Wetland Nutrient Reduction of Treated Effluent in the Upper Mill Creek

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Engineered Ecosystems

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Executive Summary

The objective of this project was to determine an optimal solution for nutrient reduction of the treated effluent from the Upper Mill Creek Water Reclamation Facility (UMCWRF). A constructed wetland with an accompanying pipe network, pump station, and outlet structure was deemed to be the most effective fix. Numerous types of constructed wetlands and outlet structures were researched and evaluated. They were ranked on effectiveness, associated maintenance and operation, site feasibility, and cost. The criteria were weighted based on the importance of each category to the Mill Creek Alliance (MCA). A final score for each option was determined and the highest-scoring design was chosen. From this evaluation a surface flow wetland design with an outlet structure of a riser and emergency spillway was recommended for optimal nutrient removal. During the design process, a pipe network, pump station, vegetation selection, and outlet structure were analyzed for the wetland design. The hydraulic parameters needed for these structural elements were also determined. These calculations included an ideal flow rate of 1-2 million gallons per day, a depth of 8-12 inches, a berm height of 2-4 feet, and a volume of 8,204.29 cubic meters. The final design has an estimated 94-96% and 96-97% removal rate for nitrogen and phosphorus, respectively. Deliverables from the design phase included a proposed pipe layout to convey treated effluent from the UMCWRF's current discharge pipe to the constructed wetland, a pump station to create flow through the proposed pipes, and an outlet structure to control the water level and discharge rate of the constructed wetland.

1.0 Introduction

1.1 Problem Statement

Engineered Ecosystems is responding to a request for proposal from the Mill Creek Alliance (MCA) regarding an optimized wetland design for the wetland adjacent to the UMCWRF in West Chester Township. There currently is a 10.64 acre stormwater control bankfull wetland, the Wildermuth Wetland, which was built after an illegal soil harvesting operation was performed to infill the 100-year floodplain of the East Fork Mill Creek. However, the wetland was not implemented to effectively maintain a retention time that allows the vegetation to uptake excess nutrients. The goal of the fall semester's proposal was to evaluate types of constructed wetlands, outlet structures, and vegetation to reduce nutrient concentrations in the Upper Mill Creek. After the best alternative was chosen, the goal of the spring semester was to design a constructed wetland that incorporated a pipe network, pumping station, outlet structure, and optimal vegetation for removing nutrients. This report summarizes the work that was done in the fall semester and provides the designs created for the chosen wetland alternatives during the spring semester.

1.2 Site Background

The Mill Creek was deemed the fourth worst polluted stream in the United States in 1999. The ranking prompted the MCA to create the Upper Mill Creek Watershed Action Plan in 2005 (Scheerhorn and Miller, 2023). The plan included the construction of several bankfull wetlands and modified retention/detention ponds to dissipate flood waters along the Mill Creek, which included the Wildermuth Wetland site (Figure 1). The implementation of a constructed wetland at the Wildermuth site occurred in 2013 when West Chester Township secured funding. The Butler County Water and Sewer Department (BCWS) was awarded a Supplemental Section 319(h) Nonpoint Source Project Grant by the Ohio Environmental Protection Agency (OEPA) that provided $100,000 in federal funds for the project (Miller, 2014). It was designed to aid in water quality improvement through the biological uptake of nutrients in the bankfull wetland. The restoration efforts were completed in 2014.

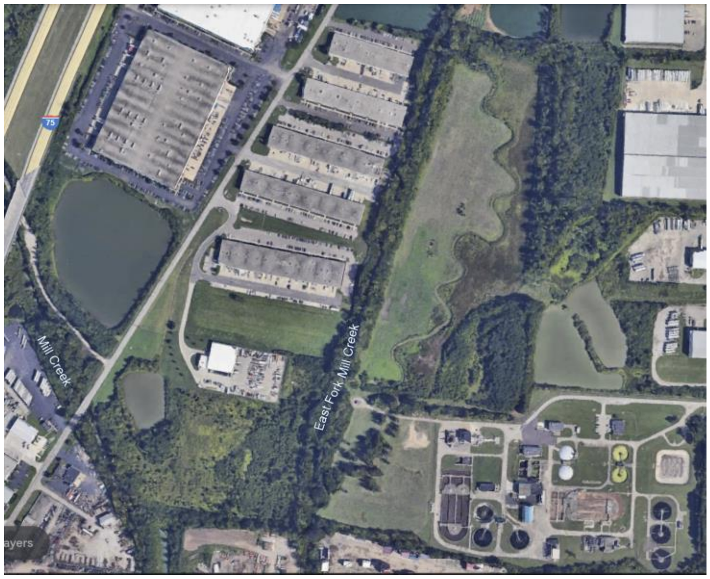

Figure 1: Overview of the Wildermuth Wetland (image taken from Google Earth).

1.3 Constructed Wetland Overview

Constructed wetlands serve many water quality purposes. They act as flood control by holding water during major rain events, provide habitat for thousands of plants and animals which promotes biological diversity, and absorb nutrients such as nitrogen and phosphorus from the water. They can even act as a source of recreation for activities like hunting, birdwatching, and plant and animal viewing (Lorion, 2001). Bankfull wetlands allow bankfull discharge stage events to flood into the wetland where it then retains the water and releases it at a slower rate back into the stream. This removes metals and nutrients and reduces turbidity throughout the waterway. They can also serve as tertiary treatment of effluent for nitrogen and phosphorus removal. These wetlands aim to increase flood storage, improve habitats for wildlife, enhance water quality, reduce nonpoint source pollution such as runoff from roads, and decrease in-stream erosion (Sackenheim, 2013). They typically incorporate multiple design elements including water level control structures and native wetland plants to accomplish the desired effects. A water level control structure is a permanent structure that provides control of the discharge of surface and subsurface drainage. They can use flashboards, gates, valves, risers, or pipes to achieve outflow control ("Water Control Structure," 2012). The Wildermuth site used an outlet pipe for the water level control structure. The original construction included planting over 400 trees and shrubs, 4,000 herbaceous plugs, and thousands of seeds. The vegetation was expected to help with nutrient absorption and erosion control.

1.4 Scope of Issue

The UMCWRF removes nitrogen and phosphorus through their treatment processes so that their treated effluent meets secondary activated sludge discharge requirements. However, the treated effluent is above the United States Environmental Protection Agency's (U.S. EPA) recommended warm water habitat limits for these nutrients within the East Fork Mill Creek. Data provided by the MCA and the UMCWRF to Engineered Ecosystems was analyzed to determine the necessary reductions needed to meet downstream limits and to identify the nitrogen and phosphorus concentration trends. The data shown in Table 1 labeled "P" demonstrates the total phosphorus level the UMCWRF discharges to the stream. It is over the recommended limit for total phosphorus recommended by the U.S. EPA seen in Table 2 which initiated the need for this project.

Table 1: Summary of data provided by the UMCWRF (Appendix 5).

	UMCWRF Effluent Concentrations 2023	
Month	NH3	P
	Conc (mg/L)	Conc (mg/L)
Jan-23	0.13	0.77
Feb-23	0.42	0.62
Mar-23	0.29	0.51
Apr-23	0.33	0.63
May-23	0.13	0.72
Jun-23	0.13	0.35
Jul-23	0.26	0.29
Aug-23	0.14	0.75
Sep-23	0.21	0.40
Average	**0.23**	**0.56**

Table 2: Nutrient Guidelines for Ecosystem Protection from the U.S. EPA (Miller, 2023).

For Ohio:	Total Phosphorus (mg/L)		Total Nitrogen (mg/L)	
	WWH	EWH	WWH	EWH
Headwaters	0.08	0.05	1.0	0.5
Wadable	0.10	0.05	1.0	0.5
Small Rivers	0.17	0.10	1.5	1.0
Large Rivers	0.30	0.15	2.0	1.5

This project aims to fix the issue by pumping effluent to the top of the wetland so it can flow through specific vegetation to remove nitrogen and phosphorus. The Wildermuth Wetland would be the first constructed treatment wetland in Southwest Ohio. The new layout will be optimized to effectively remove total phosphorus and total nitrogen from the UMCWRF's treated effluent.

2.0 Alternative Analysis

2.1 Constructed Wetlands

The constructed wetland designs evaluated include surface flow wetlands, subsurface flow wetlands, and floating wetlands. They were researched and determined to be feasible options for the Wildermuth site. This conclusion was based on compatibility with existing site conditions, background information on the characteristics of the type of constructed wetlands evaluated, and comparable case studies.

2.1.1 Surface Flow Wetlands

The first type of constructed wetland evaluated was a surface flow wetland. A surface flow wetland is where the surface water flows over the soil from an inlet point to an outlet point (Figure 2). They can also be called free water surface treatment wetlands (FWS) or horizontal flow wetlands. Surface flow wetlands consist of shallow basins in soil or other media that will support plant roots (IWA Specialists Group, 2006). In general, they contain a soil bottom, emergent vegetation, and a water surface exposed to the atmosphere. The vegetation is made up of plants able to withstand continuously saturated, anaerobic soil conditions. The water moves through the wetland above the substrate at low velocities. They promote natural decay due to exposure to air and UV rays that allow complex biological and chemical reactions to occur, similar to natural marshes. They can also provide an area for public education and recreation such as hiking and bird-watching. Constructed surface flow wetlands provide suspended solids removal through sedimentation, biodegradation of dissolved organic material through microorganisms, and advance nitrogen and phosphorus removal through plant uptake.

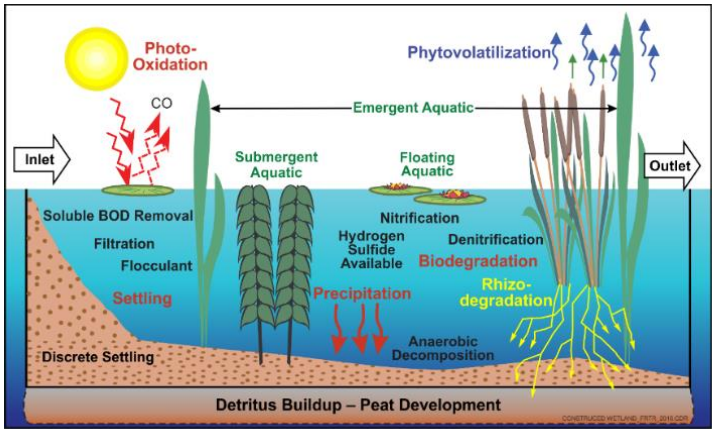

Figure 2: Surface flow wetland schematic (Tilley, 2014).

2.1.2 Subsurface Flow Wetlands

The second type of constructed wetland evaluated was a subsurface flow wetland. A subsurface flow wetland is a wetland with no exposed surface water due to vegetation and soil on top of the water (Figure 3). The water flows downward from the planted layer through the substrate and out of the wetland through an outlet structure. They help improve water quality through treating the water with microorganisms and plants (Camus, 2017). In this type of constructed wetland, the microorganisms do most of the work concerning water treatment. Bacteria that are able to degrade pollutants can attach themselves to the various surfaces and waste materials in the water. They become trapped in the pores and crevices on the media. Subsurface wetlands are best to implement at sites with porous soils such as sand or gravel. Sites with highly permeable native soils may require a liner in order to retain water in the wetland and prevent the infiltration of the waste stream into groundwater. They take up less land but are more technically challenging to design, build, and maintain than surface flow wetlands.

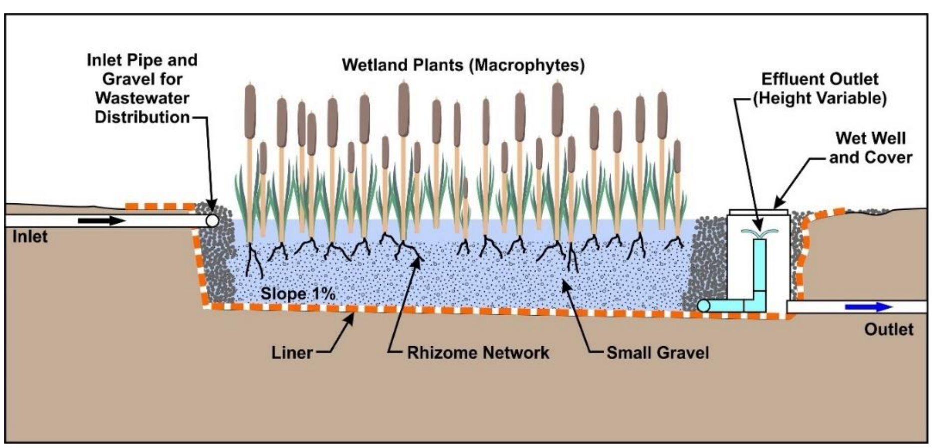

Figure 3: Subsurface flow wetland schematic (Tilley, 2014).

2.1.3 Floating Wetlands

The third type of constructed wetland evaluated was a floating wetland. Floating wetlands are systems that consist of floating islands of vegetation on the surface of wastewater, greywater, or stormwater runoff (Figure 4). The islands act as artificial platforms that allow aquatic emergent plants to grow in deeper water. The roots of the plants spread through the floating islands and down into the water creating dense columns. The dense root columns provide extensive surface area for microorganisms to grow on. The biofilm of microbes is where the majority of nutrient uptake and degradation occurs in a floating wetland system (Stanley and Grosshans, 2018). The floating mats of vegetation cover the surface of the water which reduces turbulence and mixing by wind and other environmental factors. This allows suspended solids to settle by providing an added layer of protection. The unique ecosystem that develops creates the potential to capture nutrients and transform common pollutants that would otherwise harm waterways. Floating wetlands can be implemented in several types of freshwater bodies to improve the quality of water.

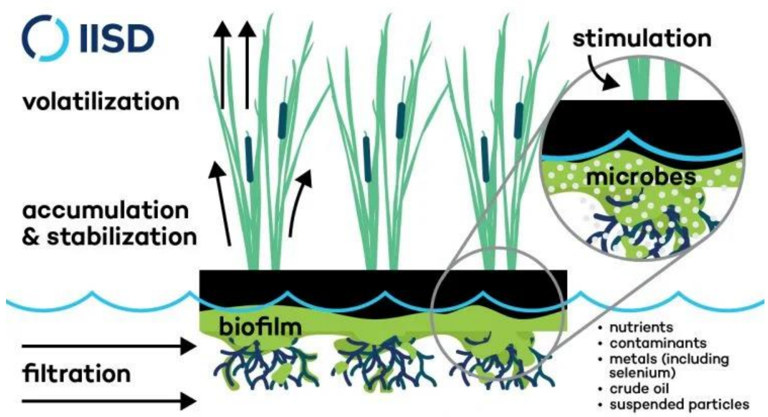

Figure 4: Floating wetland schematic (Stanley and Grosshans, 2018).

2.2 Outlet Structure Alternatives

An outlet structure is necessary with the reconstruction of the Wildermuth Wetland to control discharge rates and maintain an optimal water depth. Currently, there is no water being retained at the site so outlet structures of a broad-crested weir, riser, siphon, and spillway were analyzed to determine if they would be feasible in the final design.

2.2.1 Broad-Crested Weirs

Broad-crested weirs are a type of outlet structure that support and limit the flow of water. These designs have a horizontal crest with a specific length. Streamlines of discharge become straight and parallel over a broad-crested weir with the critical depth occurring at a point over the crest ("Discharge Characteristics of a Broad-crested Weir," 1957). This type of control structure is useful in measuring flow rates of discharge and can be constructed with a variety of materials. The structure of broad-crested weirs usually takes the form of a relatively long raised channel, and the control section can be different shapes such as triangular, circular, or rectangular (Figure 5). A thick wall or flat stop log are examples of this type of outlet structure.

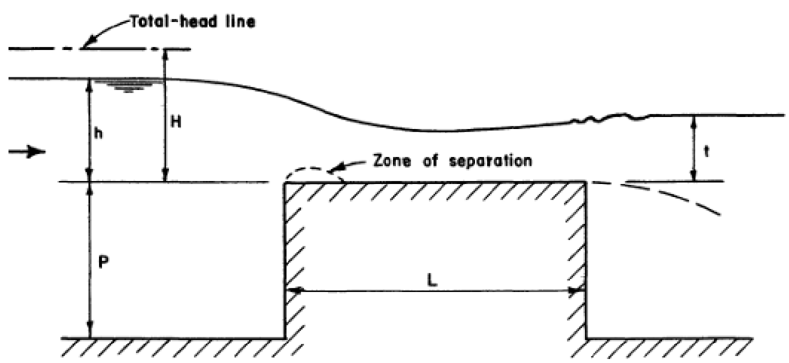

Figure 5: Schematic of a broad-crested weir ("Discharge Characteristics of Broad-Crested Weirs," 1957).

2.2.2 Riser

Risers are used in constructed wetlands to allow part of the stored water to be drawn down at a slower rate. This feature allows a wetland to have greater retention periods. A typical riser consists of a glory hole at the top (Figure 6). This is designed for flood events causing overflow. A riser structure may also be used in conjunction with orifice pipe draining controls. Risers can include orifices going vertically down the structure to provide detention heights. Another element of risers is an outlet that discharges water through a spillway. Risers provide the best distribution of daily water levels, so they are highly considered when evaluating effectiveness for water retention and storm events (Somes and Wong, 1998). The structure would need to be constructed along with an emergency spillway and embankment.

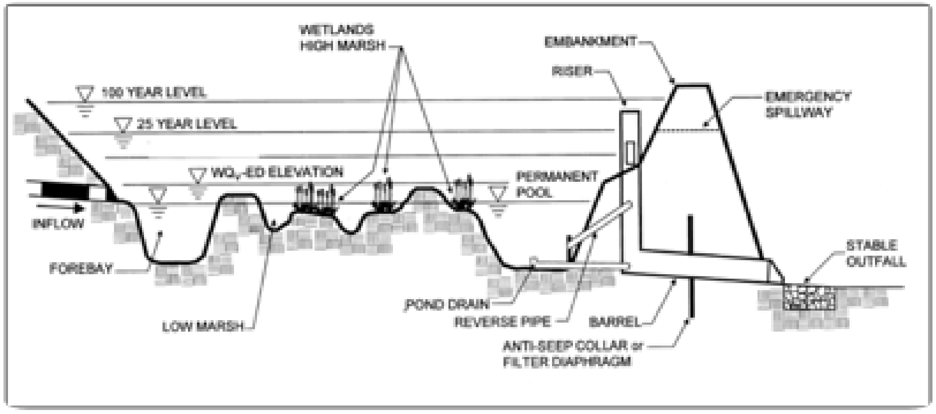

Figure 6: Typical riser structure being used with an emergency spillway ("Bowling Green, KY Official Municipal Website," 2011).

2.2.3 Siphon

A siphon is a structure typically used for large dams, irrigation, and river drainage. These controls operate near constant discharge and are good for a full range of water levels rather than just low depths (Lu et al., 2022). Once a siphon has been primed, it will operate until the permanent pool level is reached. At that point, the mechanism will be broken by air entrainment into the flow. While a siphon has the best combination of capture and providing an even distribution of water levels, it would not be able to account for stormwater events and flooding occurrences (Somes and Wong, 1998).

2.2.4 Earth Spillway

Principle spillways are a type of outlet structure that are used to regulate wetland water levels, manage wetland discharges, and safely convey wetland discharges into a downstream system. Vegetated spillways are a possible option in situations where the rate and duration of flow can be maintained at a safe velocity to a point downstream. These need to be constructed while keeping in mind a design that maintains stability under aged conditions (Figure 7). A minimum of 10-foot bottom width is required for vegetated spillways (“Vegetated Emergency Spillway”, 2011), which is achievable with the current conditions of the Wildermuth Wetland.

Vegetated spillways typically consist of an inlet channel, control section, and an exit channel lined with erosion-resistant vegetation. Flow throughout the spillway would be maintained as sub-critical in the inlet channel, and either critical or super-critical in the exit channel. In the control section, flow would pass through at critical depth. The inlet channel should be designed so the cross-sectional area is large in comparison to the flow area of the control section where the depth of the channel changes with increased flow rate. The exit channel should be designed to discharge peak flow within the channel while also preventing flow that would produce velocities large enough to erode the soil or vegetative cover.

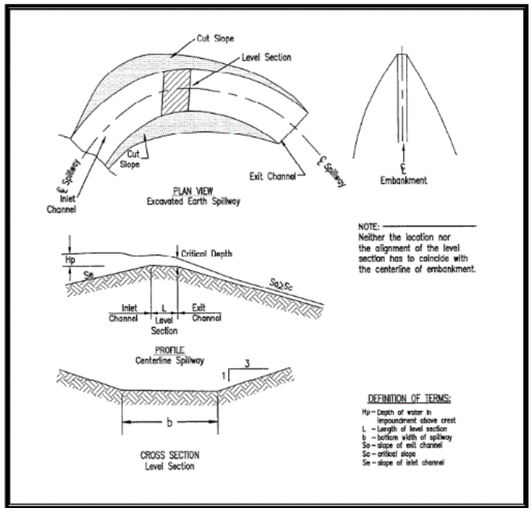

Figure 7: Schematic of general Earth spillway layout ("Vegetated Emergency Spillway," 2011).

2.3 Criteria for Analysis

The criteria that were evaluated for the constructed wetland and outlet structure option analyses were effectiveness, maintenance and operation, site feasibility, and cost of implementation. According to the research done by Engineered Ecosystems and the priorities of the MCA, it was determined these are the most important factors that summarize the overall goals for implementation of a new wetland design. Effectiveness was given the greatest weight in the analyses (4). This weight was determined because this criterion would be pivotal to ensure standards for total nitrogen and phosphorous are met within the effluent. Maintenance and operation of the alternatives was weighted second (3). The wetland should be self-sustaining. The outlet structure and type of wetland need to be easily maintained for the wetland to properly function and remove nutrients to the desired levels. Site feasibility was the next criterion that was considered and weighted (2). This factor is important because the Wildermuth Wetland site is an existing site that needs to be reconstructed to meet the specifications outlined by the MCA. The site has limitations to be considered when looking at how easily the options can be implemented and the impact they would have on the existing landscape. Cost was the criterion that was given the least weight (1) when analyzing the various options to pursue. The project was not given a budget and will eventually be funded by grants. This does not put a specific limit on the cost of reconfiguring the wetland.

2.4 Alternative Analysis

The various constructed wetland and outlet structure types were evaluated against the aforementioned criteria. Decision matrices were created to summarize the information and then the best alternatives were determined. The decided upon options were used in the final design.

2.4.1 Surface Flow Wetland

The optimal wetland type for the Wildermuth Wetland site was determined to be a surface flow wetland (Table 3). This is because it was ranked best in the maintenance and operation and site feasibility categories. A detailed explanation of the weights given in Table 3 to each type of wetland for the different categories can be seen in Appendix 6. Surface flow wetlands require piping and pumps, but they require less equipment than subsurface flow wetlands. They were determined ideal for the existing site because the most critical element of this type of wetland is clay soil with low permeability which is already present at Wildermuth. It also was not the worst option for any criterion.

