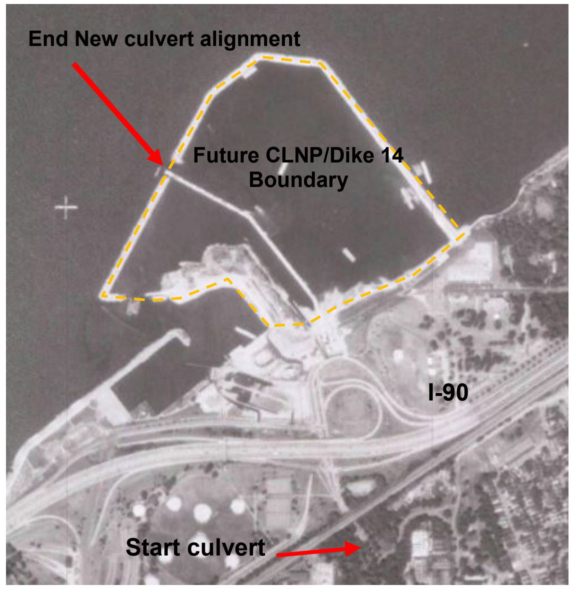


Figure 1.1 1979 Aerial

Examination of the 1927 aerial overlaid with modern streets provides a greater understanding of the original location and condition of the Doan Brook that have since been severely impacted. In Figure 1.2, arrow location 1 points to a historic channel alignment within the I-90 cloverleaf on-ramp. Arrow location 2 points to a meander bend in the Brook heading west towards the marina, which is very near to the original lake entry point. Arrow location 3 points to the existing greenspace in the corner of Dike 14. This area is bounded by a sheet pile wall and fill; behind this area is the natural shoreline, which provides good reasoning to remove it as part of the potential new estuary area.

Figure 1.2 1927 Map Overlaid with Current Aerial and Roads

2.0 ESTUARY CONCEPTS STUDIED

The EnviroScience project team reviewed several conceptual alternatives that had previously been put forth for creating a coastal estuary and/or daylighting Doan Brook including:

1. Daylighting Doan Brook with a new open-channel stream through the west end of the CLNP and exiting to the west in an area just lakeward of the Gordon Park breakwater structure. This alternative would require excavation and removal of a significant amount of material from within CLNP to reach the required grades for a stream through the highly contaminated former dredge disposal areas. This alternative would also require modification of approximately 500 linear feet of the perimeter structures at the southwest corner of CLNP.
2. Daylighting a portion of Doan Brook in a constructed diversion and valley within the CLNP. For this alternative, all flow would be directed back through the current Doan Brook culvert and outfall at the intersection with Lake Erie. This alternative would also require excavation and removal of a considerable amount of potentially contaminated material from within the CLNP to reach the required grades for a stream through the former dredge disposal areas.
3. Daylighting a portion of Doan Brook with a new valley and stream to exit through the east side of the CLNP. This alternative also requires excavation of a considerable amount of contaminated material and impacts to the perimeter structures at the CLNP. Interactions with the neighboring landowner to the east have also suggested that they may be resistant to working with the project team.
4. Daylighting a portion of Doan Brook through a new coastal estuary on the east side of Gordon Park. This alternative would require at least partial removal of the steel sheet pile bulkhead east of the Gordon Park Boat Ramp but would not require excavation and disposal of material from the dredge disposal area or impact the CLNP perimeter structure. This alternative would allow some flow from the Doan Brook to outlet into the estuary and the east end of the marina basin formed by the Gordon Park breakwater structure. This alternative also recommends daylighting a portion of Doan Brook within the I-90 cloverleaf in effort to shorten the remaining culvert distance from its starting point and CLNP.

After extensive discussion with the Technical Advisory Committee (TAC), the project team determined that due to the potential hazards and costs associated with impacting the dredge disposal areas within and surrounding structures at the CLNP, the most feasible approach for an estuary at the mouth of Doan Brook would be the concept described in Alternative 4.

3.0 EXISTING HABITAT CHARACTERIZATION

The Doan Brook flows through highly urbanized neighborhoods of the greater Cleveland area and as such, is subject to intense shifts in discharge volume and stage height. While much of the Brook has been channelized or altered over time, riparian corridors were preserved during early development (Garrity et al., 2013) While sections of the Doan Brook remain confined by retaining walls, there remains a valuable natural canopy and habitat along a majority of the Brook. Outside of this corridor, however, the natural landscape has been altered or replaced by development. To compound the landscape alterations, Doan Brook suffers from historical impacts to its confluence and interface with Lake Erie. These impacts include routing the Doan Brook through a 3,300 linear foot box culvert when the USACE created Dike 14. The goal of this study was to determine the feasibility of restoring a more natural condition than what exists today.

Prior to human disturbance and impacts from infrastructure, the confluence of Doan Brook with Lake Erie was a natural transition with wide meanders, an open floodplain, and marshlands. When Gordon Park was created at the mouth of the Brook to provide recreation in and around this estuary, construction of park facilities impacted the natural confluence. The mouth of Doan Brook was further impacted when a disposal facility (Dike 14) for Cuyahoga River dredge spoils was built in Lake Erie directly over the mouth of the stream. Other impacts included increased urbanization and the I-90 freeway interchange. Doan Brook flows in a mostly channelized environment through Rockefeller Park to I-90, where it enters a final culvert for over 3,300 linear feet under the Dike 14 site (now the CLNP) until it reaches Lake Erie. Currently, the culverted portion of the Brook that passes through the project area provides little to no quality habitat for fish, macroinvertebrates, aquatic vegetation, or riparian vegetation. The major impairments in this sub-watershed are the culverts and channels that impede fish migration, in addition to the degraded coastal habitat.

The neighboring Cleveland Lakefront Nature Preserve to the east was part of the land William Gordon willed to the City of Cleveland in 1896 for use as a public park (now Gordon Park). In the early 1960s, solid waste was dumped along the lakeshore and eventually formed an approximately 10-acre area between sunken freighters and the shoreline (Port of Cleveland, 2016). Starting in the late 1970s, USACE disposed of contaminated sediment dredged from the Cuyahoga River in a walled-off area that juts out from the Lake Erie shoreline (confined disposal facility or CDF) called Dike 14 from 1979-1999. Over this twenty-year period, sand, soil, and clay were placed within the Dike 14 CDF eventually building it to the contours seen today. Once the CDF was closed, the peninsula became filled with diverse species of vegetation and wildlife and is now known as the CLNP. Today, CLNP is 88-acres and has three trails consisting of 2.5 miles total. The area contains a diverse mix of habitats including grasslands, a forest area, meadows, mudflats, shrublands, and wetlands (Port of Cleveland, 2016).

While the CLNP does have to manage its fair share of non-native and invasive species characteristic of urban and highly impacted areas, this parcel also now serves as an opportunity to connect the proposed Doan Brook Estuary with high-quality neighboring coastal and inland habitat. According to the Port of Cleveland, plant and wildlife diversity is high and would likely be indicative of similar, if not greater, biodiversity of an estuary in Gordon Park (Port of Cleveland, 2019).

The adjacent Gordon Park (location of the proposed estuary Alternative 4) and E. 72nd Street harbor currently provide limited habitat for plants and wildlife. Gordon Park is maintained as an open lawn space with limited tree cover, a paved parking lot, and paved boat ramps. The adjacent harbor does appear to be a sheltered harbor with relatively clear water and submerged aquatic vegetation (SAV) that provides foraging and spawning opportunities for moderately-tolerant fish species. Recently, the Northeast Ohio Regional Sewer District (NEORSD) teamed up with the Cleveland Metroparks to perform electrofishing in the harbor to gain a better understanding of fish communities using the harbor. While there is anecdotal evidence of high-value fish using the harbor (muskellunge, northern pike, etc.), electrofishing results show that pollution-tolerant and non-native fish primarily use the harbor. Multiple age classes of northern pike with markings indicative of spawning were observed and tallied. Electrofishing results have also shown that largemouth bass as well as sunfish were abundant and large, offering a quality sport fishery.

While the harbor and its SAV provide foraging and shelter opportunities (and consequently sport fishing opportunities) the harbor remains separated from the shoreline behind the steel bulkhead.

The lack of natural transition from aquatic to terrestrial habitats could enhance this area and promote greater spawning opportunities for fish and wetland/beach-dependent plant and wildlife species. In early phases of the feasibility study, the Cleveland Metroparks voiced concern for the protection of this sheltered clear-water area and views this area as an important resource for Lake Erie. These concerns were incorporated into the feasibility analysis and water quality parameters became paramount to our investigation.

Despite potential challenges to creating estuary habitat in Gordon Park, Lower Doan Brook watershed's urbanized land-use and lack of habitat provide great potential for biological uplift. Already, the harbor and neighboring CLNP provide high-quality habitat for fish, migratory birds, including waterbirds and songbirds, and have been identified by Audubon as Important Bird Areas (IBA). Proposed habitats and potential biological uplift are discussed in detail in Section 4.0.

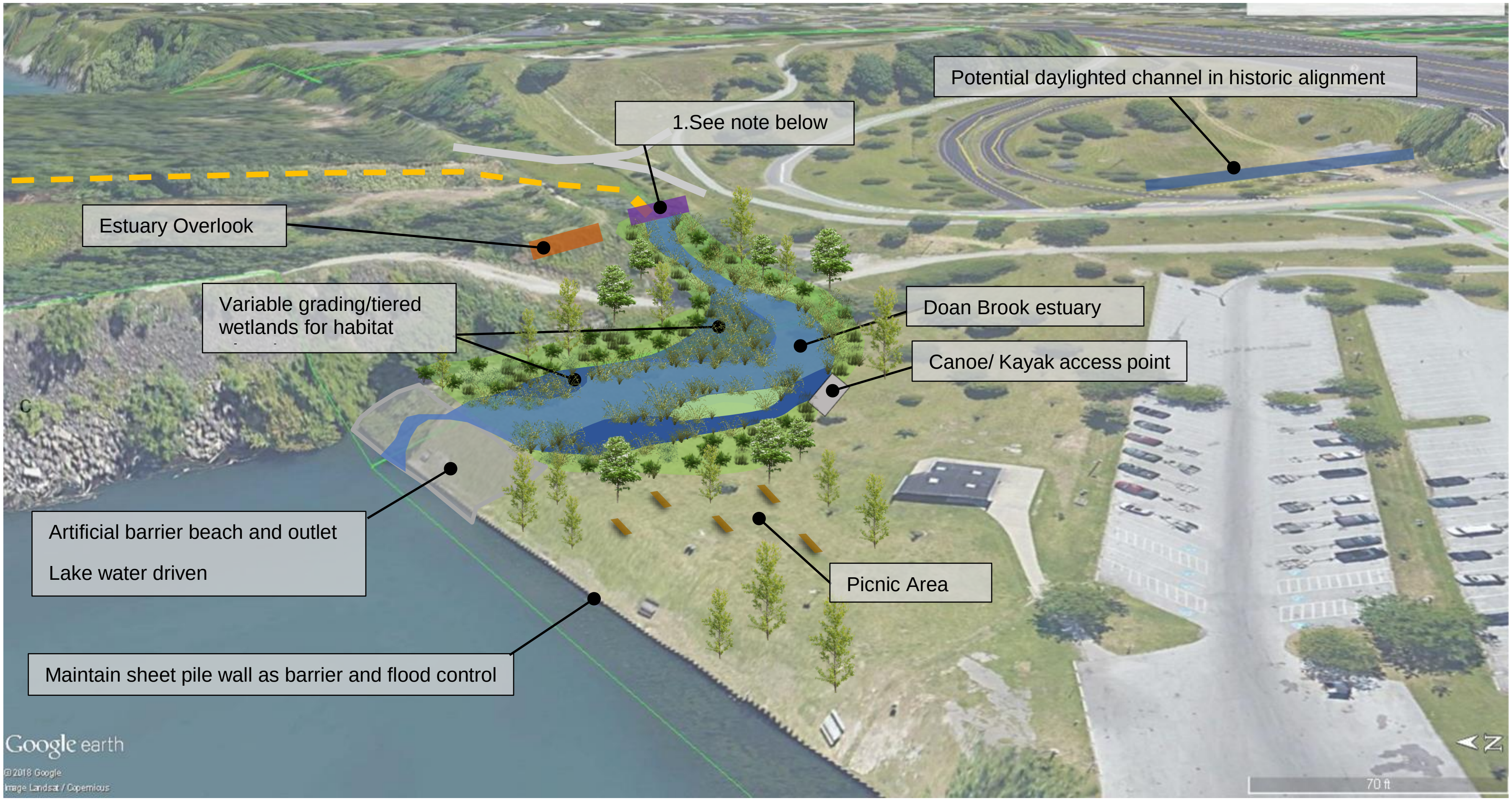
4.0 PROPOSED HABITATS

The DBWP has proposed Alternative 4, the concept of daylighting Doan Brook within the I-90 cloverleaf (where it is currently culverted) in its historical alignment and the restoration of coastal estuary habitat in Gordon Park at the former location of the natural mouth of Doan Brook. Doan Brook, once a natural estuary with sweeping meanders, wetlands, and a barrier beach, now completely lacks access and connection to the Lake. These fundamental changes to the landscape will serve as the foundation for significant improvements in the functionality and ecology of Doan Brook. The concept also builds upon the existing habitat within the CLNP by not disturbing the integrity of the dredge spoil, thereby leveraging the positive aspects of that site and further augmenting the large lakefront preserve with an adjacent estuary connection. The concept, however, does consider the water quality concerns and existing aquatic habitat within the E. 72nd St. harbor. The goal of this concept is to achieve a more natural connection to the lake and daylight as much stream channel as possible while preserving the existing culvert infrastructure under CLNP. Preserving the existing culvert and utilizing a diversion gate structure to regulate flow from the Doan Brook allows for the creation of estuary conditions when water quality is optimal while minimizing concerns regarding impacts to water quality and fish currently using the E. 72nd Street harbor. In total, the restoration would result in over 760 linear feet of restored channel and over 1.7 acres of lacustrine wetland at the mouth of the Brook (Figure 4.1).

Gordon Park is the target for the new estuary and Doan Brook connection. Gordon Park was created with fill of coastal areas behind the sheet pile wall that currently protects the Park from erosion by the Lake. The EnviroScience team performed a boring analysis in the park to verify fill to a depth of approximately 12 feet below ground surface. The proposed estuary project would involve removing this fill down to wetland elevations and restore an estuary as the focal point within Gordon Park. Gordon Park would then be enhanced with a more interactive and immersive experience that would include several new park amenities such as additional fishing, picnicking, kayaking, and hiking opportunities, and increased habit and wildlife diversity. A proposed canoe/kayak launch located close to the parking lot will provide protected, easy, and safe access to the estuary and Lake. Ample room for picnic areas would remain close to the existing rest room facilities. Lastly, a proposed overlook feature within the CLNP would provide a scenic vista of the estuary with the skyline of Cleveland in the distance.

The following Sections 4.1 and 4.2 provide additional detail on the two-part concept.

Figure 4.1 Doan Brook Estuary in Gordon Park Concept (Alternative 4)



1. Existing junction box location. See Figure 4.3.

4.1 DAYLIGHTING LOWER DOAN BROOK

The first feasible location to daylight Doan Brook is just north of Lake Shore Drive within Gordon Park near the access junction box, which lies just to the north of the fence line. The Brook could be daylighted starting near this location without impacting existing infrastructure. Although a significant portion of the culvert length would be eliminated through the restoration of an estuary habitat in Gordon Park, approximately 1,100 feet of culvert would still remain to the south that would be considered a barrier to fish passage, given that the same low-light/no-light situation will persist. To counteract the same fish passage issue that could potentially exist after the project, we proposed daylighting Doan Brook within the cloverleaf of the I-90 West on-ramp. This location would split the remaining 1,100 feet into two smaller reaches to serve as another potential maintenance access point, but more importantly, the opening would allow for light penetration to counteract the 1,100 feet low-light barrier. Also, according to mapping and aerial photos, the alignment of the Brook historically passed through this location. In its current culverted state, the lack of light could be one of the largest factors preventing or hindering fish movement through the culvert. Although this premise has not been widely studied, persistent darkness contradicts the natural biology and typical diurnal cues of the fish. The proposed grading plan for the daylighting of Doan Brook in the I-90 cloverleaf is shown in Appendix A. The current approach to the culvert daylighting is to simply cut open the top of the culvert and performed grading to create safer side slopes. The relatively short distance within the cloverleaf would be infeasible to attempt to restore the original alignment due to the culvert depth. The exposure to light will not only allow for the diurnal cues that facilitate fish passage but also promote primary production of algae and periphyton for macroinvertebrates, thereby providing additional forage for fish in this reach. Lastly, daylighting the Brook in this location would also provide the opportunity to restore critical riparian habitat in a highly urbanized environment, which provides natural contaminant filtering properties, capturing additional sediment before it reaches the potential estuary.

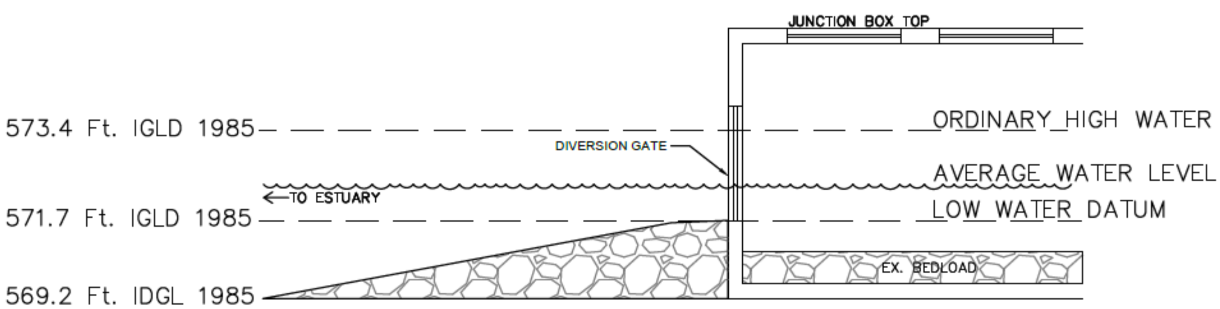
4.2 DOAN BROOK ESTUARY IN GORDON PARK

Restoration of a coastal estuary in Gordon Park (versus CLNP) was deemed most feasible of the concepts reviewed by the TAC (Section 2.0). The nexus between Doan Brook and the estuary would be located at the junction box currently within the CLNP (Figure 4.2).

