Knox Cattle Company Dam Study

Mount Vernon, Ohio

July 27, 2022

FINAL

Prepared for:

Frost Brown Todd LLC

Prepared by:

Stantec Consulting Services Inc.

Revision	Description	Author		Quality Check	
0	Final	D. Bolubasz	7/13/22	N. Mueller	7/27/22

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

Stantec was contracted by Frost Brown Todd LLC (Client) to provide professional engineering services related to the Knox Cattle Company Dam (Dam). The Client is the legal counsel for the City of Mount Vernon (City) defending it in a lawsuit filed by the State of Ohio versus numerous defendants including the City (Case No. 20IN06-0149). The State brought the action to enforce Ohio's dam safety laws for a Class I dam.

The Dam is located in Knox County, Ohio to the east of downtown Mount Vernon and is surrounded by residential and commercial development. See the Overview map on the following page for the project location. Although initially constructed for agricultural purposes, the dam is a key element in managing the stormwater originating from the surrounding residential development.

According to the Ohio Department of Natural Resources (ODNR) Dam Inventory Sheet, the existing Dam is an earthen embankment constructed in 1945. The dam is approximately 20-feet tall and 375-feet long with a top crest width of 15 feet, as noted in the Dam Inventory Sheet from ODNR. It has a drainage area of approximately 0.15 square-miles, creates a permanent pool with a surface area of approximately 4.5 acres at its crest, and has a normal pool elevation slightly below the emergency spillway elevation. Key dam elevations are shown in Table 1.

Table 1 – Key Dam Elevations[1]

Dam Feature	Elevation (ft-MSL)
Top of Dam	1107.96'
Emergency Spillway	1105.05'
Principal Spillway (upstream invert)	1091.60'

1. From Pond 1A Section AA, 'The Landings at Mount Vernon Drainage Study by Kleingers 4/1/2020

In 2008, ODNR reclassified the Dam as a Class I dam due to the risk associated with a potential failure and development downstream of the property. ODNR performed hydrologic and hydraulic analyses in 2011 indicating the dam does not satisfy OAC Rule 1501:21-13-02 because it cannot safely discharge the runoff of the Probable Maximum Flood (PMF) event. ODNR dam safety inspections in 2008, 2010, 2015, and 2020 document multiple violations of Ohio's dam safety standards, including emergency spillway channel erosion, seepage, maintenance issues, and inability of the spillway to pass the design flood (PMF). In 2020, interim risk reduction measures (IRRMs) were taken by City, effecting the lowering of the reservoir water level via siphon, and riprap armoring of the emergency spillway channel. In 2021, the City performed additional IRRMs: repairing the emergency spillway outlet and removing the rusted outlet pipe. See Figure 1 for general arrangement of dam features.

Stantec

Legend

Parcels

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0 750 1,500 Feet
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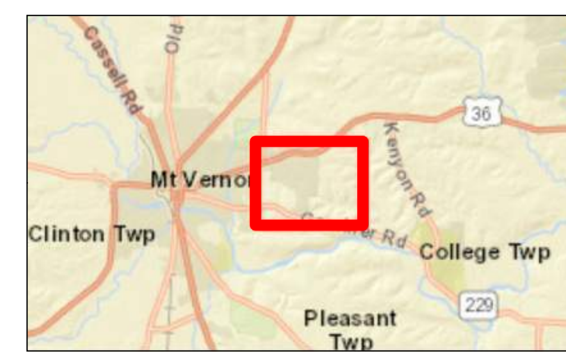
Notes
1. Coordinate System: NAD 1983 2011 StatePlane Ohio North FIPS 3401 Ft US
2. Background: 2019 Aerial Photography, Hancock County Auditior GIS Data Downloads



Project Location
Monroe Township
Knox County, Ohio

Prepared by DMB on 2022-03-02
Review by NMM on 2022-03-02

Client/Project 173410617 REVA
Frost Brown Todd LLC
Mt. Vernon Dam Study
Knox Cattle Company Dam

Figure No.
Overview

Title
Project Location

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Introduction

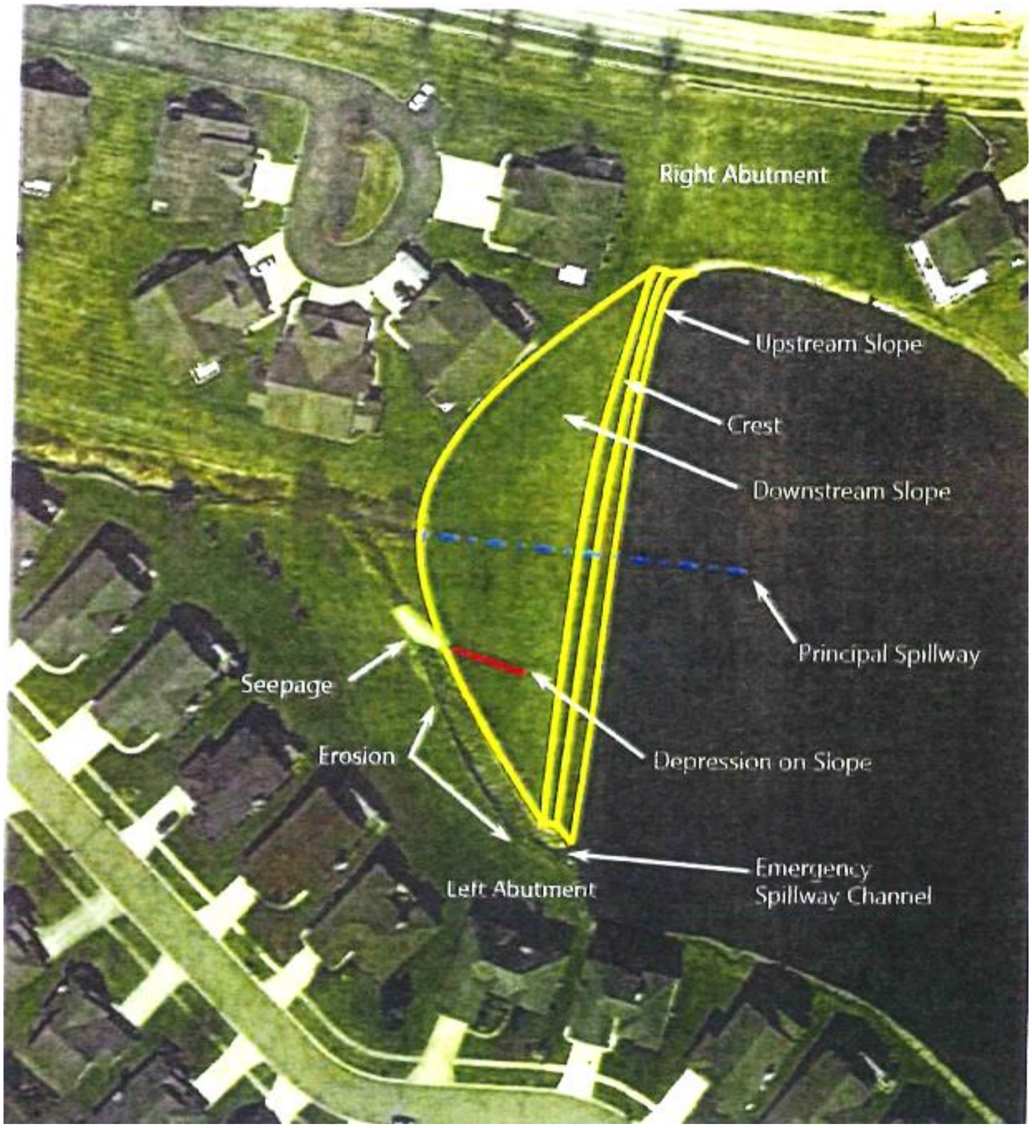


Figure 1 – Existing Dam Features Source: ODNR Dam Safety Inspection Report Nov. 25, 2019

The dam serves a stormwater management function as part of the stormwater management plans of the surrounding residential development. In August of 2018, the City of Mount Vernon issued a notice of violation to the Landings Property Owners Association for noncompliance with post-construction stormwater regulations and failure to maintain stormwater structures. The violation noted the forebay water control structure is being circumvented due to erosion; the dam spillway shows signs of erosion; stormwater inlet pipe failure at the joint upstream of the forebay; and head-cutting erosion on the south shore of the pond. The City requested repair to the issues identified and preparation of an Operations and Maintenance ("O&M") Plan.

1.2 PROJECT SCOPE

There are three conceptual alternatives to address the dam deficiencies identified by ODNR, mitigate the risks posed by the dam, and manage stormwater. They are:

1. Rehabilitate the dam and maintain the existing pool;
2. Remove the dam and pool and implement alternative stormwater management measures; and
3. Reduce the dam embankment height such that the dam is no longer subject to ODNR dam safety jurisdiction and implement alternative stormwater management measures, with options to maintain or eliminate an upstream pool.

The alternatives were evaluated considering the following criteria:

1. Comply with Ohio's dam safety laws;
2. Capital costs for construction;
3. Long-term operations and maintenance (O&M) costs following construction;
4. Stormwater management considerations; and
5. Flooding impacts, pre-and post-project (described in greater detail in Section 3.0)..

For each alternative, a planning-level opinion of probable construction costs (OPCC) and estimated long-term operation and maintenance costs were developed. The level of accuracy of the OPCC at this feasibility phase is +/- 30% due to the conceptual level nature of this study.

An estimated schedule for construction and a conceptual level figure are provided for each alternative. Permitting and regulatory considerations are also discussed for each alternative. Stormwater management and reservoir sediment management considerations are discussed for Alternatives 2 and 3.

2.0 EXISTING CONDITIONS

2.1 DATA COLLECTION

Stantec visited the site on November 23, 2021, with the Client to observe the existing conditions of the site and collect field photos. Relevant data was provided to Stantec by the Kleingers Group (Kleingers) and the City. An itemization of the data received is included in Appendix A.

2.1.1 City Data

Data provided by the City included applicable laws and regulations, ODNR dam safety inspections, original subdivision development plans, City Council meeting minutes, site photos, stormwater studies and design documents, and other related information.

2.2 EXISTING DAM DEFICIENCIES

ODNR rules require the dam to safely pass 100% of the PMF. The dam can pass only 12% as currently configured.

The principal spillway structure for the dam is an 8-inch diameter pipe. ODNR requires a principal spillway pipe to be no less than 24 inches in diameter. The dam also does not have the required lake drain to enable controlled drawdown of the reservoir. A lake drain is typically a pipe with a gate or valve that can be operated to reduce the elevation of the reservoir during an emergency or for O&M purposes. Dam safety laws require a dam this size to have an Emergency Action Plan (EAP) and dam failure inundation study, neither of which were ever prepared. Also, as noted in ODNR's inspection reports, the existing structure needs significant maintenance.

2.3 SEDIMENT

The dam reservoir acts as a sediment trap due to the change in hydraulic gradient and sediment transport ability of the modified natural channel. Stormwater flowing through the existing channel upstream of the dam into the reservoir is analogous to a ball rolling downhill. The energy of the downhill-flowing water is dissipated as it hits the flat area of the reservoir. As a result, the water can no longer carry the sediment it has collected, which drops to the bottom of the reservoir. Over time, the sediment accumulates reducing the storage capacity of the reservoir.

The effect of sediment accumulation was determined by calculating stored sediment volume relative to the design storage capacity of the reservoir. The current bottom elevation was estimated from surface contours referenced in the bathymetric survey of the reservoir prepared by Kleingers on December 5, 2019. During that survey, Kleingers measured sediment deposit thickness by inserting a probe into the sediment until it could penetrate no further (refusal). The difference from surface to refusal depth is the estimated thickness of the sediment layer. Sediment thickness in the pond ranged from 0.5 feet to 3.5 feet. This data and the below water topography, also called bathymetry, were used to create a sediment depth accumulation surface.

The sediment accumulation surface, shown in Figure 2, was used to evaluate the rate and extent of sedimentation in the reservoir. Sediment accumulation was greater in the upstream portions of the reservoir, where the two streams enter the pool, than in the middle and downstream sections. Total sediment accumulation volume in the reservoir was estimated at 7,300 CY. This is approximately 15% of the approximately 30 acre-feet storage capacity of the dam.

Figure 2. Sediment accumulation depths in the reservoir

The quantity, and possibly quality, of sediment within the reservoir has a significant impact on the alternatives analysis. Dredging and removal of sediment in the reservoir is costly and affects the upstream reservoir grading plans. Periodic dredging to maintain storage capacity of the reservoir will be required as part of the management plans for the alternatives presented.

Dams can trap and store natural and anthropogenic constituents at concentrations that may pose risks to aquatic ecosystems and/or human health. A screening level assessment of sediment chemistry in the reservoir should be conducted prior to construction to determine the potential presence and concentration of contaminants in reservoir sediment. This assessment would include taking samples from sediments and analyzing them for Resource Conservation and Recovery Act (RCRA) metals, polychlorinated biphenyls (PCB's), polycyclic aromatic hydrocarbons (PAHs), and possibly other analytes. The handling and disposal of contaminated materials could have a significant impact on construction costs and schedule.

2.4 HYDROLOGIC AND HYDRAULIC ANALYSIS

Stantec performed hydrologic and hydraulic analysis for the project watershed using Personal Computer Storm Water Management Model (PCSWMM). PCSWMM performs hydrologic computations, i.e., the quantity and rate of stormwater runoff in the watershed in conjunction with hydraulics, i.e., the dynamic routing of flow through stormwater networks, open channels, and basins within one model. PCSWMM uses a GIS based interface and the computation engine is based on the publicly available EPA SWMM software. Analysis was performed for existing conditions and following potential modifications to the dam and reservoir. The results of the analysis show that the existing structure provides substantial storage of flows during flood events. This storage reduces downstream flows and water surface elevations during and after significant rainfall events. Table 2 shows the peak flow entering, and the reduced flows leaving, the reservoir during various storm events. Additional details of the analysis are described in the H&H Analysis technical memorandum dated July 27, 2022, and are provided in Appendix D.

Table 2 – Existing Conditions Dam Inflow and Outflow Rates

Recurrence Interval Flood Event	Peak Inflow to Reservoir (cubic feet / second)	Peak Outflow from Reservoir (cubic feet / second)
1-yr	28	10
2-yr	50	16
5-yr	89	26
10-yr	132	36
25-yr	196	53
50-yr	244	69
100-yr	300	127

3.0 PROJECT DESIGN CRITERIA

The following criteria were used to inform the design of the Knox Cattle Company Dam conceptual alternatives and stormwater management features.