Table 3: Decision matrix used in the alternative analysis of types of constructed wetlands.

Constructed Wetland Design Alternative Analysis				
Criteria	**Weight**	**Surface Flow Wetland**	**Subsurface Flow Wetland**	**Floating Wetland**
Effectiveness	4	2 (8)	3 (12)	1 (4)
Maintenance & Operation	3	3 (9)	2 (6)	1 (3)
Site Feasibility	2	3 (6)	2 (4)	1 (2)
Cost	1	2 (2)	1 (1)	3 (3)
Totals (max score = 30)		**25**	23	12

2.4.2 Riser with Orifices and Earth Spillway

The optimal outlet structure type for the Wildermuth Wetland site was determined to be a riser in conjunction with an emergency spillway and embankment (Table 4). A detailed explanation of the weights given in Table 4 to each type of outlet structure for the different categories can be seen in Appendix 6. Risers are the optimal control structure to use since the water level needs to be controlled to a specific height while accounting for stormwater and other overflow events.

They allow for controlled detention volumes with orifices being included, but can also maintain a controlled retention time without them. An earth spillway and embankment can be used in conjunction with a riser to ensure water is being retained at a specific level. The riser maintains the water at a specified level whereas the spillway allows excess water to be released from the wetland. Risers are typically constructed with concrete and a pipe system, and can function without an operator. The construction of a riser would be focused in one area so it would not require excessive disturbance to the existing landscape.

Table 4: Decision matrix used in the alternative analysis of types of outlet structures.

Water Control Outlet Structure Alternative Analysis				
Criteria	**Weight**	**Siphon**	**Riser/Orifice**	**Weir**
Effectiveness	4	3 (12)	2 (8)	1 (4)
Maintenance & Operation	3	1 (3)	3 (9)	2 (6)
Site Feasibility	2	2 (4)	3 (6)	1 (2)
Cost	1	2 (2)	1 (1)	3 (3)
Totals (max score = 30)		21	**24**	15

2.4.3 Vegetation

Wetlands remove nutrients though a combination of physical, chemical, and biological processes. These processes absorb, transform, and remove the nutrients as the water flows through the wetland. The main biological process is uptake by plants, algae, and bacteria. Wetland plants uptake nitrogen and phosphorous through their roots during the spring and summer while the plants are in their growth phase. Different varieties of wetland plants were evaluated against the existing site conditions and the direction of the wetland design. The following species were selected to be planted at the Wildermuth Wetland (Appendix 7). They are all emergent wetland species because emergent plants are compatible with a surface flow wetland. These plants were selected based on their effectiveness in removing nitrogen and phosphorus, and their ability to survive in the conditions present at the Wildermuth Wetland including clay rich soil and an optimal water depth of 8-12 inches.

2.4.3.1 *Peltandra virginica*

Peltandra virginica is an aquatic perennial that is native to eastern and central North America. It is typically found in wet areas such as swamps, bogs, and marshes. The *Peltandra virginica* is also known by its common name, green arrow arum. This plant is typically grown in standing water and prefers full sun to partial shade. This plant has thick roots and produces glossy green leaves that are shaped like an arrowhead. The leaves are roughly 12 inches long and are connected to a stem that is 18–24 inches tall. This plant blooms from April to June and produces greenish-yellow flowers. (Schultz, n.d.).

2.4.3.2 *Typha latifolia*

Typha latifolia goes by the common name of broadleaf cattail. This species is a perennial herb that appears statewide across Ohio. The plant tends to have erect and stout stems, along with upright, linear, and succulent-like leaves. Male and female plants can be distinguished by the whitish yellow flower of the male and the larger brown flower of the female. The plant fruits a large cylindric collection of windborne achenes that help to spread and populate areas. Broadleaved cattails usually bloom in May, June, and July and are almost always occurring in wetlands under natural conditions. This perennial roots in shallow water and can be found in dense clumps with varying heights from 4-10 feet tall. Broadleaf cattails provide a favorable habitat for red-winged blackbirds and other marsh birds. (“Plant Database,” 2023).

2.4.3.3 *Carex vulpinoidea*

Carex vulpinoidea, commonly known as fox sedge, is an adaptable native grass and typically grows up to 3 feet. Fox sedge grass tends to grow in the Southeast and roots in medium to moist clay soils. *Carex vulpinoidea* ideally is planted for wetland mitigation, stream restoration, and constructed wetlands. This sedge grows best in shallow lands with a slight slope similar to the characteristics of the Wildermuth Wetland. (“*Carex vulpinoidea*,” n.d.).

2.4.3.4 *Calamagrostis canadensis*

Calamagrostis canadensis, commonly known as bluejoint grass, is a perennial grass. This species is native to North America, preferring clay and loam soils. Bluejoint grass prefers wet soil, making it ideal for swamps, marshes, bog gardens, and along ponds. The plant tends to grow between 3-5 feet tall, with numerous erect slender stems and many floral plumes. Bluejoint grass prefers full to partial sun exposure, and blooms from mid-spring to late fall. (“*Calamagrostis canadensis* (bluejoint grass),” n.d.).

2.4.3.5 Glyceria striata

Glyceria striata, also known as fowl mannagrass, is a perennial grass. It is native and known to grow up to 3 feet tall. The plant's leaf blades grow up to 12 inches long and 7 millimeters across. The leaves grow in a wide spread pattern and are typically flat or slightly curved. Each leaf blade is medium green to grayish blue. Fowl mannagrass ideally roots in fully sunny to lightly shaded areas. The best soil for them to root in is a wet, fertile, loamy soil. This grass requires more moisture in sunny areas than when it is growing in shaded habitats. *Glyceria striata* does most of its vegetative growth during the spring and early summer. It commonly grows in mesic deciduous woodlands, swamps, damp meadows, prairie swales, marshes, bogs, and ditches. It would be a good addition to the Wildermuth site since it can withstand water depths and the site is fully open to the sun. It is also known for nutrient uptake such as nitrogen and phosphorus adsorption (Hilty, 2020).

2.4.3.6 Angelica atropurpurea

Angelica atropurpurea is an herbaceous perennial that grows in the summer and fall. It's common name is purple-stemmed Angelica. It requires partial to full sun exposure. Purple-stemmed Angelica can grow 3-10 feet tall and spread 2-6 feet wide. It can be accommodated in clay, chalk, and loam soils. *Angelica atropurpurea* does best in wet to moist soil. It is adaptable to acidic, alkaline, and neutral soils. This plant grows dry seedlike fruits. The flowers are tiny, and they're greenish in color. The stems are smooth, dark purple, and hollow. Purple-stemmed Angelica is typically planted to provide height and structure to a landscape. It is native to central and eastern North America ("*Angelica atropurpurea* (American Angelica)," n.d.).

3.0 Design

3.1 Flow Rate

The current sources of water into the Wildermuth Wetland are precipitation and runoff. After the construction of our design, wastewater inflow will also be included. Water losses in the Wildermuth Wetland come from the outlet, evapotranspiration, and infiltration. The wetland water balance contains many variables: wetland surface area, evapotranspiration rate, groundwater infiltration rate, precipitation rate, berm loss rate, catchment runoff rate, wastewater inflow rate, wetland outflow rate, and snowmelt rate (Figure 8). The wetland surface area was determined by measuring the edge of the property on Google Maps. The total area was found to be approximately 10.64 acres or 43,070.7 square meters.

The wetland water balance for a FWS constructed wetland can be expressed in generic units (L=length; T=time) as:

$$\frac{dV_w}{dt} = Q_o + Q_c + Q_{sm} - Q_b - Q_e + (P + ET + I)A_w \quad \textbf{(4-1)}$$

where:

- A_w = wetland water surface area (L^2),
- ET = evapotranspiration rate (L/T),
- I = infiltration to groundwater (L/T),
- P = precipitation rate (L/T),
- Q_b = berm loss rate (L^3/T),
- Q_c = catchment runoff rate (L^3/T),
- Q_o = wastewater inflow rate (L^3/T),
- Q_e = wetland outflow rate (L^3/T),
- Q_{sm} = snowmelt rate (L^3/T),
- t = time (T), and
- V_w = water volume or storage in wetland (L^3).

The impact of wet weather and snowmelt on the wastewater inflow (Q_o) is external to the water balance.

Figure 8: Mathematical representation of a wetland water balance (U.S. EPA, 2000).

The evapotranspiration rate is the water loss attributed to surface evaporation and vegetation transpiration. Evapotranspiration can affect the wetland by increasing hydraulic retention time and concentrating pollutants due to the loss of water. For fully vegetated wetlands, the evapotranspiration rate is typically equal to 70-80% of the Class A pan evaporation rate. By comparing the varying water balance, it was shown that changing the percentage of pan evaporation does not have a significant influence on the final calculation. A median value of 74% pan evaporation was used.

Groundwater infiltration is the loss of water due to the soil at the floor of the wetland. Infiltration can cause a decrease in water retention time and potential for pollutant loss. The infiltration rate was tested at nine points throughout the wetland for both unsaturated and saturated infiltration. The average unsaturated infiltration rate was found to be 5,160.36 cm/day. The average saturated infiltration rate is 217.04 cm/day. A summary of the methods used and data collected can be seen in Appendix 11.

The precipitation rate was calculated through finding the total precipitation for each month in Butler County (Figure 9). The rain gauge for Butler County is located at the Butler County Regional Airport (39.36° N, 84.52° W). The current wetland consists of built-up soil berms along its edges resulting in the soil infiltration rate accounting for the berm loss rate. The Wildermuth Wetland is located in a large watershed, nearly 62 square miles (Appendix 11). Due to the proposed berm layout and expected final area, the catchment runoff rate was disregarded. This is because negligible amounts of water from the total catchment area will runoff into the wetland. The snowmelt rate accounts for water entering the wetland due to a snow event. In 2023, January received one snow day, leading to the snowmelt rate only being necessary for that month.

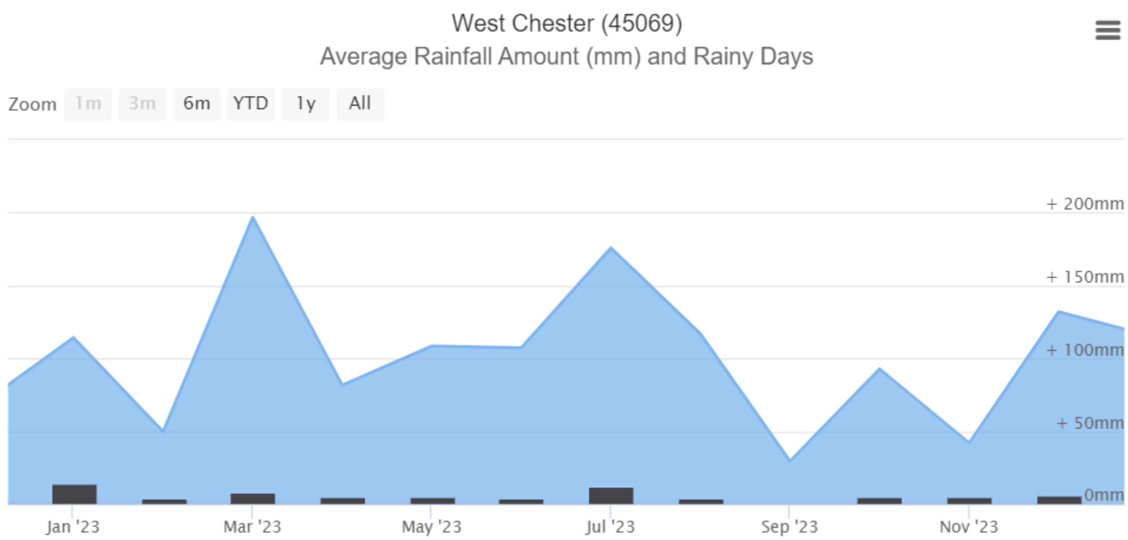

Figure 9: 2023 Monthly Precipitation Amounts for West Chester, OH ("West Chester (45069) Annual Weather Averages," n.d.).

The water budget was found by computing the ideal volume of the wetland and computing the rise of the water level from different inflow rates (Table 5). The depth recommended in the case studies reviewed by Engineered Ecosystems ranged from 8 to 12 inches. For an optimal wetland height of 0.19 meters (7.49 inches), the volume of the water would be 8,204.29 cubic meters. According to the calculations, the ideal inflow is 1 million gallons per day (MGD) into the wetland. By bringing 1 MGD into the wetland, the water depth would increase from 0.19 to 0.28 meters (10.96 inches). This enables the wetland to stay within the ideal height of 8-12 inches.

Table 5: Water Depth from Varying Inflows

Influent	Water Volume Increase (meters^3)	Water Depth Increase (meters)	Water Depth Increase (inches)
1 MGD	3785.41	0.0879	3.46
2 MGD	7570.82	0.1758	6.92
5 MGD	18927.05	0.4394	17.30
10 MGD	37854.1	0.8788	34.60

3.2 Dike

The wetland design will include a dike, or a berm, going around the entire perimeter of the Wildermuth site. A dike is typically an embankment designed to prevent water overflow. The purpose of this dike is to retain the water within the wetland, as well as keep out the water from the runoff of the subcatchment area. This will be an earth-material dike that requires the purchase of soils for construction since there is little excavation occurring in the design. The soil used for the dike should consist of at least 35% clay or other low permeability soils to prevent water loss. According to the United States Department of Agriculture, the berm needed at the Wildermuth Wetland is considered Class IV. A Class IV dike has a required freeboard height of 6 inches, a minimum top width of 4 feet, and a minimum slope of 3:1 (horizontal to vertical) (United States Department of Agriculture, 2022). The full list of dike classifications and construction standards can be seen in Appendix 10.

There will be 1-2 MGD pumped into the wetland resulting in an optimal water depth of 8-12 inches. The heights and dike requirements result in the majority of the dike being 2 feet tall. The bottom of the wetland holds more water so the dike will increase to 4 feet tall along the southern end of the project area. A drawing of these designs can be seen in Figures 10 and 11. The overall length of 2 feet tall dike is 3,475 feet (1059 meters) and the overall length of 4 feet tall dike is 799 feet (244 meters), with a 6 feet long transition in between. The layout of the dikes at the Wildermuth site can be seen in Figure 12.

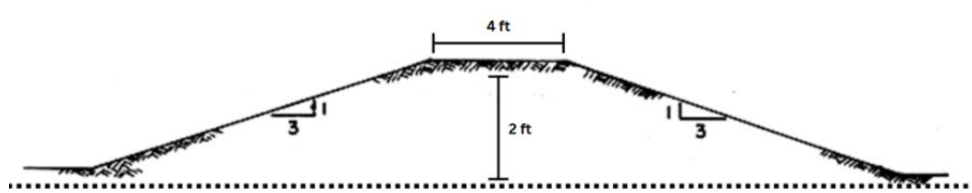

Figure 10: Design for the two feet tall dike. Note: the design is not to scale, (National Engineering Handbook, n.d.).

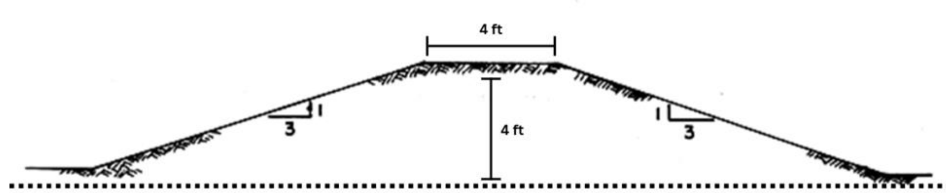

Figure 11: Design for the four feet tall dike. Note: the design is not to scale, (National Engineering Handbook, n.d.).

Figure 12: Dike layout for the Wildermuth Wetland. The blue and yellow lines represent 2 and 4 feet, respectively.

3.3 Pipe Network

Engineered Ecosystems started the pipe network design process by consulting UMCWRF and BCWS personnel to determine the optimal layout. A pipe network is needed in the redesign of the Wildermuth Wetland because some of the treated effluent from the UMCWRF's current discharge needs to be transferred to the wetland area. The discharge pipe present at the UMCWRF can be seen in Appendix 9. The piping will direct a portion of the flow from the 60-inch concrete discharge pipe to a pump station. The pump station will then move the wastewater effluent through additional piping to the desired area of the Wildermuth site. This means the pipe network will be a pressurized system since the effluent will be pumped under continuous pressure flow. The first design element of the pipe network determined was the pipe material. Butler County's standard specifications for sewer projects is to use ductile iron ("Section 3210 - Ductile Iron Sewer Force Main," 2006). Ductile iron is a typical pipe material due to its ability to withstand frigid temperatures and erosion from pollutants in effluent wastewater. The size of the pipe was the second aspect designed. It was determined that an 8-

inch diameter pipe would be used. This was calculated with an online pipe sizing tool. The pipe sizing calculator was based on Bernoulli's and Hazen Williams equations ("Calculator: Pipe sizing by pressure loss for water," 2024).

The chosen pipe layout was determined based on the hydrology of the wetland and layout of the UMCWRF. The UMCWRF is in the final design phase of an equalization (EQ) basin construction project. The EQ basin will be constructed west of the existing clarifiers and oxidation ditch (Appendix 9). The chosen pipe layout avoids that project area. Another benefit is that it requires few bends, which makes it less expensive and cause less hydraulic head loss. The final design also closely aligns with the recommendations found in the Butler County specifications for ductile iron sewer pipe installation ("Section 3210 - Ductile Iron Sewer Force Main," 2006). Lastly, it was determined the best alternative because the pipe installation will create minor disruptions to the wetland and nearby ecosystems, following Environmental Protection Agency standards for installing piping in a protected wetland area (USEPA, 2000).

The pipe from the pump station to the northern perimeter of the Wildermuth site will be ductile iron and installed underground. The 8-inch ductile iron pipe will then connect to an 8-inch perforated polyvinyl chloride (PVC) pipe. The perforated PVC pipe is flexible so it will bend upwards and surface at the ground elevation of the wetland. This layout can be seen in Appendix 2. A HARCO Fittings 8-inch Ductile Iron Transition Adapter (Figure 13) will connect the two pipe materials. This fitting was chosen because it doesn't incorporate rubber couplings that could shear or mechanical joint sleeves that allow gaps between the pipe ends which could catch debris ("HARCO Fittings - Ductile Iron Transition Adapters for ASTM D3034 to DI-OD," n.d.). It also aligns with the Butler County specifications for restrained joints on ductile iron sewer force mains ("Section 3230 - Restrained Joint Ductile Iron Sewer Force Main," 2006). The perforated PVC pipe allows for an even dispersal of treated effluent over the wetland's surface area at the outlet of the pipe network. The pipe system is pressurized so the effluent will be propelled out of the perforations to enter the wetland. In order to account for the force of the water being greater at the beginning of the PVC pipe, the perforations will have varying sizes. The size of perforations typically vary from $\frac{3}{8}$-inch to $\frac{7}{8}$-inch ("Perforated Pipe," 2024). The PVC pipe will be about 130 feet long. The first 65 feet of pipe starting from the western end of the wetland area will have $\frac{3}{8}$-inch holes. The perforations will then switch to $\frac{7}{8}$-inch holes for the remaining 65 feet to the eastern end of the wetland area. The Houghton Lake case study had a similar pipe layout connected to pumps and had success following these design parameters (US EPA, 1993).

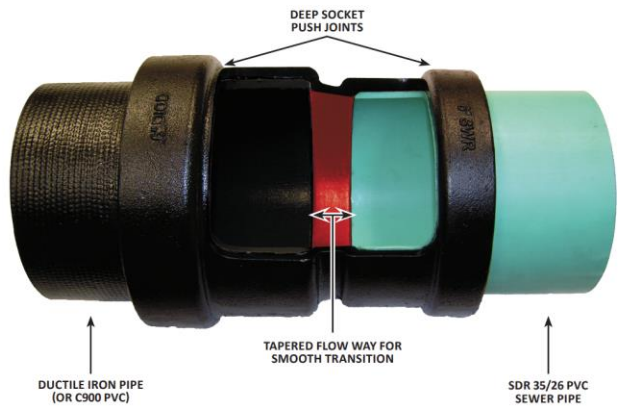

Figure 13: Diagram of HARCO Fittings 8-inch Ductile Iron Transition Adapter ("HARCO Fittings - Ductile Iron Transition Adapters for ASTM D3034 to DI-OD," n.d.).

3.4 Pump Station

After the pipe network was designed, Engineered Ecosystems had to ensure that the treated effluent had the correct hydraulics to flow through the pipes and into the Wildermuth site. The calculations showed that a pump station was needed in order to propel the wastewater effluent to the north end of the wetland. The team decided that including a premanufactured pump station package into the final design would be optimal. Several different manufacturers were researched, but ultimately the No-Vault 3 Pump Station Package from Excel Fluid Group, LLC. was chosen. It encompasses all the necessary equipment and reduces maintenance and operation efforts. This pump station "minimizes risk by providing a well-designed, safe pump station where maintenance can be performed without entering the wet well and eliminates the below grade valve vault," ("No Vault 3 (NV3) Sewage Lift Station: Excel Fluid Group," 2021). The pump station package includes: a precast concrete wet well, a polymer concrete top with access hatches to the wet well, an enclosure with an arc-sentry control panel, ductile iron piping and valves, level controls, and two submersible pumps (Figure 14). Electric utilities will need to be connected to the pump station. The extra electricity the pumps require is reflected in the cost estimate. The location of the pump station at the UMCWRF can be seen in Appendix 2.

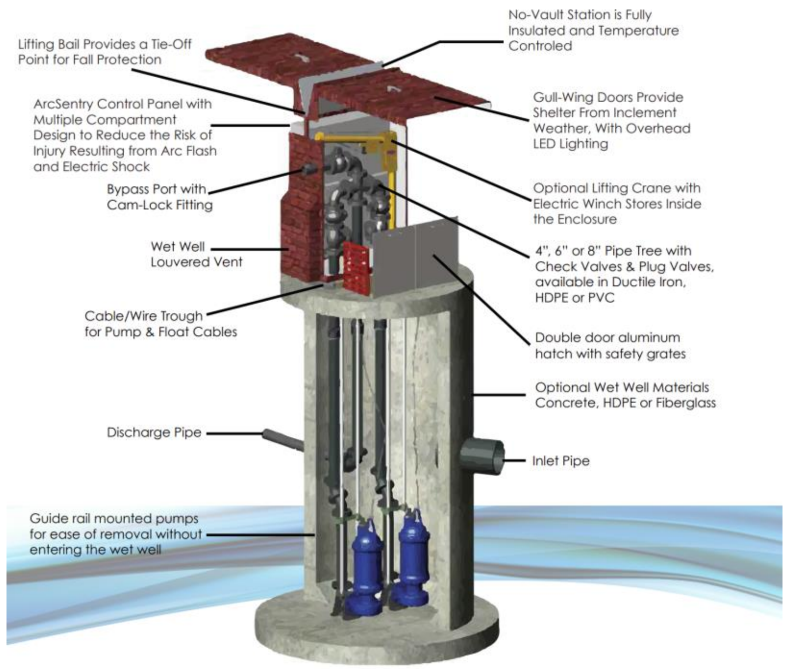

Figure 14: Diagram of No-Vault 3 pump station package ("No-Vault Package Pump Stations," 2018).