Figure 4.2 Existing Doan Brook Culvert Junction Box Location

Due to water quality concerns potentially impacting the E. 72nd St. harbor, the existing culvert and junction box would remain in place, and a diversion gate/orifice connection would be installed in the junction box to divert flow west towards Gordon Park. The diversion gate is key to the success of the concept and to maintain a adequate water quality in the proposed estuary. The proposed gate elevation (described further in Section 9.2.5) would be set at approximately a 570 elevation. The entire MLK culvert water elevation is controlled by Lake Erie water level. Therefore, if the Lake is at a 572 elevation the water elevation in the culvert and through the new gate opening would be a 572, thereby conveying 2 feet of depth through the gate entrance. The culvert invert at the junction box location is 565 elevation thereby providing 5 feet of depth from the bottom to the proposed gate outlet. This difference in elevation eliminates any concern of heavier bedload sediments such as sand and small gravel from entering and accumulating in the new estuary. Suspended sediment or dissolved pollutants will remain the primary concern, but the gate will have the ability to seal the culvert such that flow events with water quality concerns can be separated from the estuary and continue down the existing culvert as it does currently.

Figure 4.3 Profile View of Junction Box with Gate Control System



A stream channel would be restored coming out of the junction box and west into Gordon Park, where the channel would then open into a multi-tiered estuarine wetland system (see the estuary grading plan in Appendix A). The estuary system, while further improving fish passage, would also provide sediment and contaminant filtering properties as well as providing a foundational habitat that currently is very rare along Lake Erie, especially in the greater Cleveland Area.

Although it is an international destination for birding, fishing, and boating, water quality issues have impacted Lake Erie in recent years. One cause of worsening water quality is the significant loss of natural coastal estuaries and wetlands, which function like kidneys, filtering out excess nutrients from the water, such as nitrogen and phosphorus, while providing critical fish and wildlife habitat. While water quality concerns were raised at several points during the feasibility study, EnviroScience believes that water quality in the E. 72nd Street harbor can be maintained through the restoration of an estuary for sediment and contaminant filtering, as well as the diversion gate mechanism described above (shown in Figure 9.6), which can be used to reduce or eliminate flow from Doan Brook during high-flow and/or low water quality events.

Finally, many estuary systems form a barrier beach, which is a natural phenomenon caused by the accumulation of sediment from both the tributary and lake drift (Figure 4.4). The energy differential during flood discharge into the lake causes an aggradation of material, resulting in a sediment bar or beach. This beach serves as a protection against wave action but results in a slightly higher estuary water elevation than the lake. This elevation difference causes the formation of a small riffle during baseflow, allowing concentrated flow/velocities entering the lake. These connections can be highly variable in width and dimension but are important to protect the estuary from lake waves. They serve as a more consistent low water elevation control that is important for plant development and nursery habitat for fish.

Figure 4.4 Two Examples of Natural Tributaries Confluences with Lake Erie and the Formation of a Barrier Beach

Unfortunately, it is a foregone conclusion that a new Doan Brook estuary could not maintain a true barrier beach due to the protected nature of the E. 72nd St. harbor and separation of bedload sediment via the diversion gate. However, to mimic the important benefits and functions, a modified barrier beach is proposed as part of the concept. The structure is conceptualized as a modification of the existing sheet pile wall and using rock to create an opening of variable width and dimension to be determined during final design but with the intention of operating over a range of flows and mean/historic lake levels. The existing sheet pile will remain but would simply be cut and serve as the foundation in which to “key” rock to create the shape of the opening. Rock could be place on the north side (i.e., Lakeside) of the sheet pile wall as well to offer a more natural transition into the estuary. This rock, while serving as the foundation of the structure, could be backfilled as part of the design with finer grained sands and gravels or be allowed to accumulate overtime.

The concept proposed by EnviroScience is expected to expand coastal habitat and improve the ecology of the lower Doan Brook, but also provides a unique opportunity for visitors to interact with their environment. The concept protects existing picnic space, while expanding opportunities for fishing, kayaking, and hiking. The transition from aquatic to terrestrial habitats also provide extensive learning opportunities through outdoor classroom work, volunteer events, and docent-led walks.

5.0 BASELINE BIOLOGY

5.1 METHODS

Collecting new baseline biological data was not originally within the scope of this feasibility study. Concerns were raised, however, about the impacts of the project on specific biological communities, especially fish. EnviroScience worked with community and conservation partners to gather and analyze existing data to better understand the potential impacts of a coastal estuary to fish, bird, reptile, amphibian, and invertebrate communities. In the case of fish communities, some new data was collected by the Cleveland Metroparks and NEORSD staff.

5.2 RESULTS

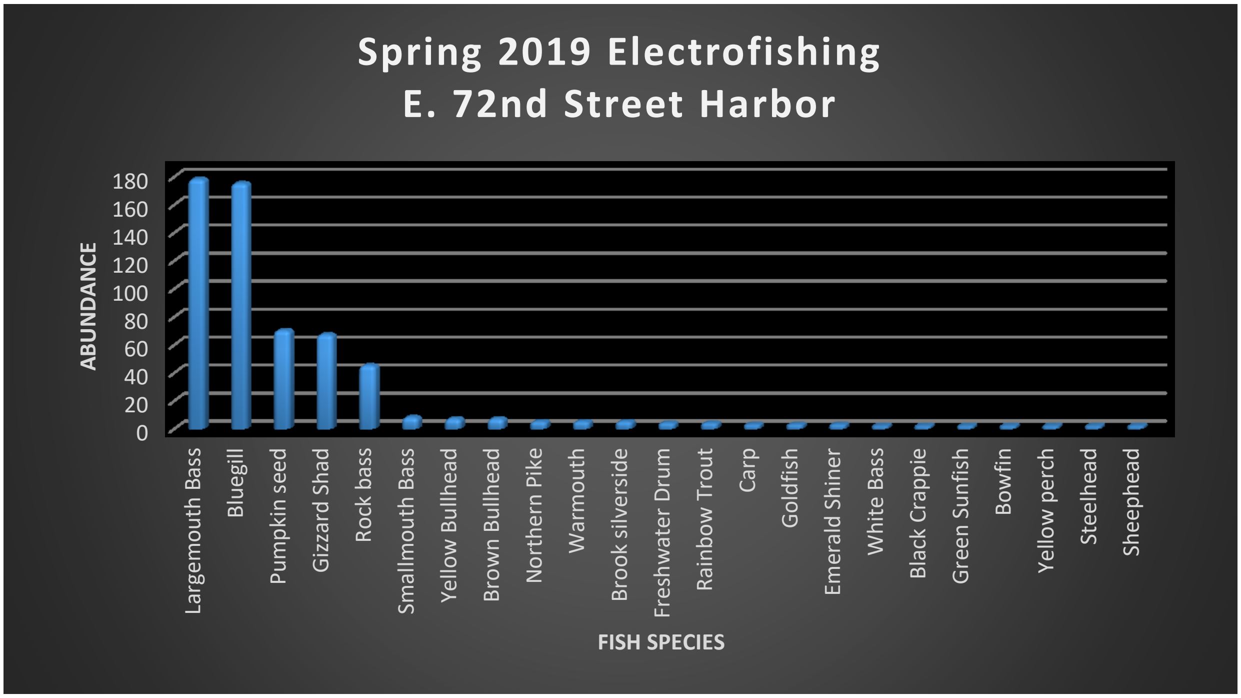
5.2.1 Fish

EnviroScience analyzed existing fish data from Doan Brook and the E. 72nd Street harbor supplied by NEORSD and Ohio Environmental Protection Agency (EPA) and compared this data with that from existing natural coastal estuaries (Arcola Creek, Old Woman Creek) as well as restored estuaries. Concern was expressed that the water quality in Doan Brook could negatively impact muskellunge habitat in the E. 72nd Street harbor if allowed to flow into Lake Erie. While EnviroScience assessed water quality impacts separately, we also reviewed literature pertaining to the life history of the muskellunge and its use of nearshore habitat.

Muskellunge (*Esox masquinongy*), northern pike (*Esox lucius*), and other species spawn in shallow water, emergent marsh on tule or bulrush (*schoenoplectus* spp.) (Roger Thoma, personal communication, March 8, 2019), logs, and submerged trees (Lane, Portt and Minns, 1996). Because spawning occurs in shallow water emergent marsh, muskellunge, and other desirable fish species are not likely resident species in the project area, but rather are passing through and foraging near SAV. Limiting factors for these desirable fish species include water quality factors such as salts, metals, and nutrient input (Dombeck, 1984).

As a result of these concerns, additional water quality and fish data was collected during the feasibility study by EnviroScience, NEORSD, and Cleveland Metroparks. Electrofishing was conducted in the E. 72nd St. harbor on April 2, 18, and 30, 2019. Species presence was recorded on April 18, but abundance was not. For the purposes of this analysis, we entered a value of “1” for any species that was observed on the 18th. Twenty-three species were observed across the three electrofishing efforts (Figure 5.1). Most of the species captured were moderately tolerant of lower water quality. The most abundant species include Largemouth bass (*Micropterus salmoides*) and Bluegill sunfish (*Lepomis macrochirus*). Both species are part of the sunfish family (*Centrarchidae*), which is moderately tolerant of pollution and habitat alterations (EPA, 2008). The Largemouth Bass is reportedly more tolerant of turbidity than the other basses of the genus *Micropterus,* especially in waters where food is abundant (Etnier and Starnes, 1993; Miller, 1975). Bluegill Sunfish is among the most tolerant of North American fishes and can tolerate low dissolved oxygen levels as well as habitat disturbance (Baker, 1983; Matthews, 1987; Killgore and Hoover, 2001). The centrarchids, however, are vulnerable to the loss of adequate midwater and benthic food items (Ohio EPA, 1987). Next most abundant species, including Pumpkinseed Sunfish (*Lepomis gibbosus*) and Rock Bass (*Ambloplites rupestris*), are often associated with clearer waters with low siltation (Bouck, 1972; Robison and Buchanan, 1988; Jenkins and Burkhead, 1994). Rock bass regional and state tolerance classifications range from "intermediate" (Whittier and Hughes, 1998; Halliwell et al., 1999) to "intolerant" (Lyons, 1992), suggesting that their presence may be linked to the clearer vegetated waters of the E. 72nd Street harbor. Non-native species caught include goldfish, rainbow trout, and common carp; however, these species occur commonly in the Great Lakes and were relatively low in abundance. Overall, the results of the spring 2019 electrofishing efforts produced a species assemblage that is representative of an urban fishery. While these findings do not indicate that the water quality in the E. 72nd Street harbor is poor or that high-value sport fish do not utilize the harbor at certain times, it does indicate that the majority of individuals that typically use the harbor may be tolerant of limited changes in turbidity, temperature, and water chemistry.

Figure 5.1 Fish Species Abundance in the E. 72nd Street Harbor in Cleveland, Ohio



5.2.2 Birds

While no baseline data exists for birds in the immediate Gordon Park project area, point count surveys have been performed at the neighboring CLNP since 1985. EnviroScience gathered data from ebird, point count surveys conducted by the Kirtland Bird Club, Western Cuyahoga Audubon, and Greater Cleveland Audubon, as well as point count data collected by Sean Zadar between 1985 and 2000. The data collected more recently by the Audubon chapters and the Kirtland bird club (systematic point count surveys at CLNP over the past 5 years) serve as a current snapshot of bird species that use the existing habitat. The list totals 204 species bird species, including rare species and those seen flying by or in the adjacent lake, as well as those seen at CLNP.

Additionally, data available on “ebird” produced a list of 274 bird species. The species list documented in this dataset is extensive (going back to 1900) and is a more indicative example of what species could utilize the habitat in this area if conditions are right. Historical data from 1900-2000 have been entered into ebird, resulting in many of the shorebirds shown on the ebird species list (including red knot). When date ranges are restricted to sightings after 2000, species richness is reduced (250 species), and the shorebird list is significantly reduced. This reduction is likely because conditions at CLNP were very different historically before the Dike 14 Confined Disposal Facility (CDF) was filled completely. Specifically, extensive mudflats persisted near the outer boundaries of what was the Dike 14 CDF during many of those years, which would naturally attract a greater diversity of shorebirds. Both datasets include birds observed on the lake as well as birds flying over. The complete list of birds currently using the CLNP area (truncated to include recent data from 2000-2019) is included in Appendix B.

5.2.3 Reptiles and Amphibians

Reptile and amphibian habitat is extremely limited in the Gordon Park area because of its manicured environment (i.e., hardscapes, lawn). The impoundment of the park behind sheet pile walls prevents a natural connection from terrestrial to aquatic areas. No baseline biological data was available for these classes.

5.2.4 Invertebrates

Diverse habitat for invertebrates is limited in the Gordon Park area because of its manicured environment (i.e., hardscapes, lawn). No baseline biological data was available for these classes.

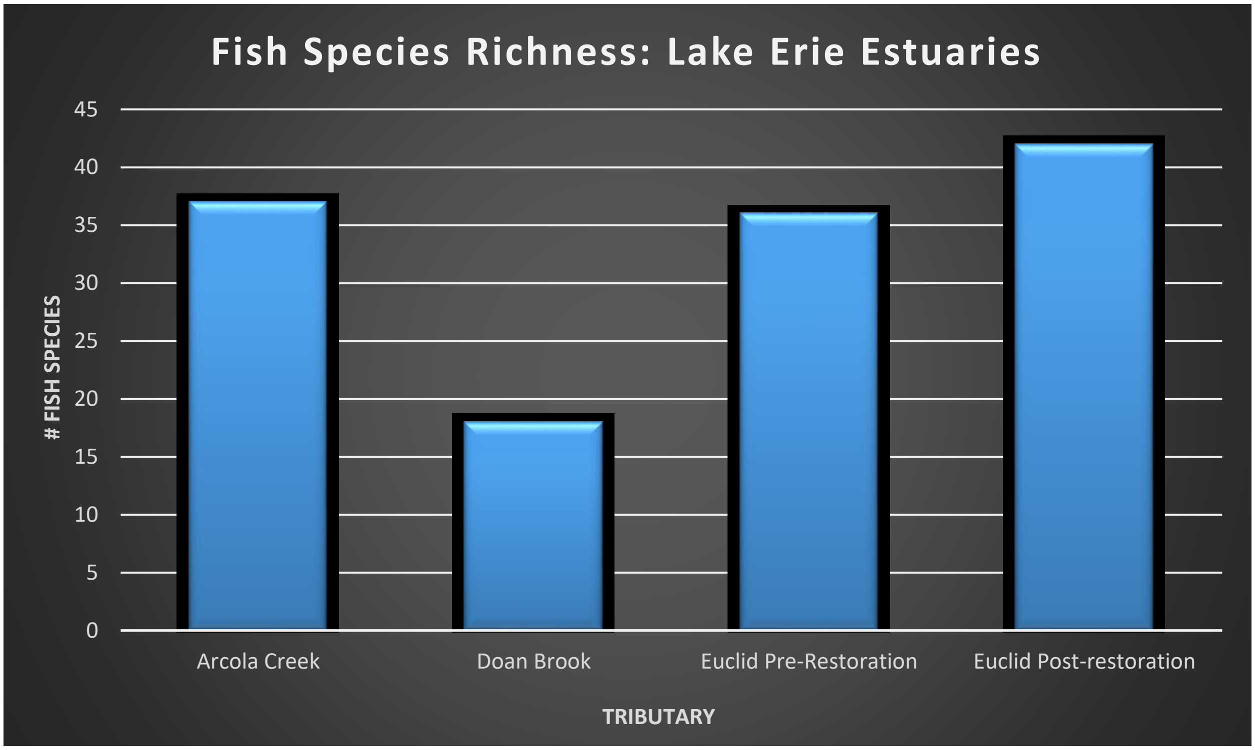
6.0 POTENTIAL BIOLOGICAL UPLIFT

6.1 FISH

EnviroScience analyzed existing fish data from Doan Brook and the E. 72nd Street harbor supplied by NEORSD and Ohio EPA and compared this data with that from existing natural coastal estuaries (Arcola Creek, Old Woman Creek) as well as restored estuaries. When assessing potential biological uplift, EnviroScience took into account that the estuary will provide ecological services that do not currently exist on this site, including rare coastal/shallow-water spawning habitat, areas of warmer water that can be more hospitable for juvenile fish, and contaminant filtering and sediment capturing properties for lake and tributary waters. Based on the available data, in addition to providing spawning habitat for a variety of fish, including muskie, the estuary also has the potential to support other rare fish, such as pugnose minnow, black chin shiner, black nose shiner, walleye, etc.

To approximate species composition in an estuary in Gordon Park, our team assessed fish species composition and richness of other direct tributaries to Lake Erie that have either a natural or restored estuary. Data collected from river miles 0-1.6 only (near mouth) were used to develop the potential fish species list to ensure that the focus was on the biological potential of the proposed estuary. Figure 6.1 illustrates the difference in species richness between current conditions in Doan Brook (near mouth) and other direct tributaries to Lake Erie with either natural or restored estuaries. Euclid Creek, in particular, is considered a useful comparison due to its similar watershed land-use/land-cover, although Euclid Creek's existing connection to Lake Erie was not altered. Arcola Creek has an intact natural estuary and natural barrier beach, which would be representative of a reference site and/ or a least-impacted condition. Figure 6.1 indicates that systems with natural connections to Lake Erie have a considerably higher species diversity than Doan Brook.

Figure 6.1 Fish Species Richness in Northeast Ohio Direct Lake Erie Tributaries



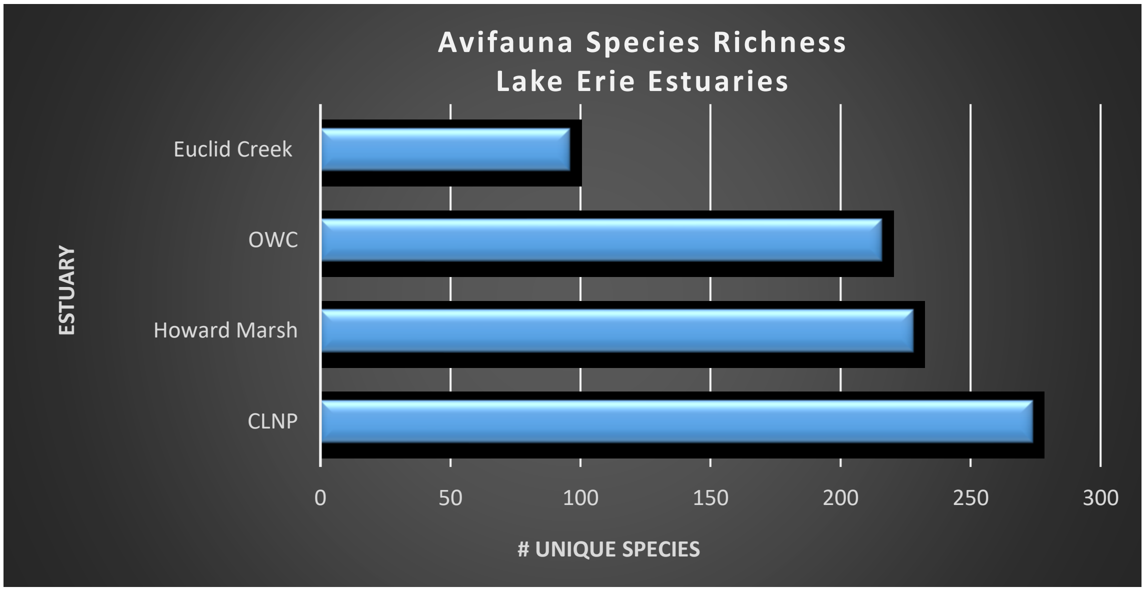
Because only a highly impacted hydrologic connection exists between Doan Brook and Lake Erie via the Doan Brook culvert at high lake levels, the fish species richness is comparatively very low. The water quality and lack of habitat in the lower Doan Brook further contribute to the lack of richness and abundance, especially in comparison to other Northeast Ohio Tributaries. In comparison with these tributaries, upon daylighting Doan Brook and restoring an estuary in Gordon Park, it does appear that significant biological uplift will be gained.