- Reduce the risk to public health and safety posed by flooding in the areas served or affected by the existing dam.
- Not increase the magnitude or frequency of flooding of habitable structures upstream and downstream of the existing dam.
  - This will be determined based on comparison of existing and post-project conditions water surface elevations, for a range of recurrence intervals (1, 2, 10, 25, 50. and 100-year 24-hour precipitation events), against finished floor field survey elevations.
- Subject to the other design criteria set forth herein, increases in flow rates upstream and downstream of the dam may be necessary.
  - Increases in flow rates downstream of the subdivision, if applicable, will be reported based on results of the hydraulic model.
  - The proposed project may increase the magnitude and frequency of non-habitable structure and lawn flooding downstream of the dam.
- The proposed project will not materially increase the frequency or severity of roadway overtopping.
  - A material increase is defined as an increase in depth of flooding of 6-inches or greater measured at the road crest.

4.0 CONCEPTUAL DESIGN ALTERNATIVES

Conceptual level, plan view figures are attached for the alternatives described below.

4.1 ALTERNATIVE 1: REPAIR AND REHABILITATION

Alternative 1 includes repair and rehabilitation of the existing dam to address the deficiencies and maintenance issues identified in the ODNR Dam Safety Inspection Report. To remedy these issues, including insufficient spillway capacity, would require additional analyses and detailed design prior to construction.

4.1.1 Conceptual Alternative

The ODNR Dam Safety Inspection Report outlines the engineering repairs and investigative measures required for the existing dam to comply with OAC Section 1501.

- A labyrinth spillway is proposed to safely pass the design flood and discharge into a riprap-lined channel downstream. A labyrinth spillway is a linear, reinforced concrete weir structure. A labyrinth weir can discharge a greater amount of flow over a total spillway length than a typical linear weir. The proposed labyrinth structure is approxiametly15 feet tall and spans 72 feet. A 20-foot-long concrete slab with concrete abutment walls would be placed just downstream of the spillway for energy dissipation. The outlet channel would transition to riprap and converge to a bottom width of about 12 feet to meet the existing downstream channel.
- Downstream improvements include 70 linear feet of a riprap-lined trapezoidal channel with a bottom width of 12 feet, depth of 3 feet, and 3H:1V side slopes. This channel would be sized to convey discharge from the dam outlet structure. A general layout is shown in Figure 1 in Appendix B.
- The existing principal spillway pipe would be replaced with a low-level outlet pipe and sluice gate to allow for controlled draining of the reservoir. The pipe would be integrated with the labyrinth spillway and drain to the downstream channel. The existing emergency spillway channel would be re-graded and any usable riprap from it placed in the proposed downstream channel.
- Areas where seepage may be occurring must be investigated and monitored until repairs are made. Stantec has not investigated the seepage concerns noted by ODNR and recommends further geotechnical investigation and analyses to determine the extent of potential seepage through the embankment or its foundation.
- For opinion of probable construction cost estimating purposes, a filtered seepage control berm is proposed with Alternative 1. The toe berm would be layered with fine aggregate, clay fill, and topsoil to provide a controlled path for seepage to exit the embankment without eroding embankment soil. The berm would also reduce uplift pressures that could occur at the downstream toe of the dam.

- Other repairs and monitoring actions include filling low areas along the dam crest, filling rodent burrows along the embankment and crest, removing trees and brush around the principal spillway outlet pipe, removing cattails in the emergency spillway channel, and re-establishing grass in bare or disturbed areas.

4.1.2 Design and Analyses

Additional design and analyses will be necessary to advance the design of Alternative 1. Probable Maximum Precipitation (PMP) / PMF hydrologic and hydraulic analysis are necessary to determine the magnitude of the inflow design flood for the spillway design. This analysis will determine the quantity of stormwater and the rate at which it enters the reservoir. Multi-frequency H&H analyses are used to determine reservoir pool levels for various size storms. These analyses will inform the design criteria for the principal and emergency spillway design and support structural stability analysis of the labyrinth structure. Erosion and scour analysis is necessary to determine channel armoring protocol. Geotechnical investigations and analyses are also required to advance Alternative 1 to design. Geotechnical field investigations and laboratory testing are recommended to characterize the embankment and foundation materials to support analysis. Seepage, stability, and settlement analysis will inform the remediation measures to be considered, such as toe berms, blanket drains, toe drains, and other potential risk reduction measures.

4.1.3 Dam Safety Considerations

Per ODNR requirements, a Class 1 Dam must be able to safely pass the design flood of 100% of the PMF. If the dam has been rehabilitated to meet this requirement, it must be maintained and inspected. The dam must have an operation, maintenance, and inspection (OMI) manual and an EAP. The EAP must include an upstream and downstream inundation map and an H&H study is required to document the design capacity of the rehabilitated dam. Expected operation and maintenance costs are included in the long-term operation and maintenance costs section below. Costs to develop an EAP and OMI document are in addition to regular OMI costs noted in this report.

4.1.4 Stormwater Management and Flooding Impacts

Rehabilitating the dam would maintain the current storage capacity of the reservoir. The labyrinth spillway can be designed such that only one or two “cycles” activate under small events, with all cycles discharging flow under larger events. A labyrinth cycle represents the singular triangular shape of the spillway from mid-point to mid-point along its length. Using varied cycle elevations, some storage capacity can be preserved in the reservoir. This function is similar to the existing structure today. When the reservoir is not drawn down, storage capacity is limited to the volume between the normal pool and the crest of the emergency spillway, which is approximately 1-foot above normal pool, per ODNR Inspection Report.

It is assumed that the existing top of embankment elevation would be preserved in this Alternative. A combination of modifying the labyrinth spillway cycle elevations and the top of the dam embankment could yield additional flood water attenuation resulting in a decrease in localized downstream flood elevations, particularly in smaller flood events.

4.1.5 Regulatory Agency Permitting

This Alternative would be subject to the federal, state, and local regulations described below.

- Section 404 of the Clean Water Act (CWA) authorizes the discharge of dredged or fill material to waters of the United States and is administered by the U.S. Army Corps of Engineers (USACE). USACE permits can be divided into two basic groups: General Permits and Individual Permits. General Permits are used for projects with small impacts; Individual Permits are required for projects with greater impacts or those not authorized under the USACE Nationwide Permit Program. It is anticipated that activities associated with Alternative 1 would require an individual 404 permit. The individual 404 permit process can be quite time-consuming and requires the applicant to demonstrate that the proposed project is the most feasible and the least environmentally damaging alternative.
- Section 401 of the CWA requires state agencies to certify that a Section 404 permit will not result in a violation of state water quality standards. Because of the size of the dam rehabilitation project, an individual 401 WQC application will be required which will extend the permitting process. The individual 401 WQC review process may require up to 8 to 12 months to complete.
- Section 106 of the National Historic Preservation Act (NHPA) requires Section 404 permittees to consider the effect of their project on historic properties included in the National Register for Historic Properties. A review of Ohio Historic Preservation Office's cultural resources database would need to be conducted to assess whether the project has the potential to cause effects to historic properties. If present, mitigation measures may be required to address project impacts.
- Lastly, an Ohio Environmental Protection Agency (OEPA) Stormwater Construction Permit, which authorizes stormwater discharges associated with construction activities, will be required for the project. Obtaining this permit is usually routine.

4.1.6 Wetlands, Threatened & Endangered Species

A desktop evaluation for the presence of wetlands in the Project area was performed using the National Wetland Inventory (NWI) data. The NWI is a nationwide map database of likely wetland areas maintained by the United States Fish and Wildlife Service (USFWS). NWI data suggest no wetlands are present in the Project area. The existing freshwater pond habitat identified in the NWI for the Project area would not be impacted by Alternative 1. The NWI provides a screening level tool to identify potential wetlands. A field level wetland delineation would be required to confirm the information presented in the NWI prior to construction.

A USFWS Information for Planning and Consultation (IPAC) review of the Project area was conducted to evaluate potential impacts to listed species and their critical habitat. The Indiana bat (*Myotis sodalis*), a federally endangered species, and the Northern Long-eared Bat (*Myotis septentrionalis)*, a federally threatened species, could potentially use the project area for foraging above the pond and/or summertime roosting in woody vegetation. Adverse effects to these species are generally avoided through proper project planning (e.g., tree clearing during the winter months).

4.2 ALTERNATIVE 2: DAM REMOVAL

4.2.1 Conceptual Alternative

Alternative 2 involves removal of the dam embankment, dewatering of the existing impoundment, restoration of the stream through the former dam footprint, and constructing new stormwater basins (Figure 2, Appendix B). This alternative would result in a more natural landscape as the valley would be restored to its approximate pre-dam topography. Additionally, there is space to create open water features in the former reservoir footprint. The current conceptual design includes two ponds to be excavated in the former reservoir on each side of the restored channel, both approximately 0.5 acres in area. Two new basins are proposed upstream of the former reservoir footprint for stormwater management and flood risk reduction.

Anticipated actions include embankment excavation, channel and pool excavation, construction of a roughened channel through the footprint of the former dam, and revegetation. The existing emergency spillway could remain in place. Alternatively, the rock could be recycled as part of stream restoration or pond creation, and the spillway filled and abandoned. Removal of the dam and grading of the valley side slopes through the former dam area would require approximately 5,900 yd^3 of excavation. Excavation of the two ponds would require approximately 11,100 yd^3 of earthwork. Except for excavation of the new channel and ponds, upstream sediments within the former reservoir extents would be left in the place unless grading was required to ensure stability of the new stream channels.

Within the former reservoir, full channel re-establishment would be performed, establishing channel pattern and dimensions utilizing a natural channel design approach based on the bankfull, or channel-forming, discharge. The design will be primarily driven by valley slope, existing site development, and the transition of the channel between the basin and stream downstream of the dam. Regional curves suggest a bankfull width of approximately 8 feet for the drainage area above the dam (0.2 mi^2). The bankfull width corresponds to the discharge at which channel maintenance is the most effective for the channel forming discharge.

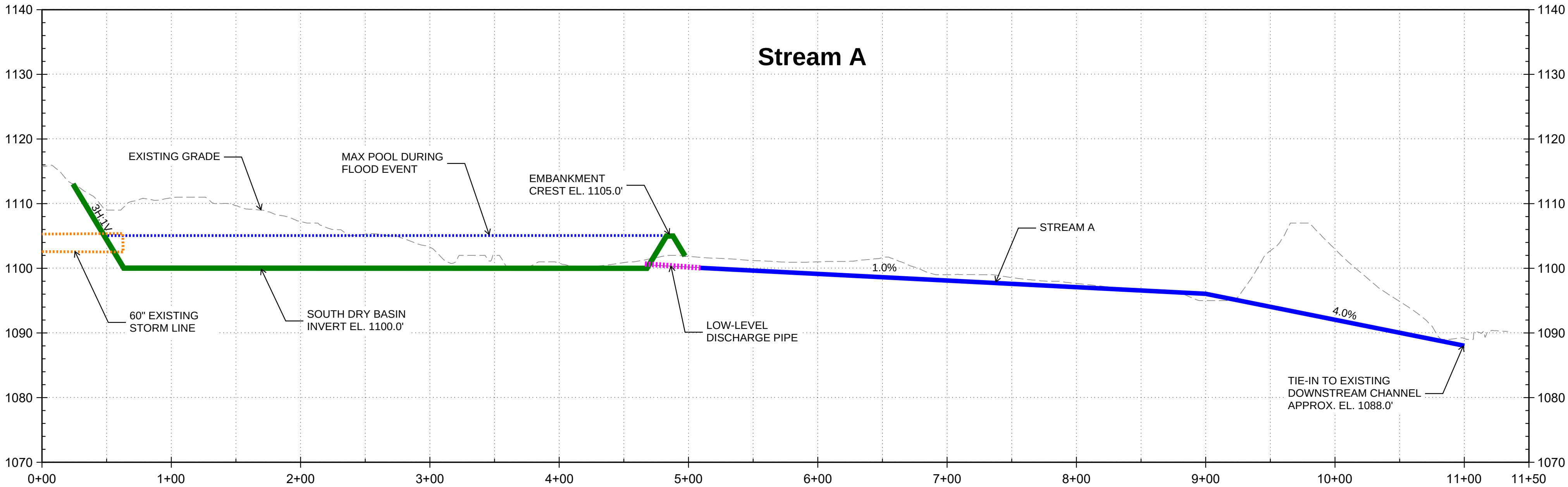
Alternative 2 proposes construction of two dry, in-line, stormwater basins upstream of the to-be-removed reservoir. The basin footprints when full are roughly 0.5 to 1-acre in area. The basins provide flood storage capacity to offset the loss of storage provided by the existing dam, and would remain dry except during storm events, where water would be temporarily stored and slowly released. Stormwater management features such as these basins are necessary to achieve the project design criteria for flood risk reduction. The northern dry basin would be formed by repairing the existing concrete weir forming the small pond upstream of the impoundment and excavating material. The weir would be modified to allow low flows to pass through unimpeded; flow from larger events would be temporarily stored. The southern dry basin would be formed by the construction of an earthen embankment with a low-level outlet pipe sized to reduce peak flows in larger events.

Alternatives to the upstream dry storage basins were considered. The benefit of modifying downstream stormwater features such as Pond 3 was evaluated in the H&H analysis. However, this option provides little benefit to achieve the flood risk reduction goals of the project as it is downstream of the dam.

Diverting existing storm sewers which currently drain into the reservoir was considered. This alternative would be costly to construct the infrastructure and would provide only a minor benefit during larger storm events such as the 100-year flood when flows typically exceed capacity of the storm network and flow overland to the reservoir. The use of one dry storage basin upstream was considered and may be feasible. However, expanding the storage capacity of the north basins will be costly due to the sloping topography as you move west from the basin and significant excavation costs required. The southern dry basin may be expanded, but the concept was sized to minimize the impact to private property due to temporary ponding of water in the basin. Expanding the southern basin may require property owner coordination (i.e., easements).