The inlet and outlet pipes need to be 8-inch to accommodate the flow leaving the UMCWRF and entering the Wildermuth Wetland as determined when the pipe network was designed. This pipe size is cohesive with the chosen pump station package. The wet well of the pump station will include 2 submersible, 7.5 HP pumps. The pump power required was determined through communication with the Excel Fluid Group team. Excel Fluid Group has a sizing calculator they use for projects that inputs the project specific pipe length, pipe material, expected flow rate, and pipe diameter to determine the pump capacity needed. They have consulted on numerous similar projects, used the same calculation methods, and produced successful systems. Excel Fluid Group's case studies are detailed in Appendix 8 on the product brochure. The team confirmed the pump size using an online pump sizing calculator from a different manufacturer, Pentair ("Pump Calculator," 2022). The Pentair calculator is based on Bernoulli's equation.

The level controls included in the pump station package will alert if the water level in the wet well is higher or lower than expected. If this occurs, the pump flow rate can be adjusted. This allows for controlled operation of the pumps and ensures that the optimal amount of water is entering the wetland.

3.5 Outlet Structure

The wetland has a natural downward slope that leads water towards the south end of the site. In order to retain water long enough for pollutant removal, a berm and riser outlet structure will be constructed to maintain a consistent water height. The structure will have an 8-inch diameter orifice with its center point at the optimal depth of 8 inches. This diameter was determined based off having an equal sized discharge pipe that allows a total flow of 1-2 MGD. The discharge pipe will be ductile iron material which can be made at an 8-inch diameter. The orifice and outflow pipe will allow for discharge at 1.41 cubic feet per second (cfs), approximately 1 MGD, when it is half full, and 2.82 cfs, approximately 2MGD, when it is completely full. These discharges are based on calculations using Equation 1 (Myburgh, 2016);

$$Q = C_W L_w {h_i}^{3/2}$$

(Eq. 1)

where *Q* represents discharge, *Cw* represents the coefficient for partially full orifices, *Lw* represents weir length, and *hi* represents head relative to the orifice invert. Since the orifice center will be at the optimal depth, the orifice will only be half full when 1 million gallons of water are pumped into the wetland each day. Equations 2 through 4 (Myburgh, 2016) can be used to incorporate cross sectional area of the orifice, head, and diameter to calculate *Lw*.

$$\text{for } \frac{h_i}{D} < 0.75, \qquad L_w = \frac{A(h_i)}{h_i}$$

(Eq. 2)

$$A(h_i) = \frac{\pi D^2}{4}\left(\frac{\theta}{360}\right) - \frac{D}{2}\sin\left(\frac{\theta}{2}\right)\left(\frac{D}{2} - h_i\right)$$

(Eq. 3)

$$\theta = 2\arccos\left(1 - \frac{2h_i}{D}\right)$$

(Eq. 4)

The cross-sectional flow area is based on circular geometry and angle of flow which are outlined in the equations above and in Figure 15.

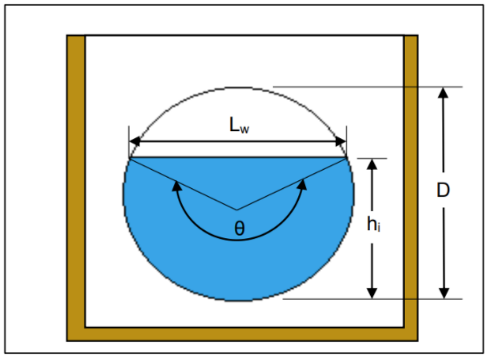

Figure 15: Cross section of circular orifice (Myburgh, 2016).

In order to account for potential storms, a glory hole opening will be featured at the top of the riser structure. The data within Table 6 outlines the precipitation falling in three different locations around the Wildermuth Wetland. The data was gathered from the National Oceanic and Atmospheric Administration's (NOAA) website. The website lists the annual maximum precipitations at different gauges based on a 90% confidence interval. For the purpose of considering potential maximums, the upper confidence interval values were used. The first location analyzed was the Wildermuth Wetland. There was precipitation data associated with the wetland address, but no gauge was present at the site so two other gauge locations were also analyzed. Averages were taken from the two gauge locations and the data allocated for the address of the Wildermuth Wetland.

Table 6: Precipitation Intensity at Various Stations Around Wildermuth Wetland

		Intensity/Exceedance probability					
Location	Storm Duration	2-year	5-year	10-year	25-year	50-year	**100-year**
Wildermuth Wetland 6055 Centre Park Dr.	24-hr	2.86 (inches)	3.70	4.27	4.99	5.55	**6.10**
West Fork Mill Creek D Station (33-8960)	24-hr	2.86	3.70	4.26	4.98	5.52	**6.07**
Kings Mills Station (33-4238)	24-hr	2.84	3.69	4.27	5.01	5.59	**6.18**
Average	24-hr	2.85	3.70	4.27	4.99	5.55	**6.12**

According to the data, the average maximum precipitation the wetland will receive in a 24-hour duration would be 6.12 inches. These potential storm events were accounted for with the opening at the top of the riser structure set at a minimum of 6 inches above the top of the orifice. This makes the outlet structure a total of 18 inches tall where any water flow above that height will be discharged through the glory hole opening and out into the spillway.

The riser will contain one orifice with a diameter of 8 inches to allow for equal discharge rates when flow rates into the wetland are at 1 million and 2 million gallons per day. The orifice should be placed so the center is at the optimal height of 8 inches. The discharge orifice and pipe at the back of the structure should also be 8 inches to match the pipe size the effluent is being pumped in through. There will be a discharge pipe made of ductile iron going underneath the berm into the spillway leading to where the wetland discharges into the East Fork Mill Creek. The final design can be seen in Figure 16 and the location it will be implemented at the site can be seen in Appendix 2.

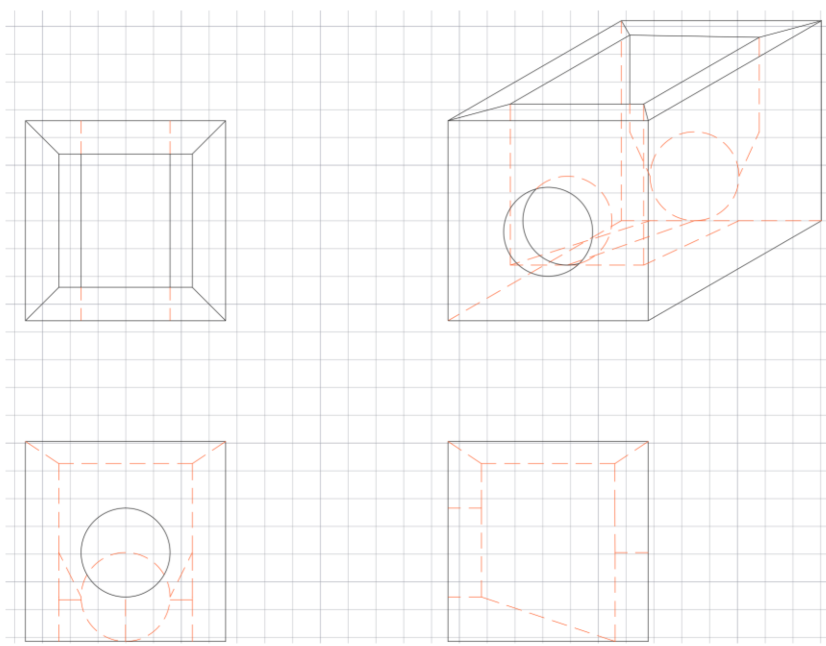

Figure 16: Proposed riser structure designed by Engineered Ecosystems.

The glory hole opening at the top of the structure will be 18 inches above the wetland base. This will allow for any water above this point to be discharged to the spillway through the riser structure. The opening will be about 225 square inches, so it is recommended to include a trash rack on the top to keep large debris from impacting the flow. The top of the structure will have sides with widths of 3 inches that slope down by 2 inches. This will assist in directing the flow downwards into the riser.

A spillway will be included in conjunction with the outlet structure and berm on the south end of the wetland. If there are large flood events, the spillway will be utilized to direct the excess flow ("Division of Water Resources Ohio dam safety laws," 2019) to the discharge point into the East Fork Mill Creek. The crest of the spillway will range from 18 inches at the lowest point, up to the top of the berm at 48 inches. Using the ratio for a 4-foot dike as discussed in Section 3.2 of this report, the sides of the spillway will have a width of 90 inches (7.5 feet) and raise 30 inches (2.5 feet) to meet the stability ratio of 3:1. The spillway will start in the southeast corner of the wetland and will be designed as pictured in Figure 17. The spillway will then run along the south end of the wetland for roughly 265 feet until it reaches the discharge point into the East Fork Mill Creek. There will still be a dike required along the south end of the wetland to maintain water levels within the area.

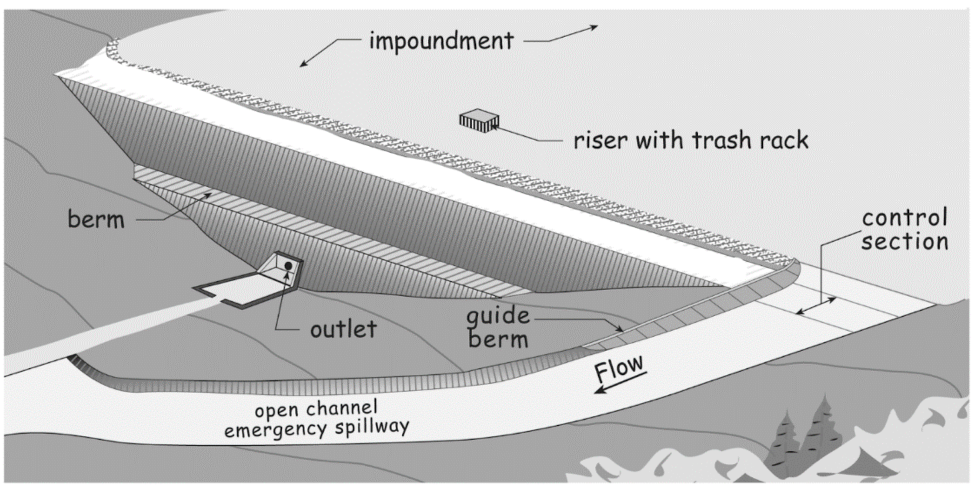

Figure 17: Typical emergency spillway ("Open channel spillways", 2024)

3.6 Nutrient Removal

The research and design of the Wildermuth Wetland was based off two similar constructed wetlands in comparable climates. The Houghton Lake, Michigan Wetland was created in 1978. It is a surface flow wetland located near a wastewater treatment plant. This wetland contains various species of sedges, willows, leatherleaf, and cattail. The water discharges 2.6 MGD and has an average depth of roughly 8 inches. The water quality of the Houghton Lake wetland was recorded from 1978-1991 and the data shows an average removal efficiency for nitrogen and phosphorous to be 96 and 97%, respectively (US EPA, 1993). The Vermontville, Michigan

Wetland was created in 1972 and consists of a series of lagoons and wetlands. This wetland is full of cattail, duckweed, grassland, and willow. The water discharges at 0.1 MGD and has an average depth of 6 inches. The water quality was tested six years after the construction of the wetland, and it was found to have a nutrient removal efficiency for nitrogen and phosphorous of 94 and 96% respectively (US EPA, 1993). The Wildermuth Wetland design is similar to both of these case studies in terms of optimal water depth, vegetation present, and climate. Due to all these similarities, the Wildermuth Wetland is expected to have a nutrient removal rate of 94-96% for nitrogen and 96-97% for phosphorous.

4.0 Cost

For this project, the team designed several constructed wetland elements that included pipes, pumps, concrete, earthwork, and vegetation. The costs of the design's associated materials and construction activities were estimated. Each deliverable was broken down into categories and calculated by unit following the project design specifications shown in Table 7.

Table 7: Estimated Cost Parameters of the Project

Component	**Unit**	**Quantity**	**Unit Costs($)**	**Total Costs($)**
Construction				
Clear and Grub	Ac	2.36	$ 1,685.09	$ 3,976.81
Excavation	Ft	22.9	$ 950.00	$ 21,755.00
Vegetation				
Planting	Each	4000	$ 3.00	$ 12,000.00
Plants	Lump Sum	4000		$ 31,000.00
Inlet Structure				
Riprap	Ton	7.61	$ 57.50	$ 437.58
Ductile Iron Coupling for PVC pipe	Lump Sum			$ 850.00
PVC perf pipe	Ft	130	$ 50.00	$ 6,500.00
Outlet Structure				
Recycled concrete	m^3	270.6004	$ 69.10	$ 18,698.49
Debris Grate	in^2	15" x 15"	$ 152.00	$ 152.00
Dikes	Yd^3	4473	$ 20.00	$ 89,460.00
Piping	Ft	2290	$ 24.44	$ 56,447.50
Operation & Maintenance - Electric (Annual)	kWh	4375650.6	$ 0.009372	$ 41,008.60
Pump	Lump Sum			$ 200,000.00
Total Cost	**$**			**482,285.97**

4.1 Construction

The installation of the pump station and 2,240 feet of ductile iron sewer pipe will require excavation and clearing of trees to fit construction equipment in the area. The team utilized Google Earth Pro to examine the project site's aerial view to determine areas of clearing. Research was conducted on the average costs of land clearing and excavation services in Cincinnati, Ohio. The cost of clearing was estimated at approximately $1,685 per acre ("Cincinnati Land Clearing Costs & Prices," 2024). Excavation was estimated to cost around $950 for every 100 linear feet (Greenberg, E.,2024).

4.2 Vegetation

The vegetation prices were estimated by researching nurseries located in and near Butler County, Ohio. Each species was priced differently for a number of plugs, seeds, and pots. In the original design for the Wildermuth Wetland there were around 4,000 specimens planted (OhioEPA, n.d.). To determine the cost per species, the total number of plants to be included in the final design (4,000) was divided by the number of species listed for the new design (6 different species). The fraction calculated was multiplied by the cost per flat, seedlings, and/or pot given from each nursery to receive an estimated total cost for the purchasing of all plant species selected for this design.

4.3 Outlet Structure

The riser and spillway design will be constructed using recycled concrete to fill the structure. The estimated cost for this material was referenced from a case study where they priced the used concrete at $69.10 per cubic meter (Cao et al., 2021). Calculating the volume of both structures seen in Appendix 10, fit to the design specifications, the total cost for recycled concrete required is approximately $18,700.

4.4 Piping

The piping prices were estimated by reaching out to several manufacturers. However, the team did not hear back from any with quotes for the pipe layout. Therefore, a past bid sheet listing the cost per foot for several different ductile iron pipe diameters was referenced to estimate the costs of materials at $24 per foot ("Fairfax Water IFB 20-07 Ductile Iron Pipe and Accessories Price List," 2021). The cost of the perforated PVC pipe was listed as $50 per foot ("Standard Prices for Cost Estimating," 2010).

4.5 Pump Station

The team requested a quote from Excel Fluid Group, LLC. on the No-Vault 3 Pump Station Package. The price varies depending on how the customer needs to alter the package for their site conditions. The quote given to the team was $150,000-$200,000.

4.6 Earthwork

The design includes implementing berms over approximately 120,888 square feet of the wetland to control water levels. The average cost for structural fill dirt for construction projects costs between $10-$30 per cubic yard (Yalkezian, 2024). The estimated total cost to fill the berms can be significantly reduced by utilizing the existing soil from excavation to fill a percentage of the berms.

4.7 Electricity

There will be approximately two million gallons of treated effluent pumped daily from the UMCWRF to the top of the wetland. The pump selected runs at 7.5 HP (5.6 kWh). The UMCWRF provided the team with past Duke Energy statements that included the electricity rates for the facility. These prices were used to estimate the annual electric cost associated with pumping treated effluent through the Wildermuth Wetland.

4.8 Grants

The team researched three grants that the Wildermuth Wetland is eligible to apply for to get funding for this project: the H2Ohio statewide wetland grant, OEPA 319A grant, and OEPA Water Resource Restoration Sponsorship Program (WRRSP). H2Ohio is a reimbursement grant program that can provide up to 100 percent funding for eligible projects. Their minimum requested amount of grant money is $50,000 and there is no funding cap (DeWine et al., 2024). Wetland creation and hydraulic restoration/enhancement of wetlands are eligible project types for this grant program. Non-profit organizations, like the MCA, can qualify for funding through H2Ohio. The grants cover costs incurred after the ODNR contract has been signed. Applications for this funding can be sent in starting on May 1, 2024 (ODNR, 2023).

The 319 Grant Program is a funding program for nonpoint source pollution projects. It’s applicable to projects intended to correct impairments to aquatic life use. OEPA receives annual Section 319 grants to correct pollution that caused impairments to surface and ground water resources (“Ohio NPSMP: Clean Water Act, Section 319 Grant Program”, 2005). These grant funds prioritize reaching Ohio water quality goals. One of the main requirements for the grant is to provide quarterly fiscal status reports on the project throughout its duration. The 2024 application deadline has already passed, and the 2025 deadline is yet to be announced.

WRRSP grants can be applied to projects that help counter the loss of biological diversity in targeted waterways ("Ohio 2016 Integrated Water Quality Monitoring", 2024). The project must also result in the full protection and/or restoration of a waterway. This project qualifies because it targets the restoration of the Mill Creek and it's biological diversity. The grant request must be submitted by July 15, 2024. Implementers under these grants can be any nonprofit organization, like the MCA. Any water pollution control loan fund can sponsor a WRRSP project. WRRSP projects usually operate under a 2-year schedule where the first year is meant for planning and the second year is meant for executing the design.
Engineered Ecosystems recommends that the MCA applies for at least the H2Ohio grant. The H2Ohio grant is the most likely to be awarded since wetland creation is one of the qualifying projects for the grant. It also qualifies non-profit organizations like the MCA, and the application window opens immediately after this project design is completed.

5.0 Conclusion

Engineered Ecosystems was tasked with determining an optimal solution for nutrient reduction of the treated effluent from the UMCWRF into the East Fork Mill Creek, performing an alternative analysis of constructed wetland design options, creating preliminary drawings of the recommended wetland design and accompanying structures, and preparing a preliminary construction cost estimate. The three researched wetland types and four researched outlet structures all have the capability to reduce nutrient concentrations in the Mill Creek. Surface flow, subsurface flow, and floating wetlands all improve water quality by slowing flow velocity and enabling nutrient uptake through plants and microorganisms. Broad-crested weirs, risers, siphons, and earth spillways all offer a controlled way to allow flow to exit the wetland area. However, they had different strengths and weaknesses concerning associated costs, maintenance and operation, nutrient removal, and site feasibility. Ultimately, a surface flow wetland design that incorporates a riser and adjacent spillway was determined the optimal method for nutrient reduction.

The team designed the constructed surface flow wetland for the UMCWRF based on construction drawings of the site and site data from Google Earth Pro. The pipes and pumps were sized through consultation with industry experts and standard equations. Approximately

2,240 feet of new ductile iron pipe will be added to transfer the flow from the current discharge through the pump station to the northern point of the wetland area. A pump station will be added to the site that utilizes two submersible pumps to create flow throughout the pipe network. An outlet structure will also be constructed to control the water levels and discharge rates exiting the wetland. The entire constructed wetland design can be seen in Appendix 2. Altogether, the total estimated cost of reconfiguring the existing Wildermuth Wetland is $482,286. Engineered Ecosystems is confident that a surface flow wetland with an accompanying pump station and riser outlet structure is the best option to reduce nutrient concentrations in the East Fork Mill Creek.