A full list of potential fish species that would benefit from the Doan Brook Estuary can be found in Appendix B.

6.2 BIRDS

To develop the list for potential bird species to benefit from the Doan Brook Estuary, our team collected lists of current observations at nearby CLNP and combined that list with historical observations (when exposed shoreline/mudflat existed) along with data from other coastal estuaries along Lake Erie. We also compared species richness with other Lake Erie estuaries to better understand where Gordon Park and CLNP fall in terms of supporting high-quality bird habitat. To compare using consistent datasets, we graphed ebird data from Euclid Creek, Howard Marsh, Old Woman Creek, and CLNP (Figure 6.2).

Figure 6.2 Avifauna Species Richness Across Lake Erie Estuaries



The CLNP and adjacent Gordon Park are part of an Audubon-designated Important Bird Area (IBA) (Figure 6.3) and showed the highest species richness of the coastal areas. Notably, this IBA designation includes the riparian corridor of Doan Brook, which preserves a variety of diverse natural habitats, including lake, stream, field, forest, marsh, and ravine, all within an urban setting. Also, within this IBA, historic mudflats generated by Dike 14 dredge disposal impoundment persisted on the Lake Erie shore and were the site of numerous exceptional shorebird records, with 38 species noted during the 1980s, including sharp-tailed and curlew sandpipers. Succession progressed into a primarily shrub/scrub stage and lakefront habitat after the CDF was filled to capacity and closed. CLNP now offers patches of exposed mud, fragments of wetlands, early and late successional fields, early successional woodland, and coniferous stands.

The potential estuary and surrounding waters, including the yacht club, breakwaters, and harbor, provide significant potential for a wide variety of birds. The area has produced confirmed sightings of sharp-tailed sandpiper, ruff, yellow rail, king rail, Le Conte's sparrow, nearby ivory gull, black guillemot, and other rarities along with a wide variety of migratory waterbirds seeking refugia and foraging opportunities. This IBA offers critical stopover habitat for a wide variety of migratory birds, acting as an "island" of habitat in an urban area along a major flyway. An expansion of this IBA to include additional habitat diversity (open stream, coastal estuary) is predicted to increase bird use of this IBA and increase species richness as well.

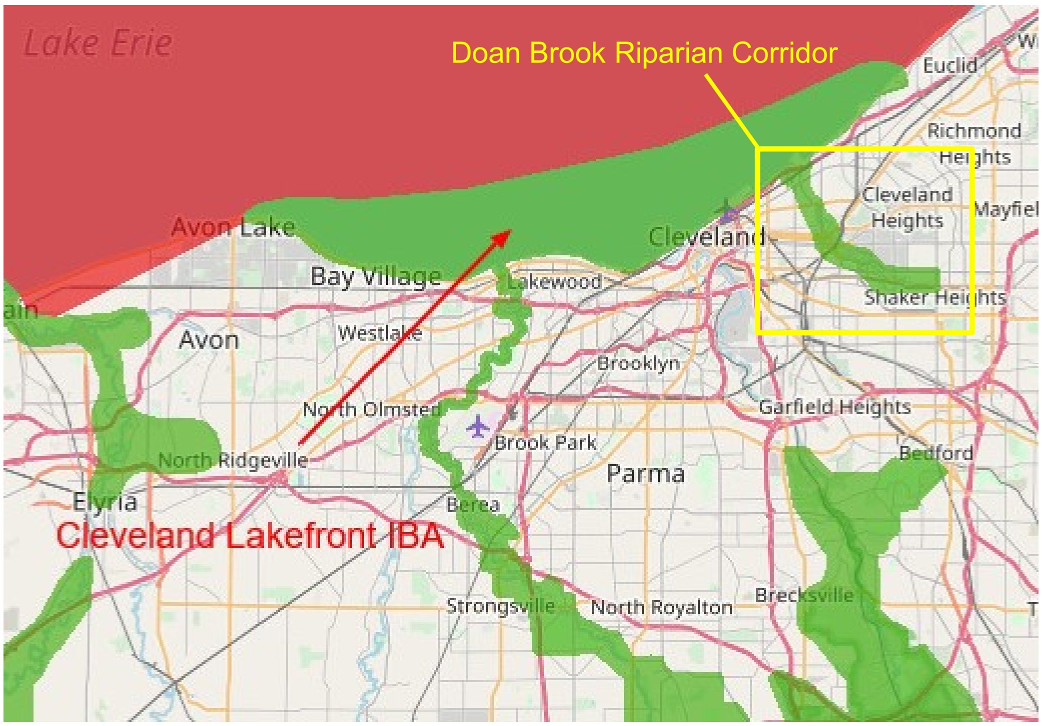
Use by Rare Birds

Both piping plover and red knot are on the historical ebird list (1985-2000), but not on the 2000-2019 list. This finding suggests that these two species would utilize coastal habitat if it was present, such as estuarine wetland, mudflat, or barrier beach. Additionally, several species on the Ohio endangered list have been observed at CLNP, including northern harrier, common tern, and American bittern. The American bittern is a species that may particularly benefit from the restoration of a coastal estuary. The wetland areas that have developed within CLNP since the invasive phragmites was sprayed are also attracting some marsh species, such as sora and marsh wren. From Ohio’s threatened species list, sandhill crane, and trumpeter swan are both observed as flyovers.

Several species from the Ohio Species of Concern list have also been observed at CLNP and use the habitat in a significant way, including marsh wren (regular migrant), sora (moderately regular migrant), black-billed cuckoo (breeding), and vesper sparrow (irregular migrant).

From the Ohio special interest list, many of the birds listed are regular migrants. Northern saw-whet owls roost on CLNP in winter. Hermit thrush are regular migrants, and a few individuals have lingered over the winter in some years. A least flycatcher was consistently singing there last summer, suggesting that it was at least attempting to nest.

Figure 6.3 Cleveland Lakefront Important Bird Area, including the Doan Brook Watershed



Adapted from: https://www.audubon.org/important-bird-areas/cleveland-lakefront

6.3 HERPTILES

A coastal freshwater estuary on Lake Erie would provide rare breeding, nesting, feeding, and predator escape habitats for many species of reptiles and amphibians. The transition between land and water found in this type of estuary, including upland buffer areas like those that naturally exist at Gordon Park, makes coastal estuaries one of the most diverse habitats in the world. The provision of ample water, abundant and diverse vegetation (based on topographic variability), which serves as a basis of food chains, and adequate cover provided by aquatic, wetland, and shore vegetation provide excellent habitat for a variety of reptile and amphibian species.

Amphibians constitute a class of vertebrate animals that include salamanders, toads, and frogs. Most amphibians lay their eggs in shallow water, making the estuary habitat ideal for species that currently have no habitat at Gordon Park. We expect that the restoration of aquatic to terrestrial habitat will benefit several species of salamanders, toads, and frogs, including giant salamanders, mole salamanders, and the lungless salamanders. Additionally, the site has the potential to support toads and frogs, including American and Fowler's toads, chorus frogs, and true frogs (bullfrog, green frog, leopard frog, etc.).

The estuary will also provide currently non-existent habitat to a variety of reptiles, including snakes and turtles. The turtles most likely to benefit from the potential estuary include musk turtles, snapping turtles, box/water turtles including painted, spotted, Blanding’s (state threatened), map, and box turtles, as well as one likely species of softshell turtles (Eastern spiny softshell).

The snakes in the study area all belong to the colubrid family or harmless snakes, including common garter snake, northern water snake, Dekay's brownsnake, northern red-bellied snake, northern ring-necked snake, and eastern milksnake. While these species are most likely to populate the estuary habitat based on the biological data from the Old Woman Creek Estuary, the habitat could potentially support reptiles that are listed as Species of Special Concern by the Ohio Division of Natural Resources (Herdendorf et al., 2006).

6.4 INVERTEBRATES

Estuaries are diverse ecosystems with a high amount of productivity that support a large diversity of invertebrates. The estuary restoration is expected to create habitat for a diversity of aquatic invertebrates such as zooplankton, benthic macroinvertebrates, crayfish, freshwater mussels, aquatic snails, worms, and insects, all of which form the basis of the aquatic food chain. We expect that the estuary restoration will likely benefit aquatic insects including EPT taxa (Orders: Ephemeroptera, Plecoptera, Trichoptera), midges (Order: Diptera), and dragonflies and damselflies (Order: Odonata). These aquatic insects with complex life cycles are an important source of food to aquatic predators as well as to the surrounding terrestrial habitat as they provide a sizeable influx of prey items during metamorphosis from the aquatic larval to the terrestrial adult stage. Many of these species have been observed at the nearby CLNP and as such, we expect these species to inhabit the proposed estuary restoration area. Additionally, a large number of terrestrial invertebrates, including spiders and insects such as moths and butterflies (Order: Lepidoptera), bees and ants (Order: Hymenoptera), beetles (Order: Coleoptera), and flies (Order: Diptera), are expected to benefit from the newly established wetland/terrestrial transitional habitat created by the estuary restoration. The conversion of the existing maintained lawn habitat to a naturalized area that will be seeded and planted with native plants will include host plants to many invertebrate species including beneficial insects (i.e., pollinators).

6.5 VEGETATION

The proposed estuary has the potential to restore a native coastal wetland plant palette that has long since been filled, removed, or impacted along the urban Cleveland lakefront. Freshwater estuaries are critical to the health of Lake Erie and Ohio’s wildlife because of their contaminant filtering and sediment capturing abilities, resulting in cleaner water entering the Lake. Recent efforts towards restoration and conservation are based on the knowledge that coastal and estuarine wetlands provide valuable benefits, including flood control, shore erosion protection, floodwater storage, nutrient control, capture of sediment, and supply of detritus for the aquatic food web (Herendorf, 1987). Potential habitat communities in the Doan Brook Estuary include freshwater marsh, open riparian, scrub-shrub, barrier beach, and upland forest (CLNP).

EnviroScience wetland experts, in collaboration with the Cleveland Museum of Natural History, developed a list of proposed plant species that would be characteristic of a natural Lake Erie estuary. Native communities at Arcola Creek, Old Woman Creek, and Mentor Marsh were used as reference sites in developing the proposed plant palette for the Doan Brook Estuary (Table 6.1).

Table 6.1 Doan Brook Estuary Target Vegetation

Species	Common Name	Habitat	Wetland Tier*
Sparganium eurycarpum	Common Bur Weed	Shallow water and wet ground at the edges of rivers, in marshes, swales, and bog pools, and elsewhere.	1
Calamagrostis canadensis	Bluejoint Grass	Habitats include wet to moist prairies, wet to moist sand prairies, wet to moist dolomite prairies, prairie swales, sedge meadows, marshes, bogs, fens, sandy pannes near Lake Michigan, swamps, and poorly drained areas along railroads.	2
Carex lacustris	Lake sedge	Habitats include depressions in floodplain woodlands, flatwoods, soggy thickets, wet black soil prairies, wet dolomite prairies, prairie swales, typical marshes and sandy marshes, typical swamps and sandy swamps, seeps and fens, sedge meadows, and borders of ponds or small lakes.	1/2
Iris virginica	Blue flag iris	Habitats include wet to moist black soil prairies, prairie swales, soggy meadows along rivers, open bottomland woodlands, swamps, fens, seeps, edges of ponds and streams, ditches, and low-lying ground along railroads and roadsides.	2
Scirpus cyperinus	Wool Grass	Wet meadows and thickets, bogs, shores of lakes and streams, marshes, ditches, openings in swamps.	1/2
Hibiscus moscheutos	Rose Mallow	Marshes, open river bottoms, and often adjacent disturbed ground. The species is more common in salt marshes of the Atlantic coast but is locally frequent in southern Michigan and other inland sites.	1
Nuphar advena	Yellow Pond Lilly	Lakes, ponds, river margins, and streams.	1
Peltandra virginica	Arrow Arum	Slow moving water and pond edges.	1
Schoenoplectus tabernaemontani	Softstem Bulrush	Wet shores and shallow water of ponds, lakes, rivers, ditches, and marshes; occasionally in bogs; on sand, marl, or peat. May form large stands by itself or with other marsh species. More often than *S. acutus* in ditches and other early successional habitats, and usually not in such deep water.	1
Juncus effusus	Softstem Rush	Widespread in wet ground: marshes, shores, banks of ditches and streams, bog borders and clearings, pastures, etc.; moist open forests and thickets.	1
Juncus spp.		Wet, marshy areas, pond edges, banks of streams, bog borders, pastures, etc.	1/2
Cornus amomum		Wet (very rarely upland) sites: marshes, swamps (including cedar-tamarack), bogs and fens; margins of ponds, lakes, and streams and on banks of streams and rivers; often forming dense thickets at the edges of swamps and bodies of water.	1/2
Rosa palustris	Swamp Rose	Bogs, wet conifer swamps, wet thickets, and swales; margins of ponds, lakes, and streams.	1
Bolboschoenus fluviatilis	Bulrush	Marshes (including salt marshes), wet shores and riverbanks, swales. Colonies vary greatly from year to year in number of culms producing inflorescences, but the robust, sharply triangular leafy stems are easily recognized when vegetative.	1
Persicaria amphibium var. emersum	Water Smartweed	Pond and lake margins, stream banks, wet meadows, roadside ditches, railroads.	1
Eleocharis spp.		Ponds, bogs or other shallow water areas	1/2
Echinochloa walteri	Saltmarsh Cockspur Grass	Banks of rivers and ponds, ditches, marshes and wet shores, locally common in the marshes at the western end of Lake Erie.	2
Cephalanthus occidentalis	Buttonbush	Hardwood swamps, wet thickets, river margins, edges of marshes, swales, and shores; often in standing water or in very deep muck.	2
Decodon verticillatus	Swamp Loosestrife	Shallow water and mucky shores of ponds, lakes, marshes, and bogs, sometimes forming floating mats, often grows in very soft substrates.	1
Glyceria septentrionalis	Floating Manna Grass	Floodplain forests, swamps, marshes, margins of ponds and lakes, sloughs, and sink holes. These habitats consist of both sandy and non-sandy wetlands.	1
Acer X Freemanii	Freeman Maple	Edges of wetland habitat	2
Boehmeria cylindrica	False Nettle	Floodplains and swamps (both deciduous and coniferous), less often in marshes or in upland deciduous forests.	2
Alisma subcordatum	Southern Water Plantain	Riverbanks, lake and pond shores, wet fields and ditches, marshes, bog margins.	2
Bidens spp.	Tickseed	Moist prairies, prairie swales, low areas along ponds and streams, gravelly seeps	2
Echinochloa crusgalli	Barnyard Grass	Roadsides, fields, gardens, and disturbed ground; often in moist meadows, on exposed shores and riverbanks, etc. (naturalized)	2
Echinochloa muricata	Barnyard Grass	Sometimes in heavily disturbed places, but more generally in moister sites than *E. crusgalli*, sometimes even in shallow water: wet shores, ditches, riverbanks, and floodplains. Apparently native in America but variable and with weedy tendencies.	2
Leersia oryzoides	Cut Grass	Wet places: ponds, shores, ditches, floodplains, stream and riverbanks, bogs, pools and wet depressions, often abundant in a distinct zone or band.	1/2
Platanus occidentalis	Sycamore	Moist to wet forests, as on floodplains, riverbanks, and borders of lakes.	2
Sagittaria latifolia	Wapato, Duck-Potato, Common Arrowhead	Wet and moist places generally: shallow water and shores of lakes, ponds, ditches, streams, rivers, swamps, marshes, and bogs.	1

An important lesson from another restored urban stream, Euclid Creek, has taught us that sediment load and water quality must be conducive to vegetative success. The revegetation effort Euclid Creek estuary restoration project was heavily influenced by siltation. After a significant flood event, as much as an inch of silt would be deposited over the area, choking out new growth and young plants. Plant material was later replanted in larger sizes to provide better opportunity for establishment. At the proposed Doan Brook estuary, vegetation success would likely be more successful as a result of the reduction in suspended sediment and silt not only from upstream daylighting efforts, but also through the weir mechanism at the junction box. Additionally, the E. 72 Street harbor already possesses a good SAV community, and this is likely attributed to the water clarity of the protected cove. Leveraging and maintaining this water clarity will be important for restored planting success of both emergent and submerged aquatic vegetation. We are confident that the current approach will be ideal for diverse plant restoration because of the ability to control flow from the Doan Brook utilizing weir technology, the water clarity in the existing harbor and the protected orientation of the project site.

6.6 INVASIVE VEGETATION MANAGEMENT

Because the proposed estuary is adjacent to the CLNP, it will be susceptible to flow from Lake Erie as well as Doan Brook, and will presumably receive seed rain as well as wildlife-introduced invasives from CLNP and surrounding areas. The most common invasive species expected to establish in the estuary are Common Reed (*Phragmites australis)*, Reed Canary Grass (*Phalaris arundinacea)*, and Narrow-leaf Cattail (*Typha angustifolia)*. While it is unlikely that invasive species can be completely prevented from entering the estuary, carefully planned and timed management efforts can be effective. Leveraging conservation partners (in this case, members of the TAC committee), stakeholders, and the public in invasive species education and management can help create a multi-faceted approach to control. The current efforts to manage the grounds at Gordon Park (approximately 58 hours and $2,500/year) will likely need to be supplemented with additional chemical treatment efforts. EnviroScience estimated the cost and level of effort needed to perform invasive species treatment at the proposed estuary. Based on acreage, our team assumes three chemical treatments per year (with an aquatic-safe herbicide such as AquaNeat® or similar) totaling approximately $4,856 per year including labor, chemical, and equipment. This cost could be shared by conservation partners and additional removal of non-native/invasive species as well as monitoring could be completed in a volunteer "BioBlitz" style event, leveraging community support. A voluntary citizen science effort could be developed to monitor invasive species and other potential management issues in the estuary (estuary/stream stewards).