Profiles for Stream A (main channel) and Stream B (tributary to Stream A) are shown below in Figure 3. Stream A would be a multi-slope channel following the existing valley to minimize the amount of grading. The slope of Stream A would be approximately 1% through the impoundment. The drop through the former dam footprint would result in a steeper slope of approximately 4%. This slope could be accommodated by the construction of a roughened cascade channel with boulder clusters to dissipate energy and provide grade control (see example photo in Figure 2, Appendix B). Re-establishment of Stream B would begin downstream of the existing gravel spillway from Pond 1B. The slope of Stream B would vary from approximately 1% to 2.8% through the impoundment. Basin streams are anticipated to be low to medium sinuosity. Limited in-stream structures, including constructed riffles, woody material, and live branch layering, could be installed in basin streams to enhance aquatic habitat and provide hydraulic variability.

Exposed reservoir sediments and disturbed areas would be seeded and stabilized. A riparian buffer could be planted within 15-20 feet of the re-established channel banks to promote long-term channel stability and water quality. The riparian plantings may consist of herbaceous cover with annual or semi-annual brush hogging maintenance to avoid colonization by woody plants. Riparian herbaceous cover would enhance riparian zone function, bank stability, and aquatic habitat. Pathways or gaps in vegetation could be left to allow for stream access. The remainder of the former lake footprint could be planted with turf grass.



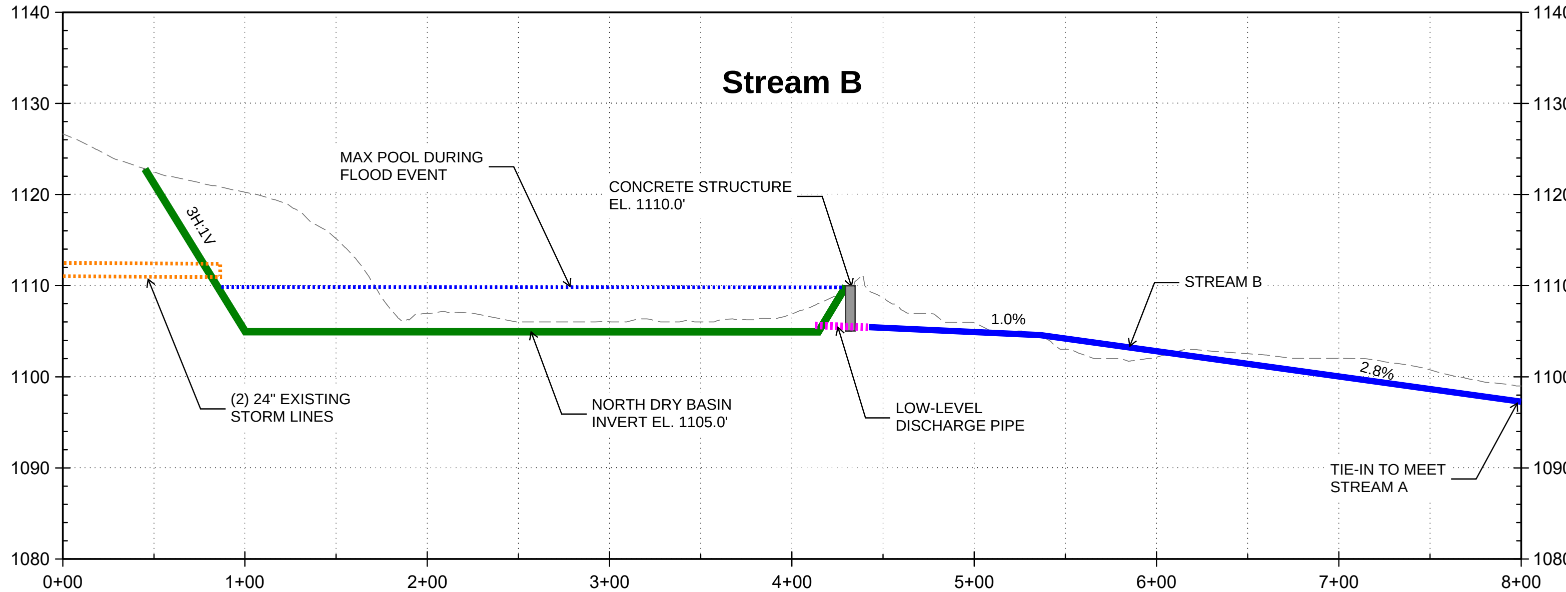


Figure 3. Alternative 2 Stream and Basin Profiles

4.2.2 Design and Analyses

Additional design and analyses will be required to advance the design of Alternative 2. The results of the H&H analysis indicate that the proposed concept does not increase the magnitude or frequency of flooding of habitable structures for the 1-year through 100-year, 24-hour precipitation events. Additional discussion of proposed project H&H model results for Alternative 2 are included in Appendix D.

During detailed design phase, erosion and scour analysis would be necessary to determine the type and extent of the erosion prevention materials that would be needed within the proposed streams and downstream receiving channel. A detailed reservoir regrading plan will need to be developed for the restoration of the natural stream and excavation of the two smaller ponds. A dam embankment regrading plan is necessary for the dam embankment removal, stabilized slopes, and revegetation of the removed and disturbed areas.

4.2.3 Dam Safety Considerations

Full removal of the dam embankment eliminates the ODNR dam safety requirements.

4.2.4 Stormwater Management and Flooding Impacts

Removal of the existing dam will result in loss of the flood storage in the current reservoir footprint. Alternative 2 proposes to achieve the stormwater design criteria for the project through the construction of upstream stormwater management features. To offset the loss of flood storage, stormwater retention will be accomplished with two new in-line dry storage basins. Some stormwater retention and infiltration benefits will be achieved through inundation of the floodplain and ponds which will take the place of the existing reservoir. The floodplain, riparian corridor, and ponds will also provide nutrient reduction benefits. Additional discussion of stormwater impacts due to the proposed alternative are discussed in Appendix D.

Basin 2 and Pond 3, located downstream of the reservoir, currently receive discharges from the spillway structure of the dam (Figure 4). Basin 2 includes the receiving stream downstream of the dam. Following completion of Alternative 2, maintenance and inspection should determine if localized areas of scour and erosion have formed due to removal of the upstream pool. Pond 3, located downstream of Basin 2, may accumulate sediment that would have been previously captured by the reservoir. However, the sediment quantity located within the reservoir today indicates that the sediment load to the system is relatively low. Nonetheless, Pond 3 is the first pond located downstream and could accumulate sediment over time.

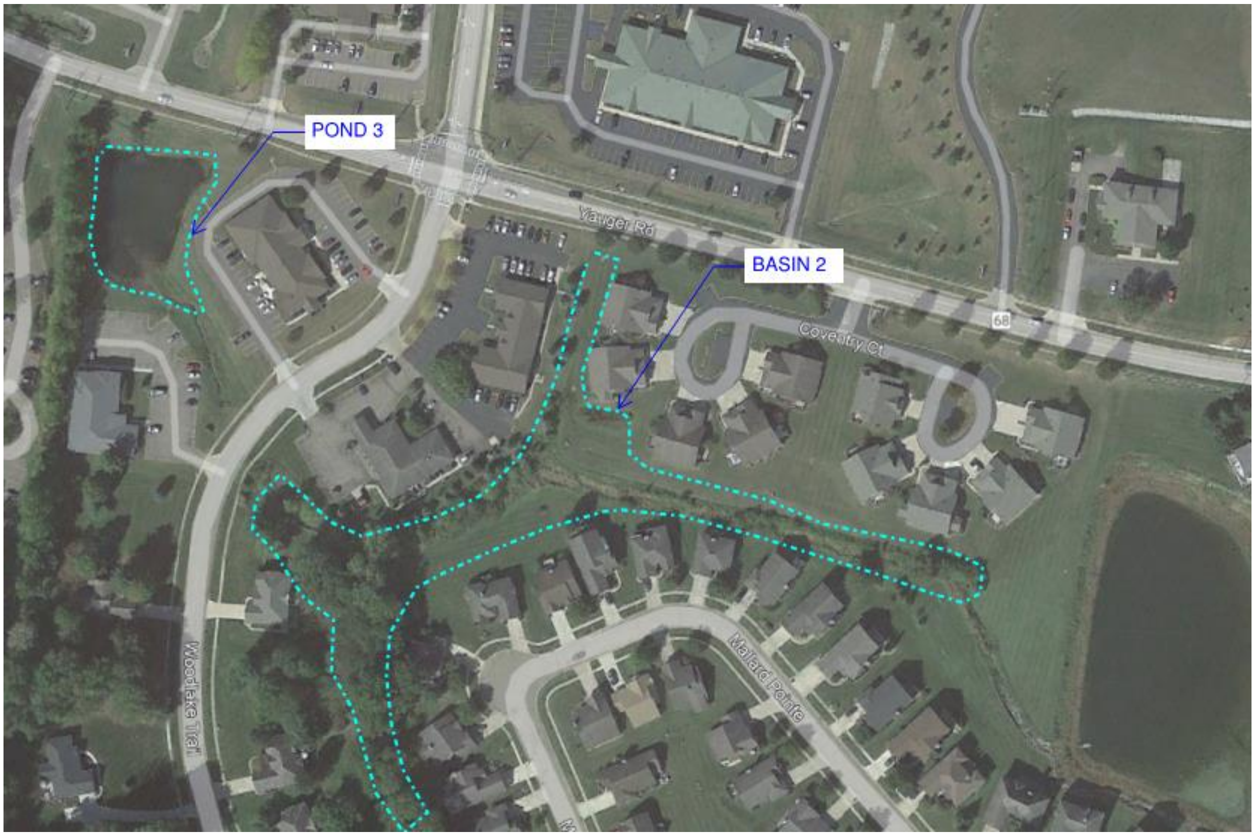


Figure 4. Downstream Stormwater Features

4.2.5 Regulatory Agency Permitting

It is anticipated that Alternative 2 could be permitted under Nationwide Permit (NWP) 27 (Aquatic Habitat Restoration, Enhancement, and Establishment Activities). NWP 27 authorizes activities that result in net increases in aquatic resource functions and services. Re-establishment of the free-flowing channel through the existing reservoir and incorporation of natural design elements (riffles, wood, etc.) would likely qualify as improvements to aquatic resources in the Project area. Native riparian plantings would also increase net environmental benefits for the alternative. As previously stated, the general NWP permitting process is typically quicker than for an individual permit, with an expected timeline of less than six months.

States have the option of placing restrictions on the usage of NWPs. In Ohio, this authority is administered by Ohio EPA. OEPA has placed significant limits on the use of the general NWPs for impacts to high quality streams. The stream in the project area is designated as a “Yellow” stream, signifying that the stream is possibly eligible for water quality certification under NWPs. Further communication with OEPA will be necessary to determine if the project is eligible for authorization under a NWP.

Other permitting requirements for this alternative, such as Section 106 consultation and OEPA Stormwater Construction Permit, will be the same as those for Alternative 1. See Section 3.1.6.

4.2.6 Wetlands, Threatened & Endangered Species

These considerations are functionally the same as Alternative 1. Please refer to section 4.1.6.

4.3 ALTERNATIVE 3: DAM MODIFICATION / LOWERING

4.3.1 Conceptual Alternative

Two variations of Alternative 3 are presented.

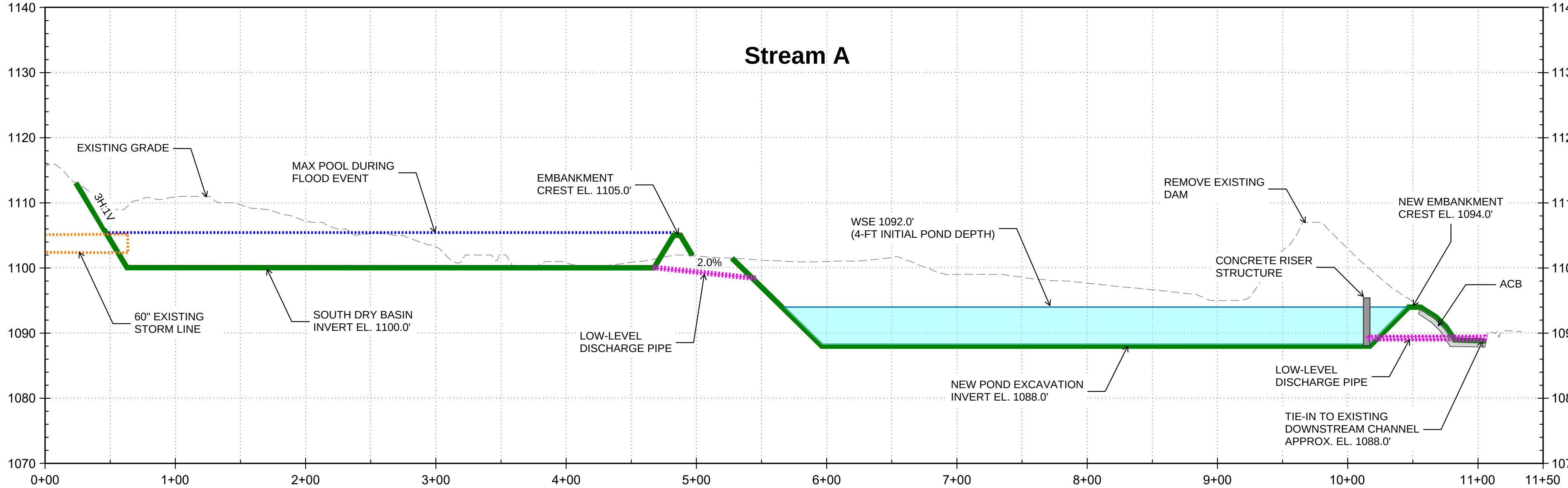
4.3.1.1 Conceptual Alternative 3A

Alternative 3A involves lowering the height of the dam to under six feet to reduce dam safety risk and remove the structure from the ODNR jurisdiction. The alternative proposes to establish a new permanent pond upstream of the modified dam. The current crest elevation of the embankment would be lowered from 1108’ to approximately 1094’, such that the new dam crest is six feet, or less, above the channel invert below the dam (1088’). The modified embankment would have a crest width of 15 feet with the upstream face of the embankment graded to a 5:1 slope. Since the new embankment height (1094’) is lower than the existing reservoir bottom elevation (1094.8’), modification of the dam would result in loss of the upstream pool. A new pond would need to be excavated which would be approximately 3 acres in area with a permanent pond area of 2 acres and an assumed water depth of 4 feet. A conceptual grading plan is shown in Figure 3 in Appendix B. Excavation of a new pond and modification of the dam would require approximately 41,100 CY of earthwork, more substantial than Alternative 2, and drives much of the cost for this alternative.