6.0 Appendices

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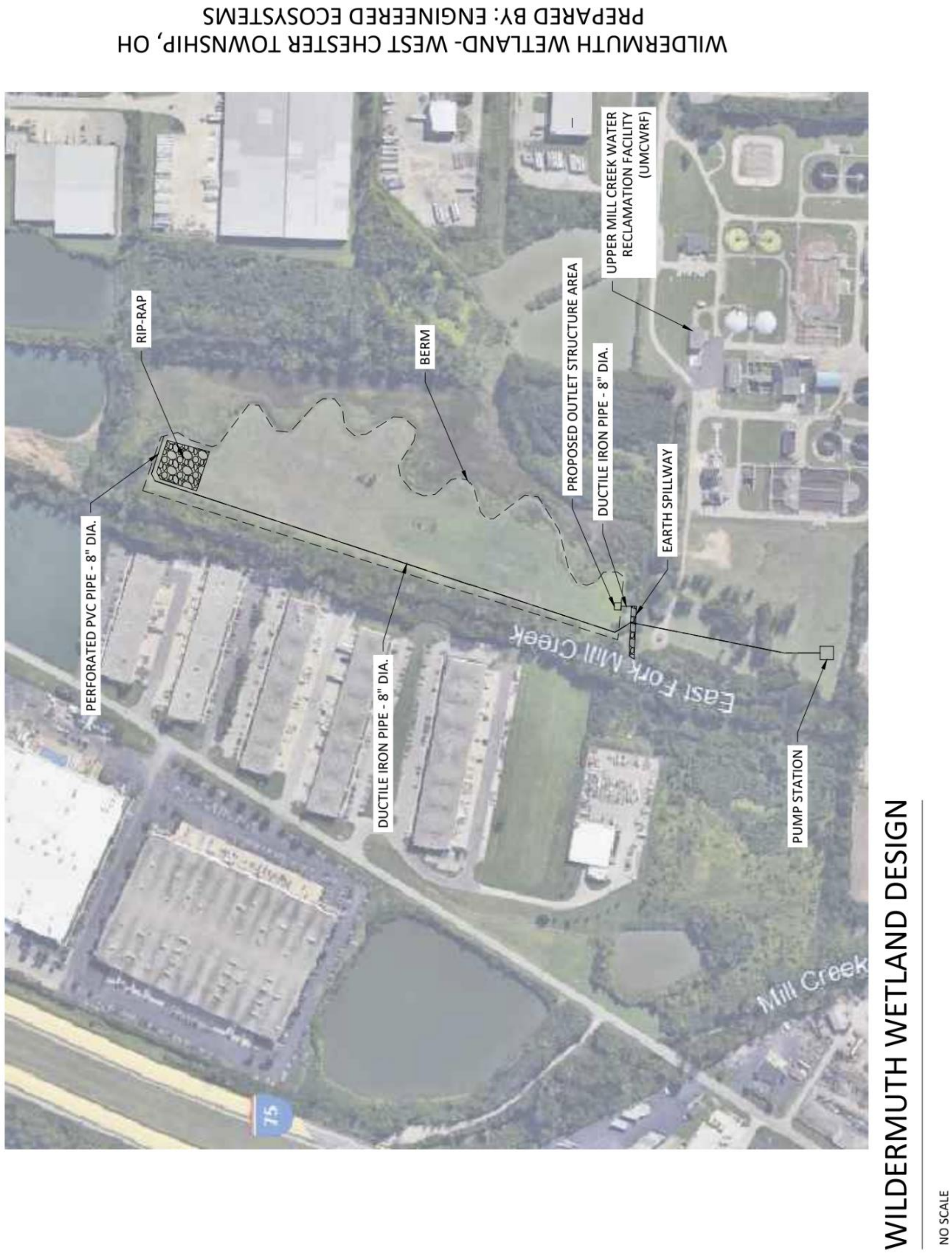
Appendix 2 – Engineered Ecosystems Wildermuth Wetland Design

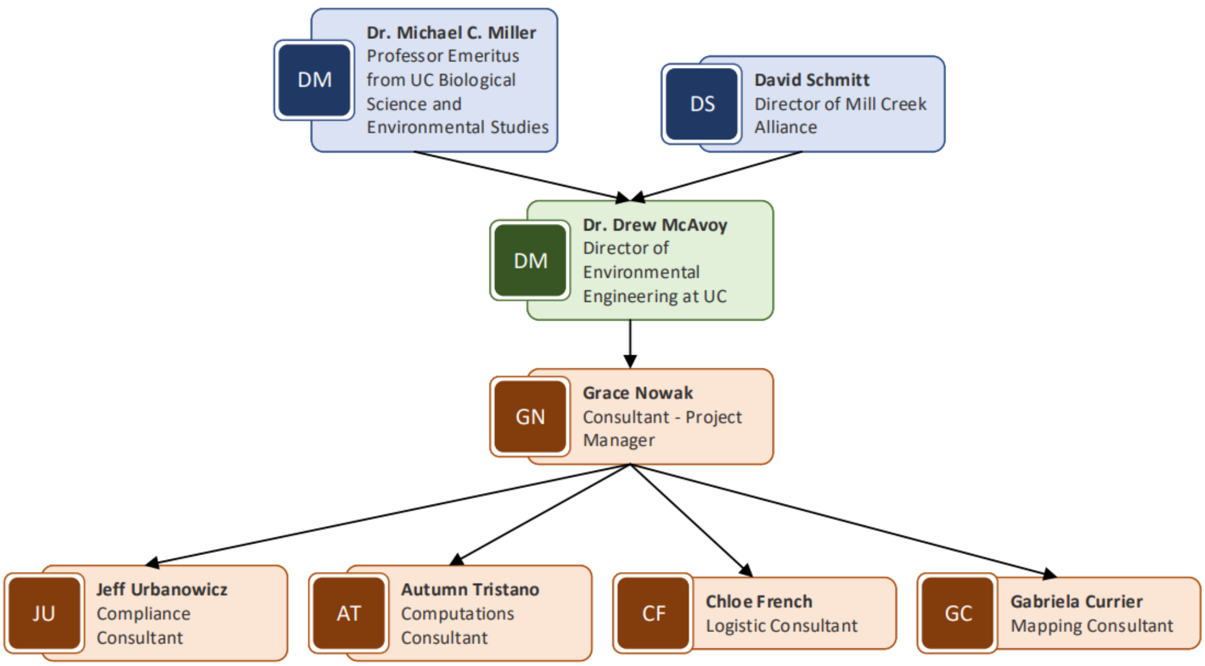


Appendix 3 - Engineered Ecosystems

Vision Statement:

"We innovate solutions that further the life of watersheds, work with natural wetlands, and implement safety, efficiency, and sustainability principles."

Organizational Chart:



Biographies:

Gabriela Currier is a fifth-year environmental engineering student in the College of Engineering and Applied Science at the University of Cincinnati. She completed two co-op rotations with the Ohio Department of Transportation District 08 - Environmental and Planning unit as an Environmental Intern learning wetland surveying and environmental permitting. She completed one co-op rotation with Cincinnati Incorporated, an industrial manufacturing company as the Environmental Health and Safety Intern learning hazardous material management and developing technical writing skills. She completed one co-op rotation with Jacobs Engineering Solutions as the Civil (Water) Engineering Intern learning conveyance work and has accepted a full-time position as an entry level Water Resource Engineer post-graduation with them.

Chloe French is a fifth-year environmental engineering student at the University of Cincinnati. She has completed one co-op rotation at Jurgensen Construction as a quality control co-op where she worked with the effluent of aggregate and asphalt plants. She also completed three co-op rotations at Okeanos, a company that specializes in alternative plastic, where she worked as the lead engineer in plastic films and obtained her OSHA-10 certification. She learned environmental compliance, federal reporting, polymer science, and more throughout her co-op semesters. She has accepted a full-time offer from Strand Associates after graduation in May 2024.

Grace Nowak is a fifth-year environmental engineering major at the University of Cincinnati. She completed one co-op rotation at Husky Energy, an oil refinery, in the Lima Environmental department. She has completed one co-op rotation at Gerdau Steel, a specialty steel mill, in the Monroe Environmental department. She has completed two co-op rotations at Fishbeck, a multidisciplinary engineering and architecture firm, in the Cincinnati Water & Wastewater department. She learned environmental compliance, federal reporting, AutoCAD software, and more throughout her co-op semesters. She has accepted a full-time offer from Fishbeck after graduation in May 2024.

Autumn Tristano is a fifth-year environmental engineering major at the University of Cincinnati. They completed one co-op rotation at Cincinnati MSD, two rotations with Moss & Associates, and one rotation at Consulting Services Inc. They have gained experience in wastewater treatment, environmental compliance, alternative energy construction, and soil analysis. Autumn has accepted a full-time offer as a Solar Project Engineer with Moss & Associates.

Jeff Urbanowicz is a fifth-year studying environmental engineering at the University of Cincinnati. He has completed two co-op rotations with Independence Excavating and two rotations with Marathon Petroleum Corporation (MPC). Jeff was able to focus on air quality and compliance with MPC and brings valuable permitting knowledge to the team. He was able to gain experience during his co-ops while working on projects related to construction, industrial demolition, downstream natural gas processing, crude storage, and transportation industries. Jeff has accepted a full-time position with PennEnergy Resources following graduation.

Resumes:

Gabriela Currier
2364 Ohio Avenue |Cincinnati, OH 45219

(863) 255-3060 | Curriegs@mail.uc.edu
www.linkedin.com/in/gabriela-currier

OBJECTIVE

Junior environmental engineering student with professional work experience seeking full-time opportunities in the Spring and Summer of 2023 with interest in water, storm water, and waste management.

EDUCATION

University of Cincinnati – College of Engineering and Applied Science | Cincinnati, OH *Bachelor of Science in Environmental Engineering* — **Expected in 05/2024** *GPA: 3.0/4.0*

- Applicable Coursework
  - Water and Wastewater Management
  - Hydraulic Systems

EXPERIENCE

Ohio Department of Transportation – District 08 | Lebanon, OH *Environmental Intern* — **05/2022 – 08/2022**

- Reviewed design plans for required National Environmental Policy Act documentation and permitting to meet project approval deadlines
- Implemented an efficient project tracking strategy through an Excel spreadsheet displaying which project each intern was assisting with Category 1 and Category 2 level tasks, avoiding miscommunication amongst project engineers
- Attended project field scoping meetings with local agencies to determine design considerations and permitting on projects impacting the local environment

Ohio Department of Transportation – District 08 | Lebanon, OH *Environmental Intern* — **08/2021 – 12/2021**

- Applied Geographic Information Systems knowledge to perform local, topographical, aerial, and ecological mapping for road improvement projects allowing environmental engineers to analyze the project field for potential environmental impacts
- Observed ecological field reviews of project sites with environmental engineers to determine amount of clearing/deep excavation required for future construction
- Organized minimal level road, bridge, and culvert repair project tasks and submitted to the companies' project management filing software for review by the District Environmental Coordinator

ACTIVITIES

College of Engineering and Applied Science Tribunal *Engineering Week Co-Chair* — **2019-2021**

- Worked with my co-chairs to organize team-leadership events for engineering students that raised funds to donate to a local charity of the winning team's choice during the end of the week banquet
- Communicated with local community through email and teams to organize location, dates, and catering for the annual Engineering Week banquet that fit within our budget set by the organization's treasurer

Kappa Delta- Omega Xi Chapter *Active Member* — **2021-Present**

- Participate in social and volunteering events to raise awareness for our philanthropy and support the community

SKILLS

- Time Management
- Attention to Detail
- Problem-Solving
- Self Starter

PERSONAL INTEREST

- Alpine Ski
- Intramural Soccer

CHLOE FRENCH

(513) 934-5227

chloefrench1023@gmail.com

EDUCATION

University of Cincinnati — May 2024, 3.43 GPA

- College of Engineering and Applied Science: Environmental Engineering

EXPERIENCE

Okeanos Made from Stone

- *Environmental Associate* — 05/22 – PRESENT
  - Tested the physical properties of plastics and generated reports which identified potential replacements for current plastics and areas of improvement for alternative plastics
  - Acted as lab manager and kept an organized record of the status, storage, and data of all lab samples to guarantee the lab operated efficiently
  - Led the operation of the blown film line where controlled experiments were conducted on alternative and degradable plastic films
  - Assisted in formulating new compounds to meet the specifications of individual customers
  - Certified the qualification of new alternative plastic compounds manufactured globally
  - Obtained an OSHA 10 certification

Jurgensen Construction – Valley Asphalt

- *Quality Control Co-op* — 08/21 – 12/21
  - Collected and tested water samples for pH, total suspended solids, chlorine, and dissolved oxygen
  - Renewed and applied for permits
  - Completed monthly reports for the EPA to ensure compliance with standards
  - Created task tracking software to help the environmental department meet their deadlines

Rally House

- *Senior Team Sales Lead* — 01/20 – 05/22
  - Promoted twice in the span of 1.5 years
  - Trained new employees on customer service, company policy, and operating processes
  - Facilitated the opening of new stores by preparing logistics, displaying merchandise, and training new employees

ACTIVITIES

Lebanon Raptors Softball Coach — 04/22 – PRESENT

- Coached 12 players, organized practices, provided instruction, facilitated team building exercises

Member of Young Life – College Life — 08/19 – PRESENT

- A club that is centered around Jesus. This club helps to build community among young Christians

Member of UC knits — 08/22 – PRESENT

- A club that comes together to knit and crochet. The group makes hats, scarves, and gloves to be donated to homeless people in Cincinnati

Grace Nowak

129 Calhoun Street, Cincinnati, OH 45219
419-764-1465 | nowakge@mail.uc.edu | www.linkedin.com/in/grace-nowak-1891221a7

EDUCATION

Bachelor of Science, Environmental Engineering Expected May 2024
University of Cincinnati, Cincinnati, OH

- GPA: 3.9
- Relevant Coursework: Water and Wastewater Treatment, Air Pollution, Transport 1

EXPERIENCE

Water and Wastewater Co-op 5/2022-11/2023
Fishbeck, Blue Ash, OH

- Enhanced knowledge of AutoCAD platforms and utilized skills for projects
- Evaluated flow monitoring data to incorporate into graphic metrics for customers on 3 projects
- Facilitated in-field sewer monitoring and hydrant testing

Environmental Engineering Co-op 8/2021-12/2021
Gerdau Monroe Mill, Monroe, MI

- Analyzed data for emissions tracking for multiple pieces of equipment
- Implemented plant-wide documentation system for all environmental procedures
- Collaborated on reports and disclosed results to the EPA

Air Compliance Co-op 1/2021- 5/2021
Husky Energy Refinery, Lima, OH

- Developed new Excel tool to track emission sources for the refinery's 2 cooling towers
- Performed laboratory sampling methods for water and air sources weekly
- Applied EPA 40 CFR regulations to data to determine compliance

EXTRACURRICULAR ACTIVITIES

Executive Committee Head Present
Theta Tau, Cincinnati, OH

- Coordinated 3 community service events for the chapter
- Enhanced presentation skills by presenting a weekly slide detailing community service effort
- Established professional relationships with local organizations including the Civic Garden Center

Volunteer Present
Rosh Street Cafe, Cincinnati, OH

- Delegated 3 hours per week to facilitate smooth operations of the non-profit organization
- Advanced communication skills through conversing with over 20 customers a day
- Acquired knowledge of sustainable practices and local sourcing initiatives

Club Member Present
NET Impact, Cincinnati, OH

- Developed criteria to determine if a company is sustainable
- Implemented first green career fair through communicating with companies and expanding awareness of sustainability positions

HONORS & AWARDS

Cincinnatus Century Scholarship Present
University of Cincinnati, Cincinnati, OH

- Amount: $2,500 / year
- Criteria: 3.2 cumulative GPA, 30 hours of community service annually

217 Emming St., Cincinnati, OH 45219
(614) 801-0365 | tristaas@mail.uc.edu

Autumn Tristano

EDUCATION

University of Cincinnati, Cincinnati, OH

Expected Graduation: 5/24

- Bachelor of Science in Environmental Engineering
- Minor – Mathematics
- GPA 3.35/4.0, Dean's List 3 Semesters

EXPERIENCE

Moss & Associates, Pueblo, CO — *Project Engineer Intern*

5/22 – 8/22

- Managed RFI and Submittal Process
- Led bi-weekly SWPPP inspections for site
- Conducted Quality Control walk downs after task completion

Moss & Associates, Pueblo, CO — *Project Engineer Intern*

8/21 – 12/21

- Organized and lead daily progress updates with owner's representation
- Performed quantity takeoffs and published reports for owner review
- Drawing review and management

Cincinnati Metropolitan Sewer District, Cincinnati, OH — *Plant Operator Co-Op*

1/21 – 4/21

- Monitored and maintained the process control of the facility
- Tested and analyzed daily levels of Fecal Coliform at plant

ACTIVITIES & MEMBERSHIP

- Society of Environmental Engineers – 8/19 – PRESENT
    - Mill Creek Alliance Water Quality Monitoring Team – 3/21 – PRESENT
    - Monthly sampling of the Great Miami River to monitor industrial runoff

JEFF URBANOWICZ

3584 Antony Drive | (440) 591-0512
Broadview Heights, OH 44147 | urbanojj@mail.uc.edu

Graduating in May 2024 and looking for a full-time environmental engineering position. Experience in construction, industrial demolition, downstream natural gas processing, crude storage, transportation industries, and emergency response drills. Seeking a position where I can utilize my current air quality knowledge while expanding into additional disciplines.

EDUCATION

University of Cincinnati, *Bachelor of Science in Environmental Engineering.* Expected May 2024

EXPERIENCE

Marathon Petroleum, Canonsburg, PA 05/23 - 08/23
Gathering & Processing – Environmental Engineering Co-op

- Supported collaborative audits and determined compliance status of air pollution control devices at 5 gas processing facilities in WV and ND
- Created Permit Review and Responsibility Sheets (PRRSs) outlining roles for Title V and minor source air quality permits compliance-related tasks
- Led the review of compliance history using EPA's ECHO database and developed procedure for reporting data errors

Marathon Petroleum, Findlay, OH 01/23 - 05/23
Pipeline – Environmental Engineering Co-op

- Calculated emissions using TankESP and generated reports and templates for future use
- Reviewed PRRSs and made updates based on recent permit revisions
- Developed monthly emission tracking sheets to ensure compliance with tank and rack permit limits

Independence Excavating, Independence, OH 05/22 - 08/22
Environmental Engineering Co-op

- Conducted air samplings for asbestos, silica, and respirable dust and reported results
- Inspected stormwater plans at 3 sites weekly and ensured pollutants were not entering the system
- Communicated with companies to quote nonhazardous environmental waste for demolition bids

Independence Excavating, Brook Park, OH 08/21 - 12/21
Demolition Project Engineering Co-op

- Tracked daily scrap shipments and communicated with management about quantities
- Conducted weekly stormwater pollution prevention plan inspections
- Surveyed elevation of old basement and tracked backfilling

CERTIFICATIONS

OSHA10 hour | RCRA Hazardous Waste and Materials Handling

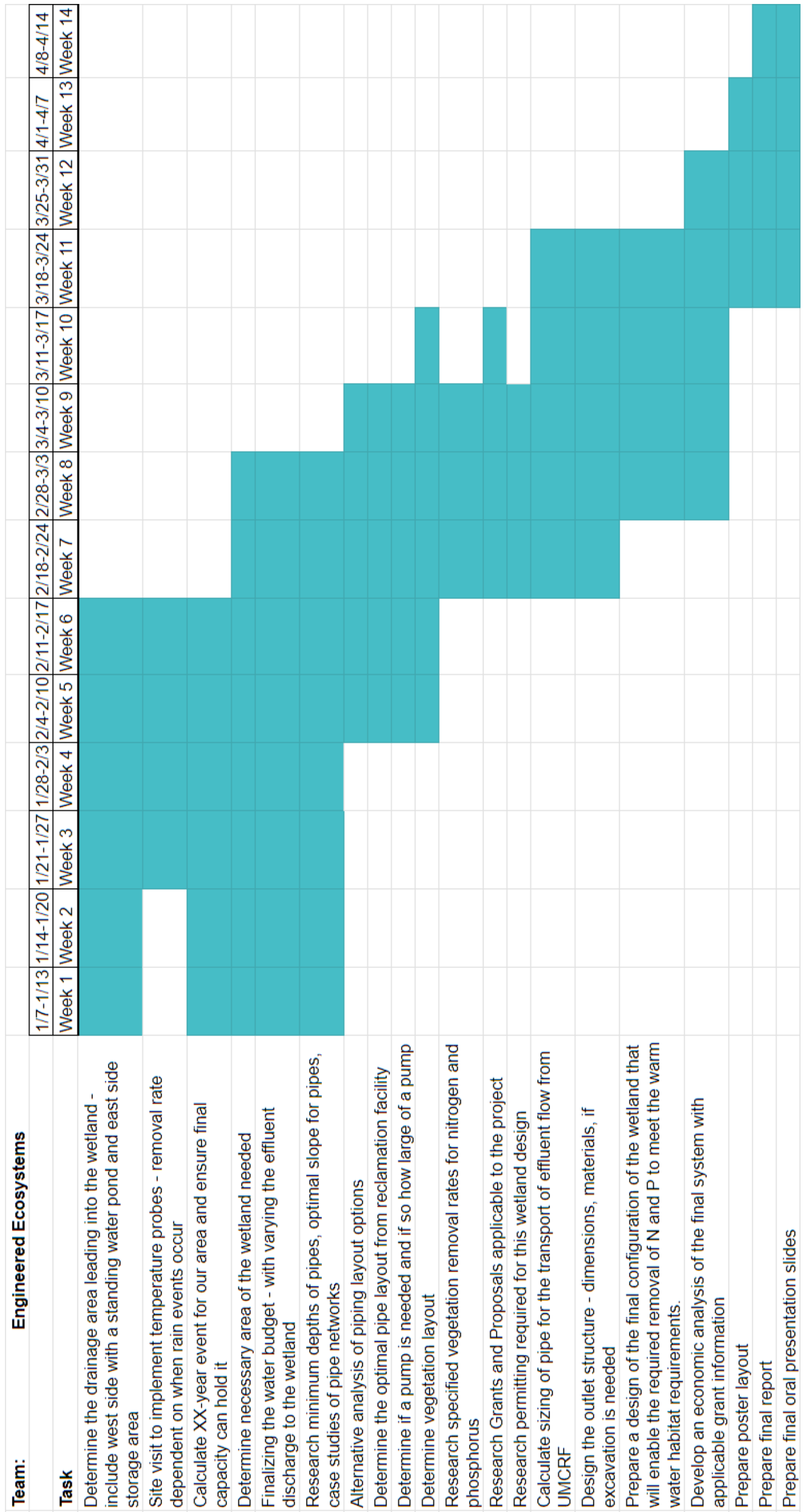
MEMBERSHIPS

- Co-op Diversity, Equity, and Inclusion — Member — 01/23 - 05/23
- Mill Creek Water Sampling — Volunteer — 09/22 - Present

PROFESSIONAL ACTIVITIES

- The Society of Environmental Engineers 01/20 - Present
  Secretary/Vice President *05/22 - Present*

GANTT Chart:


Team:
Engineered Ecosystems
1/7-1/13
1/14-1/20
1/21-1/27
1/28-2/3
2/4-2/10
2/11-2/17
2/18-2/24
2/28-3/3
3/4-3/10
3/11-3/17
3/18-3/24
3/25-3/31
4/1-4/7
4/8-4/14
Task
Week 1
Week 2
Week 3
Week 4
Week 5
Week 6
Week 7
Week 8
Week 9
Week 10
Week 11
Week 12
Week 13
Week 14
Determine the drainage area leading into the wetland - include west side with a standing water pond and east side storage area
Site visit to implement temperature probes - removal rate dependent on when rain events occur
Calculate XX-year event for our area and ensure final capacity can hold it
Determine necessary area of the wetland needed
Finalizing the water budget - with varying the effluent discharge to the wetland
Research minimum depths of pipes, optimal slope for pipes, case studies of pipe networks
Alternative analysis of piping layout options
Determine the optimal pipe layout from reclamation facility
Determine if a pump is needed and if so how large of a pump
Determine vegetation layout
Research specified vegetation removal rates for nitrogen and phosphorus
Research Grants and Proposals applicable to the project
Research permitting required for this wetland design
Calculate sizing of pipe for the transport of effluent flow from UMCRF
Design the outlet structure - dimensions, materials, if excavation is needed
Prepare a design of the final configuration of the wetland that will enable the required removal of N and P to meet the warm water habitat requirements.
Develop an economic analysis of the final system with applicable grant information
Prepare poster layout
Prepare final report
Prepare final oral presentation slides

Appendix 4 - Acknowledgements

Dr. Michael Miller, with the MCA, Jermey Hamel, with the UMCWRF, and Jeff Fretchling, PE, with BCWS, have been immensely helpful to Engineered Ecosystems over the past several months. Dr. Drew McAvoy, PE has also been incredibly supportive throughout the project term. They have been responsive and continually answered Engineered Ecosystems' questions.

Appendix 5 – UMCWRF Daily Effluent

Daily Effluent (MDG) of the UMCWRF provided by the UMCWRF.