7.0 ENVIRONMENTAL REVIEW

EnviroScience conducted a Desktop Environmental Review as part of a feasibility design for a potential estuary at the confluence of Doan Brook and Lake Erie at the CLNP and Gordon Park North.

7.1 METHODS

The objective of the desktop review is to provide a review of available site information and an assessment of the risks associated with the likelihood of impact to the site due to contamination from hazardous substances and/or petroleum products and to make recommendations for further investigation, as appropriate. EnviroScience reviewed the following data as part of the Phase I Environmental Assessment (ESA):

- Available geologic data and relevant reports from the study area.
- Descriptions of topography, regional geology, and soils.
- A records review prepared by Environmental Data Resources, Inc. (EDR) to provide a report summarizing the federal, state, tribal, and local environmental record source database listings for the site and for the adjoining and surrounding properties within specified search radii, as well as physical setting information for the Site and surrounding area, as required by ASTM E1527-13.
- Property history through interviews, aerial photographs, on-line planning portals, and historical mapping (as available).
- Soil borings and analysis (two) within the project area in Gordon Park.

7.2 RESULTS

EnviroScience performed a Phase I ESA of the site in conformance with the scope and limitations of ASTM Practice E1527-13 for Phase I ESAs. The major findings of the report are summarized below. The full report is included in Appendix C.

7.2.1 Site Vicinity and Use

The site vicinity is comprised of a mixture of recreational (park land and nature preserves), industrial, and residential properties. The site is currently parkland, nature preserves, and recreation areas.

The current uses of the adjoining properties include:

- North: Lake Erie.
- South: Vacant land, commercial and industrial, and residential.
- East: Federally owned, including the former Nike Missile Site CL-02 Bratenahl.
- West: Former Cleveland Electric Illuminating Facility and other industrial.

7.2.2 Physical Setting

The following describes the regional and site physical setting.

Physiography

The Cleveland, Ohio area is located within the Lake Plains subprovince of the Central Lowland physiographic province. In northeastern Ohio, the subprovince is characteristically a 5 to 10-milewide strip of relatively flat land along the south shore of Lake Erie. Terrain at the site is relatively flat, sloping toward Lake Erie

Topography
According to information obtained from the U.S. Geological Survey (USGS) 7.5 Minute Series Topographic Map of the Cleveland North and East Cleveland quadrangles dated 2013, the site is at an approximate elevation of 570 feet above mean sea level and is generally flat. The topography of the surrounding area is also flat with a generally higher topographic gradient to the south.

Geology
Geologic information in the EDR report specifies that the sediments beneath the site have been identified as part of the Upper Devonian Series of the Paleozoic Era. Regionally, the thick sequence of sedimentary strata of the Paleozoic age, which exists in the northern region of Ohio, is extensively mantled by Pleistocene glaciolacrustine and glacial till deposits. Precambrian crystalline basement rocks underlying the Paleozoic strata are predominantly gneiss and granites.

Unconsolidated surface deposits on the land region surrounding Cleveland, Ohio are derived from materials associated with Pleistocene glaciation, low-relief fossil beaches, and ridges marking various periods in the development of Lake Erie, and weathering of exposed bedrock.

At the former Dike 14 site, several approximately 50-foot test borings were installed prior to construction. The borings penetrated a gray, silty clay of medium stiffness. Two borings were advanced to bedrock, which was a hard shale. The borings encountered bedrock at depths of 72 feet and 91.5 feet below the lake bottom, respectively.

According to the United States Department of Agriculture (USDA) Soil Conservation Service, the site is underlain by the urban land. No soil properties were identified.

7.2.3 Hydrology

Surface Water
Lake Erie is located on the northern extent of the site. Doan Brook is culverted near the southern property boundary of Gordon Park South and discharges from the culvert on the northwest side of the CLNP.

Wetlands
According to information obtained from the U.S. Fish and Wildlife Service National Wetland Inventory (NWI) included in the EDR report, NWI-delineated wetland areas are located on the site, which include the waters of Lake Erie.

Flood History and Risk
According to information obtained from the Federal Emergency Management Agency (FEMA), the site is not located within a 100-year or 500-year flood zone. A 100-year flood zone is located near the northwest portion of the site and along the aerial portion of Doan Brook south of the site.

Hydrogeology
As depicted on the ODNR Groundwater Resources Map of Cuyahoga County, the subject area is underlain by fine sand, silt, and clay of a buried valley aquifer system. Drilled wells in the buried valley deposits produce approximately 3 to 10 gallons per minute unless encountering thin, isolated sand and gravel lenses.

7.3 SITE HISTORY

Historically, Doan Brook had an open floodplain and coastal wetlands with sweeping bends entering its confluence with Lake Erie. Gordon Park was opened in 1983 at the confluence to provide opportunities for recreation and appreciation of nature near the transition from stream to open lake. Construction of park facilities impacted the natural confluence. Later a CDF (Dike 14) for Cuyahoga dredge spoils was built in Lake Erie directly over the mouth of the stream. The confluence was further impacted with expanding urbanization, the I-90 freeway interchange, and progressive filling of Dike 14, which completely covered the culverted mouth of Doan Brook.

The former Dike 14 CDF is a multi-sided site adjoining the lakeshore that consists of a containment wall adjacent to lake and harbor waters. The land did not exist prior to 1979. The former Dike 14 CDF operated from 1979 to 1999 to hold soils and sediments dredged from the Cuyahoga River and Cleveland Harbor deemed too hazardous to dump into the open. Based on Environmental Review, EnviroScience has performed a Phase I ESA of the site in conformance with the scope and limitations of ASTM Practice E1527-13 for Phase I ESAs. This assessment has revealed evidence of a Recognized Environmental Condition (REC) and Historical Recognized Environmental Condition (HREC) in connection with the site. EnviroScience recommends a limited Phase II ESA to assess the possible release of petroleum constituents to soil at the site.

The site was not identified on the federal National Priority List (NPL). In addition, no NPL or delisted NPL sites were identified within the study area, therefore there are no known current releases or threatened releases of hazardous pollutants or contaminants. Given the nature of the listings, the listed sites are unlikely to present an environmental impact concern to the potential estuary if it is located in Gordon Park. The former Dike 14 (now CLNP) CDF, however, was identified on the EPA's U.S. Brownfield list. Several contaminants, including lead, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs) were identified at the site. A five-acre area located near the southwest corner was remediated by capping the area. Because of the site's history, excavating within CLNP could lead to exposure to contaminants. Soil sampling analysis in the potential future project alignment would provide more information about contaminants present in designated excavation areas.

Within Gordon Park, a leaking underground storage tank (LUST) facility was identified at the site as the Cleveland Lakefront Park located at 740 East 72nd Street, Cleveland, Ohio. ODNR was identified as the owner with two separate release notifications. Both release investigations resulted in a No Further Action finding. Four underground storage tanks were closed by removal at the facility. EnviroScience performed limited soil sampling to investigate the area for any remaining petroleum product in the soils if the future Doan Brook alignment and estuary would be located in Gordon Park.

The Resource Conservation and Recovery Act (RCRA) sites do not pose an environmental concern to the site. Three CORRACTS (Corrective Action) sites were identified in the search area. Given the nature of the listings, the listed sites are unlikely to present an environmental impact concern to the Gordon Park site. Limited soil analysis will provide further detail on contaminants present in Gordon Park and/or CLNP soils, depending on potential location of estuary.

7.4 RECOMMENDATIONS

The historical use as an auto repair/body shop facility and storage of petroleum in unregulated aboveground storage tanks without secondary containment are RECs in connection with the site. Two LUSTs were discovered and removed with no further action recommended. EnviroScience recommends a limited Phase II ESA to assess the possible release of petroleum constituents to soil at the site.

The full desktop environmental review is included in Appendix C.

8.0 GEOTECHNICAL BORINGS AND SOIL ANALYSIS

8.1 METHODS

GPD Group, a subconsultant to EnviroScience, performed limited soil borings in Gordon Park, the preferred location of the potential estuary. The soil borings were performed both with a hand auger and a rubber-tracked drill rig. Each boring was advanced with a truck or track-mounted rotary drill rig using hollow stem augers to depths of 15 feet each or rock refusal. Soil samples were obtained by split-spoon sampling procedure at depths of 1, 3.5, 8.5, and 13.5 feet. The augers have a diameter of 6 inches.

Wildcat and hand-augering were not productive below the grass and topsoil due to a fill soil that contained sandstone fragments. When trying to drive the Wildcat Penetrometer, GPD was met with resistance (50+ blow counts) at both test locations and could only drive it about 12 inches below the surface. To gain useful information about soils in potential excavation areas, GPD then returned to the sampling site to complete the work with a drill rig with permission of the Cleveland Metroparks. Figure 8.1 shows the location of the drill rig sampling effort, which was designed to target the area of deepest excavation according to the proposed grading plan.

Figure 8.1 Soil Sampling (Boring) Location in Gordon Park

8.2 RESULTS

Soil boring logs indicated that the soils at the sampling site are a mixture of junk fill material underlain by potentially native soils. From the ground elevation at 578 feet, the boring consisted of junk fill comprised of damp, dense, brown and black, fine to coarse sand and silt; minor gravel; and traces of brick and slag down to about 7 feet. From 7 feet below ground surface down to 12 feet, the fill was comprised of brick and slag. Beyond approximately 12 feet, the boring consisted of wet, very dense, gray and black, fine to medium sand, a possible characteristic of native glacial deposits. No petroleum was detected at the time of sampling, though soil samples have been sent for laboratory analysis.

GPD Group also conducted a hand-auger soil sampling event at Gordon Park. Sampling was performed approximately 2 feet south of the previous bore hole 1 location. One (1) soil sample was collected using a hand auger to a terminal depth of 3.5 feet to 4.0 feet below ground surface (bgs). The soil sample was submitted to Summit Environmental Technologies and was analyzed for Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), Polychlorinated biphenyls (PCBs), and Total Petroleum Hydrocarbons (TPH). Results from the analysis revealed VOCs, SVOCs, and PCBs below analytical detection limits. Slightly elevated levels of TPH were detected within the soil sample; however, the results were below applicable State regulatory standards. The results of the laboratory analysis of the soil samples at Gordon Park indicate that while our sample fell below State thresholds for the contaminants tested, contamination does exist on the site, consistent with contaminants found within the neighboring CLNP. A full soil report is included in Appendix D. These findings suggest that if the project moves forward to the design and construction phases, additional soil sampling efforts will be required for the health and safety of the construction team as well as the appropriate public uses of the site.

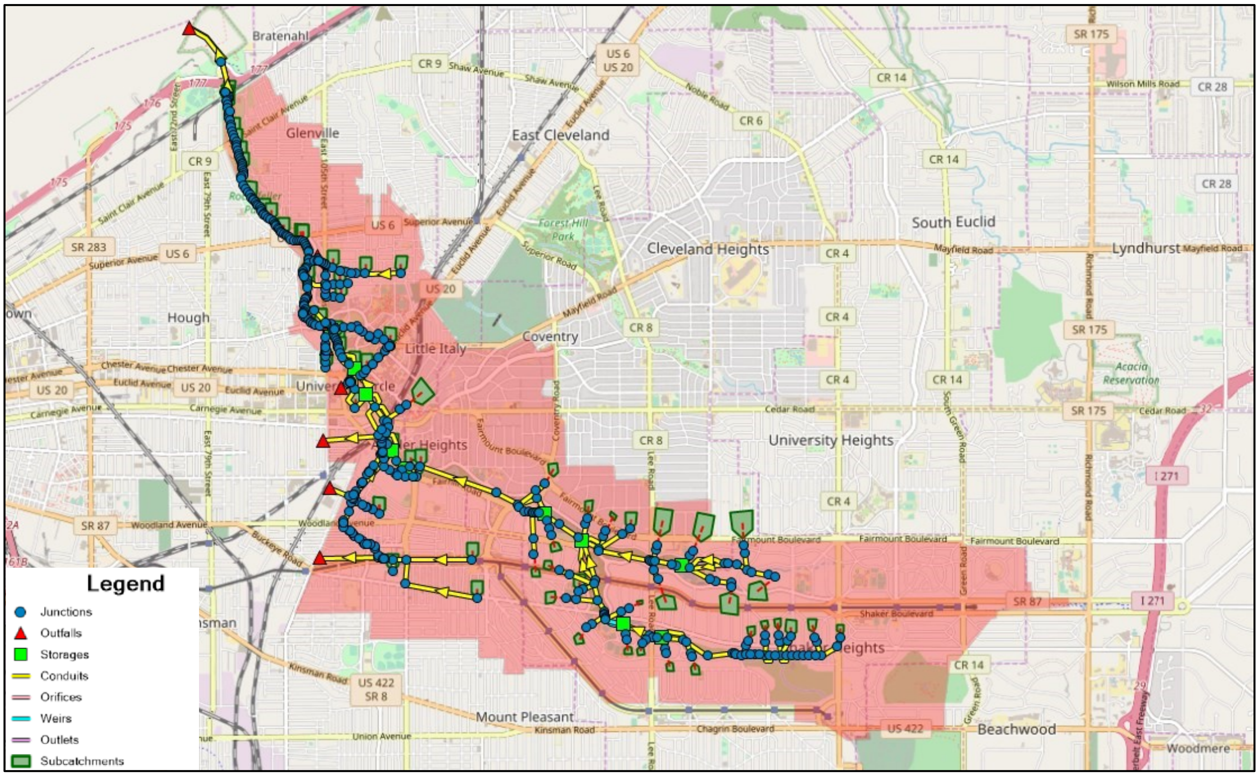
9.0 HYDROLOGIC AND HYDRAULIC MODELING RESULTS

9.1 METHODS

9.1.1 Existing Conditions Model

The Doan Brook watershed encompasses approximately 11.7 square miles within the cities of Cleveland, Cleveland Heights, and Shaker Heights and drains to Lake Erie within the CLNP. GPD Group obtained a copy of the hydrologic and hydraulic model for Doan Brook via email from NEORSD in November of 2014 for a different project in the watershed. The model was developed using the EPA Storm Water Management Model (SWMM). Based on the information contained within the model, it was imported from a previous model platform to SWMM in 2006 with updates completed in 2010. For this study, SWMM was utilized within PCSWMM software developed by Computational Hydraulics International. SWMM is the calculation engine used within PCSWMM. The vertical datum for the model is National Geodetic Vertical Datum of 1929 (NGVD 29). Included notes also indicate that the model was never fully calibrated, meaning additional work would be needed on the model for it to be usable. Figure 9.1 below shows the SWMM model schematic overlain with the overall Doan Brook watershed. Please note that while the hydraulic components of the SWMM model are generally geographically located and sized, the subwatersheds within the model where not geographically located. However, the area data for the subwatersheds does correspond to the overall watershed size of 11.7 square miles.

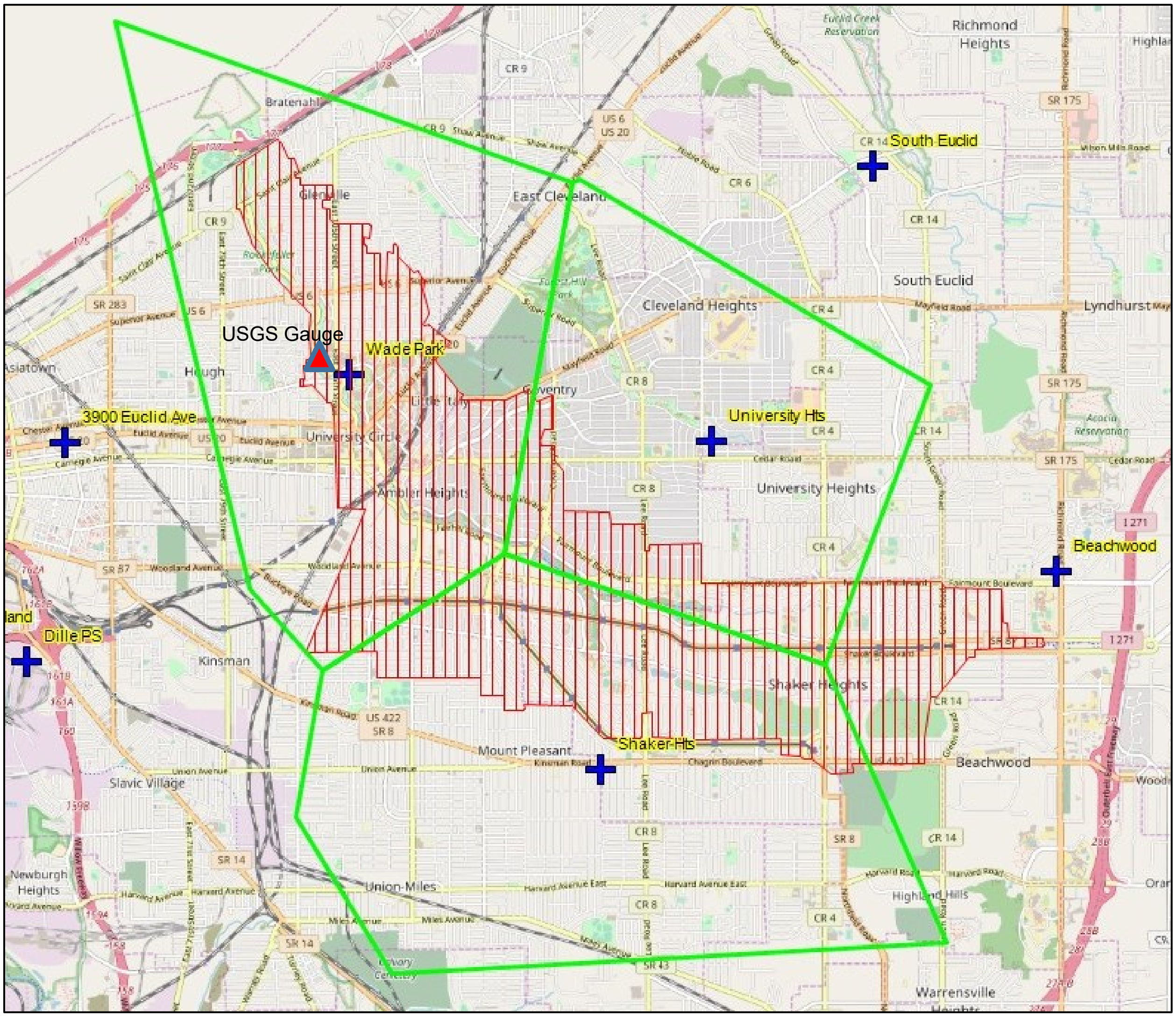
Figure 9.1 Doan Brook Model Schematic and Watershed



The existing model was reviewed to verify that none of the parameters were significantly beyond industry accepted standards. Thirteen subcatchments had storage depth parameters that were well beyond normal standards, and as no information was provided indicating why the parameters were chosen, they were revised. Additionally, the transects defining the channel and floodplain between the project area and Saint Clair Avenue were revised based on the survey provided by NEORSD stormwater master planning efforts and NEORSD LiDAR as they did not contain all the flow for large simulated events. The supplemental data was transformed from the North American Vertical Datum of 1988 (NAVD 88) to NGVD 29. Lake levels for Lake Erie were used as the boundary condition for the model and are based on the International Great Lakes Datum 1985 (IGLD 85). Lake levels were converted to NGVD 29, which is approximately 0.98 feet higher than IGLD 85 and 0.73 feet higher than NAVD 88. It should be noted that a detailed review of the model was not completed as it was outside the scope of this project.