To offset the loss of flood storage due to dam modification, Alternative 3A proposes construction of two dry, in-line storage basins upstream of the former reservoir. This approach is similar to the approach described in Alternative 2. The profile of the proposed pond and dry basins can be seen in the diagrams in Figure 5. The configuration in Alternative 2 was developed with consideration for other dry-basin geometries and storm sewer diversions as described in Section 4.2.1. There are numerous configurations which vary the shape and geometry of the north and south dry basins and various options to revise the footprint of the permanent pond shown in 3A. Ultimately, earthwork will be required to create the flood storage. The amount of earthwork is expected to be similar between each of the possible configurations. Other considerations for 3A are that the depth of the permanent pond may be increased from the 4-feet shown, but at additional cost for excavation.

This alternative would allow for minor opportunities for stream re-establishment in the transition from the existing headwaters of the channels to the new pool. A floodplain depression would be graded to allow for inlet channel development above the pool for Stream A and B (Figure 3, Appendix B). Re-establishment of Stream B would begin downstream of the existing gravel spillway from Pond 1B. This alternative would also allow for the potential development of fringe wetlands along the perimeter of the new reservoir because of the elevated water table resulting from the modified dam. Fringe wetland development could be supported through native plantings.

It is expected that, over time, sedimentation will occur and impact the depth and storage capacity of the new reservoir. Recurring dredging of reservoir sediment may need to be incorporated into the long-term maintenance plan to maintain a functioning pool. Dredging frequency should be determined based on observed sedimentation rates. Based on current sediment depths measured in the reservoir, sediment load to the reservoir appears to be low. Maintenance dredging may be needed roughly every 25 years.



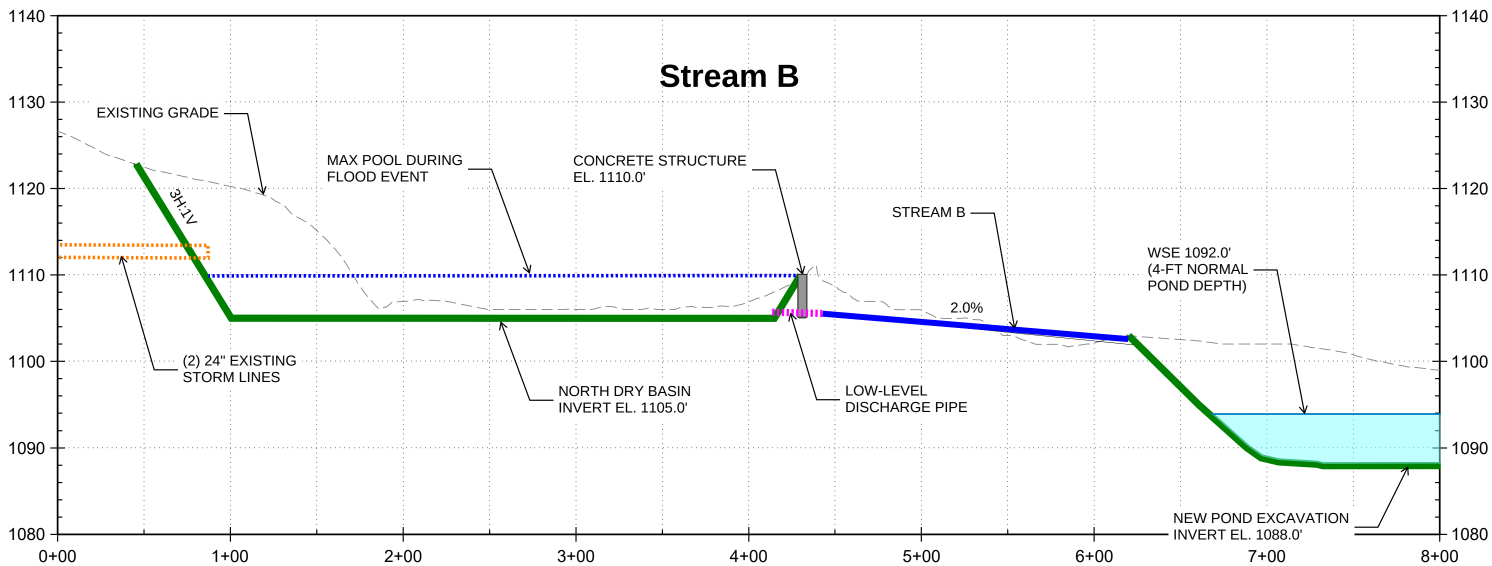


Figure 5. Alternative 3A Stream and Basin Profiles

4.3.1.2 Conceptual Alternative 3B

Alternative 3B provides another option to manage stormwater flows while reducing the risk associated with the current dam. Alternative 3B proposes excavation of a single dry, in-line storage basin in the former reservoir footprint. The dry basin would be constructed similar in size to Alternative 3A (approximately 3 acres of grading) but would remain dry due to the installation of a low-level outlet pipe to keep normal flows moving through the basin. During larger storm events, outflows would be restricted through the structure, storing floodwater and reducing downstream flow rates. The existing small pond upstream of the main reservoir (~0.3 acres) would be retained with modifications to the existing concrete weir structure.

Alternative 3B should not require the construction of additional stormwater basins upstream as shown in Alternatives 2A and 3A because the stormwater storage is achieved with the construction of the dry basin. The cost savings of this Alternative (versus 3A) is attributable to the substantial reduction in necessary earthwork. A conceptual profile of this configuration is shown in Figure 6.

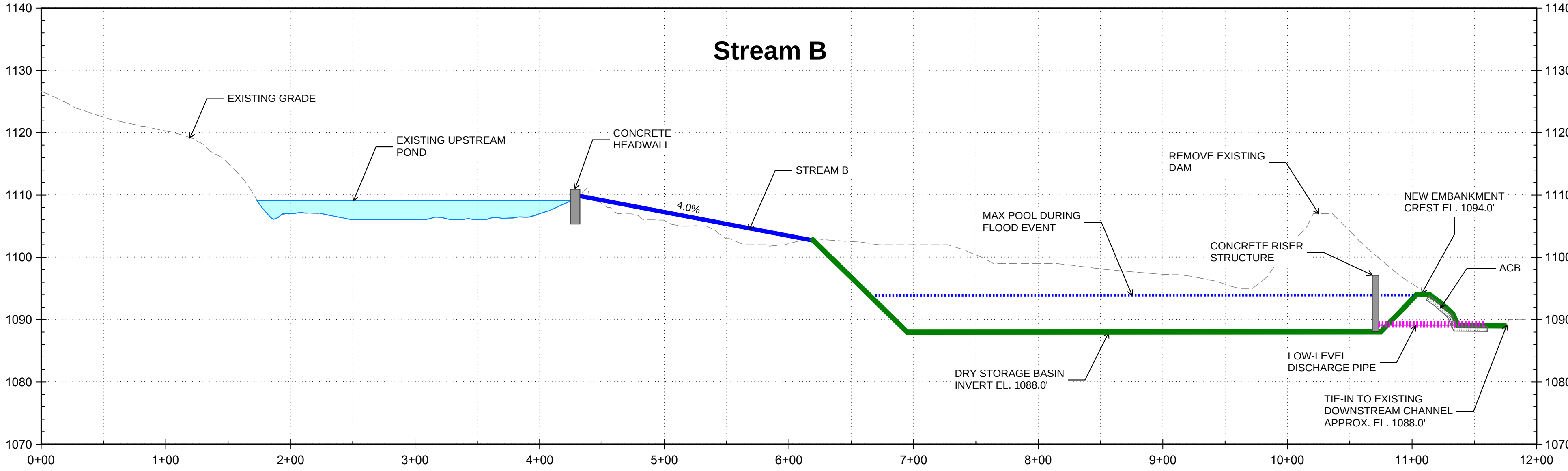


Figure 6. Alternative 3B Stream and Basin Profile

4.3.2 Design and Analyses

Additional design and analyses will be required to advance the design of Alternative 3A or 3B. Erosion and scour analysis is necessary to determine the type and extent of erosion prevention materials such as riprap. A detailed grading plan is also recommended. Inlet channels will be designed using natural channel design principles to enhance function of the aquatic ecosystem and promote channel stability. A detailed dam embankment regrading plan is necessary for the lowering of the dam embankment, stabilized slopes, and revegetation of the disturbed areas.

4.3.3 Dam Safety Considerations

Reducing the dam height to 6 feet and a storage capacity of less than 50 acre-feet changes the ODNR dam classification from a Class I dam to a Class IV dam. Dams that are 6 feet or less in height, regardless of total storage, are exempt from the Ohio Revised Code (ORC) Section 1506.062 safety rules. However, the impoundment still has potential to cause damage to downstream infrastructure should an overtopping event occur, with the dam owner potentially liable for those damages.

4.3.4 Stormwater Management and Flooding Impacts

The stormwater management / flood control value of Alternatives 3A and 3B is limited by the maximum height of the new embankment and the desire to maintain a permanent pool of water during baseflow conditions (Alternative 3A). The proposed system maintains a similar freeboard height as the existing pond but will have a smaller surface area (approximately 2 acres, or 450 x 250 feet). An outlet control structure is proposed for both Alternatives 3A and 3B. The results of the H&H analysis indicate the embankment will overtop during larger events, and overtopping protection will be required on the downstream face of the embankment. Options that may be considered for overtopping protection are riprap or articulated concrete blocks.

Alternative 3A will provide the stormwater management function through the construction of upstream dry-storage basins. Alternative 3B provides stormwater management through use of a dry-storage basin in the former reservoir footprint. Additional details of the H&H modeling results and flood impacts are included in Appendix D.

The impact to the sediment transport function of Basin 2 and Pond 3 resulting from Alternative 3A or 3B is likely less than Alternative 2. By maintaining a significant reservoir upstream of the remaining embankment, the sediment accumulating function of the reservoir would likely be comparable to its current function. Therefore, significant change in sediment accumulation downstream of the reservoir is unlikely.

4.3.5 Regulatory Agency Permitting

As is the case with Alternative 1, Alternatives 3A and 3B would likely not qualify under a general NWP and, therefore, would require an individual 404 and 401 WQC permit application. This would prolong the project implementation timeline. See section 4.1.5.

4.3.6 Wetlands, Threatened & Endangered Species

These considerations are functionally the same as previous alternatives in regard to wetlands. Please refer to section 4.1.6. As described above for Alternative 2 in 4.2.6, Alternative 3 would also allow for the potential development of fringe wetlands at the edge of the new reservoir because of the elevated water table.

Potential adverse effects to the Indiana bat (*Myotis sodalis*), a federally endangered species, and the Northern Long-eared Bat (*Myotis septentrionalis)* could be avoided through removal of any trees during the winter months.

5.0 COMPARISON OF ALTERNATIVES

OPCC have been developed for each alternative. The OPCC is based on conceptual level planning and should be considered accurate to within +/-30%. Construction costs include a 25% or 30% estimate for field survey, design services, permitting and construction administration services. An estimate of the long-term O&M costs for each alternative is included below. Maintaining the dam as described in Alternative 1 will require annual and periodic O&M activities. The primary contributor to O&M costs for Alternatives 2, 3A and 3B is mowing and vegetation management. Detailed line-item costs for each alternative are attached in Appendix C. These costs are based on historic unit rate bids for similar types of projects. However, ongoing global supply chain issues, increased commodity prices, and inflation could have significant impacts on these OPCCs. Nevertheless, the estimates can be used as a basis for comparing the cost of alternatives.

5.1 OPINION OF PROBABLE CONSTRUCTION COSTS

Table 3 – Alternative OPCC

Alternative	Description	Total Capital Cost
1	*Repair and Rehabilitate Dam, Maintain Pond*	$ 2,560,000
2	*Remove Dam, Construct Smaller Ponds and Upstream Dry Basins*	$ 1,390,000
3A	*Modify Dam, Construct Permanent Pond, and Upstream Dry Basins*	$ 2,120,000
3B	*Modify Dam, Construct Dry Basin*	$ 1,610,000

5.2 LONG-TERM OPERATION AND MAINTENANCE COSTS

Table 4 – O&M Costs

Alternative	Description	Annualized Operations & Maintenance Cost
1	*Repair and Rehabilitate Dam, Maintain Pond*	$ 36,500
2	*Remove Dam, Construct Smaller Ponds and Upstream Dry Basins*	$ 38,500
3A	*Modify Dam, Construct Permanent Pond, and Upstream Dry Basins*	$ 34,200
3B	*Modify Dam, Construct Dry Basin*	$ 35,700

5.3 CONSTRUCTION SCHEDULE

An estimated construction duration is included below. It is important to note that the current bidding and construction environment has been impacted by labor and supply shortages in recent months. Industry conditions at the time of future construction may significantly impact construction duration.

Table 5 – Construction Duration Estimate

Alternative	Description	Estimated Construction Duration
1	*Repair and Rehabilitate Dam, Maintain Pond*	6 – 9 months
2	*Remove Dam, Construct Smaller Ponds and Upstream Dry Basins*	4 – 6 months
3A	*Modify Dam, Construct Permanent Pond, and Upstream Dry Basins*	4 – 6 months
3B	*Modify Dam, Construct Dry Basin*	4 – 6 months

6.0 CONCLUSIONS/RECOMMENDATIONS

The alternatives presented in this report are intended to address the dam safety concerns associated with the existing structure. However, multiple factors are important to consider in determining the next steps for the dam and reservoir. A matrix has been developed below to qualitatively assess various impacts associated with each alternative. Green, yellow and red cell colors are used to indicate the overall impact to the category noted. Green represents the most advantageous while red is the least advantageous impact for the category noted.