	January	February	March	April	May	June
1	8.96	10.25	9.69	14.79	9.54	8
2	8.02	9.93	9.54	16.59	10.21	8.08
3	8.64	9.87	9.42	13.94	11.07	7.68
4	13.27	9.46	26.15	12.61	10.42	7.2
5	11.11	8.81	18.04	12.57	10.14	7.04
6	10.01	8.41	13.81	21.54	9.36	7.73
7	9.41	8.73	13.36	18.12	8.47	7.11
8	8.53	8.87	11.42	14.87	11.23	7.88
9	8.67	8.85	10.72	12.32	10.86	7.98
10	8.49	9.51	10.34	11.38	10.19	7.8
11	8.64	8.84	9.97	11.14	9.3	6.54
12	8.61	8.65	9.03	10.34	9.22	7.39
13	11.73	8.25	9.33	10.19	9.19	8.15
14	11.17	8.47	9.22	9.8	8.57	8.14
15	9.82	8.58	9.31	9.56	8.09	8.27
16	9.35	8.59	9.19	9.26	9.03	8.01
17	9.81	14.63	9.14	9.24	9.15	7.7
18	9.71	12.98	9.49	9.35	9.31	7.36
19	10.32	11.14	8.79	8.76	8.98	6.49
20	12.34	10.08	8.71	9.96	8.37	7.9
21	11.07	10.45	8.69	9.51	8.07	7.87
22	9.98	10.14	8.64	10.2	7.76	7.87
23	9.86	10.63	8.59	10.56	8.54	7.72
24	10.24	10.57	11.23	9.91	8.39	7.42
25	10.58	9.37	26.23	9.72	8.23	7
26	16.02	9.13	25.87	9.54	8.23	6.72
27	14.35	8.79	15.95	7.81	7.68	7.53
28	12.2	9.78	14.34	9.78	6.65	7.45
29	11.05		12.33	10.15	6.27	7.49
30	10.28		11.25	9.16	7.12	7.81
31	10.15		10.52		8.78	
Total	322.39	271.76	378.31	342.67	276.42	227.33
Average	10.3997	9.7057	12.2035	11.4223	8.9168	7.5777

July	August	September	October	November	December
7.81	8.88	8.73	7.05	9.68	
7.48	8.73	7.89	7.14	9.47	
7.48	9.25	6.79	8.08	8.83	
8.09	8.34	6.58	8.15	8.44	
6.91	8.06	7.43	7.97	7.55	
8.43	7.45	9.29	8.06	7.09	
8	7.24	8.6	7.76		
7.99	10.01	8.04	6.97		
8.34	8.28	7.53	7.1		
7.15	9.45	7.13	8.16		
8.23	9.09	6.93	7.68		
8.13	8.63	7.85	7.93		
8.3	7.52	8.14	7.88		
8.28	7.2	8.1	7.87		
7.67	10.32	7.87	7.44		
9.13	9.97	7.55	6.96		
7.66	8.89	6.4	7.9		
8.63	8.98	6.88	8.17		
10.4	8.34	7.74	8.09		
9.57	7.44	7.74	8.04		
9.16	7.27	8	8.37		
8.84	9.31	7.75	7.22		
7.32	8.42	7.41	7.05		
7.33	8.28	6.46	8.04		
8.78	10.5	6.62	8.04		
8.12	9.89	7.42	7.9		
8.6	8.03	8.39	7.96		
10.16	8.24	9.52	7.85		
7.37	8.99	9.07	8.09		
8.88	8.81	8.52	9.73		
7.82	8.94		10.86		
256.06	268.75	232.37	245.51	51.06	
8.26	8.6694	7.7457	7.9197	8.51	

Appendix 6 – Decision Matrices

Constructed Wetland Type

The three types of constructed wetlands were evaluated based on how effectively they're known to remove nutrients from water. Subsurface wetlands are optimal for nutrient removal due to the media providing more small surfaces, pores, and crevices where treatment can occur. The least efficient wetland is a floating wetland due to the fact that the plants need to be routinely harvested in order to remove nutrients completely from the wetland. If the plants are not physically removed then they can get reintroduced to the wetland's nutrient cycle.

The next criteria the types of constructed wetlands were analyzed against was their associated operation and maintenance schedules. The floating wetland was ranked last in this category similar to the reasoning for its efficiency ranking. Floating wetlands requires regular weeding and vegetation maintenance which is time-consuming and costly. Subsurface flow wetlands require pumps or blowers to push the water being treated beneath the porous soil. The extra equipment means that they require more maintenance than surface flow and floating wetland types. Surface flow is also less intensive in terms of operation and maintenance comparatively because surface flow wetlands tend to involve less piping. This is because subsurface flow wetlands need to pump water down and throughout the wetland area as opposed to just throughout.

Site feasibility was the third criterion considered for the types of wetlands being evaluated. This considered how well the construction and design of the new wetland fits with the existing site conditions. Surface flow wetlands were determined optimal for this since the most critical element of these wetlands is the thick soil which is already present at the Wildermuth site. Floating wetlands were determined to be the least compatible with the existing site hydrology because the floating vegetation needs large water depths to operate fully. The large water depths allow the vegetation to float and have room for the biofilm to form. The existing wetland basin is approximately 6 inches deep which is not adequate to accommodate a floating wetland. Therefore, if a floating wetland were to be implemented excavation would need to occur.

The last category the types of constructed wetlands were evaluated against was cost. The floating wetlands are known to be the least expensive to initially construct. This is because they don't require a specific ground-lining or excavation if the site is compatible. Subsurface flow wetlands are typically more costly than the surface flow wetlands due to the reasoning discussed when evaluating associated maintenance. Subsurface flow constructed wetlands require more equipment, such as blowers, and larger amounts of piping making them more expensive than surface flow wetlands.

The rankings were weighted based on what Engineered Ecosystems deemed appropriate following the MCA's priorities, background research, and case study review. The optimal wetland type for the Wildermuth Wetland site was determined to be a surface flow wetland

Constructed Wetland Design Alternative Analysis				
Criteria	Weight	Surface Flow Wetland	Subsurface Flow Wetland	Floating Wetland
Effectiveness	4	2 (8)	3 (12)	1 (4)
Maintenance & Operation	3	3 (9)	2 (6)	1 (3)
Site Feasibility	2	3 (6)	2 (4)	1 (2)
Cost	1	2 (2)	1 (1)	3 (3)
Totals (max score = 30)		**25**	23	12

Outlet Structure Type Results

Three different types of outlet control structures were evaluated for the reconfiguration of the Wildermuth Wetland. The first criterion they were analyzed for was effectiveness. Risers are the optimal control structure to use in the scenario since the water level needs to be controlled to a specific height while accounting for stormwater and other overflow events. Risers can allow for controlled detention rates with orifices being included but can also maintain a controlled retention time without them. An earth spillway and embankment can be used in conjunction with a riser to ensure water is being retained at a specified level. However, earth spillways are typically used to release excess water. This is a feasible option but would not be able to support a consistent volume of water within the wetland as desired. Siphons could also be effectively used to achieve a desired volume but would not be ideal for the long term since they break once the desired water level is achieved. Broad-crested weirs were the third structure analyzed. They would be effective in maintaining a water level but would not be able to account for overflow events.

The structures were also evaluated based on the amount of maintenance and operation that would be required. The wetland is planned to be long lasting and self-sustaining which requires minimal maintenance. If constructed correctly, risers would be optimal. Risers are typically constructed with concrete and a pipe system and can function without an operator. Broad-crested weirs would be the next easiest to maintain. If the structure is constructed properly, there should be little to no maintenance required. The weir would act as a dam made of erosion resistant material such as bentonite and function to let water flow above the crest. The maintenance could become important if the bentonite mixture begins to decay or shows signs of erosion. A siphon was ranked lowest for this category based on the maintenance that is required when air entertainment occurs and breaks the system.

Site feasibility was evaluated for the structures as well. The most feasible structure to construct would be a riser. Each structure will require reconstruction of the outlet area of the wetland. This could entail excavation and fill material. A riser would require concrete and other materials but would be focused in one area that would not require excessive disturbance to the wetland. Siphons were ranked next because they would require the same materials and space as a riser. However, the pipe system is more complex and would require precise placement to ensure it functions properly. To construct a broad-crested weir at the site, movement of soil and compaction would be the first steps. The structure would need to be constructed at a height to contain the water within the wetland and compacted to a point where a bentonite mixture would be laid over the ground to control potential erosion. The structure will need to be created in a form that forces the excess water to flow over the weir-crest at the desired elevation and point along the length. The crest would need to be shaped to allow flow but also should not be the same height as the barriers and top of the structure.

To create a more erosion-resistant spillway, vegetation or other features could be added to the structure to ensure stability. An emergency spillway is considered with each of these control structures and their site feasibility.

Cost is the final factor that is necessary to consider when analyzing outlet control structures. An earth constructed spillway would be the least expensive because the expenses would only require what is necessary to excavate and repurpose the land that already exists in the wetland. Additional costs could be considered for more effective erosion control techniques, but it is not a necessity if vegetation can serve the same purpose. A broad-crested weir would be the least expensive structure based on costs for the repurposing of the existing material, additional material to build up a berm to maintain an elevation level, material to use in a bentonite-mixture for erosion control, and possibly other material, like concrete or gravel, to ensure the strength of the structure. A siphon would cost more than a weir in the scenario since it would require the same excavation for repurposing the land and creating a berm or wall feature and a piping system to go with it. A riser would be the most expensive structure because it would need to be constructed with concrete and include a pipe system.

The rankings were weighted based on what Engineered Ecosystems deemed appropriate considering the MCA's priorities, background research, and case study review. The optimal outlet structure type for the Wildermuth Wetland site was determined to be a riser in conjunction with an emergency spillway and embankment.

Water Control Outlet Structure Alternative Analysis				
Criteria	**Weight**	**Siphon**	**Riser/Orifice**	**Weir**
Effectiveness	4	3 (12)	2 (8)	1 (4)
Maintenance & Operation	3	1 (3)	3 (9)	2 (6)
Site Feasibility	2	2 (4)	3 (6)	1 (2)
Cost	1	2 (2)	1 (1)	3 (3)
Totals (max score = 30)		21	**24**	15

Appendix 7 - Vegetation

Table summarizing the vegetation Engineered Ecosystems deemed optimal for the Wildermuth project.

Plant Species:	Type:	Soil Type:	Feasible:	Picture:
Peltandra virginica (Schultz, *n.d.*)	Emergent	Clay, Loam, and Sand	Yes	Green Arrow Arum  *(picture from Google Images)*
Typha latifolia ("Plant Database", *n.d.*)	Emergent	Clay and loam	Yes	Broadleaf Cattail  ("Plant database," *n.d.*)
Carex vulpinoidea (Hoffman, *n.d.*)	Terrestrial/emergent	medium-moist to wet soils, including clay	Yes	Fox Sedge  *(picture from Google Images)*
Calamagrostis canadensis ("Calamagrostis canadensis (bluejoint grass)," *n.d.*)	Terrestrial/emergent	Clay and loam	Yes	Bluejoint Grass  *(picture from Google Images)*
Glyceria striata (Hilty, 2020)	Terrestrial/emergent	Clay and loam	Yes	Fowl Mannagrass  (Hilty, 2020)
Angelica atropurpurea ("Angelica atropurpurea (American Angelica)," *n.d.*)	Terrestrial/emergent	Chalk, loam, and clay	Yes	Purple-stemmed Angelica  *(picture from Google Images)*

Appendix 8 - Specifications

SECTION 3210 - DUCTILE IRON SEWER FORCE MAIN

PART 1 - GENERAL

1.1 SCOPE OF WORK:

Provide all labor, materials, equipment and services required for furnishing and installing all piping and appurtenances specified herein. All sewer force main and fittings shall be ductile iron. No other pipe will be accepted as equal.

1.2 RELATED WORK SPECIFIED ELSEWHERE:

A. Trench Excavation for Sewer Force Mains: Section 3725

B. Bedding and Backfill for Sewer Force Mains: Section 3735

PART 2 - PRODUCTS

2.1 DUCTILE IRON PIPE AND FITTINGS:

A. Pipe:

1. Ductile Iron Pipe shall be push-on joint type. Pipe shall conform to AWWA C151 (ANSI A21.51), and shall be centrifugally cast pipe. For sizes up to and including 18" nominal diameter, pipe shall be minimum thickness Class 53. Pipe larger than 18" nominal diameter shall be at least Pressure Class 350.

2. The interior of the pipe shall be lined in accordance with Section 3240. The exterior of all pipe, unless otherwise specified, shall receive either coal tar or asphalt base coating a minimum of 1 mil thick.

3. Each piece of pipe shall bear the manufacturer's name or trademark, the year in which it was produced and the letters "DI" or word "DUCTILE". The pipe manufacturer shall furnish a notarized certificate of compliance to the above AWWA or ANSI specifications.

4. Ductile iron pipe to be installed in casing pipe bored and jacked under highway and railroad shall be restrained joint type.

5. Pipe shall be furnished in manufacturer's standard lengths, not to exceed 20 foot lengths.

B. Fittings:

1. All fittings shall be ductile iron only. No grey cast iron fittings will be allowed.

2. Fittings shall be Class 350 ductile iron fittings in accordance with AWWA C153 (ANSI A21.53) or AWWA C110 (ANSI A21.10) and shall conform to the details and dimensions shown therein with the exception of the manufacturer's proprietary design dimensions and thicknesses. Fittings shall have all bell ends (unless otherwise shown on the plans or permitted by the ENGINEER) with mechanical joints meeting the requirements of AWWA C111 (ANSI A21.11). Fittings shall have interior lining as specified in Section 3240. The exterior shall be coated with an asphaltic coating or coal tar epoxy.

3. Plugs or caps, where required, shall be ductile iron mechanical joint dished or flat plugs or caps in accordance with AWWA C153 or C110. Joints for plugs and caps shall be restrained with the use of ductile iron mechanical joint retainer glands (Mega-Lug, MJ Field Lok, or approved equal).

4. Only factory welded tees will be allowed. Field fabricated outlets will **not** be accepted.

C. Joints for Pipe and Fittings:

1. The joints for ductile iron pipe shall be push-on type conforming to AWWA C111 (ANSI A21.11). Joints for fittings shall be mechanical joint conforming to AWWA C111 (ANSI A21.11).

2. Push-on type joints shall have an annular recess in the pipe socket to accommodate a single rubber gasket. Plain ends shall be suitably beveled to permit easy entry into the bell. Plain ends shall have home marks to indicate when the spigot is fully seated in the bell. The gasket and annular recess of the socket shall be so designed and shaped that the gasket is located in place against displacement as the joint is assembled. Push-on joints shall be of a type that employs a single elongated groove gasket to effect the joint seal such as "Tyton" (US Pipe), "Fastite" (American Cast Iron Pipe Company), "Super Bell-Tite" (James B. Clow & Sons), or approved equal.

3. Mechanical joints shall be bolted and of the stuffing box type and shall consist of a bell, with exterior flange and interior recess for the sealing gasket, a pipe plain end, a sealing gasket, a follower gland, tee-head bolts and hexagon nuts. All joints for fittings shall be restrained with "Mega-Lug" retainer glands, MJ Field Lok, or approved equal.

4. The cleaning and assembly of pipe and fitting joints shall be in accordance with these specifications, the manufacturer's recommendations and AWWA standards.

5. Mechanical joint bolts shall be of Cor-Ten® Steel only, conforming to AWWA C-111, 11-7.5 and ANSI A21.11.

PART 3 - BASIS OF PAYMENT

Payment for furnishing and installing the ductile iron sewer force main will be made at the Contract unit price per linear foot, complete in place, which price shall include compensation for furnishing, hauling, excavation (including rock), bedding, laying, jointing, testing, backfilling, surface restoration (except pavement replacement), and cleanup. The quantity of sewer force main to be paid for shall be the length of the complete force main measured along the centerline without any deduction for lengths of fittings, valves or other appurtenances.

END OF SECTION

SECTION 3230 - RESTRAINED JOINT DUCTILE IRON SEWER FORCE MAIN

PART 1 - GENERAL

1.1 SCOPE OF WORK:

Provide all labor, materials, equipment and services required for furnishing and installing all piping and appurtenances specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE:

A. Trench Excavation for Sewer Force Mains: Section 3725

B. Bedding and Backfill for Sewer Force Mains: Section 3735

C. Ductile Iron Sewer Force Main: Section 3210

PART 2 - PRODUCTS

2.1 RESTRAINED JOINT DUCTILE IRON PIPE AND FITTINGS:

A. When joint restraint for push-on joint pipe installation is required by the specifications or indicated on the plans, restrained push-on joint pipe and restrained mechanical joint fittings utilizing ductile iron components shall be provided. Pipe and fittings shall meet requirements of Section 3210 in addition to those specified below. Pipe and fittings shall have restrained push-on joints for lengths, as directed by the Engineer or pipe manufacturer, sufficient to withstand the test pressure with no thrust blocking. Calculations shall be based on the worst case soil type to be encountered on the project with Type I laying conditions. Use of the "Thrust Restraint Design for Ductile Iron Pipe" computer program by Ductile Iron Pipe Research Association, Birmingham Alabama, to determine restraint distances is suggested. Concrete thrust blocking may only be used by direction of the Engineer when connecting to existing piping that does not have sufficient thrust restraint.

B. Restrained joint pipe shall be ductile iron manufactured in accordance with the requirements of AWWA C151 ANSI (A21.51) push-on joints for such pipe shall be in accordance with AWWA C111 (ANSI A21.11). For sizes up to and including 18" nominal diameter, pipe shall be minimum Thickness Class 53. Pipe larger than 18" nominal diameter shall be at least Pressure Class 350. Pipe shall be standard push-on joint pipe, U.S. Pipe TR FLEX pipe, American Flex-Ring pipe, or equal. Restraint for push-on joint pipe shall consist of Field-Lok gaskets or approved equal. Retainer glands of any style are **not** acceptable for pipe-to-pipe joints.

C. Restrained joint fittings shall be ductile iron in accordance with AWWA C153 (ANSI A21.53) or AWWA C110 (ANSI A21.10) and shall conform to the details and dimensions shown therein with the exception of the manufacturer's proprietary design dimensions and thicknesses. All fittings shall have mechanical joints meeting the requirements of AWWA C111 (ANSI A21.11).

D. Lining for pipe and fittings shall be in accordance with Section 3240. Bituminous outside coating shall be in accordance with AWWA C151 (ANSI A21.51) for pipe and AWWA C110 (ANSI A21.10) for fittings.

E. Restrained push-on joints for pipe and fittings shall be designed for water operating pressure of 350 psi in sizes 4-inches through 24-inch.

F. Restrained push-on joint pipe and fittings shall be capable of being deflected after assembly.

G. Field fabricated restrained joints for pipe-to-fitting joints shall utilize Mega-Lug, MJ Field Lok, or approved equal. All other joints shall be fabricated at the place of manufacture only.

PART 3 - BASIS OF PAYMENT

Payment for furnishing and installing the restrained joint ductile iron sewer force main will be made at the Contract unit price per linear foot, complete in place, which price shall include compensation for furnishing, hauling, excavation (including rock), bedding, laying, installation of pipe, testing, backfilling, surface restoration (except pavement replacement), and cleanup. The quantity of sewer force main to be paid for shall be the length of the complete force main measured along the centerline without any deduction for lengths of fittings, valves or other appurtenances.

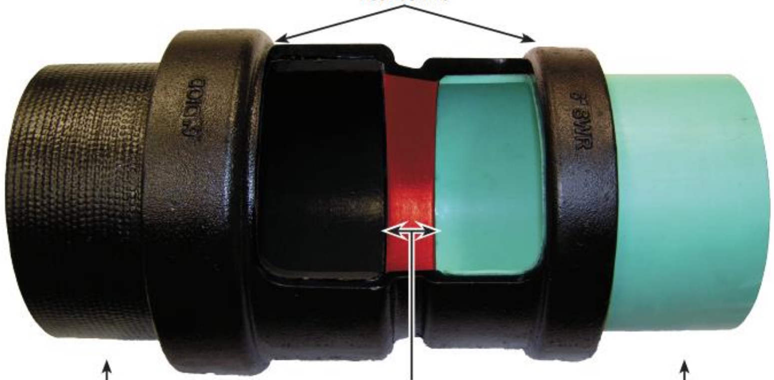
Restrained joint ductile iron sewer force main required by the plans or specifications will be paid for at the same unit price as standard ductile iron sewer force main. The Bidder shall adjust his prices appropriately.

END OF SECTION

HARCO
FITTINGS

PRODUCT SHEET

DUCTILE IRON TRANSITION ADAPTERS
For ASTM D3034 to DI-OD



What Do You Use To Transition Pipes Between Manholes in Gravity Sewer Lines?

If you don't allow for transitions of pipe to be made between gravity sewer manholes it is probably due to not having a reliable product. Harco now offers a rigid ductile iron coupling that makes a smooth transition and passes air tests. No more Rubber Couplings that could shear. No more MJ Sleeves that allow gaps between the pipe ends which can catch inspection cameras and debris. Harco Ductile Iron Transition couplings allow for lower material costs by not having to run manhole to manhole with ductile iron pipe. Installation is able to move faster from installing PVC Pipe instead of heavy ductile iron pipe.

FEATURES

- Deep push joint gasketed bells
- Ductile Iron body
- Machined gasket grooves
- Tapered flow way
- Variety of coatings available

BENEFITS

- Easy to install
- Reliable air testing
- No bolts or nuts
- High strength & rigidity
- Reduced "pull out" risk
- Will not obstruct flow or inspection

SIZES

4" to 12" depending on configuration

CONFIGURATIONS

DI x Sewer

- Gasket x Gasket
- Gasket x Spigot
- Spigot x Gasket

THE HARRINGTON CORPORATION
P.O. Box 10335 ◆ Lynchburg, VA 24506-0335
Phone: (434) 845-7094 Fax: (434) 845-8562
sales@harcofittings.com
www.harcofittings.com

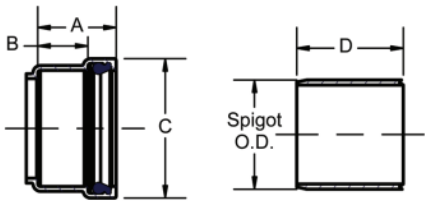
PF149-121609

DUCTILE IRON SEWER ADAPTERS

PRODUCT SHEET

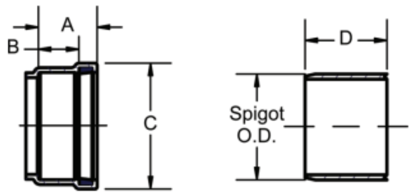
For ASTM 3034 to DI-OD

BELL & SPIGOT DIOD SPECIFICATION



SIZE	A	B	C	D	SPIGOT OD
4	3.9	2.1	6.3	-	4.8
6	4.8	3.1	8.5	-	6.9
8	5.6	3.4	10.7	5.8	9.0
10	5.8	3.5	13.1	6.0	11.1
12	6.1	3.7	15.2	6.3	13.2

BELL & SPIGOT SEWER SPECIFICATION

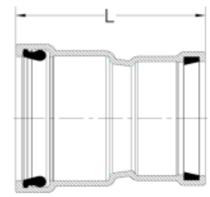


SIZE	A	B	C	D	SPIGOT OD
4	3.0	1.9	5.5	-	4.2
6	3.6	2.5	7.6	-	6.3
8	4.1	3.0	9.7	-	8.4
10	4.8	3.3	12.0	-	10.5
12	5.3	3.7	14.1	-	12.5

SUGGESTED SPECIFICATION:

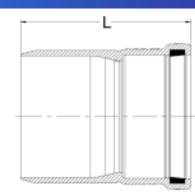
Transition Couplings used to join Ductile Iron or C900 Pipe and D3034 PVC sewer pipe shall be Ductile Iron, deep bell, push on joint, and air test rated. Ductile Iron material shall comply with ASTM A536, Grade 65-45-12 or 80-55-06. Bell depths shall meet the minimum socket depth requirements of ASTM F1336. Gasket grooves shall be machined. Gaskets shall be of SBR rubber and comply with ASTM F477. No transition gaskets are permitted. All couplings shall have pipe stops and a flow way tapered to allow a smooth transition between the pipes. Fittings shall be manufactured by the Harrington Corporation of Lynchburg, VA.