The USGS, in partnership with NEORSD, has been maintaining a stream gauge on Doan Brook just downstream of Martin Luther King Jr. Drive and approximately 600 feet upstream of Wade Park Avenue. Discharge data is available dating back to October 2017 and gauge height data is available dating back to November 2018. The watershed area upstream of the gauge is 9.9 square miles or approximately 85% of the overall watershed. As a majority of the watershed drains to the gauge location, it was used as a calibration point for the model. NEORSD maintains rain gauges within their service area and several are within the limits of the Doan Brook watershed. Figure 9.2 shows the location of the USGS Gauge, the NEORSD rain gauges, and the thiessen polygons used to assign the rain gauges to the proper subcatchments. As the subcatchments were not drawn to actual size, it was assumed that their location in the model was correct and as such the gauges were assigned to the subcatchments that fell within the associated thiessen polygon. The Wade Park, University Heights, and Shaker Heights gauges were used, while the Beachwood gauge was not, as the model components didn't extend beyond the thiessen polygon for the other gauges.

Figure 9.2 Gauge Location Map



The Wade Park gauge data was only available from October 2018 and as such, the time period used for calibration was October 4, 2018 through March 20, 2019. Using an inter-event time of 12 hours, 16 distinct rainfall events occurred during the calibration period. The duration and magnitude of the events are shown in Table 9.1.

Table 9.1 Rainfall Data Summary

Date	Total Depth (in)			Peak Intensity (in/hr)			Total Duration (hours)	Recurrence Interval
	WP	UH	SH	WP	UH	SH		
Oct. 12, 2018	1.63	1.19	1.10	0.72	0.36	0.36	18.1	2 mo. ~ 6 mo.
Oct. 26, 2018	1.87	2.24	1.87	0.72	0.60	0.48	70.3	4 mo. ~ 9 mo.
Oct. 31, 2018	2.78	2.72	2.87	0.72	0.84	0.84	80.3	1 yr. ~ 2 yr.
Nov. 15, 2018	0.61	0.48	0.57	0.12	0.12	0.12	17.4	< 2 mo.
Nov. 26, 2018	0.79	1.04	0.95	0.24	0.24	0.24	26.4	< 2 mo.
Dec. 20, 2018	0.74	0.71	0.87	0.24	0.24	0.24	17.2	< 2 mo.
Dec. 31, 2018	0.92	0.88	1.01	0.72	0.96	1.2	18.9	~ 2 mo.
Jan. 8, 2019	0.84	0.87	0.78	1.32	0.96	0.96	42.8	< 2 mo.
Jan. 19, 2019	0.26	0.29	0.54	0.12	0.12	0.12	18.2	< 2 mo.
Jan. 23, 2019	1.30	1.25	1.36	0.36	0.24	0.36	29.5	2 mo. ~ 3 mo.
Feb. 6, 2019	0.28	0.26	0.28	0.24	0.12	0.24	15.1	< 2 mo.
Feb. 7, 2019	0.45	0.41	0.42	0.24	0.24	0.24	8.2	< 2 mo.
Feb. 11, 2019	0.99	0.94	0.92	0.48	0.48	0.48	26.1	< 2 mo.
Feb. 20, 2019	0.34	0.29	0.31	0.24	0.24	0.24	20.2	< 2 mo.
Mar. 9, 2019	0.63	0.66	0.43	0.24	0.36	0.36	15.3	< 2 mo.
Mar. 14, 2019	0.46	0.35	0.37	0.84	0.48	0.60	14.5	< 2mo.

The flow data from the USGS gauge for the January 19th – February 7th events were in error, which could have been due to ice buildup as a review of daily temperatures around those events revealed below freezing temperatures. The remaining 12 events were utilized for a general calibration of the model. Note that multiple calibration points would be necessary to perform a more reliable calibration for a watershed of this size. For the calibration process, the following subcatchment parameters were adjusted: width, percent impervious, and depth of pervious storage. Table 9.2 below displays the observed versus modeled results for the 12 events. Hydrographs that show the observed vs. modelled flows and associated information are provided in Appendix E.

Table 9.2 Calibration Results

Date	Observed (Conduit 3200.1)		Modelled (Conduit 3200.1)		% Difference*		ISE**		R^2
	Peak Flow (cfs)	Volume (ft^3)	Peak Flow (cfs)	Volume (ft^3)	Flow	Vol.	Rating	Value	
Oct. 12, 2018	223	4,727,000	653.4	9,340,000	193.0	11.4	VG	5.66	0.86
Oct. 26, 2018	308	10,200,000	413.6	11,360,000	34.3	11.4	E	1.27	0.93
Oct. 31, 2018	381	20,100,000	306.5	15,980,000	-19.6	-20.5	E	1.59	0.94
Nov. 15, 2018	22.3	1,065,000	56.48	2,184,000	153.3	105.1	VG	3.96	0.65
Nov. 26, 2018	56.8	2,910,000	55.3	3,901,000	-2.6	34.1	E	1.54	0.89
Dec. 20, 2018	127	2,565,000	111.1	3,145,000	-12.5	22.6	E	2.08	0.85
Dec. 31, 2018	402	6,029,000	480	5,752,000	19.4	-4.6	E	2.48	0.89
Jan. 8, 2019	239	6,559,000	221.4	5,490,000	-7.4	-16.3	E	2.56	0.78
Feb. 11, 2019	272	8,621,000	141.5	4,684,000	-48.0	-45.7	G	6.72	0.76
Feb. 20, 2019	88.6	1,399,000	70.1	1,258,000	-20.9	-10.1	E	1.96	0.94
Mar. 9, 2019	110	1,960,000	76.7	2,138,000	-30.3	9.1	E	2.82	0.63
Mar. 14, 2019	238	1,462,000	248.5	1,467,000	4.4	0.3	E	2.87	0.96

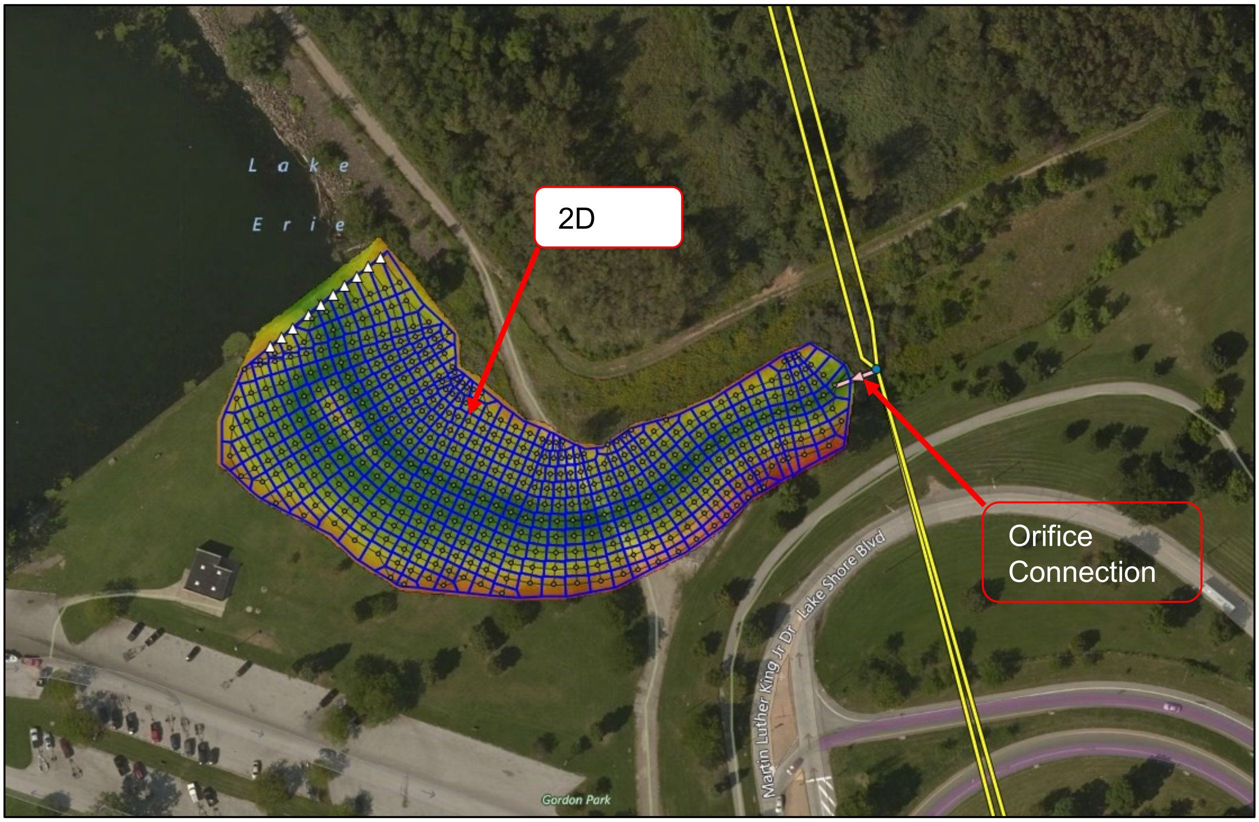
*Cells in red are beyond acceptable ranges
**G = Good, VG = Very Good, E = Excellent

For this calibration effort, observed and modelled peak flows and volumes were compared and values beyond +/- 20% difference were considered outside acceptable ranges. Only two events (Nov. 15th and Feb. 11th) had both peak flow and volume beyond acceptable ranges, and they were both small events. Additionally, the predicted peak flow for Oct. 12th is well beyond the observed peak flow, but otherwise most of the events were within or close to acceptable ranges. Two other means of comparison were used to evaluate the quality of the calibration, the Integral Squared Error (ISE) and the Coefficient of Determination, R^2. For the ISE, values between 0 – 3 are considered excellent, 3 – 6 are considered very good, and 6 – 10 are considered good. For this effort, a rating of excellent was considered acceptable. For R^2, a value beyond 0.85 was considered acceptable. Based on the various comparisons, it can be concluded that the model is sufficient for the purposes of this feasibility study.

9.1.2 Proposed Conditions Model

The calibrated existing conditions model was then used as the baseline model to incorporate and evaluate the proposed estuary improvements. The primary parameters evaluated for the proposed estuary were the amount of flow entering the estuary from Doan Brook and the impacts of lake level. The grading concept developed for the proposed estuary was used to develop the hydraulic parameters for the estuary in the proposed conditions model. The estuary was developed as a 2D area within PCSWMM. PCSWMM has developed routines to utilize SWMM features to perform a 2D analysis. A series of nodes and conduits are developed based on the proposed grading to simulate flow through the estuary. A 6-foot-wide by 3-foot-tall opening to divert flow to the estuary is proposed in the existing structure located just north of Lakeshore Blvd. within the limits of Dike 14. The opening was analyzed as an orifice within the model and assigned an orifice coefficient of 0.6. The diversion opening is proposed to be approximately 5 feet above the invert of the existing Doan Brook structure, which will place the bottom of the opening below the level of the lake. No other significant changes were made to the model versus the existing conditions model. The schematic of the model setup is shown in Figure 9.3.

Figure 9.3 Proposed Model Schematic



The proposed conditions were evaluated based on the NGVD 29 lake levels shown in the table below.

Table 9.3 Lake Level Boundary Condition Elevations

Lake Condition	IGLD 85	NAVD 88	NGVD 29
Historic Mean	571.36	571.61	572.34
Highest Historic Monthly Max	574.28	574.53	575.26

The Soil Conservation Service (SCS) Type II, 24-hour rainfall distribution was used with rainfall depths from Bulletin 71, Rainfall Frequency Atlas of the Midwest. The associated recurrence interval and depths are shown in Table 9.4.

Table 9.4 Rainfall Data

Recurrence Interval	Rainfall Depth (in)
1-Year, 24-Hour	2.04
2-Year, 24-Hour	2.50
5-Year, 24-Hour	3.10
10-Year, 24-Hour	3.60
25-Year, 24-Hour	4.39
50-Year, 24-Hour	5.11
100-Year, 24-Hour	5.89

While the lake level does have a significant impact on the water levels and function of Doan Brook, it would not have as large of an influence on the amount of flow that may be diverted into the estuary. This lack of influence is due to the invert elevation of the proposed diversion opening being under water for all but the lowest of lake levels. Table 9.5 shows the percentage of flow entering the estuary versus continuing through the Doan Brook culverts to Lake Erie for the different design storms. Also, the table indicates if the proposed diversion opening will be submerged or completely under water, based on lake level, during the analyzed event. Note that for the Highest Historic Monthly Max Lake Elevation, the diversion opening would always be submerged.

Table 9.5 Proposed Model Results

	Lake Level at Historic Mean			Lake Level at Highest Historic Monthly Max		
	Total Flow in Doan Brook (cfs)	Flow into Estuary (cfs)	Diversion Gate Surcharge	Total Flow in Doan Brook (cfs)	Flow into Estuary (cfs)	Diversion Gate Surcharge
1-Year	1923	30	No	1929	35	Yes
2-Year	2419	43	No	2423	55	Yes
5-Year	3004	53	No	2990	64	Yes
10-Year	3341	61	No	3317	66	Yes
25-Year	4286	104	Yes	4261	95	Yes
50-Year	5214	135	Yes	5215	120	Yes
100-Year	5970	156	Yes	5927	145	Yes

The results shown in the table above indicate that the proposed diversion of flow into the estuary will be relatively small when compared with the amount of flow in Doan Brook. Furthermore, the modeling effort assumed that flow would enter into the estuary during a storm events; however, the gate would likely be closed to prevent poor water quality conditions from impacting the estuary and harbor. The amount of sediment diverted from Doan Brook into the estuary can be assumed to also be relatively small based on the low flows through the diversion structure. As such, the proposed estuary is feasible from a hydraulic perspective.

9.2 SEDIMENT AND TURBIDITY ANALYSIS

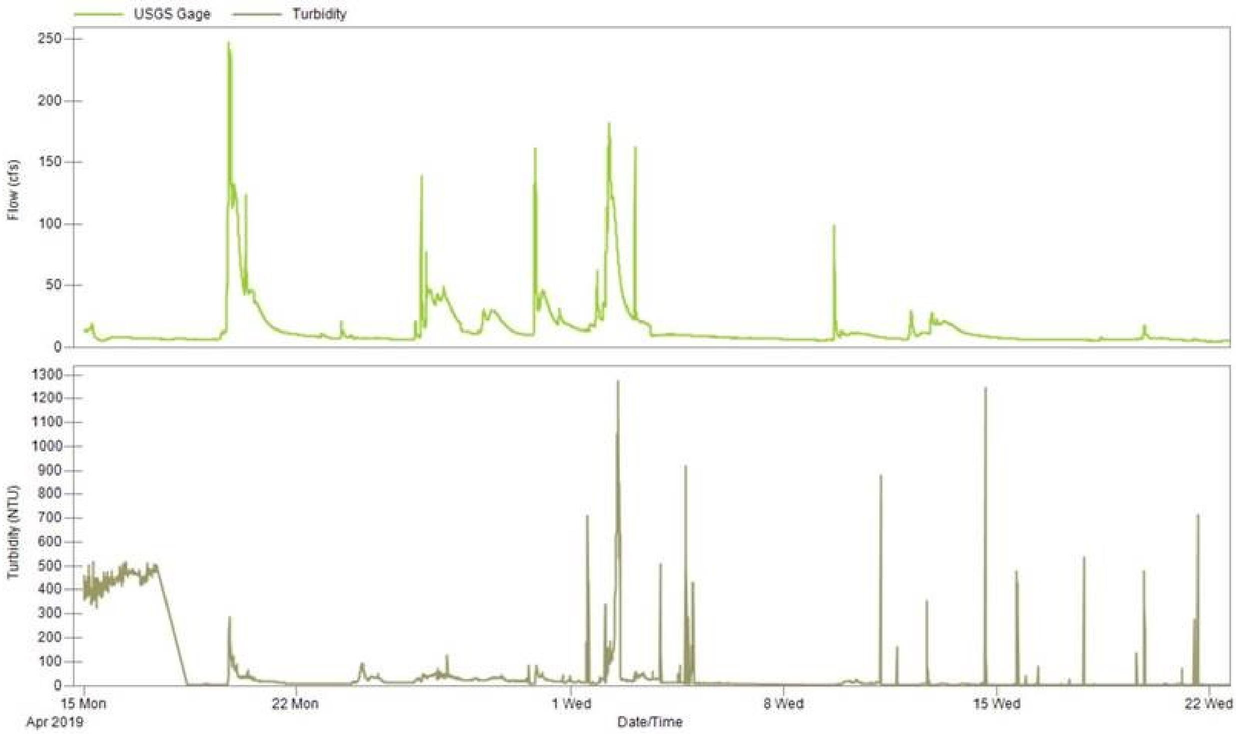
Turbidity data was supplied to EnviroScience by NEORSD in the winter of 2018 and spring of 2019. The data was collected by a permanent sonde located at the intersection of Broad Ave. and Martin Luther King Jr. Blvd. in Rockefeller Park, Cleveland, Ohio. The sonde, maintained and managed by NEORSD, collects temperature, turbidity, conductivity, pH, and dissolved oxygen data at a recurrence interval of 15 minutes. EnviroScience processed and analyzed the data and focused specifically on turbidity and conductivity analysis to better understand how suspended sediment, salts, and metals may compare to and affect the quality of water in the harbor.

9.2.1 Turbidity Methods

Turbidity levels are based on the amount of light scattered by particles in the water column. The more particles present, the more light that will be scattered. As such, turbidity and total suspended solids (TSS), both of which can affect water clarity and quality, are related. It should be noted that turbidity is not a direct measurement of the total suspended materials in water. However, turbidity has been used to estimate TSS loads (or in this case, bedload), in some research by using measured flow and turbidity data along with numerous TSS samples by using linear regression.