Table 6 – Alterntaives Comparison Matrix

Alternatives Matrix							
	Category						
Alternative	Dam Safety	Downstream Risk	Stormwater & Flooding	Permitting	Aesthetics/ Environment	OPCC	Long Term O&M
1 (Rehab)	Addresses Dam Safety Requirements	Dam remains and potential residual risk downstream remains	Stormwater management, flood risk reduction achieved through rehab and maintaining permanent pond	ODNR Dam Safety, USACE, Ohio EPA permitting may be required	Pool remains for aesthetics, ecological benefits are low relative to Alt. 2	Highest	O&M costs similar to other alternatives, but additional requirements to maintain dam safety related aspects
2 (Removal)	Dam is Removed	Downstream residual risk associated with dam eliminated	Some stormwater management and flood risk reduction function primarily achieved with upstream dry basins	ODNR Dam Safety, USACE, Ohio EPA permitting may be required	Ecological benefits improved. New ponds incorporate aesthetic benefits	Lowest	O&M costs necessary, largely for mowing
3A (Lower, Permanent Pond)	Dam sufficiently lowered and removed from Dam Safety Inventory	Risk reduced, but embankment still present leading to some residual risk	Stormwater management and flood risk reduction primarily achieved with upstream dry basins.	ODNR Dam Safety, USACE, Ohio EPA permitting may be required	Pool remains, however ecological benefits are low relative to Alt. 2	High	O&M costs necessary, largely for mowing
3B (Lower, Dry Basin)	Dam sufficiently lowered and removed from Dam Safety Inventory	Risk reduced, but embankment still present leading to some residual risk	Stormwater Management and flood risk reduction achieved through construction of larger dry basin in former reservoir footprint.	ODNR Dam Safety, USACE, Ohio EPA permitting may be required	No permanent pool, area remains largely mowed lawn outside of small defined channels	Middle	O&M costs necessary, largely for mowing

Appendix A – EXISTING DATA INVENTORY

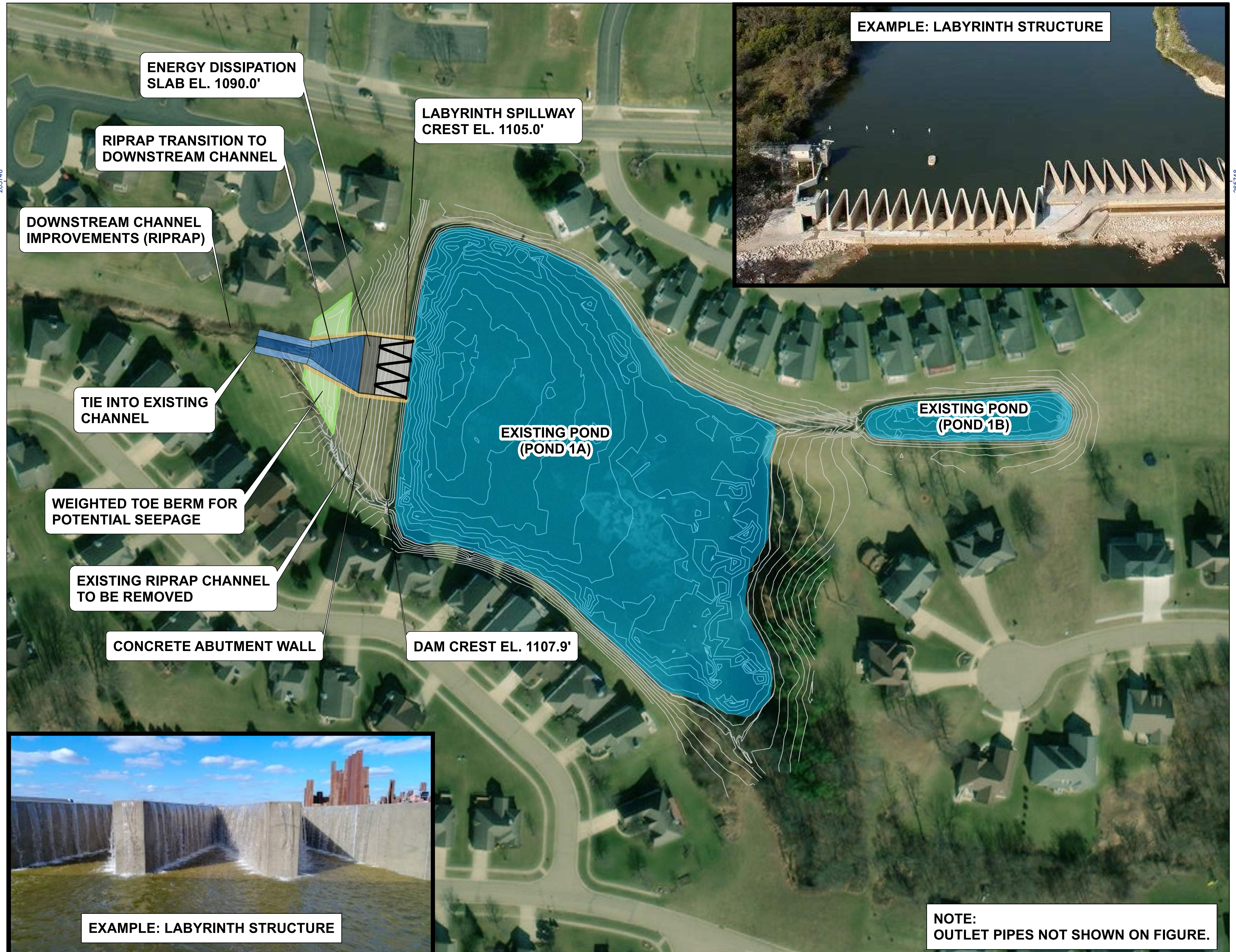
Knox Cattle Co. Dam
Mount Vernon, OH
Existing Data Received

Stantec

12/14/2021

Data	Description	Available (y/n)	Source	Date Collected	Notes
Dam Design and/or Construction Drawings and Reports	*Design or as-built drawings of existing dam or improvements (embankment, outlet structures)*		Original Development Plans	2005	TIF files for the Landing (various phases, plans and profiles)
			Stormwater Design Report - The Landing 08.27.1999	1999	Hydrologic computations for ponds 1, 2 & 3; Appendix C: Computer Basin Routings; Model: HydroCAD 5.11 (hydrographs, elevation-discharge)
			Stormwater Plans & Calculations - Stonewater Apartments	1999	Proposed development stormwater calculations
			Random Files > Sheet 4 of 23 Water Quality Pond Design	2005	PDF with proposed water quality outlet structure
Geotechnical exploration and laboratory information	*Within the vicinity of the embankment and impoundment*		Yauger Road Subsurface Investigation Report	1996	Pavement condition and subsurface investigation for improvements to Yauger Road (pavement condition, boring logs, gradation curves)
Ohio DNR Inspection Reports	*Historic inspection reports from ODNR*		Dam Safety Inspection Report 11-2015	2015	ODNR dam safety inspection report
			knox Cattle Company Dam 2019 Inspection Report Redacted	2019	ODNR dam safety inspection report, site map, inspection checklist with suggested remediation
Ohio DNR communication / recommendations	*Recommendations provided by ODNR related to IRRM and other communication as can be shared*		Dam Safety Inspections: ODNR Letter 5 Aug 2016 and ODNR Letter 24 Aug 2016	2016	Letter provided by ODNR to dam owners about dam inspection
			ODNR Amended Complaint - 4838-0321-8671.2	2020	Letter provided by ODNR to dam owners about not addressing public safety issues; Knox Cattle Company Dam is not compliant with Ohio dam safety laws
Existing Hydrologic Model	*Watershed hydrologic modeling, including dam and impoundment, digital/native file format.*		Reference Files > _Design > _Storm Drainage	2020	(2) HYS files (190565DET000 - Dry Pond 1A.hys and 190565DET000.hys)
			2020-05-27 Stormwater Executive Summary	2020	Project name: The Landings; Model: Hydrology Studio v 3.0.0.14 (hydrographs, stage-storage curve, stage-discharge curve)
Existing Hydraulic Model	*Hydraulic modeling upstream and/or downstream of the existing dam, digital/native file format.*	N			
Topographic Field Survey	*Topgraphic data of the dam and surrounding areas. Topographic information within the watershed that has been collected. Digital format - .dwg, gis, etc.*		Stormwater Map for the Landing Subdivision		PDF with contours, outfalls, storm and sewer
Bathymetric Survey	*Below water topography within the impoundment. Digital Format -.dwg, gis, etc.*		190565CBX000.dwg	2019	DWG with pond sediment elevation points
			Reference Files > _Project Record > _Correspondence Out > Pond Cross Sections	2019	PDF with bathymetric contours based on sediment levels in pond
			Reference Files > _Project Record > _Correspondence Out > 2020-04-03 Updated Pond X-Sec	2020	PDF with updated Pond 1A xs based on 2019 bathymetric survey
Hydraulic Structure Field Survey	*Field survey of stormwater features (culverts, basin inlet/outlet structures, control strucutres, outfall, etc.). Of most import. are those included in the H&H modeling. Digital format - .dwg, gis, etc.*		190565CBX000.dwg	2019	Survey with storm and sewer, ponds, sediment levels in Pond 1, channels, hydraulic structures
Principal Spillway CCTV	*If available, CCTV or photos of existing pipe inspections*	N			
Probable Maximum Flood Analysis	*If available, may have been completed by Ohio DNR. Calculations, assumptions, and modeling*	N			
Parcel Boundaries	*Property boundaries within vicinity of embankment and impoundment. Digital format - .dwg, gis*		knox co gis.dwg		DWG file provided with parcels, street centerlines and ROW
Underground Utility Locations/Information	*Storm, Sanitary, Water, Electric, Fiber, Gas or other underground utility information within the vicinity of the embankment and upstream impoundment. Digital format - .dwg, gis*		190565CBX000.dwg		DWG file provided with existing storm lines and structures
			Additional Yauger Road Storm Documents	varies	PDFs provided showing storm, sanitary, and water lines along and near Yauger Road (68)
Overhead Utility Locations/Information	*Electric, Tele-Com. Infor within the vicinity of embankment and upstream impoundment. - Digital format - .dwg, gis*				
Easements or other property information	*Utility, HOA, or other property restrictions within vicinity of the dam and upstream impoundment.*		Public and Private Stormwater Infrastructure_final_hi_res	2019	PDF map with planned development and HOA subdivisions
Photographs	*Those that may be useful, such as ones that accompany the field survey.*		Photos		General site photos
			Stormwater Designs > Inspections		Inspection photos

Appendix B – CONCEPT FIGURES



Stantec

Legend

- Existing 1-ft Contours
- Extents of Preserved Pond
- Labyrinth Spillway
- Abutment Wall
- Concrete Bottom Slab
- Riprap Channel Bottom
- Riprap Side Slope
- Seepage Toe Berm

N

0 100 200 Feet

Notes
1. Coordinate System: NAD 1983 2011 StatePlane Ohio North FIPS 3401 Ft US
2. Background: Microsoft Virtual Earth BING layer

Project Location
Monroe Township
Knox County, Ohio

Prepared by DMB on 2022-06-28
Reviewed by NMM on 2022-06-28

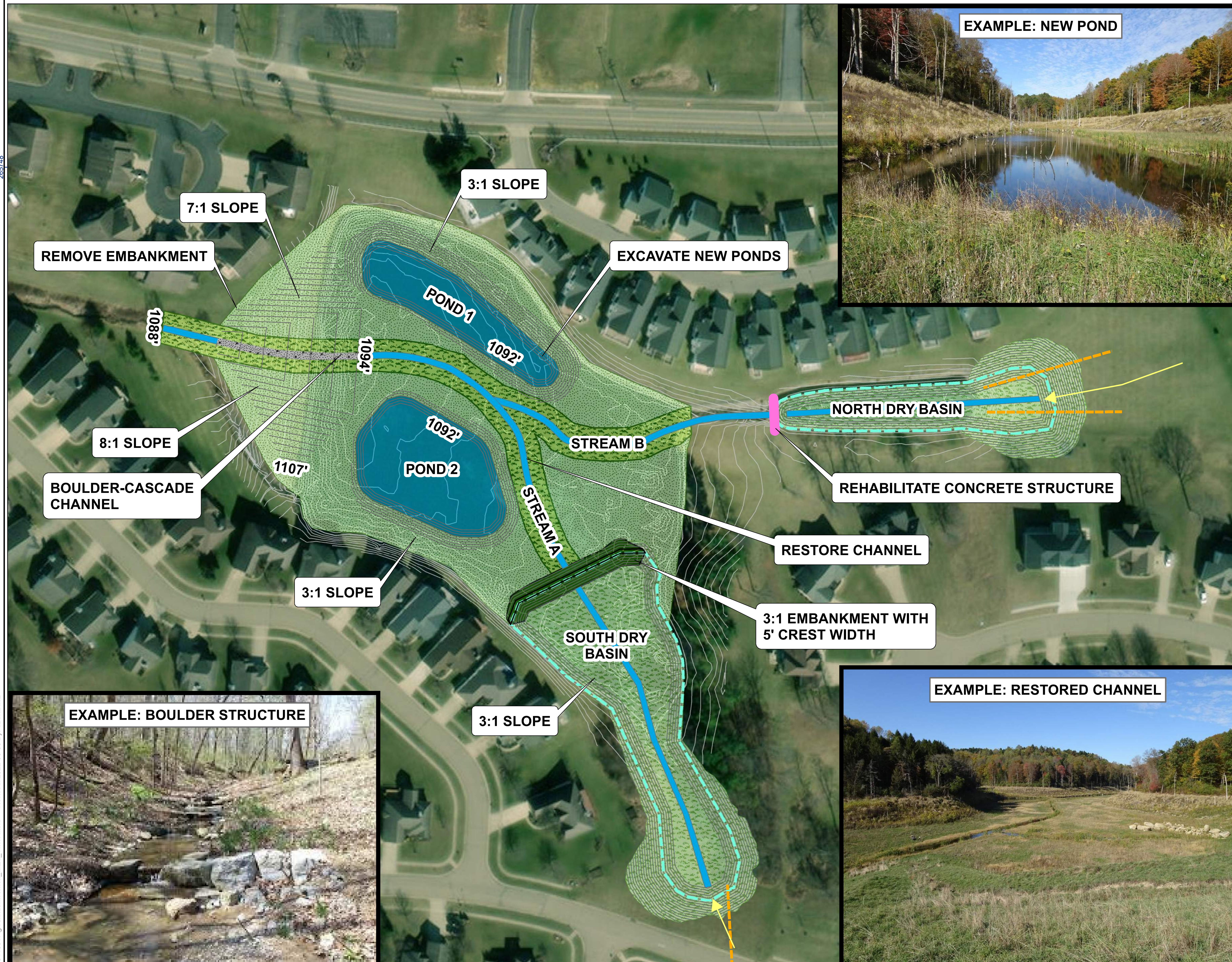
Client/Project
173410617 REVA
Frost Brown Todd LLC
Mount Vernon Dam Study
Knox Cattle Company Dam