DI-OD GASKET x 3034 GASKET



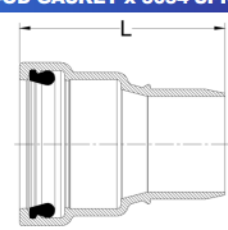
SIZE	PART #	L	WT. (APPROX.)
6	2837-060	9.7	20.0
8	2837-080	11.0	31.5
10	2837-100	12.1	51.1
12	2837-120	12.9	67.3

DI-OD SPIGOT x 3034 GASKET



SIZE	PART #	L	WT. (APPROX.)
8	2834-080	10.5	26.2
10	2834-100	11.5	39.2
12	2834-120	12.3	54.2

DI-OD GASKET x 3034 SPIGOT



SIZE	PART #	L	WT. (APPROX.)
4	2836-040		11
6	2836-060		18

MATERIALS OF CONSTRUCTION

- **Body:** Ductile Iron (ASTM A536)
- **Gaskets:** SBR Rubber (ASTM F477)

COATINGS AVAILABLE

- Bituminus (AWWA C153)
- Fusion Bond Epoxy (AWWA C116)
- Coal Tar Epoxy (AWWA C210)
- Protecto 401
- Others on request

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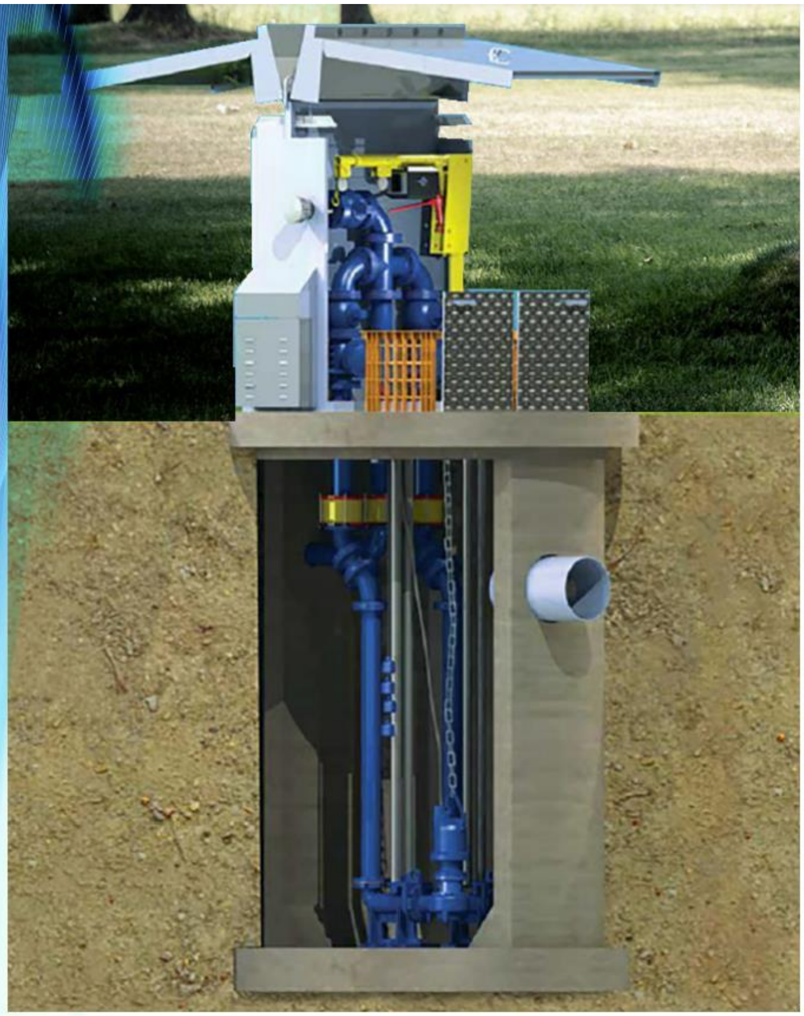


EXCEL

FLUID GROUP LLC

Technology Innovation Solutions

No-Vault Package Pump Stations

Product Overview

EXCEL FLUID GROUP is a premier manufacturer of complete vault-less pump station enclosures that give you full access and control of your lift station equipment without the hazards of confined space entry and arc-flash electrical concerns.

Built with a rugged aluminum housing and features designed for operational ease, the No-Vault Pump Station is by design, one of the most service friendly pump stations on the market today.

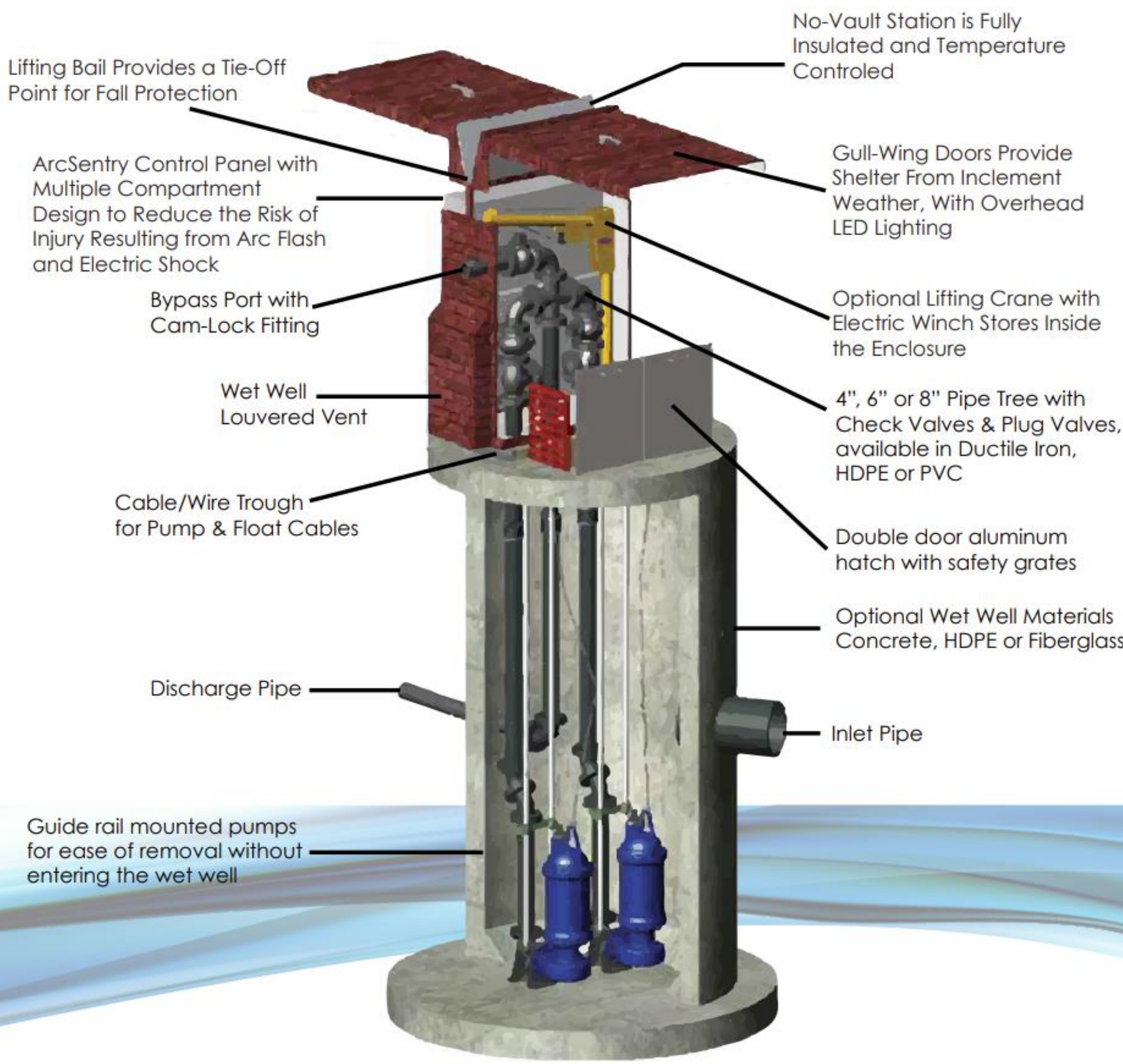
The No-Vault Pump Station provides an industry leading approach to Water and Wastewater Management. Our engineering team can modify standard construction features to fit almost any application.

EXCEL FLUID GROUP provides the advantage of a single-source supplier accommodating all brands of pumps and the No-Vault Pump Station can be mounted on concrete, HDPE or fiberglass wet wells, with your choice of controls.

Package Pump Systems

A sewage wet well is a very dangerous confined space that has claimed many lives in years past. According to OSHA, about 90 deaths involving confined spaces occur every year. This places a special obligation and responsibility on all those involved in the selection and design of pump stations, as well as servicing and installing pump stations. In addition, Safety and Service Directors are responsible for the safety of their Maintenance Personnel which obligates them to eliminate as many hazards as possible from their collection systems.

EXCEL FLUID GROUP has worked with clients to develop the Excel No-Vault Pump Station to minimize risk by providing a well designed, safe pump station where maintenance can be performed without entering the wet well and eliminates the below grade valve vault.

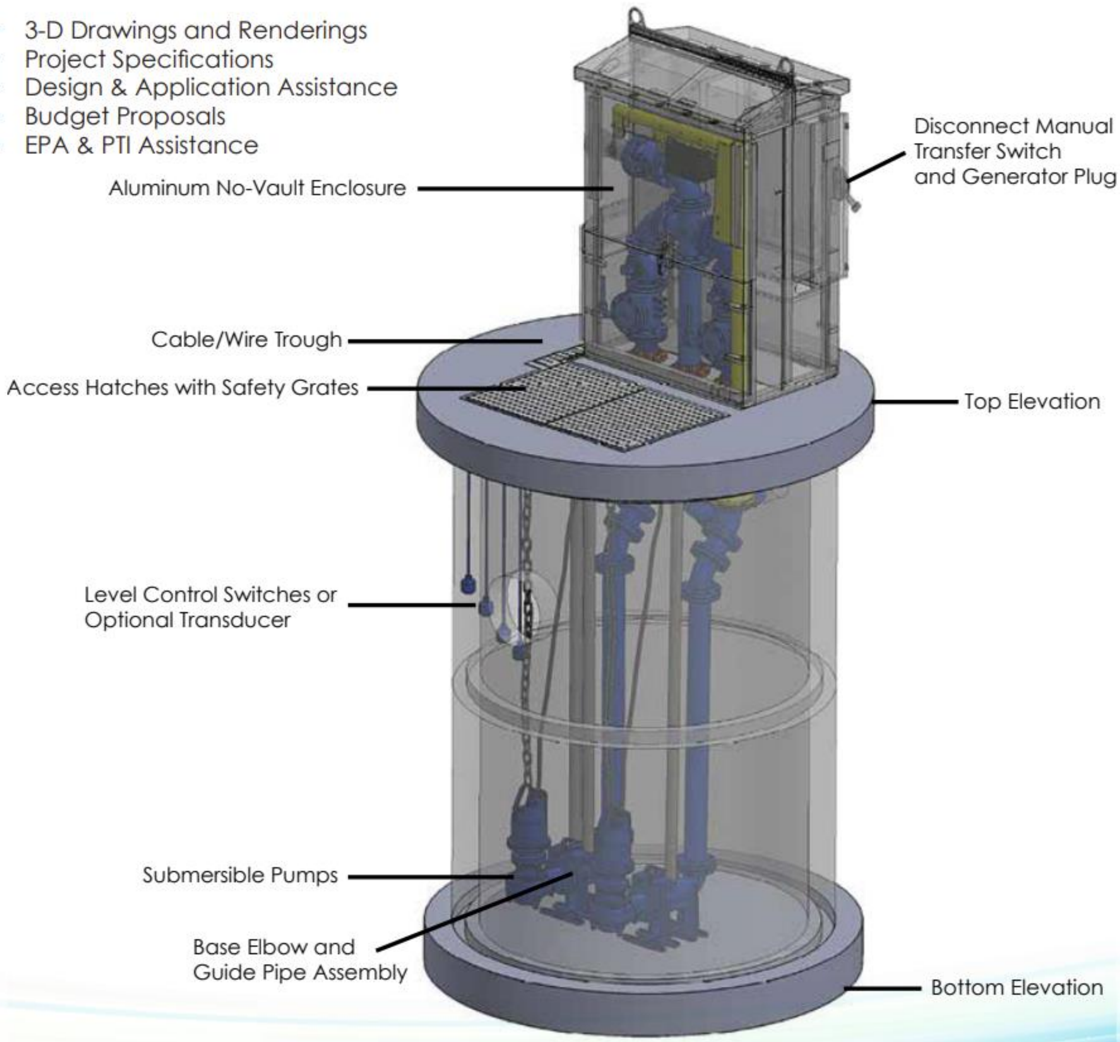


Application and Design

The Excel No-Vault design incorporates the valves and lift station controls within the footprint of the main wet well. For installation in areas with limited space the Excel No-Vault provides all of the features commonly found in conventional lift stations.

EXCEL FLUID GROUP invites you to discuss specific projects that are in initial planning or design stage, and our engineering team will assist you by providing the following services:

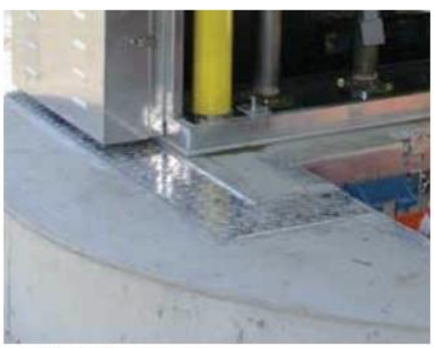
- ~ 3-D Drawings and Renderings
- ~ Project Specifications
- ~ Design & Application Assistance
- ~ Budget Proposals
- ~ EPA & PTI Assistance



Advantages

Above Ground Enclosure:
Eliminates Confined Space Safety Hazards and reduces Real Estate Requirements

Arc-Sentry Control Panel:
Design Reduces Arc Flash Hazards and Includes User Friendly Controls

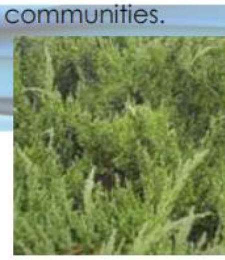


Cable/Wire Trough:
Simplifies Pump Installation and Maintenance and Eliminates the Need for Underground Electronic Conduit or Junction Box in Wet Well

Electrical Plugs and Receptacles:
Ensures Correct Pump Rotation and Reduces Installation, Maintenance and Service Time

Exterior No-Vault Covering Options

The No-Vault Pump Station is offered with custom aesthetics to blend into its surrounding environment. This makes it a first choice for many developers, engineers and communities.



No-Vault Pump Station Installation References

The Plains WWTP Lift Station: Athens County, OH
Triplex No-Vault Pump Station

- ~ 10.0' Dia. x 26.5' Deep Concrete Wet Well
- ~ Aluminum No-Vault NV3 6x6 Enclosure
- ~ Arc-Sentry Control Panel with Variable Frequency Drives
- ~ Submersible 20 HP Explosion Proof Vortex Pumps

Meadow Wood Lift Station: Ashtabula County, OH
Duplex No-Vault Pump Station

- ~ 5.0' Dia. x 20.0' Deep Concrete Wet Well
- ~ Aluminum No-Vault NV2 4x4 Enclosure
- ~ Arc-Sentry Control Panel
- ~ Submersible 7.5 HP Vortex Pumps

Air Force One Hanger Lift Station: Joint Base Andrews, MD
Duplex No-Vault Pump Station

- ~ 8.0' Dia. x 15.0' Deep Concrete Wet Well
- ~ Aluminum No-Vault NV2 4x4 Enclosure
- ~ Duplex Control Panel
- ~ Submersible 7.5 HP Non-Clog Pumps

Bell Acres Municipal Authority: Allegheny County, PA

Duplex No-Vault Pump Station

~ 8.0' Dia. x 17.0' Deep Fiberglass Wet Well
~ Aluminum No-Vault NV3 6x6 Enclosure
~ Arc-Sentry Control Panel with Variable Frequency Drives
~ Submersible 40 HP Explosion Proof Non-Clog Pumps

Duplex No-Vault Pump Station

~ 6.0' Dia. x 11.0' Deep Fiberglass Wet Well
~ Aluminum No-Vault NV2 4x4 Enclosure
~ Arc-Sentry Control Panel with Variable Frequency Drives
~ Submersible 7.5 HP Explosion Proof Non-Clog Pumps

NEORSD Stone Levee Lift Station: Cleveland, OH

Duplex No-Vault Pump Station

~ 10.0' Dia. x 23.0' Deep Concrete Wet Well
~ Aluminum No-Vault NV3 6x6 Enclosure
~ Arc-Sentry Control Panel with Variable Frequency Drives
~ Submersible 14 HP Explosion Proof Non-Clog Pumps

Common Wastewater Industry Challenges

- ~ Increasing Asset Ownership Cost from Maintenance of Ageing Infrastructure
- ~ Inflated Installation Costs of Traditional Concrete Pump Stations
- ~ Traditional Concrete Stations are Compromised by Hydrogen Sulfide (H2S) Corrosion, unless protected by an interior coating that is costly to install and maintain.
- ~ Groundwater Infiltration (I&I) Into Sanitary Sewer System
- ~ Service Hazards of Confined Space Entry and Injury From Electrical Shock

Contact Us For A No-Vault Package Pump Station Solution

Design Criteria for No-Vault Package Pump Stations

- ~ What is the average daily flow rate in gallons per minute (GPM) into the pump station?
- ~ What is the proposed forcemain size, length to discharge point and construction?
- ~ What is the grade elevation at the proposed pump station location?
- ~ What is the grade elevation at the proposed discharge point of the forcemain?
- ~ What is the gravity sewer invert pipe elevation?
- ~ Confirm the jobsite electrical service details.
- ~ Advise if emergency power connection or standby power service is required.
- ~ Advise if remote telemetry system is required.

EXCEL FLUID GROUP LLC

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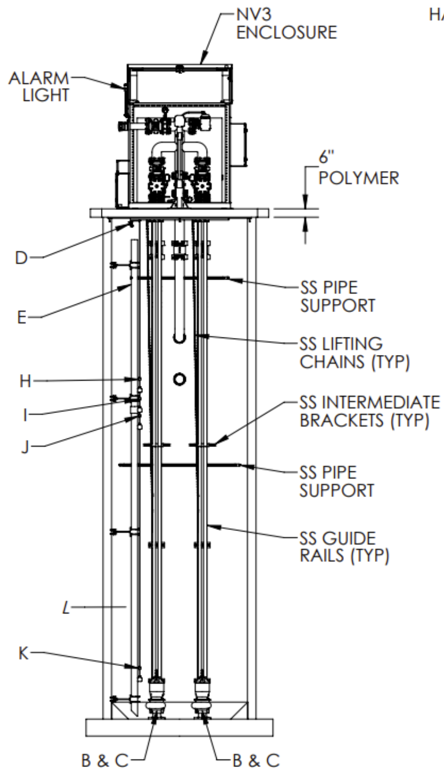
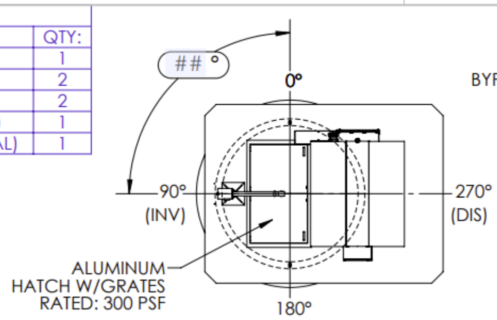
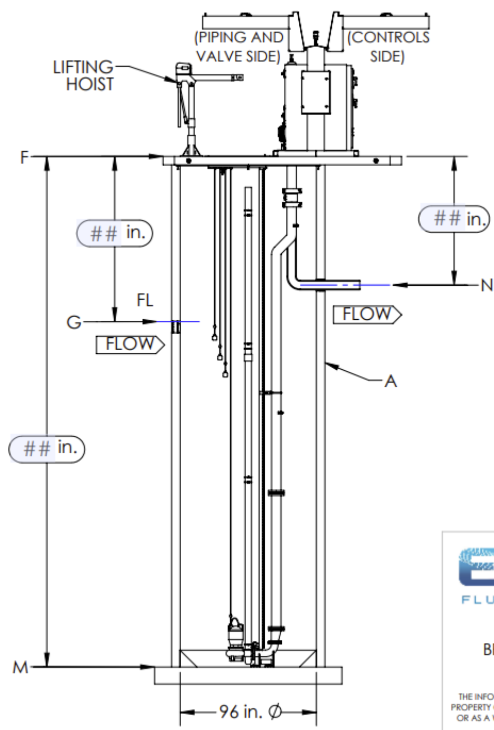
EXCEL HEAD OFFICE
15950 Commerce Park Drive
Cleveland, OH 44142
P. 216-941-1500 | F. 216-941-9916

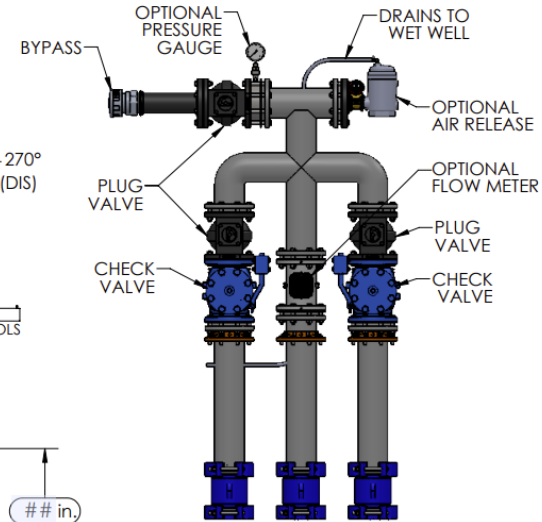
EXCEL FLUID GROUP PUMP STATION		
ITEM:	DESCRIPTION:	QTY:
A	CONCRETE WET WELL Ø96"	1
B	SUBMERSIBLE PUMP	2
C	BASE ELBOW	2
D	FLOAT BRACKET ASM (#FLOATS OPTIONAL)	1
E	TRANDUCER W/STILLING TUBE ASM (OPTIONAL)	1