Flow data for the Doan Brook was obtained from a USGS gage located approximately 3,650 feet upstream of the sonde. While the devices are not in the same location, the best available existing data was utilized for this feasibility study. Typically, flow and turbidity data are casually related; however, as you can see in Figure 9.4 below, the turbidity in Doan Brook does not always correlate strongly to discharge. In most cases however, turbidity does appear to spike following high flow events.

Figure 9.4 Flow and Turbidity Data for Doan Brook



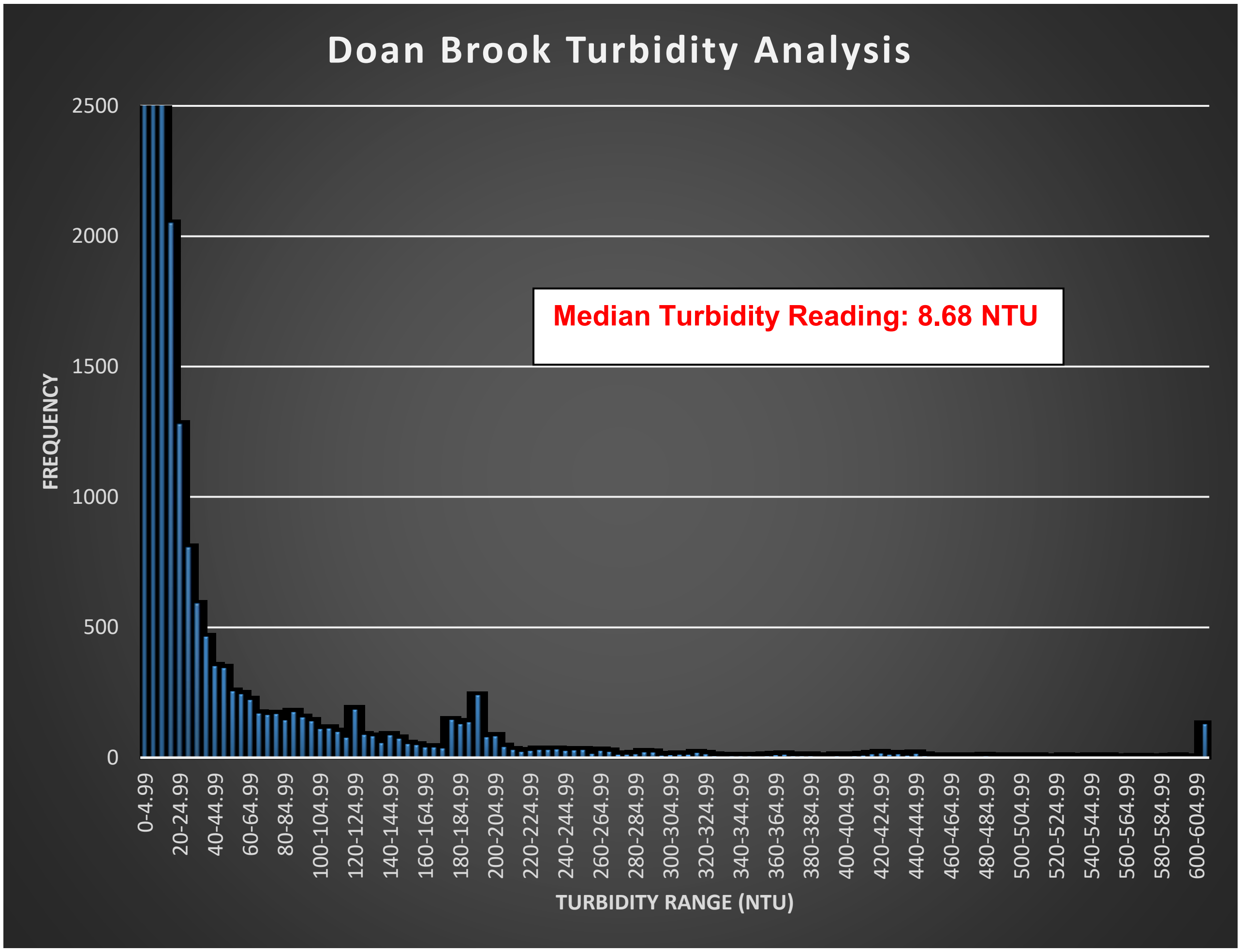
EnviroScience also compared the data collected from the sonde in Doan Brook to grab samples in the E. 72nd Street harbor. Samples from the harbor were taken on April 19, April 25, May 3, and May 10, 2019. Because sampling efforts in the harbor were very limited in comparison to the Doan Brook data, this comparison should be used for informational purposes only.

9.2.2 Turbidity Results

Turbidity in Doan Brook falls within comparable values to turbidity readings taken from the E. 72nd Street harbor approximately 60% of the time (Figure 9.5). The average and median turbidity in the harbor was 4.1 NTU. The high was 5.3 and the low was 3.0 NTU. While this turbidity is very low, especially for open water, the turbidity of the Brook was often close in range. This finding is likely because at the time the data were collected, Lake Erie levels were nearing record highs causing a backwater condition throughout the entire culvert and the lower Doan Brook. In comparing the two water bodies, we chose to compare the median reading versus the average because there were outliers in the data from the Doan Brook sonde that did not appear to correlate with legitimate readings.

For the purposes of our analysis, we divided the Doan Brook data into turbidity ranges of 5 NTUs and plotted the frequency of occurrences within those selected ranges. Approximately 60% of the occurrences fall within 0-10 NTU. Twenty-four percent of datapoints fell between 10 and 20 NTU, at which point the frequency drops sharply. Eight percent of the data exceeded ranges of 100-104.9 NTU. This data suggests that in order to prevent a negative impact on harbor water quality, water from the Doan Brook should be reduced or cut off from the potential estuary during high-turbidity events (typically following very heavy rainfall).

Figure 9.5 Turbidity Readings in the Lower Doan Brook from December 2017 – April 2019



Another item to consider with turbidity is that it can be impacted by the amount of dissolved particles in the water.

9.2.3 Sediment Analysis Methods

EnviroScience completed two bedload sampling events in the Doan Brook in the spring of 2019. The first sampling event took place on February 12, 2019, and the second event took place on June 20, 2019. At the February 12 sampling event, EnviroScience staff measured discharge and collected bedload samples in the Doan Brook approximately 50 feet upstream of the entrance to the Doan Brook culvert (near the intersection of MLK Jr. Dr. and Broad Ave.). The wetted width was divided by 20 to determine sampling stations. At each sampling point, the bedload sampler was held underwater, facing the flow on the bottom of the channel for 30 seconds. After 30 seconds, the sampler was pick up and moved to the next sampling point. The cumulative bedload material from the entire width of stream was dried and weighed. The first sample (February 12) yielded no bedload – detritus only. This was likely due to the prolonged backwater conditions in the lower Doan Brook as a result of record high water levels in Lake Erie. The second sampling event was conducted further upstream during a high-flow event to best capture bedload conveyed by the Brook during these types of events.

9.2.4 Results

While many more samples would be necessary to perform a true regression analysis, the June 20 sample was used to make a ballpark estimate for sediment load that may be upstream of the proposed estuary. Using the single sample against two months of sonde data indicated that approximately 60 lbs of bedload would be transported over those two months. Extrapolated over an entire year, this would equal 360 lbs. This estimate would not include smaller particles that stay suspended for longer periods of time and therefore the load is likely higher. Another factor to consider when evaluating sediment includes whether the backwater is due to water levels in Lake Erie. During the time of this feasibility study, the lake level was high and approaching record levels. This backwater influence could have impacted the turbidity measurements at the sonde and thus the total load estimate. While not conclusive, it appears that the sediment load may not be of a magnitude to negatively impact the proposed estuary. The sediment transport through Doan Brook should be studied in more detail in the design phase.

9.2.5 Potential Sediment Management Strategies

EnviroScience and GPD investigated mechanisms to control the flow from the Doan Brook culvert into the proposed estuary during periods of high flow at the existing junction box. Gates could be mounted either inside or on the outside of the existing junction box. After evaluating several gate and weir options, an externally mounted gate appeared to be the most effective solution to manage sediment and water quality (Figure 9.6). This gate will provide the control necessary and would be more cost-effective than a gate mounted inside the junction box. Other options for control could be backflow prevention devices; however, these only prevent flow in one direction and therefore would not be the appropriate tool for this project.

Figure 9.6 External Gate Example with Electric Motor

The proposed gate could be controlled manually by means of a hand crank, hand wheel, or an electric motor. The electric motor could be controlled remotely and therefore reduce the amount of manpower necessary to control the gate. The proposed gate should be constructed of 316 Stainless Steel, which has increased corrosion resistance versus 304 Stainless Steel. GPD contacted several manufacturers regarding a 6-foot-wide by 3-foot-tall stainless-steel gate (per EnviroScience's proposed concept). The manufacturers included:

- Fontaine-Aquanox
- Hydro Gate
- RW Gate
- Rodney Hunt

The approximate cost for an externally mounted gate opened by hand is $14,000 - $19,000. The approximate cost for an externally mounted gate with an electric motor is approximately $22,000 - $28,000. If desired, the gate be controlled from a remote location, but additional costs will be required for the controls, communication equipment, etc. To determine an accurate cost for these types of controls, the project team would need to determine the following:

- From where will the gate be controlled?
- How many different settings will the gate need related to Doan Brook flows? For example, will the gate be flow controlled, level controlled, etc.?
- Is fiber available or would cellular communication be needed?

The benefit of this the externally mounted gate is that it could completely restrict flows from entering the estuary should conditions occur where isolation of the estuary is needed, such as times when Doan Brook is carrying larger than average amounts of sediment. The control of the gate can be automated and/or controlled remotely, which allows for a great deal of flexibility when it comes to controlling flow into the estuary.

10.0 WATER QUALITY ANALYSIS

10.1 STATISTICAL COMPARISON OF THE DOAN BROOK AND THE E. 72ND ST. HARBOR

EnviroScience performed an analysis of conductivity and turbidity in the Doan Brook and the E. 72nd Street harbor using data from the sonde in the Doan Brook at the culvert entrance and the water quality grab samples from the harbor performed by NEORSD in May 2019. Performing this analysis provides another perspective on the similarities and differences in water quality between the two bodies of water. This analysis should not be considered all-encompassing or predictive in any way. Having only four data points for the harbor water quality limits our ability to understand conditions in the harbor over time and under specific weather scenarios. Therefore, this analysis should be used for informational purposes, with additional data collection and analysis recommended for the next phase of the project.

10.1.1 Methods

Monthly means were developed for both conductivity and turbidity in the Doan Brook and the E. 72nd St. harbor. In order to best compare the limited data that was available, only data from the same months/years were compared (April 2018 / 2019, and May 2018 / 2019). The means were log transformed to account for the high variability in both conductivity and turbidity readings. A Kolmogorov-Smirnov text was performed (non-parametric test comparing means) with a 90% confidence interval ($p<0.05$).

Table 10.1 Comparison of Conductivity and Turbidity in the Doan Brook and the E. 72nd St. Harbor

Kolmogorov-Smirnov Test (Spreadsheet21) By variable System (Doan Brook versus Harbor). Marked tests are significant at p <.05000									
	Max Neg	**Max Pos**	**p-level**	**Mean**	**Mean**	**Std.Dev.**	**Std.Dev.**	**Valid N**	**Valid N**
Log_Conductivity	-1.00000	0.00	p > .10	0.119433	0.314988	0.011079	0.032212	2	3
Log_Turbidity	-1.00000	0.00	p > .10	0.711787	1.824677	0.005963	0.663696	2	3

10.1.2 Results

The test result shows that there is no statistically significant difference between the turbidity and conductivity in the Brook and harbor during the months of April and May 2019 based on the limited data available. While this analysis does not mean that there are not differences in water quality between the two bodies of water, it tells us that the differences between the two at the time of sampling are not enough to warrant statistical significance. In order to better understand the differences in water quality of these two bodies of water at the same time and/or during specific weather events (i.e., large storms), we recommend collecting additional water quality data in the E. 72nd Street harbor. Ideally a sonde set up in the harbor over a period of months with a recurrence interval of every 15 minutes (same as the sonde in Doan Brook) would provide a more appropriate sample size and thus a better comparison.

Finally, we strongly recommend an analysis of bacterial, nutrient, and metal content in the Doan Brook to better understand how those parameters could impact harbor waters. Contaminant transport and fate modeling using this data would provide a more in-depth and accurate picture of what contaminants are present in the Brook, how they would be transported into the harbor, and how mixing in open water would impact their effect on flora/fauna, if any. This level of water quality analysis would also provide important information regarding appropriate recreational use of the estuary waters for kayaking and fishing.

10.2 COASTAL FORCES ANALYSIS

10.2.1 Methods

EnviroScience included KS Associates, Inc. (KS) on the project team as a subconsultant for coastal engineering services. KS performed an analysis of meteorological and oceanographic conditions (metocean analysis) at the intersection of the proposed estuary and Lake Erie. The scope of the metocean analysis includes a study of design water levels, wind, waves, ice forces, and a qualitative review of nearshore processes at the east end of Cleveland Harbor. The results of the metocean study are used to generate preliminary recommendations for shore stabilization in the proposed estuary project area.

Metocean Analysis

The study of meteorological and oceanographic conditions (metocean analysis) is critical for the selection of appropriate design criteria for coastal structures and systems. The results of the metocean analysis will support the study of the impacts to Doan Brook and the design of coastal structures to support the new coastal estuary. The KS team investigated the following:

- A review of historic water levels and available published, recommended design levels to assist with the selection of appropriate water levels for the design of the proposed improvements.
- A review of design wave heights that may induce forces on the proposed coastal structures and system at the range of design water levels selected for the project. This requires a review of wind conditions and resulting fetch-limited waves, depth limited waves, boat wakes, and calculation of resultant transmitted waves from diffraction of open water waves based on hindcast data.
- An estimation of ice forces on structures in the proposed project area.
- A qualitative assessment of nearshore processes and possible impacts from the proposed project.

The analysis led to recommendations based on design water levels of Lake Erie and design wave heights for use when designing the structure protecting the potential estuary. Whether this structure is a breakwater or a barrier beach, careful design will be necessary to take water levels, wave forces, and nearshore processes into account.

10.2.2 Results

Design Water Levels

The deep water diffracted wave case results in waves greater than the waves expected to be generated by wind and fetch but less than the depth limited wave case. Therefore, waves generated in deeper waters are expected to be the controlling condition.

Table 10.2 Design Wave Heights

Return Period (Years)	Water Level (IGLD 1985)	Controlling Case	Wave Height (Feet)
2	574.2	Open Water	7.44
5	574.9	Open Water	8.31
10	575.1	Open Water	8.98
25	575.7	Open Water	9.84
50	576.1	Open Water	10.48
100	576.4	Open Water	11.13

Nearshore Processes

Nearshore processes within the harbor will affect water flow in the proposed Doan Brook estuary area. Pumping action from changes in water level due to wind setup and seiche often affect coastal estuaries. In areas of shallower water, such as an estuary, localized changes in water level can be amplified and can generate currents as water flows in and out of embayments due to water level changes. This can cause scour of finer grain sediments. In certain conditions, the pumping action from changes in water level also provide beneficial water circulation. It is recommended that design height of protective structures be tuned to allow for water circulation but prevent scour or erosion in the estuary.

Due to the distance from the mouth of the Cuyahoga River to the project site, the water quality of the Cuyahoga River is not anticipated to have a significant impact on the water quality in the proposed estuary or adjacent marina basin. Most of the Cuyahoga River flow enters Lake Erie through the opening of the offshore breakwater near the mouth of the river. The remaining flow inside the breakwater is primarily transported into the open water of Lake Erie past the eastern edge of the breakwater, approximately 3,500 feet west of Dike 14.

Other potential contamination sources from surface water run-off and several outfalls along the shore of Cleveland Harbor will likely impact water quality in the project area, particularly during periods where strong winds cause shifts in nearshore currents. In most cases, water within Cleveland Harbor will be mixed with open lake water and dispersed into the lake at the east end of the Cleveland Harbor Breakwater, but there is potential for strong north winds and wave energy to push harbor water toward the shore at the project site.

Some potential exists for flow from the Doan Brook culvert to introduce nutrients or contaminants into the basin at the outlet of the proposed estuary. During most wind and wave conditions, flow from the estuary is expected to flow toward Lake Erie. During periods of strong north to northwest winds, waves and wave generated currents within the harbor may impede this transport. These concerns could be alleviated with the inclusion of a breakwater to direct flow away from the marina basin in the final design.

Shoreline Stabilization

The shore at the east end of Gordon Park is currently armored with an existing steel sheet pile bulkhead. While the existing structure is effective at stabilizing the shore, it provides no benefit in terms of aquatic habitat. The proposed estuary concept will result in a partial or full removal of portions of the breakwater to allow for the construction of a coastal estuary or daylighted portion of Doan Brook. KS recommends installing new armor stone breakwaters or revetments to replace the removed portions of the steel sheet pile bulkhead. Stone breakwater or revetment structures will provide several benefits at the site:

- The structures will dissipate wave energy as waves run-up their sloped angular surface. This dissipation results in less wave reflection into the nearshore and reduces the potential for scour at the base of the structure.
- Armor stone structures will provide beneficial aquatic habitat in the voids between stones.
- Structures can be designed to dissipate wave energy but still be overtopped to allow transmission of water and energy into an estuary system (similar to a barrier beach).

To assist with the conceptual design of the estuary stabilization, KS provides the following recommendations.

Ice Forces
Lake Erie is the shallowest of the Great Lakes and most prone to freezing over. The lake typically freezes annually between the months of December to March. Due to the water depths in the project area, an ice loading calculation was performed for the site. The analysis of ice forces showed that the forces on a revetment become lower as the structure has a shallower slope. If the estuary is protected by the armor stone (see structural recommendations below), then the ice forces within the estuary will be minimal. It is anticipated that the entire estuary will freeze over in the winter.

Structural Recommendations
KS recommends constructing an armor stone breakwater or revetment along the shore of the project site. Quarried limestone is recommended for breakwaters and revetments along Lake Erie due to the low cost and ease of construction. For the conceptual design, KS recommends 3 to 5-ton armor stone placed at a 2 horizontal to 1 vertical slope over a filter layer of 12 to 24-inch diameter stone. The slope should be supported with 4 to 6-ton toe stone entrenched a minimum of 2 feet into the lakebed. The structure crest elevation and width will need to be selected based on the final estuary design, grading plan, and amount of water and wave energy transfer desired.