Figure No.
1

CONCEPT

Title
Alternative 1

U:\173410617\gis\mxd\mtvernon_alt1_11x17.mxd Revised: 2022-06-30 By: dBolubasz



Stantec

Legend

- Existing 1-ft Contours
- Proposed 1-ft Contours
- Existing Storm Pipe
- Flow Arrow
- Grass
- Riparian Buffer - Native Plantings
- Boulder-Cascade Channel (3%)
- Restored Channel
- Dry Basin
- Embankment
- Pond (4-ft depth)

N

0 100 200 Feet

(At original document size of 11x17)
1:1,500

Notes
1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Background: 2019 Aerial Photography, Hancock County Auditior GIS Data Downloads

Project Location
Monroe Township
Knox County, Ohio

Prepared by DMB on 2022-06-28
Review by NMM on 2022-06-28

Client/Project
173410617 REVA
Frost Brown Todd LLC
Mount Vernon Dam Study
Knox Cattle Company Dam

Figure No.
2
CONCEPT

Title
Alternative 2

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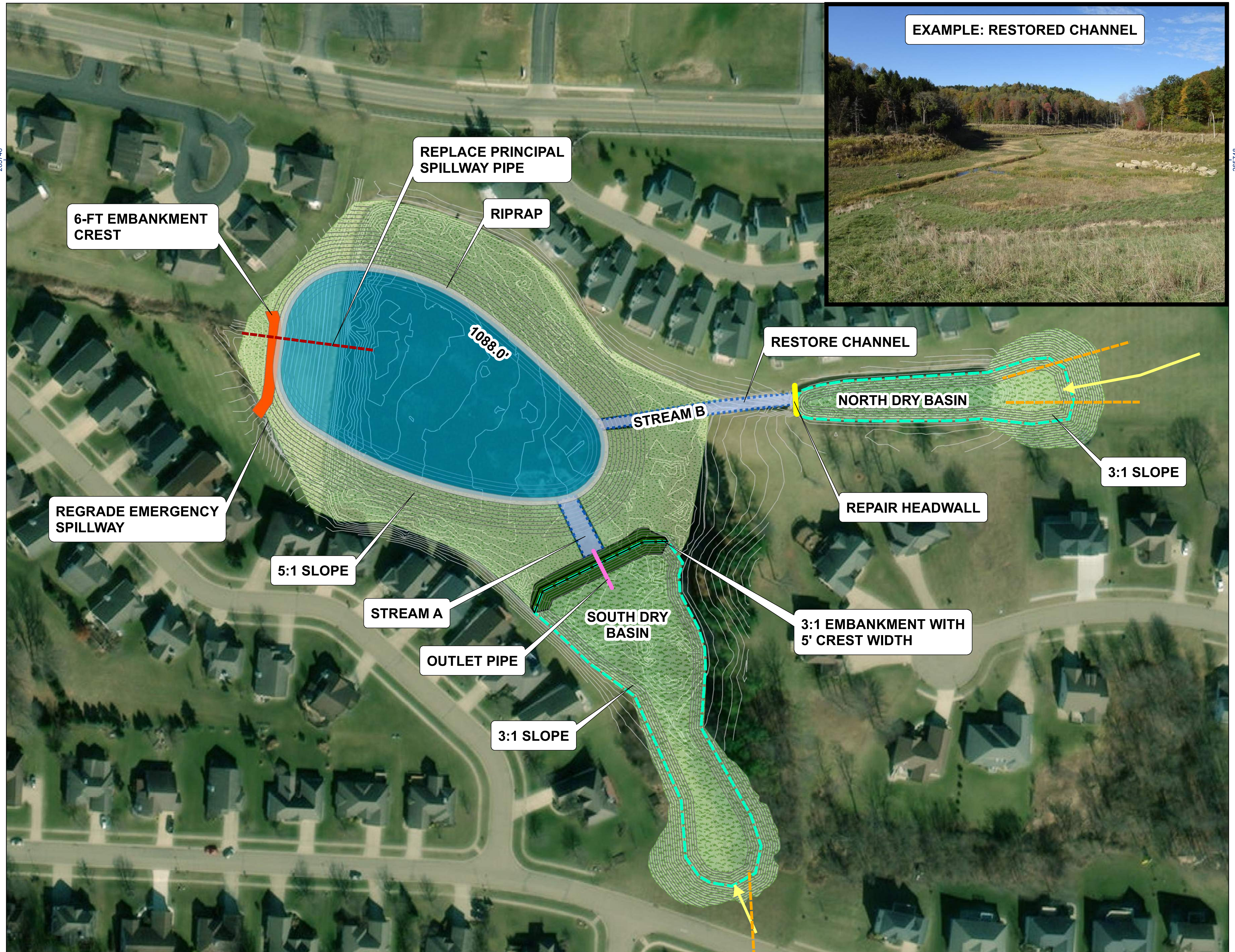

Stantec

Legend

- Existing 1-ft Contours
- Proposed 1-ft Contours
- Existing Storm Pipe
- Flow Arrows
- New Embankment Crest (<6 ft)
- New Upstream Pond (4-ft depth)
- Riprap
- Inlet Channels
- Dry Basin
- Embankment
- Grass

N

0 100 200 Feet

(At original document size of 11x17)
1:1,500

Notes

1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Background: 2019 Aerial Photography, Hancock County Auditior GIS Data Downloads

Project Location
Monroe Township
Knox County, Ohio

Prepared by DMB on 2022-06-28
Review by NMM on 2022-06-28

Client/Project
173410617 REVA
Frost Brown Todd LLC
Mount Vernon Dam Study
Knox Cattle Company Dam

Figure No.
3

CONCEPT

Title
Alternative 3A

U:\173410617\gis\mxd\mtvernon_alt3a_11x17.mxd Revised: 2022-06-30 By: dBolubasz

Stantec

Legend

- Existing 1-ft Contours
- Proposed 1-ft Contours
- Existing Storm Pipe
- Flow Arrows
- New Embankment Crest (<6 ft)
- Pilot Channel
- Grass
- Dry Storage Basin
- Water

N

0 110 220 Feet

(At original document size of 11x17)
1:1,500

Notes
1. Coordinate System: NAD 1983 StatePlane Ohio North FIPS 3401 Feet
2. Background: 2019 Aerial Photography, Hancock County Auditior GIS Data Downloads

Project Location
Monroe Township
Knox County, Ohio

Prepared by DMB on 2022-06-28
Review by NMM on 2022-06-28

Client/Project
173410617 REVA
Frost Brown Todd LLC
Mount Vernon Dam Study
Knox Cattle Company Dam

Figure No.
4
CONCEPT

Title
Alternative 3B

Appendix C – OPCC DERIVATION

Mt. Vernon Dam Study

Alternative 1 - Opinion of Probable Construction Cost (OPCC)

Repair and Rehab Dam, Maintain Pond

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
	CONSTRUCTION ACTIVITIES				
1	Mobilization / Demobilization	1	LS	$166,730	$166,730
2	Temporary Erosion & Sediment Control	1	LS	$20,000	$20,000
3	Clearing and Grubbing	0.2	AC	$15,000	$3,000
4	Dam Embankment Excavation and Grading	2,150	CY	$22	$47,300
5	Dredge Sediment	7,280	CY	$25	$182,000
6	Temporary Diversion / Care of Water	1	LS	$15,000	$15,000
7	Concrete for Labyrinth Spillway	700	CY	$1,350	$945,000
8	Concrete Abutment Walls	210	CY	$1,350	$283,500
9	Low-Level Outlet and Sluice Gate	1	EA	$24,000	$24,000
10	Regrade Emergency Spillway Channel	333	CY	$10	$3,333
11	Riprap (ODOT Type C) in Outlet Channel	100	CY	$150	$15,000
12	Fill Low Areas Along Crest and Rodent Burrows	333	SY	$20	$6,667
13	Filtered Seepage Control Berm	800	CY	$150	$120,000
14	Topsoil and Seeding	1.0	AC	$2,500	$2,500
15	Construction Observation	1	LS	$133,384	$133,384
				Base Construction Cost	**$1,968,000**
				Survey, Design, Permitting, Construction Administration (30% of base cost)	**$590,400**
				Alt 1. Total Construction Cost Estimate (+/- 30%)	**$2,558,400**
	ANNUALIZED OPERATION AND MAINTENANCE COSTS				
1	Periodic Dredging to Maintain Storage Capacity	1	EA	$8,000	$8,000
2	Debris, Vegetation Removal from Spillway Structures	1	LS	$6,000	$6,000
3	Concrete Surface O&M	1	LS	$5,000	$5,000
4	Repair / Fill Rodent Burrows	1	LS	$4,000	$4,000
5	Mowing and Vegetation Trimming	1	LS	$12,800	$12,800
6	Annual Dam Fee (ODNR)	1	LS	$532	$532
				Alt. 1 Total Annual O&M Cost Estimate	**$36,332**

Mt. Vernon Dam Study

Alternative 2 - Opinion of Probable Construction Cost (OPCC)

Remove Dam, Construct Smaller Ponds and Upstream Dry Basins

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
	CONSTRUCTION COST ITEMS				
1	Mobilization / Demobilization	1	LS	$94,008	$94,008
2	Temporary Erosion & Sediment Control	1	LS	$25,000	$25,000
3	Clearing and Grubbing	3.0	AC	$5,000	$15,000
4	Demolition (Utilities, Drains, Spillways)	1	LS	$50,000	$50,000
5	Excavate New Ponds within Former Reservoir	11,100	CY	$22	$244,200
6	North Dry Basin	5,100	CY	$22	$112,200
7	North Dry Basin Outlet Structure	1	LS	$20,000	$20,000
8	South Dry Basin	8,300	CY	$22	$182,600
9	South Dry Basin Embankment and Outlet Structure	1	LS	$25,000	$25,000
10	Dam Embankment Excavation and Placement	5,850	CY	$25	$146,250
11	Natural Channel Excavation and Grading / Channel Stabilization	1,740	LF	$40	$69,600
12	Boulder Cascade Channel	175	LF	$175	$30,625
13	Topsoil and Seeding	5.6	AC	$3,500	$19,600
14	Construction Observation	1	LS	$75,206	$75,206
				Base Construction Cost	**$1,110,000**
				Survey, Design, Permitting, Construction Administration (25% of base cost)	**$277,500**
				Alt. 2 Total Construction Cost Estimate (+/- 30%)	**$1,387,500**

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
	ANNUALIZED OPERATION AND MAINTENANCE COSTS				
1	Mowing and Vegetation Trimming	1	LS	$26,000	$26,000
2	Two Year Stream Maintenance	1	LS	$7,500	$7,500
3	Periodic Dredging of Ponds / Dry Basins	1	EA	$5,000	$5,000
				Alt. 2 Total Annual O&M Cost Estimate	**$38,500**

Mt. Vernon Dam Study

Alternative 3A - Opinion of Probable Construction Cost (OPCC)

Modify Dam, Construct Permanent Pond, and Upstream Dry Basins

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
	CONSTRUCTION COST ITEMS				
1	Mobilization / Demobilization	1	LS	$143,710	$143,710
2	Temporary Erosion & Sediment Control	1	LS	$25,000	$25,000
3	Temporary Diversion / Care of Water	1	LS	$15,000	$15,000
4	Clearing and Grubbing	3.0	AC	$5,000	$15,000
5	Dam Embankment Excavation, Grading of New Pool	41,050	CY	$22	$903,100
6	Concrete Riser Structure	1	LS	$35,000	$35,000
7	North Dry Basin	5,100	CY	$22	$112,200
8	North Dry Basin Outlet Structure	1	LS	$20,000	$20,000
9	South Dry Basin	8,300	CY	$22	$182,600
10	South Dry Basin Embankment and Outlet Structure	1	LS	$25,000	$25,000
11	Grading of Inlet Channels	500	LF	$35	$17,500
12	Replace Principal Spillway Pipe	175	LF	$75	$13,125
13	Rehabilitate Emergency Spillway Outlet Channel	1	LS	$10,000	$10,000
14	Regrade Downstream Receiving Channel	80	SY	$25	$2,000
15	Downstream Embankment ACB Protection	2,250	SF	$11	$23,625
16	Downstream Channel and Pond Riprap Protection	165	CY	$150	$24,750
17	Topsoil and Seeding	4.4	AC	$3,000	$13,200
18	Construction Observation	1	LS	$114,968	$114,968
				Base Construction Cost	**$1,696,000**
				Survey, Design, Permitting, Construction Administration (25% of base cost)	**$424,000**
				Alt. 3 Total Construction Cost Estimate (+/- 30%)	**$2,120,000**

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
	ANNUALIZED OPERATION AND MAINTENANCE COSTS				
1	Periodic Dredging to Maintain Storage Capacity	1	EA	$2,500	$2,500
2	Annual Inspection and Monitoring	1	LS	$2,500	$2,500
3	Debris Removal	1	LS	$3,200	$3,200
4	Mowing and Vegetation Trimming	1	LS	$26,000	$26,000
				Alt. 3 Total Annual O&M Cost Estimate	**$34,200**

Mt. Vernon Dam Study

Alternative 3B - Opinion of Probable Construction Cost (OPCC)

Modify Dam, Construct Dry Basin

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
	CONSTRUCTION COST ITEMS				
1	Mobilization / Demobilization	1	LS	$109,135	$109,135
2	Temporary Erosion & Sediment Control	1	LS	$25,000	$25,000
3	Temporary Diversion / Care of Water	1	LS	$15,000	$15,000
4	Clearing and Grubbing	1.0	AC	$5,000	$5,000
5	Dam Embankment Excavation, Grading of New Dry Storage Basin	41,050	CY	$22	$903,100
6	Concrete Riser Structure	1	LS	$35,000	$35,000
7	Replace Principal Spillway Pipe	175	LF	$75	$13,125
8	Repair Concrete Headwall	1	LS	$15,000	$15,000
9	Grading of Inlet Channels	500	LF	$35	$17,500
10	Rehabilitate Emergency Spillway Outlet Channel	1	LS	$10,000	$10,000
11	Downstream Embankment ACB Protection	2,250	SF	$11	$23,625
12	Regrade Downstream Receiving Channel	80	SY	$25	$2,000
13	Downstream Channel Riprap Protection	80	CY	$150	$12,000
14	Topsoil and Seeding	5.0	AC	$3,000	$15,000
15	Construction Observation	1	LS	$87,308	$87,308
				Base Construction Cost	**$1,288,000**
				Survey, Design, Permitting, Construction Administration (25% of base cost)	**$322,000**
				Alt. 3 Total Construction Cost Estimate (+/- 30%)	**$1,610,000**

Item #	Description	Quantity	Unit	Unit Cost	Total Cost
	ANNUALIZED OPERATION AND MAINTENANCE COSTS				
1	Periodic Dredging to Maintain Storage Capacity	1	EA	$4,000	$4,000
2	Annual Inspection and Monitoring	1	LS	$2,500	$2,500
3	Debris Removal	1	LS	$3,200	$3,200
4	Mowing and Vegetation Trimming	1	LS	$26,000	$26,000
				Alt. 3 Total Annual O&M Cost Estimate	**$35,700**

Appendix D – H&H TECHNICAL MEMO

Stantec

Memo

To:	Stephen P. Samuels Frost Brown Todd LLC	From:	David Hayson Stantec Consulting Services Inc.
File:	173410617	Date:	July 14, 2022

Reference: Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio

INTRODUCTION / BACKGROUND

Stantec Consulting Services Inc. (Stantec) was contracted by Frost Brown Todd LLC (Client) to provide professional engineering services related to the Knox Cattle Company Dam (Dam), including a hydrologic and hydraulic (H&H) analysis of the local watershed. This technical memorandum provides a summary of the tasks related to the H&H study, including:

- Development of a PCSWMM model,
- Existing conditions modeling analysis, and
- Alternatives analysis and results.