NOTE:
1) CONFIRM INVERT PIPE SIZE, MATERIAL, AND ORIENTATION

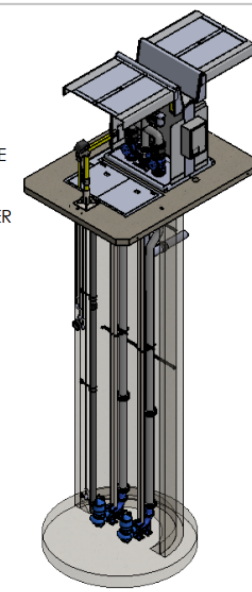








EXAMPLE PIPE AND VALVE HEADER
SEE SHEET 2 FOR OPTIONS



EXCEL FLUID GROUP STATION ELEVATION TABLE		
ITEM:	DESCRIPTION:	ELEVATION
F	TOP OF STATION	-ENTER-
G	INVERT (CONFIRM SIZE/TYPE)	-ENTER-
H	HIGH WATER ALARM FLOAT	-ENTER-
I	LAG PUMP ON FLOAT	-ENTER-
J	LEAD PUMP ON FLOAT	-ENTER-
K	PUMPS OFF FLOAT	-ENTER-
L	FLOAT (OPTIONAL 5TH FLOAT)	
M	FLOOR OF WELL	-ENTER-
N	DISCHARGE	-ENTER-

EXCEL FLUID GROUP, LLC
5350 WEST 137TH ST.
BROOK PARK, OH 44142

PROPRIETARY AND CONFIDENTIAL

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±1/16"
ANGULAR: ±0.5°
DECIMAL: ±.06

DRAWN BY: NAME
DATE:
SCALE: 1:75
DO NOT SCALE DRAWING

TITLE: ASM, DUPLEX NV3 PRECAST PUMP STATION
DWG. NO. 7200038
SIZE: B REV: 0 SHEET: 1 of 2

EXCEL FLUID GROUP NV3 PUMP STATION SELECTIONS:

NV3 ENCLOSURE WRAP SELECTION		
NV3 ALUMINUM	NV3	-SELECT-
NV3 ARBORVITAE	NV3A	
NV3 SANDSTONE	NV3S	
NV3 BRICK	NV3B	
PIPE AND VALVE SIZE (IN) SELECTION		
6" PIPE SIZE	6	-SELECT-
8" PIPE SIZE	8	
WET WELL AND HEADER PIPE & DISCHARGE MATERIAL SELECTION		
DUCTILE IRON	D	-SELECT-
HDPE	H	
STAINLESS STEEL (304)	S	
PVC (SCH80)	P	
WET WELL SIZE SELECTION (DIA" X DEPTH") - SEE NOTE 1		
EXAMPLE: Ø96" X 180" DEEP = 96180	(DIGITS)	-ENTER-
PIPE HEADER AND VALVE SELECTION - SEE NOTE 2		
BYPASS	01	-SELECT-
BYPASS, AIR RELEASE	02	
BYPASS, DIGITAL GAUGE	03	
BYPASS, AIR RELEASE, DIGITAL GAUGE	04	
BYPASS, FLOW METER	05	
BYPASS, FLOW METER, DIGITAL GAUGE	06	
BYPASS, FLOW METER, AIR RELEASE	07	
BYPASS, FLOW METER, AIR RELEASE, DIGITAL GAUGE	08	
BYPASS, DIAL GAUGE	09	
BYPASS, AIR RELEASE, DIAL GAUGE	10	
BYPASS, FLOW METER, DIAL GAUGE	11	
BYPASS, FLOW METER, AIR RELEASE, DIAL GAUGE	12	
SUBMERSIBLE PUMP BRAND SELECTION		
SUBMERSIBLE PUMP BRAND	(WRITE-IN)	-SELECT-
SUBMERSIBLE PUMP TYPE SELECTION		
NON-CLOG PUMP	NC	NC
EXPLOSION PROOF NON-CLOG PUMP	XXNC	
AIR FILLED SOLIDS HANDLING PUMP	ASH	
EXPLOSION PROOF AIR FILLED SOLID HANDLING PUMP	XASH	
AIR FILLED CHOPPER PUMP	ASC	
EXPLOSION PROOF AIR FILLED CHOPPER PUMP	XASC	
OIL FILLED SOLIDS HANDLING PUMP	OSH	
EXPLOSION PROOF OIL FILLED SOLIDS HANDLING PUMP	XOSH	
OIL FILLED CHOPPER PUMP	OSC	

Additional Comments (Preferences, etc.):

- None -

LEVEL CONTROL SELECTIONS		
4 FLOAT LEVEL CONTROL	4F	-SELECT-
5 FLOAT LEVEL CONTROL	5F	
SUBMERSIBLE TRANSDUCER LEVEL CONTROL	T	
SUBMERSIBLE TRANSDUCER LEVEL CONTROL w/2 FLOAT BACKUP	T2F	
SUBMERSIBLE TRANSDUCER LEVEL CONTROL w/4 FLOAT BACKUP	T4F	
INCOMING POWER SELECTION		
208 VOLT/SINGLE PHASE	208V1PH	-SELECT-
208 VOLT/THREE PHASE	208V3PH	
230 VOLT/SINGLE PHASE	230V1PH	
230 VOLT/THREE PHASE	230V3PH	
460 VOLT/THREE PHASE	460V3PH	
MOTOR STARTER OPTIONS SELCTION		
ACROSS THE LINE STARTERS	ATL	-SELECT-
VARIABLE FREQUENCY DRIVES	VFD	
SOFT STARTERS	SS	
FLOW & HEAD SELECTION (GPM @ TDH)		
EXAMPLE: 150 GPM @ 90 TDH = 150F90	(DIGITS)	-ENTER-
ADDITIONAL ADD-ON SELECTIONS		
WET WELL AERATION BLOWER	I	-SELECT-
AREA LIGHT	J	-SELECT-
ALUMINUM LADDER	K	-SELECT-
STAINLESS STEEL LADDER	L	-SELECT-
CAST-IN STEPS	M	-SELECT-
INLET GRINDER W/GUIDE RAILS (Ø72" MIN WELL ONLY)	N	-SELECT-
INLET BAFFLE	O	-SELECT-
INLET TRASH BASKET W/GUIDE RAILS	P	-SELECT-
ELECTRICAL METER BASE	Q	-SELECT-
DISCONNECT SWITCH	R	-SELECT-
DIESEL GENERATOR	S	-SELECT-
NATURAL GAS GENERATOR	T	-SELECT-
MANUAL TRANSFER SWITCH	U	-SELECT-
AUTOMATIC TRANSFER SWITCH	V	-SELECT-
POWER PEDESTAL	W	-SELECT-
GENERATOR RECEPTACLE	X	-SELECT-

NOTES:
1) AVAILABLE WET WELL SIZE: Ø96"
2) ALL PIPE HEADER SELECTIONS INCLUDE CHECK VALVES AND PLUG VALVES

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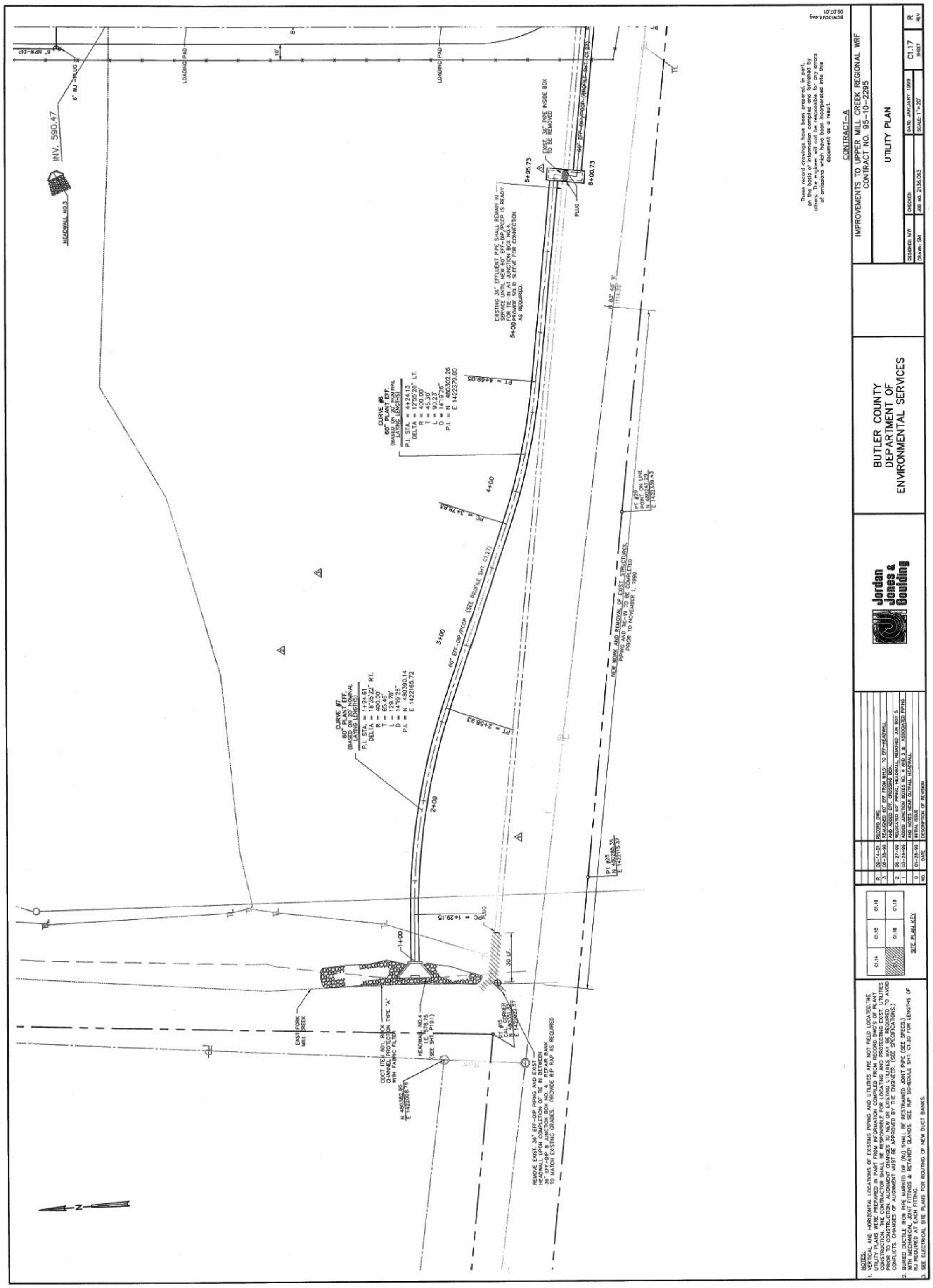
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES; TOLERANCES: FRACTIONAL ±1/16"; ANGULAR: ±0.5°; DECIMAL: ±.06

DRAWN BY: NAME
DATE:
SCALE: NA
DO NOT SCALE DRAWING

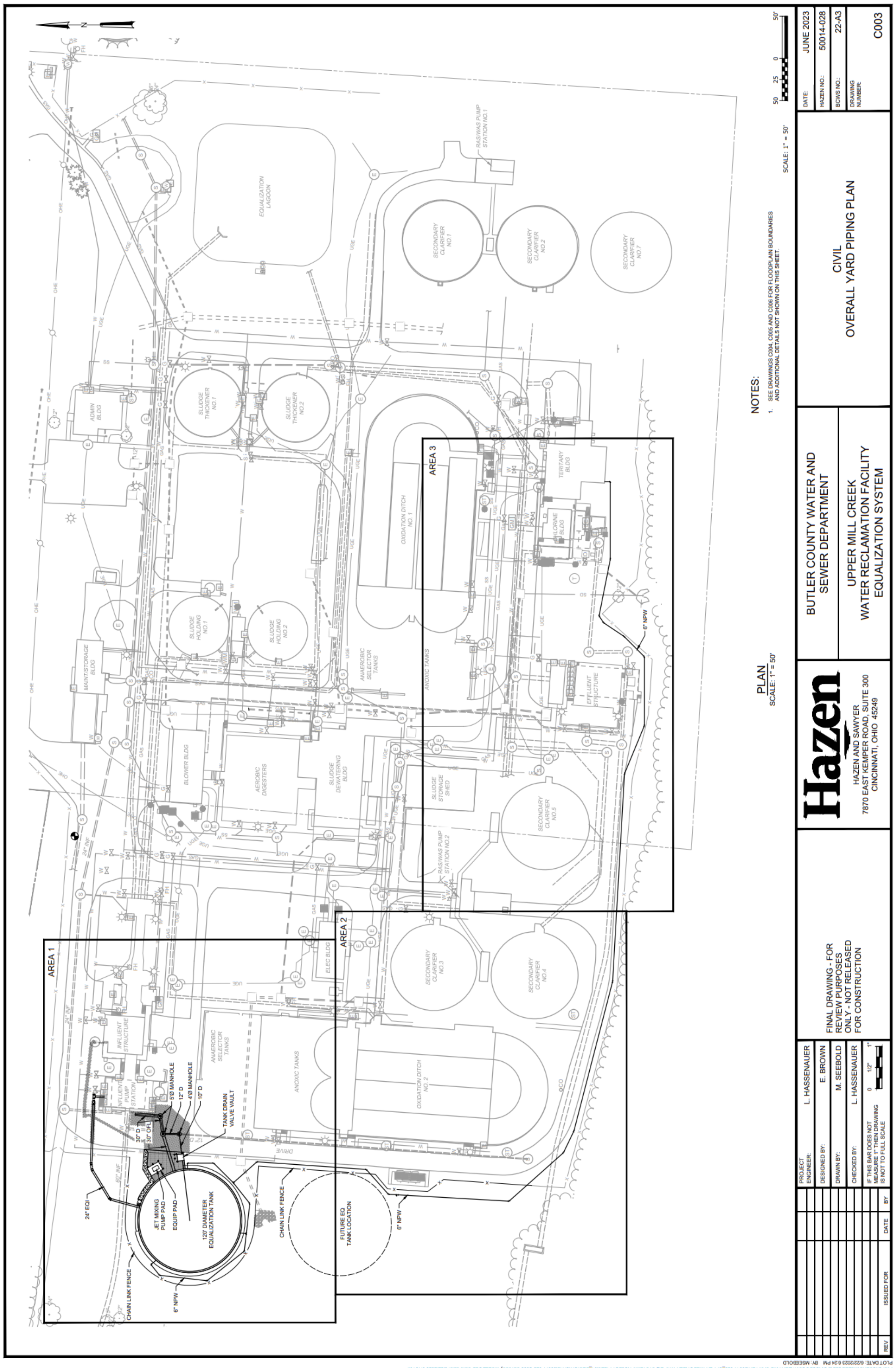
TITLE: ASM, DUPLEX NV3 PRECAST PUMP STATION
DWG. NO. 7200038
SIZE: B REV: 0 SHEET: 2 of 2

Appendix 9 – Construction Drawings of UMCWRF

Depiction of UMCWRF's current discharge pipe.



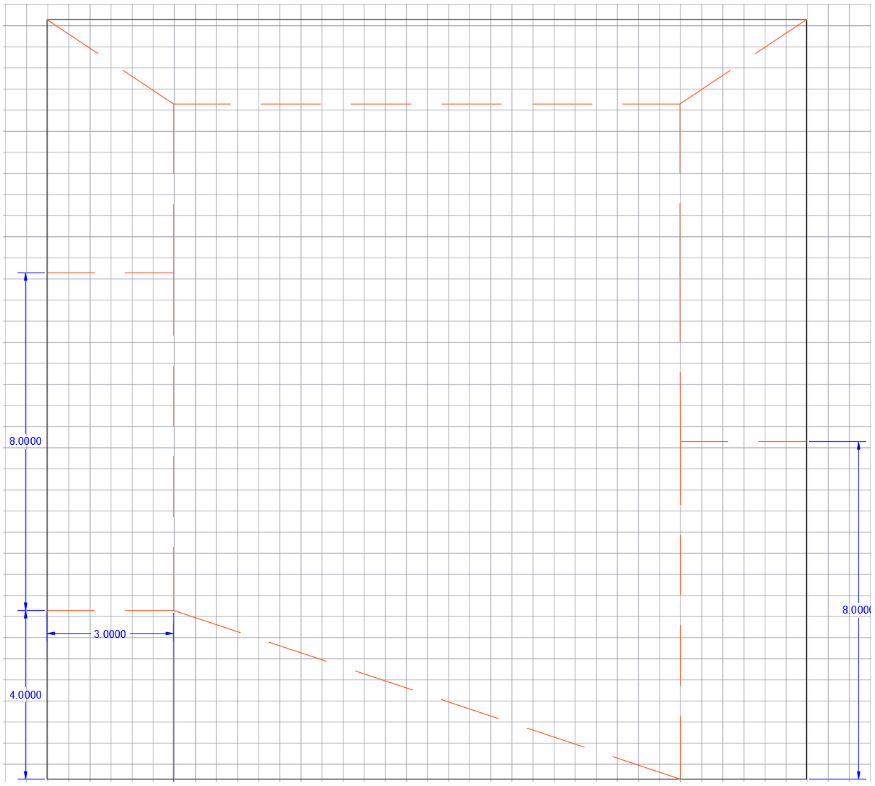
Depiction of UMCWRF's future EQ basin.



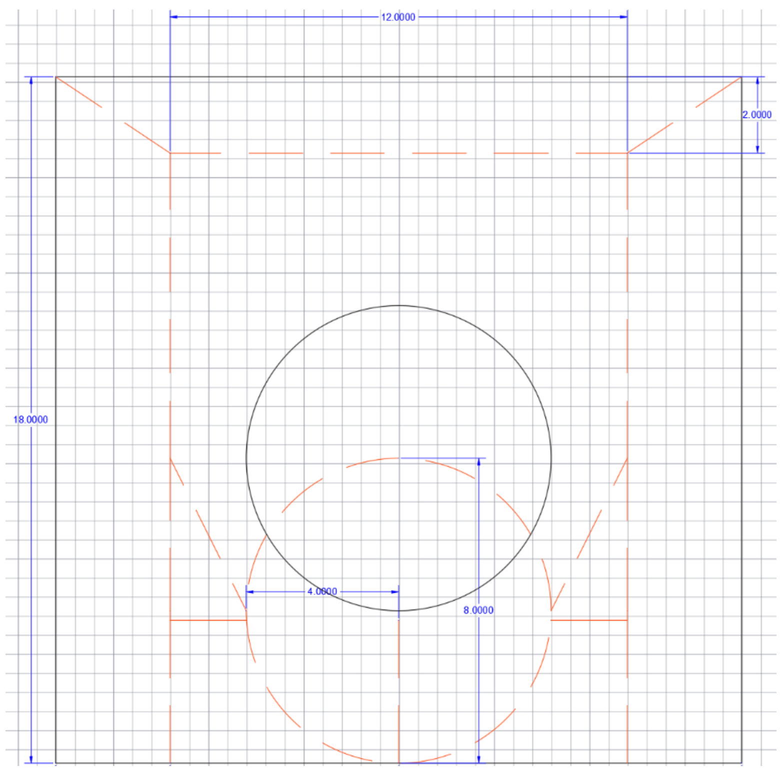
Appendix 10 – Dikes and Outlet Structure

The classification and construction standards for dikes (United States Department of Agriculture, 2022).

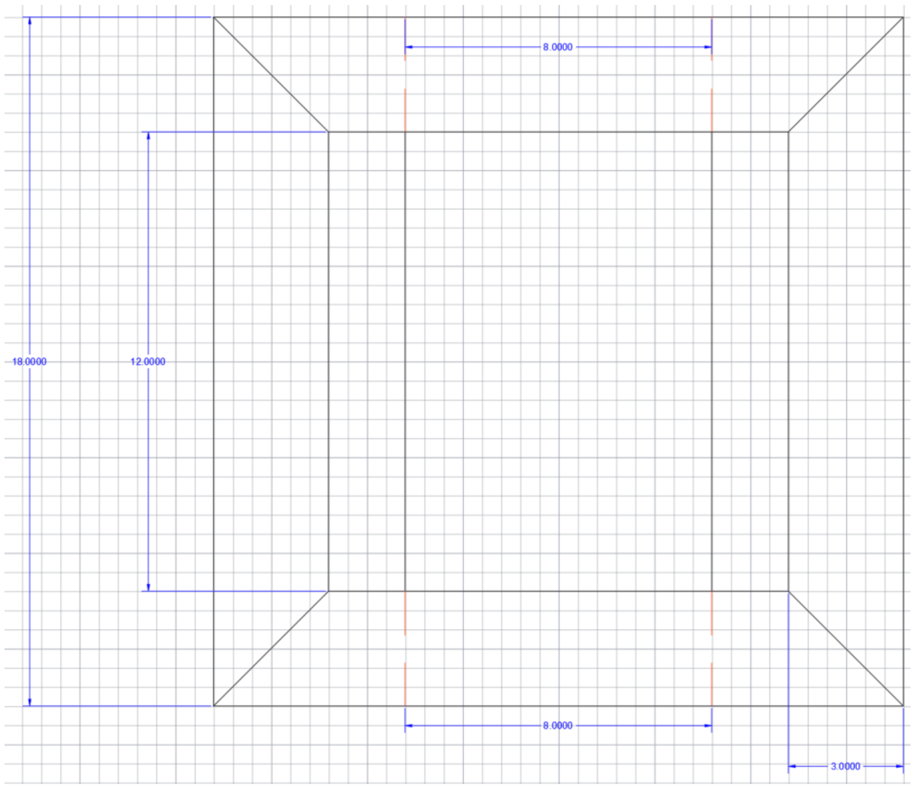
Classification	Material[1/]	Design High-Water Height (H) in feet[2/]	Minimum Storm Design Frequency in years	Minimum Freeboard in feet	Minimum Top Width in feet	Minimum Side-Slope Ratio[3/] (H:V)	Wave and Stability Berm Width in feet [4/]
Class I	Mineral Soils	0–6	100	H/3	10	3:1	12
		> 6–12	100	2	10	Note[4/]	Note[4/]
		>12–25	100	3	12	Note[4/]	Note[4/]
		> 25	100	3	14	Note[4/]	Note[4/]
	Manufactured	0–8	100	H/4	N/A	N/A	Note[4/]
		> 8–12	100	2	N/A	N/A	Note[4/]
		> 12	100	3	N/A	N/A	Note[4/]
Class II	Mineral Soils	0–6	25	H/3	6	3:1	12
		>6–12	25	2	8	3:1	15
	Manufactured	0–8	25	H/4	N/A	N/A	Note[4/]
		> 8–12	25	2	N/A	N/A	Note[4/]
Class III	Mineral Soils	0–3	10	H/3	4	3:1	8
		> 3–6	10	1	6	3:1	8
		> 6–12	25	2	8	3:1	8
	Organic Soils[5/]	0–2	10	H/2	4	3:1	10
		> 2–4	10	1	6	3:1	10
		> 4–6	10	2	8	3:1	15
	Manufactured	> 6–8	10	N/A	N/A	N/A	Note[4/]
Class IV	Mineral Soils or Organic Soils[5/]	< 6	10[6/]	0.5[7/]	4	3:1	N/A
	Manufactured	< 6	10[6/]	0.5[7]	N/A	N/A	N/A



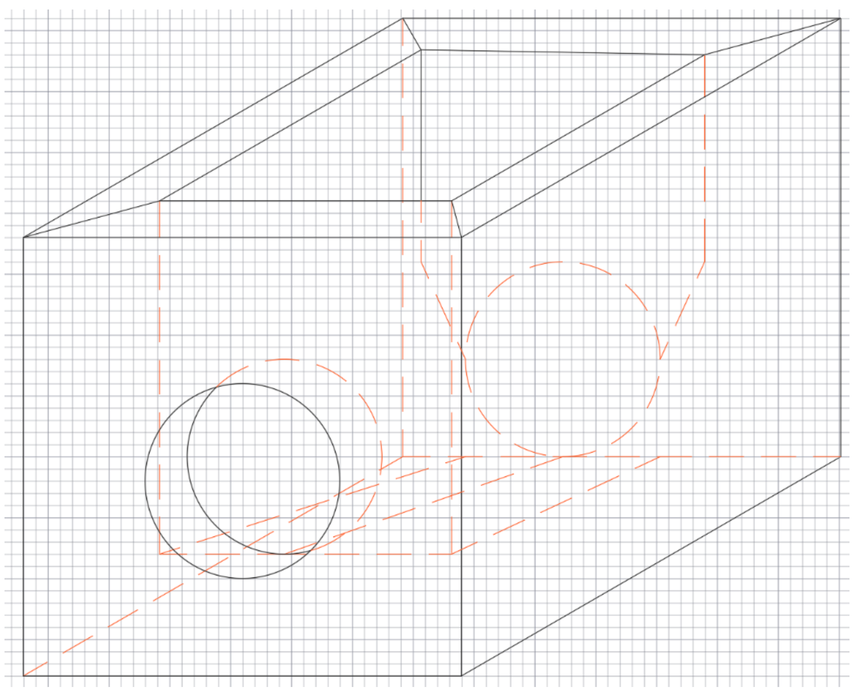
Side view of the outlet structure showing dimensions.