With consideration of nearshore processes at the east end of Cleveland Harbor, structural solutions are also available to direct flow from the estuary to Lake Erie and prevent impacts to water quality and existing habitats as a result of the estuary. The proposed estuary and associated shoreline impacts can be constructed without encroaching on the Gordon Park Boat Ramp or adjacent marina entrance channels, limiting impacts to boating or existing infrastructure.

Based on the coastal engineering analysis described above, the effects of water levels, wind, wave, and ice forces can be accounted for in the design of the outlet structures for the proposed coastal estuary. The recommended shore structures are based on common coastal construction materials and techniques along the shore of Lake Erie. Therefore, the coastal engineering analysis did not generate any concerns regarding the feasibility of the proposed estuary.

Final design recommendations for the shoreline stabilization features can be found on page 18 of the Coastal Analysis Report (Appendix F).

10.3 EXISTING INFRASTRUCTURE ANALYSIS

EnviroScience was contracted by NEORSD to perform an underwater/topside inspection of a double box culvert approximately 3,000 feet long per side in Cleveland, Ohio. EnviroScience performed the inspection during a three-day period between May 5 and May 28, 2019. The purpose of the inspection was to evaluate the condition of the culvert and to identify type and depth of sediment deposited within the culvert, if any. Photographs and videos were taken documenting defects and typical condition of the culvert.

10.3.1 Methods

Initially, two divers working in tandem with live video and communications were to perform the inspection for the first 950 feet of culvert on each side from the entrance, and then again for the same distance from a removable grating assumed to be a viable entrance at approximately the 1,500-foot mark. Based on both water conditions and the conclusion that the assumed entry point at the 1,500-foot mark would not be a viable option, EnviroScience changed to a topside approach and continued the inspection via a small boat equipped with light probing and video equipment.

The EnviroScience team performed a comprehensive inspection of both sides of the double box culvert from the entry point until the gradient of the culvert verses the water/lake level lowered the air space to a point where the team had no more room to continue. The team was able to inspect the culvert to approximately 1,900 feet of the right side and 2,300 feet of the left side.

Stationing was marked at 10-foot intervals along the length of the interior of the culvert. Stationing began at 0+00 at the entry point of each side respectively. The left side culvert began approximately 420 feet before the right.

10.3.2 Inspection Findings

Interior of culvert (Stations 0+00 to 19+00 L, 23+00 R)

The field notes included in Appendix G give detailed notes by station for this section of the inspection, including visual observations, water depths, and sediment depth measurements. Notable observations are detailed below.

Culvert Condition Assessment

The culvert is a double box culvert measuring 14 feet high by 15 feet wide and extending approximately 3,000 feet from the south of I-90, terminating at Lake Erie. The overall condition of the culvert was observed as very good. There was no evidence of major cracking, spalling, or material failure. Minor cracks were occasional and limited to what appeared to be older sections of the culvert. ODOT has also rated this culvert a “7,” which indicates that according to their assessment, the culvert is in very good condition.

Backwater conditions persisted for the entire length of culvert surveyed. Lake levels were nearing an all-time high at the time of the survey (574.4) and have remained very high throughout the spring. While hydraulic conditions in the culvert will change when lake levels drop, this should not impact the function of the culvert.

Sediments in the culvert consisted of fine, sandy muck which ranged in depths from 6” - 24” on bottom of the culvert. At the time of the inspection, no course sediment was observed. There was also no large woody material or debris in the culvert at the time of the inspection. There was very minimal trash and the occasional small floating debris, suggesting that most trash/debris is being captured upstream before Doan Brook enters its culvert.

There were no unexpected drop structures in the culvert and the slope appeared consistent with EnviroScience's interpolations from existing culvert invert elevations at the entrance and the mouth.

10.4 PROJECT IMPACT OF DOAN VALLEY STORAGE TUNNEL

10.4.1 Methods

EnviroScience met with NEORSD on multiple occasions to learn about the potential impacts of the Doan Valley Interceptor (DVI) as well as the predictions for CSO reductions. NEORSD shared background information on the DVI as well as the data from the stormwater and CSO modeling efforts.

10.4.2 Results

The Doan Valley Storage Tunnel (DVT) Project is part of NEORSD's plan to reduce the volume of combined sewer overflows (CSOs) released into Lake Erie and its tributaries in the Greater Cleveland area during wet weather. The project includes nearly four miles of tunnel divided into three segments: the DVT itself, the Martin Luther King Conveyance Tunnel (MLKCT), and the Woodhill Conveyance Tunnel (WCT). All three segments of the DVT Project will be located on the east side of Cleveland, as shown on the map on the right. The project is currently under construction, which is scheduled to be completed by 2021 (NEORSD, 2016).

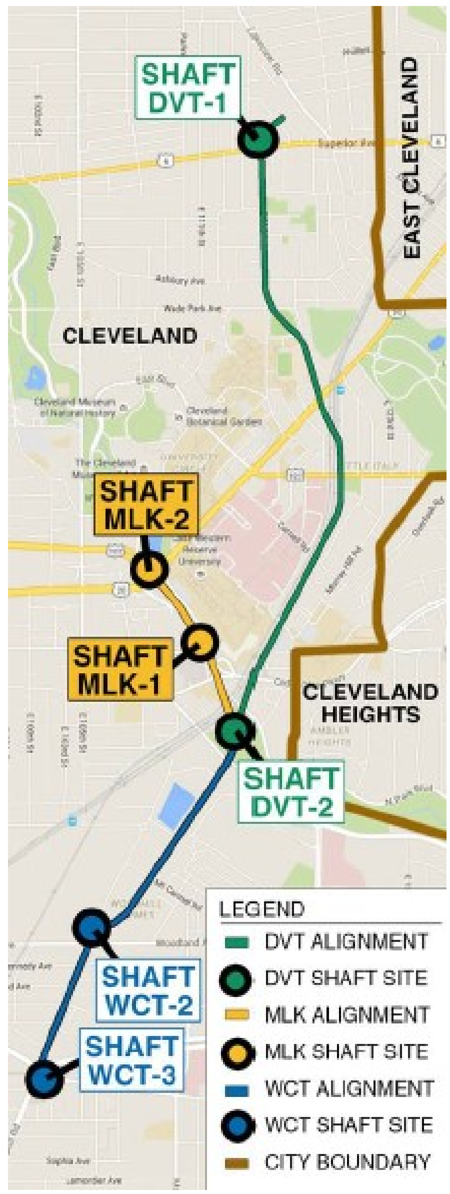


Figure 10.1 Doan Valley Interceptor Tunnel location (NEORSD, 2016)

Project Benefits

As part of NEORSD's Project Clean Lake, the DVT is intended to help attain Clean Water Act standards and address water quality issues in Doan Brook and Lake Erie. According to NEORSD, the DVT system will help control overflows at 11 permitted CSO locations along Doan Brook from Shaker Heights to Lake Erie. Controlling these CSOs will help reduce more than 90% the 4.5 billion gallons of CSOs discharged each year. Additionally, the DVT system will reduce CSO volumes discharged into Doan Brook by 365 million gallons each year. This drastic reduction will help to improve water quality in Doan Brook by reducing *E. coli* colonies, reducing public health risks associated with CSOs, and improving recreational opportunities through cleaner water and beaches (NEORSD, 2016).

Segment 1: DVT Segment

- Extends 10,000 feet from Ambler Park to Superior Avenue at East 115th Street.
- The 18-foot diameter tunnel is in rock at depths between 50 and 120 feet.
- Traverses three neighborhoods: Forest Hills, Glenville, and University Circle.

Segment 2: MLK Segment

- Extends 3,000 feet from Ambler Park at Shaft DVT-2 to Euclid Avenue at MLK Jr. Drive.
- The 8.5-foot diameter tunnel is in rock at depths between 45 and 90 feet.
- Traverses University Circle neighborhood.

Segment 3: WCT Park Segment

- Extends 6,400 feet from Ambler Park at Shaft DVT-2 to Buckeye Road at Woodhill Road.
- The 8.5-foot diameter tunnel is in rock at depths between 25 and 80 feet.
- Traverses under or near four neighborhoods: University Circle, Fairfax, Woodland Hills, and Kinsman.

The Doan Valley Interceptor Tunnel is slated to drastically reduce CSO events, thereby improving the water quality of the Doan Brook significantly. The table below shows the reduction of gallons (in millions) projected for each CSO located along the DVT. These projections are based on the model calibration performed by NEORSD in November of 2018 to incorporate baseline (existing conditions modeling) to reflect a more accurate understanding of how current conditions would be affected post-DVT construction.

Table 10.3 Updated Modeling for CSO Reduction with the DVT (NEORSD, 2016)

CSO Number	Baseline Revised (Nov 2018 Baseline Project Model)		Final Agreed Upon Plan (Nov 2018 Project Model)	
	Volume	**# of Overflows** (millions of gallons)	**Volume**	**# of Overflows** (millions of gallons)
73	46.26	33	7.56	2
215	0	0	0	0
216	0	0	0	0
217	0.85	7	0.06	2
218	67.61	45	0.14	1
219	0.53	12	0.01	3
220	5.85	9	0.37	2
221	11.64	45	0.1	2
222	158.49	45	36.28	2
223/224	5.69	13	0.42	1
225	0.05	3	0	0
226	0.02	1	0	0
234	9.72	16	0.11	1
236	Eliminated per CSO236R as-built	Eliminated	0	0
DVT Total	**306.72**		**45.05**	

10.5 IMPACTS TO BOATING/NAVIGATION

10.5.1 Methods

KS Associates studied potential impacts of the proposed estuary to boating and the marina in the E. 72nd Street harbor. To assess impacts, KS analyzed the project grading plan and shoreline modifications compared with navigational pathways into and out of the Inter-City Yacht Club Marina.

10.5.2 Results

KS mapped the navigational pathway for the marina and found that the proposed estuary plans do not encroach or the entry/exit to the marina in the harbor. The proposed estuary and associated shoreline impacts can be constructed without encroaching on the Gordon Park Boat Ramp or adjacent marina entrance channels, limiting impacts to boating or existing infrastructure.

Figure 10.2 Navigational Pathway for the Inter-City Yacht Club

10.6 TRASH REMOVAL

Figure 10.3 Trash in Cleveland Harbor

EnviroScience consulted agencies involved in debris removal within the potential project area, including NEORSD, the Port of Cleveland, and the Cleveland Metroparks. NEORSD staff indicated that their debris removal efforts are limited to clearing upstream blockages typically involving large woody debris (Paul Kovalcik, personal communication, May 10, 2019). NEORSD does not perform any debris removal of smaller floatable trash items (Figure 10.3).

Similarly, the Port of Cleveland focuses their debris removal efforts on the Cuyahoga River and Cleveland Harbor. Their debris collection boats, Flotsam and Jetsam, make their rounds collecting floating debris and logs May through October from 8 a.m. to 4 p.m (Figure 10.4). The boats and their efforts to remove debris from Cleveland's waters are a partnership between the Port, the Downtown Alliance, and the Cleveland Metroparks.

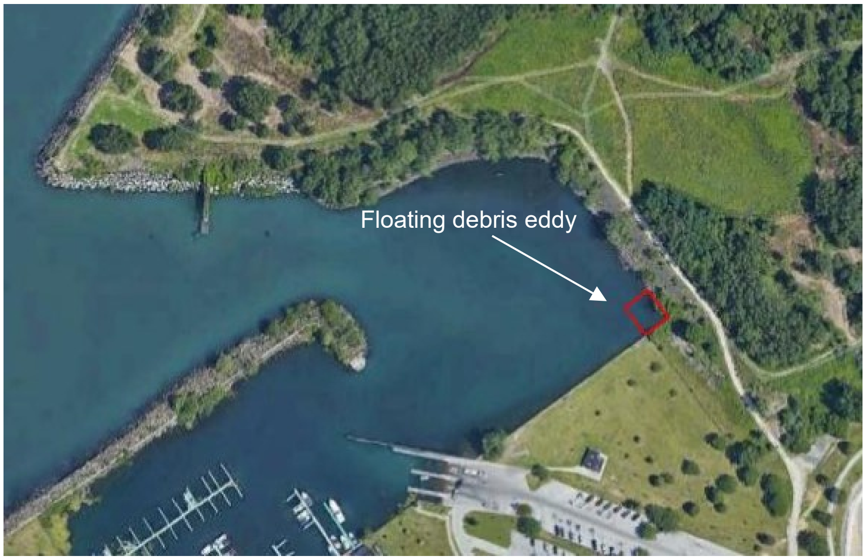
Figure 10.4 Boats Flotsam and Jetsam Removing Debris in the Cleveland Harbor

Source: www.lakeassault.com

While the debris removal efforts of the Port do not currently include the E. 72nd Street harbor, their efforts to remove floating debris may help to minimize floating debris pushed into the E. 72nd Street harbor by wind and wave currents.

The Cleveland Metroparks, as the land manager at Gordon Park, also performs trash and debris removal near the E. 72nd Street harbor. Currently, park staff do not remove debris floating in the harbor or marina, but they do remove any debris that is washed or blown up onto the boat ramps as part of their efforts to maintain safe access to the lake (Matt Krems, Senior Park Manager, Lakefront Reservation, personal communication, May 29, 2019). After a discussion with Gordon Park staff, we learned that the floating debris mat that typically becomes temporarily trapped in an eddy in the southeast corner of the harbor (Figure 10.5) often ends up on or near the boat ramps when the winds shift. Although trash and debris does make its way into the E. 72nd Street harbor, it does not appear to affect use of the harbor or the marina.

Figure 10.5 Location of Eddy Trapping Floating Debris in the E. 72nd St. Harbor



To understand the possible impact of Doan Brook on trash flow into the potential estuary, EnviroScience used dive inspection to investigate the condition of the Doan Brook culvert between Broad Ave. and MLK Jr. Drive (entrance) and the outfall at Lake Erie. During the culvert inspection, no large debris was discovered inside of the culvert. Additionally, very little floating small debris was present, suggesting that most trash/debris is being captured upstream before Doan Brook enters its culvert. While this does not mean that debris will not be contributed from Doan Brook into the potential estuary, this investigation does provide anecdotal evidence that the debris load may not be heavy as anticipated as a result of Doan Brook's highly urbanized watershed and more complex stream channel upstream of the culvert.

Future Debris Management
We do not anticipate the need for additional debris management outside of the efforts currently conducted by the Cleveland Metroparks Lakefront staff. If wind and wave energy does, in fact, carry significant amounts of debris towards or onto the boat ramps, existing efforts should be sufficient to manage the debris load. If, however, either the currents do not move debris towards the boat ramps and/or the debris load from Doan Brook is higher than anticipated, additional debris removal efforts may be necessary. A team approach to debris management in this case may be most effective, including periodic debris collection by the Port in the harbor itself and some level of debris collection within the Gordon Park alignment of the estuary by Metroparks staff. To better understand the current flow of debris in the harbor, it may be helpful for Lakefront Metroparks staff to conduct informal monitoring of trash flow in the harbor over a period of several months, covering the spring and fall seasons. Lessons learned could be applied to estuary design and future debris management efforts.

10.7 LOCATION OF UTILITIES

10.7.1 Methods

EnviroScience contacted Ohio Utilities Protection Services (OUPS; 811) to assist in locating utilities in the potential project area. A design ticket was opened by OUPS and a PDF of the utilities located on/near the project was submitted to EnviroScience on May 28, 2019.

10.7.2 Results

Upon review of the utilities map from OUPS, no utilities are located within the proposed project location (Gordon Park). Lighting fixtures are located within the park, but none appear to be located in the area of the proposed estuary (Appendix G). If this project advances to the design and permitting phase, a construction ticket should be opened with OUPS to confirm these findings and develop a plan for the movement and/or relocation of any utilities that may be affected by project construction.

10.8 LESSONS LEARNED FROM SIMILAR PROJECTS

The following sections detail paraphrased interviews with entities and owners who have performed similar estuary projects. Their feedback will be considered and incorporated into the possible design.

10.8.1 Howard Farms (Ducks Unlimited, TNC, Metroparks Toledo)

This interview was conducted with Denis Franklin of the Toledo Metroparks via phone on 5/29/19 regarding the Howard Mash restoration project.

What are some of the biggest challenges in management the estuary?

So far, we have had only two years of water, with good vegetative response. A small area of invasive species has been an issue, including phragmites, flowering rush, and European frog bed. Accessibility and GPS mapping, etc., was key for managing these populations and monitoring the vegetation. Since the invasive population were small so far, you want to catch it early and treat it right away. Being out there monitoring is important to catch issues early. Time is an issue as far as being on-site. Things to monitor and document would include invasive species, water levels, and rainfall. These factors drive vegetation, which in turn drives wildlife. You should consider having a water level plan for the long-term, since these wetlands take 15-20 years to evolve.

What are biggest threats to water quality? How have you dealt with them?

- Howard Marsh gets stormwater runoff from two communities. The runoff used to be pumped out to Lake Erie unfiltered. It is now pumped directly into the wetland, which has been successful in terms of sediment attenuation. Water quality research is forthcoming.
- We have been dealing with algae (filamentous algae) that you often see in any wetland and roadside ditches. It is unsightly but comes with the territory. We have made the public aware and asked them to limit exposure.
- The yacht club did not have concerns about water quality. We had two public meetings. The biggest concern of nearby residents was flooding.

How have you dealt with trash/debris in the estuary?

We have dealt with some trash from the public access area (Howard Rd.), but have been fortunate not to deal with any trash/debris from stormwater. Our pump systems do have trash racks (which may be beneficial for a gate/weir design). Some small woody debris collects in the county ditch, which ends up on trash racks that are cleaned once every two months.

How do you manage sediment?

Turbidity in Howard Marsh is not high, even with stormwater inflow from residents nearby. We do, however, deal with turbidity kicked up as a result of the long fetch.

Can you characterize the vegetation in the estuary? If you have a list, that would be preferable.

Mostly the estuary is comprised of native freshwater wetland species. Small communities of invasive species exist, which we monitor regularly. We will share our current data.

Do you have wildlife (birds, mammals/reptile, invertebrates) lists?

For birds, at least 10,000 people came within the first week for the Biggest Week in American Birding. This year saw the same thing. Within the first 15 days before the Biggest Week in American Birding (May 1 -15), we had about 20,000 people. Almost 300 species of birds were observed; the wildlife response has been incredible. Black Swamp Bird Observatory does all of our bird monitoring.

For vegetation, we have had some initial monitoring results. We monitor at least twice a year. We can share that information.

For fish, we have not done research yet. Lake Erie water levels are preventing us from opening our gates/pump structures to allow water to flow in and out based on the lake. We've not been able to do this because the levels have been so high, and it cannot carry water in above a 572 in Unit 1 (Ohio Dam Safety Jurisdiction).