The Dam is located in Knox County, Ohio to the east of downtown Mount Vernon and is surrounded by residential and commercial development.

According to the Ohio Department of Natural Resources (ODNR) Dam Inventory Sheet, the existing Dam is an earthen embankment that is approximately 20-feet tall and 375-feet long with a top crest width of 15 feet. The Dam has a drainage area of approximately 0.15 square miles, creates a permanent pool impounding approximately 4.5 acres of water at its crest, and has a normal pool elevation slightly below the emergency spillway elevation. Figure 1 shows a general arrangement of the Dam features.

Reference: Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio

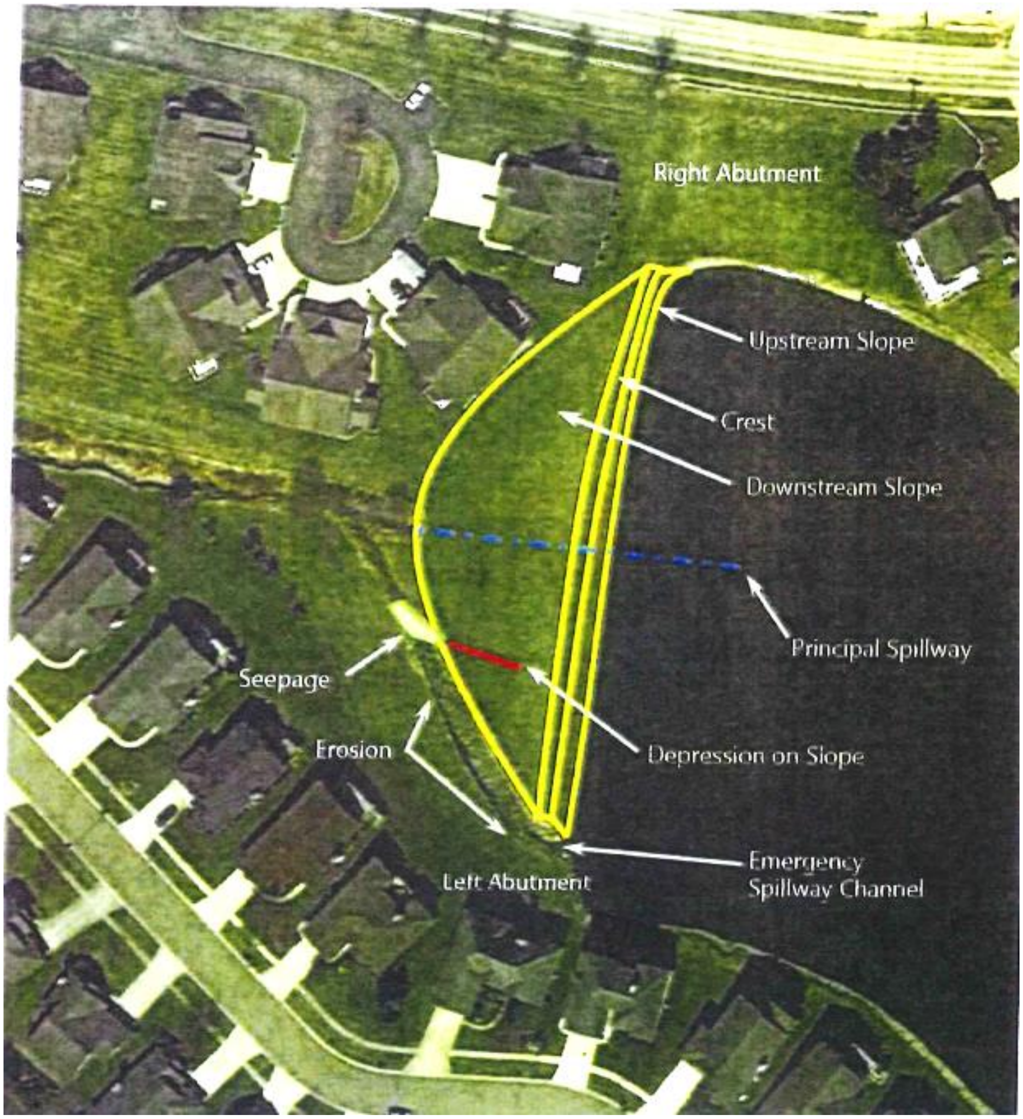

Figure 1 – Existing Dam Features Source: ODNR Dam Safety Inspection report Nov. 25, 2019

EXISTING DATA / MODEL DEVELOPMENT

Stantec received existing data in electronic format from The Kleingers Group (Kleingers). The data provided included AutoCAD Civil 3D TIN surfaces of the existing dam embankment, impoundment bathymetry, and topographic information of local stormwater basins. Other data provided included delineated drainage areas, parcel information, stormwater features, H&H modeling files in a proprietary software (Hydrology Studio), and the associated drainage study report dated May 2020. The Client requested that Stantec develop a new stormwater model for the Dam and surrounding watershed based on existing conditions. Stantec built the hydrologic and hydraulic model in Personal Computer Stormwater Management Model (PCSWMM), Version 7.4 (Reference 1), using the data provided, and publicly available information.

HYDROLOGY

Watershed Delineation

The studied watershed area is based on the same spatial extents and outfall location previously modeled by Kleingers. The drainage areas include the contributing watershed of the Dam, and the subbasins downstream of the Dam draining to a point near the intersection of Yauger Road and Woodlake Trail.

Sub-watersheds were delineated using a 2.5-foot Digital Elevation Model (DEM) created by the Ohio Geographically Referenced Information Program (OGRIP) (Reference 2). The DEM was derived from Light Detection and Ranging (LiDAR) data collected in 2007 by OGRIP. Digital storm sewer information provided by the Client was used in addition to the DEM in order to refine the sub-watershed delineations in instances where conveyance pipes crossed a sub-watershed divide. Figure 2 shows an overview of the watershed delineations and Table 1 details the area in acres of each sub-watershed.

Table 1 – Sub-Watershed Areas

Sub-Watershed Name	Area (Acres)
Basin_1	6.43
Basin_2	6.60
Basin_3	1.06
Basin_4	23.23
Basin_5	3.41
Basin_6	36.99
Basin_7	24.77
Basin_9	6.13
Basin_10	22.41
Basin_11	32.53
Basin_12	5.10
Basin_13	19.12
Basin_14	2.91
Basin_15	30.31
Basin_16	8.20
Basin_17	11.13
Basin_18	14.69
Basin_19	25.50
Total	**280.52**

1981623 1984904

265748 265748

1981623 1984904

Stantec

Legend

Sub-Watersheds

Ponds

Terrain Elev. (NAVD88)

Value

High : 1210.19

Low : 1029.05

N

0 300 600 Feet

(At original document size of 11x17)
1:6,000

Notes

1. Coordinate System: NAD 1983 2011 StatePlane Ohio North FIPS 3401 Ft US

2. Background: Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Project Location
Mt Vernon
Knox County, Ohio

Prepared by DTH on 2022-05-20
Review by NMM on 2022-05-22

Client/Project 173410617 REVA
Frost Brown Todd LLC
Mt. Vernon Dam Study
Knox Cattle Company Dam

Figure No.
2 DRAFT

Title
Watershed Delineation - Subwatersheds

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Precipitation Data

Precipitation data were used as inputs for the PCSWMM models. Rainfall depths were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 2, Version 3 through the NOAA Precipitation Frequency Data Server (PFDS) (NOAA, 2006) (Reference 3). Precipitation depths obtained from the PFDS are listed in Table 2. The point rainfalls were used as reported from the PFDS. No areal reduction factor was applied in the analysis due to the relatively small watershed area. The Soil Conservation Service (SCS), Type II rainfall distribution was used as the temporal distribution for these events.

Table 2 – Point Rainfall Data

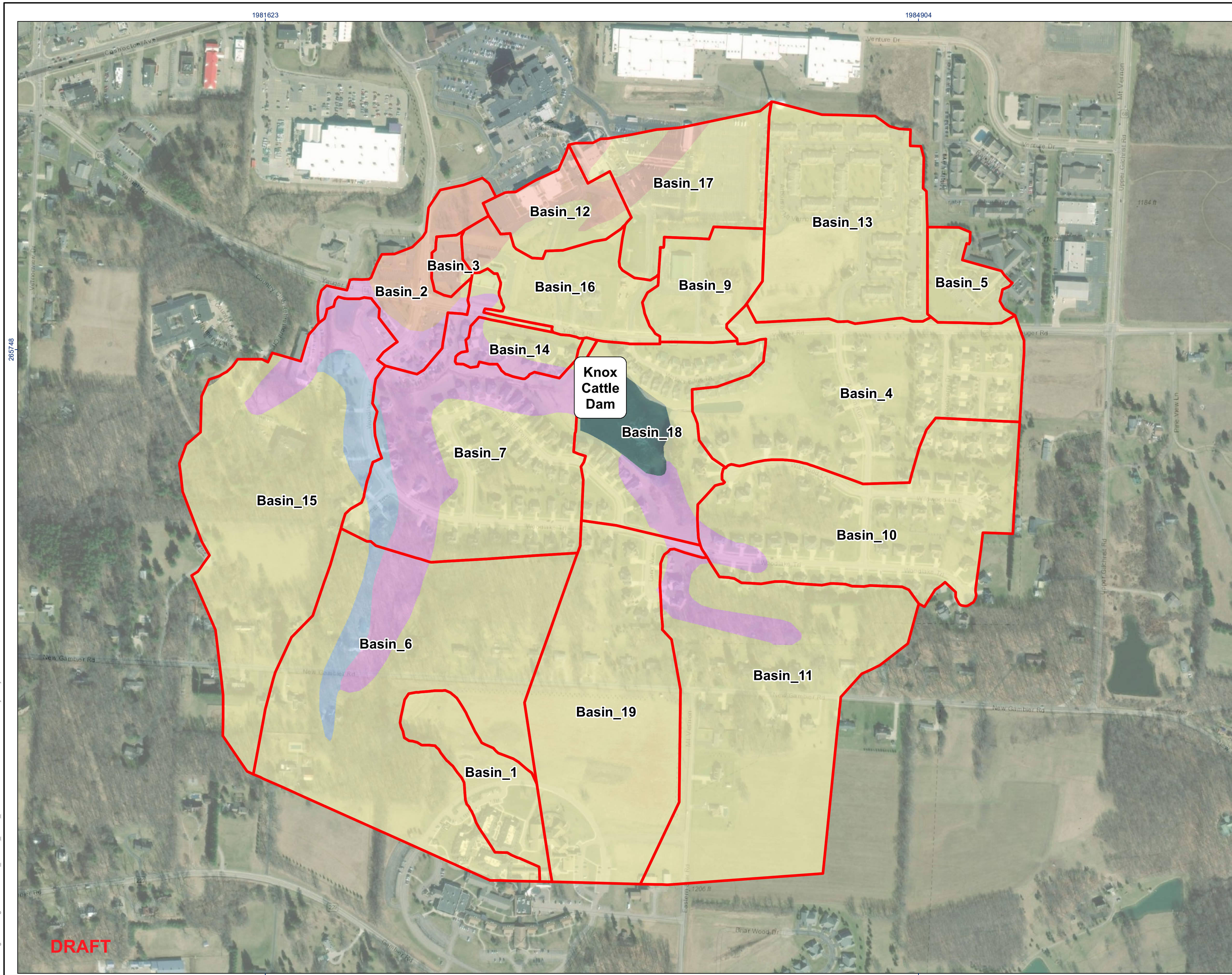
Average Annual Recurrence Interval	Depth (Inches)
1-Year, 24-Hour	2.18
2-Year, 24-Hour	2.61
5-Year, 24-Hour	3.23
10-Year, 24-Hour	3.73
25-Year, 24-Hour	4.44
50-Year, 24-Hour	5.03
100-Year, 24-Hour	5.66

Precipitation Loss / Infiltration Methodology

The Curve Number infiltration method was used in the PCSWMM model. This methodology is based on the National Resources Conservation Service (NRCS) Curve Number Method for evaluating rainfall excess (NRCS, 1986) (Reference 4). The SWMM model uses a modified form of the method, accounting only for the infiltration portion of the Curve Number Method, with other abstractions, such as depression storage, accounted for separately.