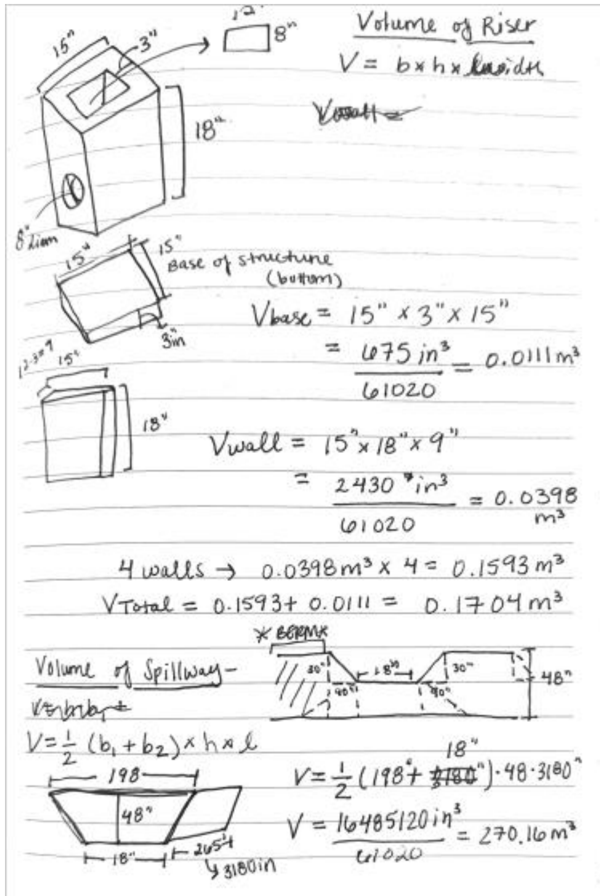
Front view of the outlet structure showing orifice dimensions.

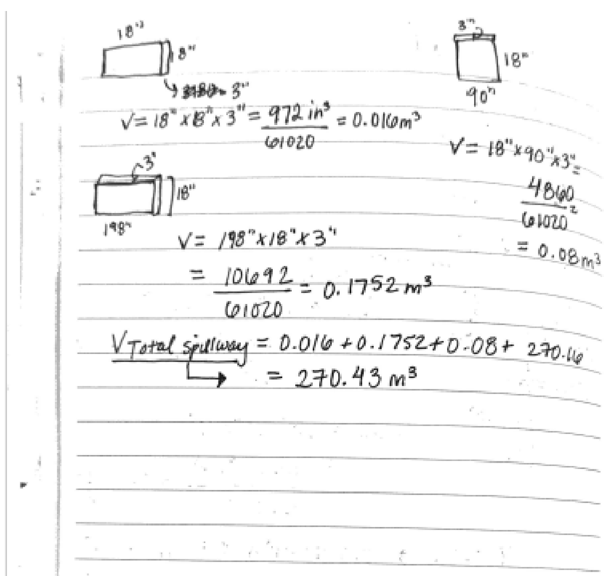


Top view of outlet structure showing dimensions.



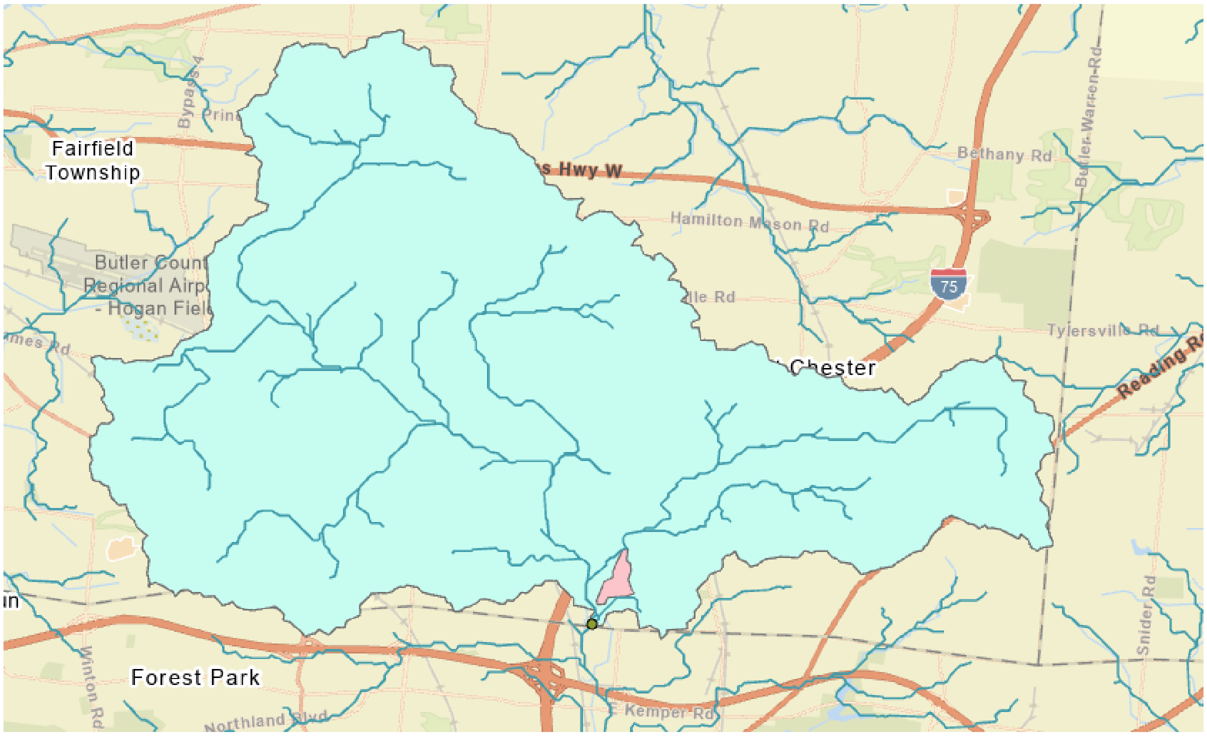
Orthogonal view of the outlet structure.



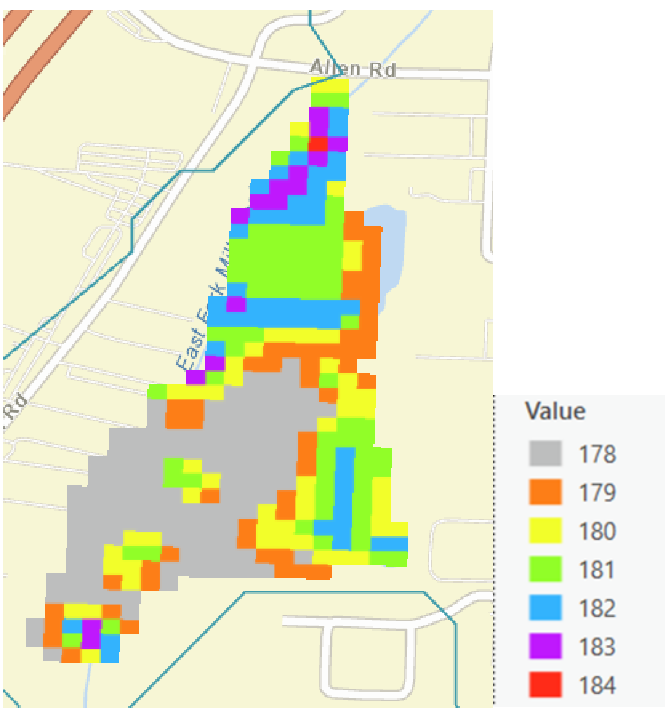


Volume calculations for riser and spillway structure.

Appendix 11 – Water Budget Calculations



Map of the watershed and the Wildermuth Wetland (image generated using GIS).



Map of the Wildermuth Wetland elevation profile (image generated using GIS). Note: The elevations are recorded in meters.

Table of precipitation for Butler County in 2023.

Precipitation						
2022	January	February	March	April	May	June
Monthly (Millimeter)	75.9	172.1	75.2	113.3	129.1	57.1
Monthly (Meters)	0.0759	0.1721	0.0752	0.1133	0.1291	0.0571
2023	January	February	March	April	May	June
Monthly (Millimeter)	114.3	49.7	196.9	81.65	108.5	107.35
Monthly (Meters)	0.1143	0.0497	0.1969	0.08165	0.1085	0.10735

July	August	September	October	November	December	Total	Average
124.8	78.4	42.3	26	68.8	69.8	1032.8	86.06
0.1248	0.0784	0.0423	0.026	0.0688	0.0698	1.0328	0.08606
July	August	September	October	November	December	Total	Average
175.85	116.8	28.39	92.77	42.01	131.94	1246.16	103.85
0.17585	0.1168	0.02839	0.09277	0.0421	0.13194	1.24616	0.10385

Infiltration Rate Determination Protocol

1. Gather materials.
    a. 4” PVC pipe
    b. Piece of plywood
    c. Hammer
    d. Water
    e. Timer
2. Determine the dose of volume required for 1” of water to be standing in the PVC pipe.

    V = (area)*(depth) $= \left(\frac{\pi}{4} * D^2\right) * d$, where D = pipe diameter and d = depth

    $= \left(\frac{\pi}{4} * 4^2\right) * 1 = \ 12.56$ cubic inches or 206 mL
3. Measure 206 mL of water in a graduated cylinder.
4. Pour the measured water into a 500 mL amber bottle and mark the height for 206 mL.
    a. This allows for the accurate amount of water to be measured in the field.
5. Once in the field, drive pipe 4” into the ground using the piece of plywood and hammer.
6. Pour the 206 mL on top of the soil within the PVC pipe.
7. Time how long it takes for the water to flow through the soil.
8. Repeat steps 6 and 7 either 2 or 3 times.
    a. The first time is an “unsaturated soil” infiltration rate.
    b. The second and third times are “saturated soil rates.”

c. If the test is taking more than 35 minutes, measure the remaining water in the PVC pipe and use that volume and time to calculate the rate.

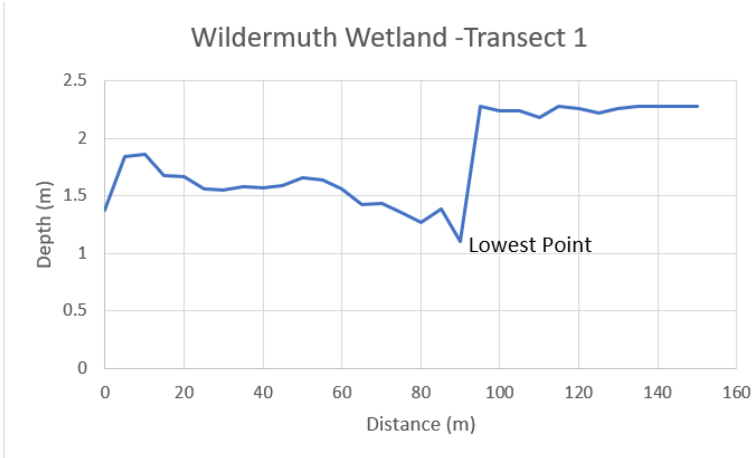
9. Repeats steps 5-8 at 9 different sites throughout the wetland to get an accurate representation of soil type.

Table of unsaturated versus saturated soil infiltration rate for Wildermuth Wetland

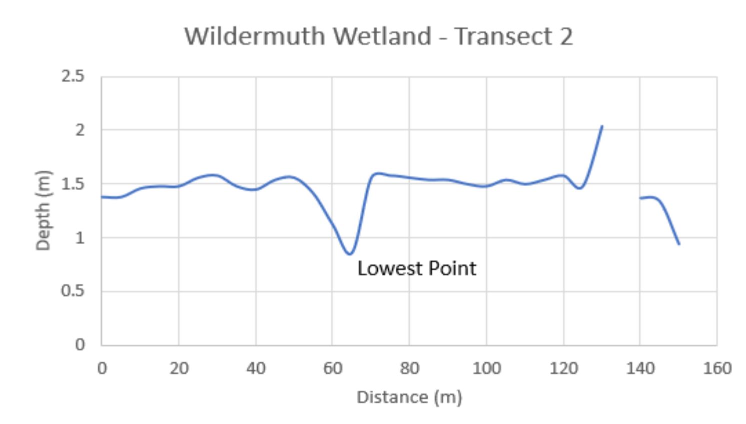
	Unsaturated	Saturated
Average Infiltration Rate (mm/min)	35.83582	1.507209
Average Infiltration Rate (cm/day)	5160.36	217.04

<u>Elevation Transect Measurement Protocol</u>

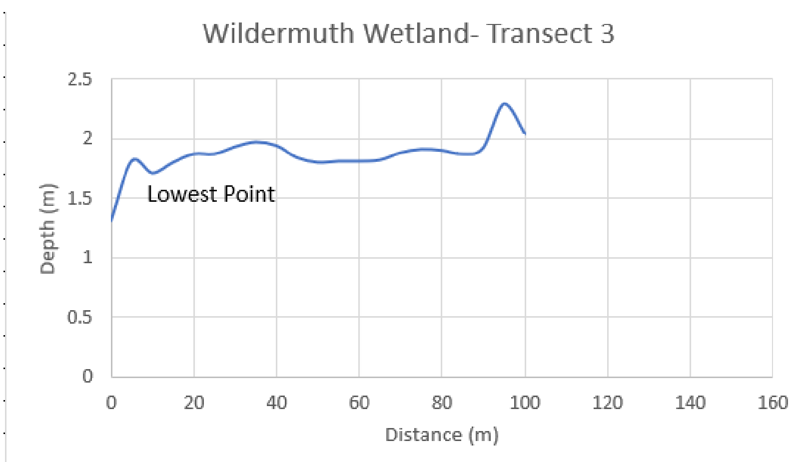
1. Gather Materials.
    a. 15-foot transect pole
    b. Tape measures
    c. Optical tripod with magnifier lens
    d. Compass with latitude and longitude capabilities
2. Start by choosing base points along the wetland to record the depth of elevation at every 5m.
3. Starting at the first base point, the optical tripod is set up by one operator while another team member walks a tape measure from the baseline on the left-hand side of the wetland across the width of the area to the end of the wetland (140 m).
4. Next, two team members walk a 15’ transect pole to each 5 m point across the width while the operator records the elevation data at each point using the magnifier to approximate depth on the transect pole.
5. Steps 3-4 are repeated at 3 base points along the left-hand side of the wetland site.



Graph of the lowest point (depth) of Transect Path 1 taken on site.



Graph of the lowest point (depth) of Transect Path 2 taken on site.



Graph of the lowest point (depth) of Transect Path 3 taken on site.

Appendix 12 – RFP

UC Environmental Engineering Senior Capstone Project

RFP Wetland Nutrient Reduction of Treated Effluent in the Upper Mill Creek

Sponsor: Mill Creek Alliance

Introduction

The nonprofit 501 (c)3 Mill Creek Alliance (MCA) works on the Mill Creek Watershed in two counties to reverse centuries of abuse to the stream. Past issues include hydraulic constrictions, bank erosion, bank encroachment, 80 brownfield sites along its 27-mile length, barriers and dams that prevent fish movement much of the year, channelization, and channel hardening. The MCA has been highly effective in mitigating 11 fish barriers with rock riffles. Only three barriers remain, which are planned to be removed in the next two years. Nutrients have been reduced phenomenology since 2000 by improvement in the 10 MGD Upper Mill Creek Water Reclamation Facility (UMCWRF) in Butler County (Figure 1), but they are still stubbornly higher than is acceptable for a TMDL (Total Maximum Daily Load) to meet the Clean Water Act's Warm Water Standard in Ohio.

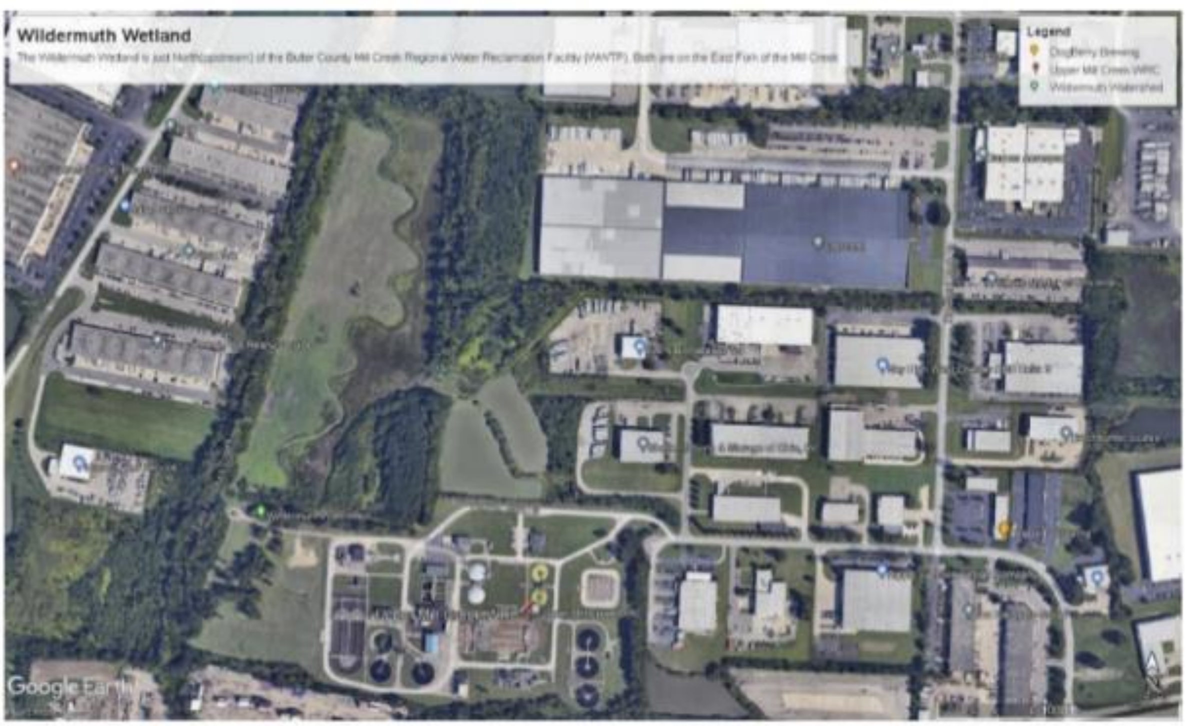


Figure 1. Site map for UMCWRF and Wildermuth Constructed Wetland.

Project Description

Nutrient standards for Warm Water Habitat from Ohio EPA are exceeded in the Mill Creek below the effluent from the UMCWRF. Next to the treatment plant there is an 11-acre Wildermuth Wetland that was built after an illegal soil harvesting operation was performed to infill the 100- year floodplain of the East Fork of the Mill Creek (Figure 1). The wetland was developed to primarily remove silt from upstream flood waters and return flow to the river downstream of the wetland. However, it is mostly dry throughout the year and thus does not act as a wetland with few aquatic species present.

The purpose of this project is to determine if and how much treated effluent from the UMCWRF may be processed to remove total phosphorus (TP) and nitrate-N (NO3-N) by pumping effluent to the top of the wetland and letting it pass at an appropriate rate to remove TP and denitrify NO3-N to N2 gas under lightly reductive conditions. This would be the first such treatment wetland in SW Ohio and if operating properly would greatly improve the water quality of the recovering Mill Creek. UMCWRF already does an excellent job in removing TP and N from its waste stream and meets secondary activated sludge discharge requirements. However the receiving water still does not meet nutrient standards for warm water habitats in Ohio.

The project would utilize an existing constructed wetland adjacent to the UMCWRF (Figure 2). This wetland has a conservation easement that would have to be modified for permitting. The effluent from the UMCWRF would have to be pumped several hundred yards to the top of the wetland. It is anticipated that the pumping and piping from the treatment plant to the wetland would be the greatest cost of this project.

Figure 2. Picture of the constructed wetland adjacent to the UMCWRF.

- Determine the volume at each depth in the wetland to estimate the flooded acreage.
- Compute the retention time in the wetland at the water level sustained by 1, 2, 3, 5 and 10 MGD of treated effluent.
- Examine options to optimize N and P removal for treating the most effluent possible by modification of the downstream wetland dam, by dividing the wetland into upper and lower sections, or by recirculating the wastewater wholly or partially 2, 3 or 4 times.
- Determine the pump size and pipe diameter required to generate the appropriate retention time in the wetland for N and P removal.
- Generate cost estimates of each of the options to help make the project affordable with a grant from Green Ohio Fund, 319 a funds, WRSP interest fund in Ohio, or a tax rate millage.

1. Prepare a final report that includes the design specifications, recommended modifications to the existing wetland, and expected cost via an economic analysis.
2. Provide an oral presentation on key findings at the end of the semester.

Contacts

- Dr. Michael C. Miller, Professor Emeritus from UC Biological Science and Environmental Studies mmmillermc@gmail.com (phone: 513-675-0293)
- David Schmitt, Director of Mill Creek Alliance, Board Member of American River