We have seen carp in the ditches. We have fish exclusion grates on our pump station. The carp are trying to get into the marsh to breed. Metzger Marsh has become an excellent fishery. Northern pike can get in when there's still ice (under ice) in mid-March. The carp move in when water is 50+ degrees. That's when you drop your grates in, but you can't keep everything out. You should allow time for vegetation to establish.

Do you have issues with managing invasive species, if so, what species? What is done to manage them (treatment, frequency, cost)?

Last year we had about two weeks of invasive species treatment, including herbicide application and monitoring where we looked for populations (especially in shallower areas). Herbicide costs were minimal – less than $200. Could consider doing a BioBlitz.

What lessons have you learned regarding public perception of the estuary?

There have been concerns about property values. We did some research and found that in all cases properties values should rise. We've held three public meetings, asking about what the public wanted to see. We looked for ways to improve drainage, such as a pump system or levees.

The community response has been overall very good – they are very excited. Adjacent landowners (lakeshore sliver up north) are angry about birdwatchers.

What forms of recreation do you most often observe in and around the estuary?

Kayaking, bird watching, walking trails, and recently we have opened recreation space for bicycles.

Other Lessons Learned?

The Army Corps permit took forever. I believe it was a Nationwide Permit 27. Possibly a different permit, since we had to breach a dike.

We wanted to limit access to protect marsh. We didn't want picnicking/playgrounds, etc., only kayak/walking access.

10.8.2 Euclid Creek (NEORSD, Cleveland Metroparks)

This interview was conducted with Claire Posius (formerly with the Cuyahoga County Soil and Water Conservation District), who was the project manager of the Euclid Creek Lacustrine restoration project, on 6/7/19.

What are some of the biggest challenges in management the estuary?

- We had a lot of trouble with the Army Corps. Have a flexible engineer and good contingency money for possible redesign. Otherwise, the project has gone well considering the hurdles.
- Backwater in the wetland and sediment has been an issue. We thought there would be more flushing with the spillway and big rain events. However, whole areas of vegetation couldn't be established.
- The Cleveland Metroparks had to step in as land manager. Invasive species are not "hellacious," but we do have to spray every season.
- We had a problem with fishermen who come in and trample estuarine vegetation. We limited public access early on. People thought it was a land bridge. Now the only areas not established are those the fishermen trampled.
- Talk to Elizabeth Hiser. She is the new Euclid Creek Watershed Program Manager.

What are biggest threats to water quality? How have you dealt with them?

- No known issues with nutrients, debris, or trash.
- People were worried about ice jams upstream, but the wetland actually acted as a storage area.
- NEORSD has data on contaminated waters – ask them if water quality has improved since the wetland was put in.
- We weren't moving our water to a high-quality area – water flows in same alignment.
- Check Cuyahoga County Soil and Water Conservation District webpage – Euclid Creek Stream and Wetland Restoration project.

How have you dealt with trash/debris in the estuary?

Since the amount is minimal of trash/debris that wasn't already there, we have two cleanups per year. No additional trash management is done, but then again flow into the estuary was not altered so we did not have to do anything different than we normally would have.

How do you manage sediment?

We did not take any corrective actions. We wanted to watch the system to see what it was doing. It's a "tough system when you have an entire watershed going into a wetland." We will wait and see. Perhaps more recent plantings have been done? Ask Elizabeth Hiser. Also ask her about BHEI.

Can you characterize the vegetation in the estuary? If you have a list, that would be preferable.

Mostly it's native freshwater wetland species. Small communities of invasive species have appeared, which we monitor regularly. We will share our data. "All the money goes to control invasives." ODNR pulled out of lakefront parks and gave Cleveland Metroparks $12M to get "up to speed."

Do you have wildlife (birds, mammals/reptile, invertebrates) lists?

People were underwhelmed – the bugs [stream macroinvertebrates] did not establish the way we were hoping, therefore the fish community didn't establish either. I think sedimentation was definitely part of the issue, though I believe the only areas that are currently not vegetated at this point are the areas that fisherman regularly trample.

Do you have issues with managing invasive species, if so, what species? What is done to manage them (treatment, frequency, cost)?

We are consistently managing small populations, but they are not taking over the site. It does require on-going management. Euclid Creek Watershed Council or Elizabeth Hiser may have more updated information.

What lessons have you learned regarding public perception of the estuary?

Everyone now is excited about it – except for people that liked Japanese knotweed. There is some educational gap. Most people in the neighborhood love it. At the public meetings there were concerns about mosquito breeding grounds, disruption, construction projects, flooding, etc. it required lots of education to address their concerns. We did not get a lot of public engagement beforehand (all agency folks), but after groundbreaking, we had 100 people show up to that meeting. Nobody cared about the design – everyone was OK with it, but they were more upset about how it looked during construction. Several people expressed concerns over impacts to their viewsheds. This was a difficult issue because this project was surrounded by a dense residential area

What forms of recreation do you most often observe in and around the estuary?

Nothing has changed in terms of recreation. Kayakers and fishermen were always there using the space, but this gave them more places to go. For the Doan Brook, you should plan for creative places for fishermen to fish so as to keep them out of other areas.

Other Lessons Learned?

The 404 U.S. Army Corps permit took a very long time since historical issues were discovered on site. Permitting-wise, the Doan Brook team should take this into account. Allow ample time for permitting (at least one year).

10.8.3 Old Woman Creek National Estuarine Research Reserve (OWC NERR)

This interview was conducted with Janice Kerns, ODNR, Old Woman Creek National Estuarine Research Reserve on 6/3/2019.

What are some of the biggest challenges in management the estuary?

The true focus at OWC NERR is the management of upstream sources of nutrients; we don't manage them. OWC NERR does the research that would inform management decisions. Sediment loading and invasives species are other significant challenges that we manage on an on-going basis.

What have you learned from monitoring nutrient input? How does this impact aquatic/estuarine species?

We partner with the Erie Soil and Water Conservation District's (ESWCD) watershed manager to work with farmers in the watershed to adopt conservation practices, particularly no till and cover crops. We are collaborators on a Great Lakes Restoration Initiative grant to the ESWCD to conduct cost-benefit analyses of different conservation practices at the field level for participating farmers. They are provided a financial "reward" for improvements in the quality of water coming off their fields and another for improvements in the overall watershed water quality.

Total phosphorus tends to be more of a problem than dissolved reactive phosphorus, relative to other watersheds in western Lake Erie.

The estuary is effective at transforming and taking up dissolved forms of phosphorus and nitrogen (nitrate, nitrite), reducing loading to Lake Erie. The estuary tends to export ammonia.

What challenges, other than nutrients does OWC NERR face? The estuary in particular?

- Erosion and, as a result, sediment loading is a large problem.
- Invasive species

What are biggest threats to water quality? How have you dealt with them?

- Nutrients from agriculture
- Erosion/sediment loading

What else has been done to address the threats?

At least two different groups conducted studies to identify hot spots of sediment loss in the watershed. I think the U.S. Army Corps might have been one of those groups. Identifying hot spots allows us to encourage landowners in those areas to adopt sediment conservation practices. We have a Watershed Action Plan that identifies the watershed challenges along with goals and targets for water quality improvement.

We collaborate with the ESWCD to run a volunteer (citizen science) watershed stream monitoring program to better monitor changes to water quality in the watershed and to encourage local citizens to take action toward improving water quality.

How have you dealt with trash/debris in the estuary? If OWC NERR does not manage debris, are you aware of any removal efforts?

We don't actively manage debris from the watershed. We do, as needed, cleanup of tires and other large debris when we can. We have had some beach clean-ups and do marine debris outreach (that's more focused on marine debris in the lake though).

How do you manage sediment?

OWC does not manage sediment, they just monitor conditions.

What have you learned from monitoring sediment? How does this impact aquatic/estuarine species?

Sediment coming into the estuary is a big concern (see above). I think that most of our efforts have been to encourage farmers to adopt conservation practices, especially the use of cover crops, to reduce sediment loss and improve soil health more generally. Other conservation practices include buffers and modified banks. Our collaborator at ESWCD could answer these questions much better.

Can you characterize the vegetation in the estuary?

Below the site profile chapter on our website, we have atlases of different taxonomic groups. An atlas for aquatic vegetation can be found here:

http://coastal.ohiodnr.gov/portals/coastal/pdfs/owc/owcatlas_wetlandplants.pdf

A new invader is European frog bed which is not included in the atlas.

Do you have issues with managing invasive species, if so, what species? What is done to manage them (treatment, frequency, cost?)

We have had issues with phragmites and reed canary grass. The rapid increase in lake (and therefore estuarine) water levels in combination with the use of glyphosate has helped control the phragmites to a large extent. We have trouble controlling it in some less accessible areas. The reed canary grass became a problem as a result of the loss of ash tree canopy cover. We treated those areas last year and planted wetland vegetation. Our original plan was to plant willow stakes to provide early woody growth and cover in order to eventually restore trees. However, high lake levels caused that area to become too inundated with water for the willow to survive. Right now, cattail appears to have grown in place of the reed canary grass.

What lessons have you learned regarding public perception of the estuary?

Most perception is positive or neutral. We have a lot of regular visitors that seem to have developed a strong sense of place here. We also have a lot of locals who have never visited! Some of the adjacent landowners have had their property negatively impacted (i.e., flooded) by rising lake and estuary water levels.

What forms of recreation do you most often observe in and around the estuary?

We typically see a lot of hiking, kayaking, and bird watching.

11.0 COST ESTIMATE

EnviroScience worked with RiverReach Construction to develop a rough cost estimate for the construction of the daylighting of the Doan Brook in the I-90 Cloverleaf as well as for the estuary construction.

For the daylighting of the Doan Brook within the I-90W cloverleaf, this project would likely have a construction cost between $175,000 and $250,000 with the following assumptions made:

- All soils can and will be spoiled on site
- Any debris will have to be hauled-off site
- Revegetation will be completed by a firm other than the construction contractor
- No water control will be needed on-site during construction

For the estuary construction, including the cut in the junction box, the creation of stream channel coming out of the junction box, and the estuary wetlands, this project would likely have a construction cost between $500,000 and $750,000 with the following assumptions made:

- All soils can and will be spoiled on-site
- Construction will require 20,000 to 25,000 cubic yards of excavation per EnviroScience's conceptual grading plans
- Erosion fabric will be required on all slopes
- Revegetation will be completed by a firm other than construction contractor
- Junction box gate/weir will be installed by others

These estimates are based on conceptual details developed by EnviroScience and should be used for informational purposes only. Actual construction costs will depend on final linear feet of stream and acreage of wetlands determined at the 30% and 60% design levels.

12.0 REGULATORY REQUIREMENTS OF PROPOSED ESTUARY

The project will require a consultation and permit from the USACE and approval from the Ohio EPA as part of the Section 404 Clean Water Act and 401 Water Quality Certification programs. The streambank stabilization work will likely require a Nationwide Permit (NWP) 27 for stream restoration activities. Accompanying any NWP, a wetland delineation will be necessary to evaluate potential impacts to wetland and waterways as a result of project construction or access. We anticipate that the permitting timeframe for a project such as this would be 3-6 months after a complete application is submitted and accepted by the USACE.

While the project is not in a FEMA regulatory floodway, the project does propose to create "new" stream alignment, wetland complexes and a cut in the sheet pile bulkhead in Gordon Park. These proposed features would likely require a FEMA map revision. Project design would ultimately determine the correct path of coordination with FEMA, but modeling and consultation with FEMA can take from 6 to 12 months. Cost of this coordination and map revision would be determined after 60% design and consultation with regulatory agencies.

Finally, taking into account the known risks of exposure to contaminated dredge spoils located near the Cleveland Lakefront Nature Preserve (and particularly near the junction box), any potential material excavation areas will need to undergo prior testing to determine levels of contaminants of concern. The proper level of consultation with the Ohio EPA Division of Hazardous Waste would be based on results of laboratory analysis.

Table 12.1 Permit Requirements for Doan Brook Daylighting and Estuary

Coordination/Permit	Agency	Timeline	Cost Estimate*
CWA 404/Nationwide 27 (Stream Restoration)	USACE	3-6 months	$5,000
CWA 401	EPA	3-6 months	$7,000
CWA Section 10- Rivers and Harbors Act	EPA	3-6 months	$5,000
ODNR Consultation (Protected species)	ODNR	1-2 months	$3,000
Authorization/Remedial plan for movement of contaminated soils	Ohio EPA	TBD following soil testing and analysis	TBD following soil testing and analysis
FEMA Coordination	FEMA/Cuyahoga County	6-12 months	TBD
SWPPP	Cuyahoga County	2 months	$6,000
ODNR Authorization and Coordination (I-90 Cloverleaf)	ODOT	3 months	$3,000
Landowner and Land Manager and Infrastructure Manager Coordination	Cleveland Metroparks, Port of Cleveland, NEORSD, City of Cleveland	3-6 months	TBD

**All costs are approximate based on permitting for projects of a similar scale*

13.0 NEXT STEPS

Below is a list of tasks required to further develop, design, and refine the Doan Brook daylighting and estuary restoration concepts.

- Stakeholder engagement and feedback
- Project design contract advertisement
- Project Design
  - Topographic and Morphologic Survey
  - Data Analysis
  - 30% Design
  - Hydrologic and Hydraulic Modeling (H&H) HEC-RAS model of the existing and proposed conditions
  - Permitting
  - 60% Design
  - Earthwork and water control installation cost estimate
  - Restoration concept and estimate
- Coordination Meetings with regulatory agencies and land/infrastructure owners and managers
- Construction contract advertisement
- Project construction

Based on EnviroScience's extensive design-build experience, we have developed a sample timeframe for a project of this scale (Table 13.1).

Table 13.1 Next Steps and Timeframe for Planning, Design, and Construction

Streambank Stabilization Actions	Timeline (# Months)
Data collection and Preliminary Design (30%)	3
Hydraulic and Hydrologic Analysis	2
Permits and Approvals	2-5
60% Plans	2
Construction	3-5
Streambank/estuary Revegetation	1-2

14.0 CONCLUSIONS

14.1 FEASIBILITY SUMMARY

EnviroScience, GPD Group, and KS Associates investigated and analyzed results for the following parameters:

- Environmental Review
- Geotechnical Borings and Analysis
- Hydraulic and Hydrologic Modeling
- Sediment and Turbidity
- Ice Flow & Trash Evaluations
- Camera Monitoring of Ice and Trash Flow Near Future Estuary
- Biological Conditions – Current and Potential
- Water Quality
- Location of Utilities
- Structural Stability of Existing Infrastructure
- Impact of The Doan Valley Interceptor Tunnel
- Navigation/Boating Impacts
- Lessons Learned from Similar Projects
- Regulatory Requirements

Based on the data collected as part of this study, the project team did not discover any data that would impact the feasibility of the project based on the parameters listed above. Because this investigation was limited in terms of scope and funding, EnviroScience does, however, recommend additional investigation and collection of new data (water quality, sediment) if the project advances to the next phase to better inform future phases of the project.

The water quality in the lower Doan Brook may have some impact on the potential estuary and possibly the E. 72nd Street harbor; however, it was not in our scope to model these potential impacts. We recommend collecting updated water quality samples and modeling potential transport and fate of sediment and known contaminants to better understand this impact. Of particular significance would be the levels and transport fate of nutrients and heavy metals, both of which can be limiting factors for the health of fish populations. As part of our study, however, we were able to research and recommend tools for managing high flows of lower water quality, such as weirs and gates. This strategy is likely the most efficient and effective option for regulating the flow of Doan Brook and controlling when and how much flow is received by the estuary and harbor.

The proposed estuary also provides several potential benefits, from the potential to increase fish bird, reptile, amphibian, and invertebrate species richness, to filtering contaminants, capturing sediment, and increasing flood and ice storage. These benefits should be considered against the potential impacts of the lower water quality events in Doan Brook. Our investigation resulted in significant ecological uplift potential, while also considering realistic management challenges.

If the estuary does come to fruition, the new habitat will likely require a partnership model to management of the new natural area. Management of the estuary would best be achieved through a collaborative management approach, incorporating agency teamwork across multiple scientific disciplines (Metroparks, Ohio EPA, grass roots conservation groups), public/private partnerships, and community engagement.

14.2 FEASIBILITY CHECKLIST

Results of the feasibility study were applied to a checklist. If, after investigation, the estuary is deemed feasible from the standpoint of the study parameters, a feasibility recommendation is made. If additional study is recommended to make a stronger feasibility recommendation, it has been noted in the "Additional Study Recommended" column.

Table 14.1 Feasibility Checklist

Study Parameter	Feasibility Recommendation	Additional Study Recommended
Environmental Review/Site History	✓	
Geotechnical Borings and Soil Analysis	✓	✓
Sediment and Turbidity	✓	✓
H & H Modeling	✓	
Coastal Forces	✓	
Ice/Trash Evaluation	✓	
Biological Benefit	✓	✓
Water Quality (with Gate Structure)	✓	✓
Navigation/Boating Impacts	✓	
Utilities	✓	
Existing Infrastructure	✓	

15.0 LITERATURE CITED

Dombeck, Michael Paul. (1984). Ecological factors affecting muskellunge (*Esox masquinongy*) reproduction in Midwestern lakes. *Retrospective Theses and Dissertations*. 8983.

Garrity, L., V. Mills and B. Yingling. (2013). Doan Brook Watershed Action Plan. Accessed at www.doanbrookpartnership.org. May 2019.

Grabarkiewicz, J. and W. Davis. (2008). An introduction to freshwater fishes as biological indicators. *EPA-260-R-08-016.* U.S. Environmental Protection Agency, Office of Environmental Information, Washington, D.C.

Herdendorf, G.E. (1987). The ecology of the coastal of coastal marshes of western Lake Erie: A community profile. U.S. Fish Wildl. Serv. Biol. Rep. 85 (7.9). 171 pp + microfiche appendices.

Herdendorf, Charles E.; Klarer, David M.; and Herdendorf, Ricki C. (2006). *The Ecology of Old Woman Creek, Ohio: An Estuarine and Watershed Profile (2nd Ed.).* Ohio Department of Natural Resources, Division of Wildlife, Columbus, Ohio. 452 pp.

Lane, J.A., C.B. Portt and C.K. Minns. (1996). Spawning habitat characteristics of Great Lakes fishes. Can. MS Rep. Fish. Aquat. Sci. 2368: v+48p.

Northeast Ohio Regional Sewer District. (2016). *Doan Valley Interceptor Tunnel Fact Sheet*. Provided to EnviroScience by Paul Kovalcik, Stormwater Projects Specialist. April 18, 2019.

Port of Cleveland. (2016). Cleveland Lakefront Nature Preserve. Accessed via http://www.portofcleveland.com/environment-infrastructure/cleveland-lakefront-nature-preserve/. May 2019.