The Curve Numbers calculated for the model were based on local soil information from the Soil Survey Geographic (SSURGO) database (Reference 5) and land use information from the National Land Cover Data (NLCD) dataset (Reference 6). Recent aerial imagery from Google Earth (Reference 7) was utilized to visually adjust the land use types, as necessary. For example, the area near the Knox Community hospital was shown as “Developed, Open Space” in the NLCD dataset. However, additional development has occurred since the NLCD information was established. These areas near the hospital were manually adjusted and assigned land use values applicable to “Developed, High Intensity” because the land use is now predominantly impervious surface.

Hydrologic soil group information for the study area is presented in Figure 3 and land use information is shown in Figure 4.



Stantec

Legend

Hydrologic Soil Group

- B
- B/D
- C
- C/D
- D
- Sub-Watersheds

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(At original document size of 11x17)
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Notes
1. Coordinate System: NAD 1983 2011 StatePlane Ohio North FIPS 3401 Ft US
2. Background: Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community

Project Location
Mt Vernon
Knox County, Ohio

Prepared by DTH on 2022-05-20
Review by NMM on 2022-05-22

Client/Project
173410617 REVA
Frost Brown Todd LLC
Mt. Vernon Dam Study
Knox Cattle Company Dam

Figure No.
3

DRAFT

Title
Hydrologic Study - Soils

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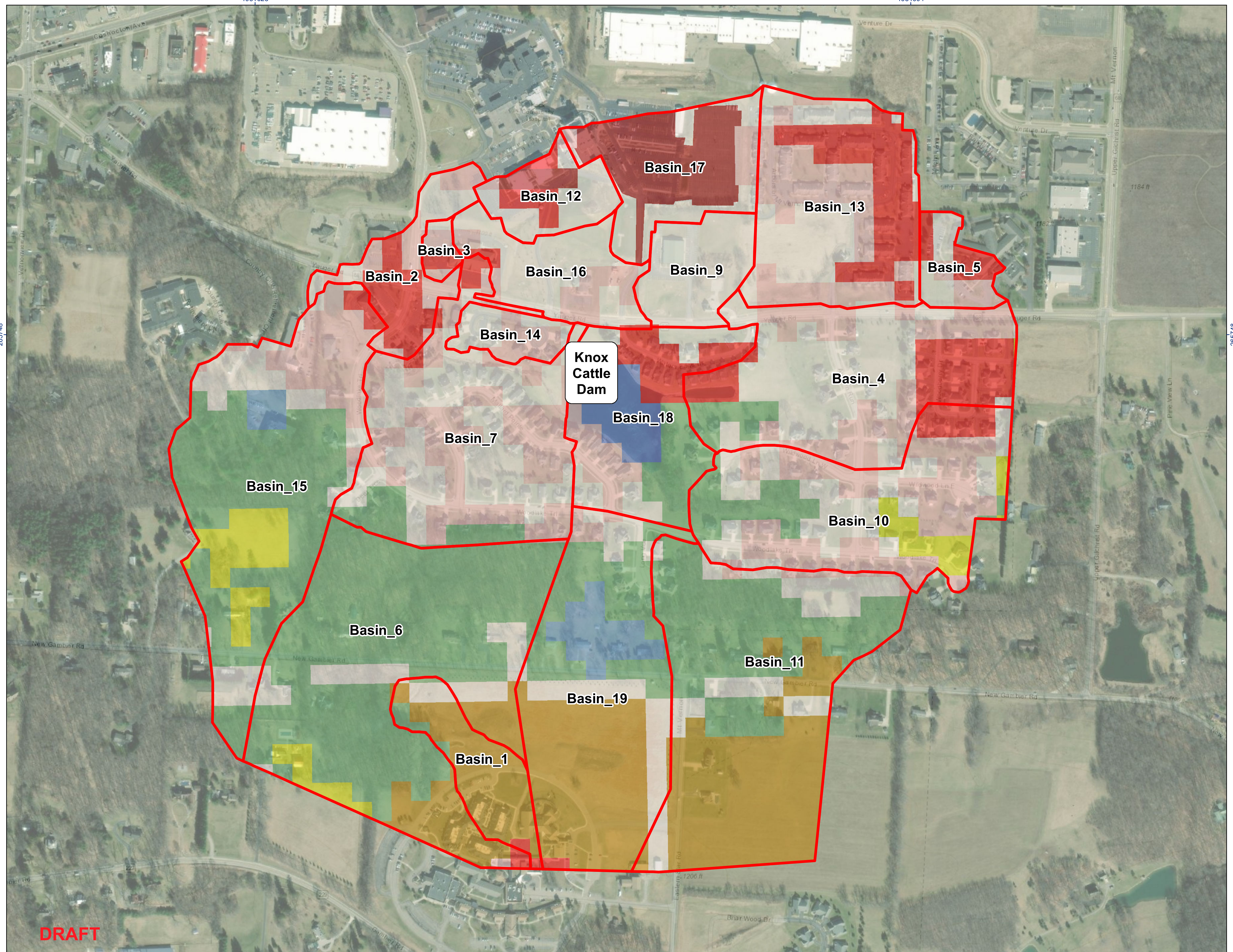

Stantec

Legend

- Cultivated Crops
- Deciduous Forest
- Developed, High Intensity
- Developed, Med. Intensity
- Developed, Low Intensity
- Developed, Open Space
- Evergreen Forest
- Grassland/Herbaceous
- Mixed Forest
- Open Water
- Pasture/Hay
- Shrub/Scrub
- Sub-Watersheds

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0 300 600 Feet

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Notes

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Prepared by DTH on 2022-05-20
Review by NMM on 2022-05-22

Client/Project 173410617 REVA
Frost Brown Todd LLC
Mt. Vernon Dam Study
Knox Cattle Company Dam

Figure No.
4 DRAFT

Title
Hydrologic Study - Land Use

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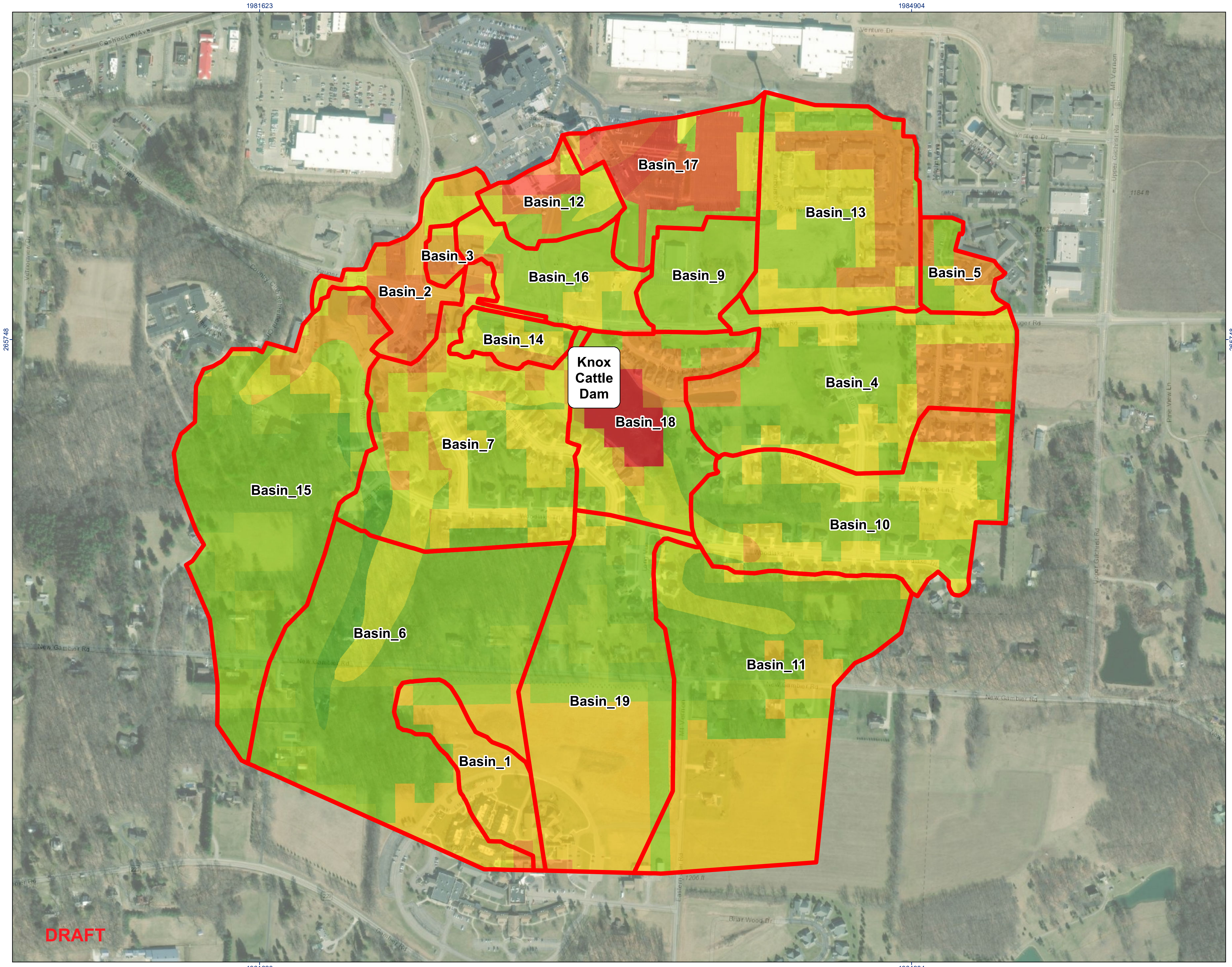
Reference: Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio

Published values in Tables 2-2a through 2-2d found in Technical Release – 55: Urban Hydrology for Small Watersheds (TR-55) (Reference 4) were used to assign curve numbers to the watershed based on the SSURGO hydrologic soil group information and land use information from the NLCD dataset. Table 3 lists the curve numbers used in the study. When the hydrologic soil group was listed as “B/D” or “C/D”, the soil was assumed to be soil group “D” due to absence of more detailed soil testing or drainage improvements information. Figure 5 shows the curve numbers when the soil and land use information are combined.

A composite curve number was derived using area weighted values for each sub-watershed. Area-weighted composite curve numbers for each sub-watershed are shown below in Table 4. Composite curve numbers for the sub-watersheds ranged between 75 and 89. Percent impervious values were set to zero for each subbasin in PCSWMM. Percent impervious values were assumed to be accounted for by the NLCD information.

Table 3 – Study Curve Numbers

Grid Code	Land Cover	Curve Number				Condition
		HSG A	HSG B	HSG C	HSG D	
11	Open Water	99	99	99	99	Water
21	Developed, Open Space	49	69	79	84	Open space, fair
22	Developed, Low Intensity	61	75	83	87	1/4 acre residential
23	Developed, Medium Intensity	77	85	90	92	1/8 acre residential
24	Developed, High Intensity	89	92	94	95	Business urban districts
31	Barren Land	77	86	91	94	Bare soil
41	Deciduous Forest	36	60	73	79	Woods, fair
42	Evergreen Forest	36	60	73	79	Woods, fair
43	Mixed Forest	36	60	73	79	Woods, fair
71	Herbaceous		71	81	89	Herbaceous, fair
81	Hay/Pasture	49	69	79	84	Pasture, fair
82	Cultivated Crops	72	81	88	91	Straight row crops, poor
90	Woody Wetlands	98	98	98	98	Water
95	Emergent Herbaceous Wetlands	98	98	98	98	Water



Stantec

Legend

CN

- 39
- 55
- 61
- 70
- 74
- 75
- 77
- 80
- 83
- 85
- 87
- 90
- 92
- 94
- 95
- 99
- Sub-Watersheds

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Notes

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Review by NMM on 2022-05-22

Client/Project 173410617 REVA
Frost Brown Todd LLC
Mt. Vernon Dam Study
Knox Cattle Company Dam

Figure No.
5 DRAFT

Title
Curve Numbers

Table 4 – Composite Curve Numbers

Sub-Watershed Name	Area (Acres)
Basin_1	86.1
Basin_2	80.8
Basin_3	81.0
Basin_4	85.9
Basin_5	84.0
Basin_6	83.0
Basin_7	76.5
Basin_9	81.0
Basin_10	89.3
Basin_11	86.3
Basin_12	82.0
Basin_13	88.4
Basin_14	88.5
Basin_15	81.9
Basin_16	83.8
Basin_17	75.5
Basin_18	81.6
Basin_19	79.0

HYDRAULICS

Subcatchment runoff was routed through the PCSWMM model using Dynamic Wave analysis. This analysis type solves the complete form of the St. Venant flow equations and accounts for channel storage, backwater effects, entrance/exit losses, culvert flow, flow reversal, and pressurized flow (SWMM Reference Manual Volume II – Reference 8). This methodology integrates results at both junctions and through conduits, accounting for downstream flow restrictions such as weirs and orifices.

Reach Routing

Generally, open channels are the dominant form of conveyance in the undeveloped areas in this watershed, while storm sewer is generally present in the residential areas. Channel lengths, slopes and cross sections were measured using Geographic Information System (GIS) software and LiDAR terrain data. Manning's "*n*" values were assigned based on aerial imagery.

Where a hydraulic network of pipes or culverts were present, Stantec relied upon data provided in the report, *Stormwater Executive Summary*, dated May 27, 2020, developed by Kleingers and the CAD file titled 190565DRN000.dwg as the basis for development of the hydraulic network in the PCSWMM model. This data included local stormwater basin geometry, stormwater structure information, topographic field survey and local stormwater utility information. Field survey data were not independently verified and were assumed to be reflective of existing conditions. Where discrepancies were identified between the *Stormwater Executive Summary* report and the CAD *.dwg file, engineering judgment was exercised to determine the appropriate model input.

Reservoir Routing

Fourteen (14) reservoir elements were added to the PCSWMM model to route flow into basins such as the Dam (Pond 1A), Basin 2, and Pond 3 as shown in Figure 6 through the existing spillways, and potentially over the top of the dam. Stantec used the Kleingers report and provided *.dwg CAD file information to model the retention /detention basins in the study watershed. Figure 7 shows a cross section through the Knox Cattle Company Dam (Pond 1A) used to input data associated with this retention basin. Elevation-area curves were developed using information from the Kleingers report and provided *.dwg CAD file. Figure 8 shows the resulting PCSWMM model schematic of the subcatchments in relation to the modeled hydraulic network.

Figure 6 – Ponds Downstream of The Dam

Reference: **Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio**

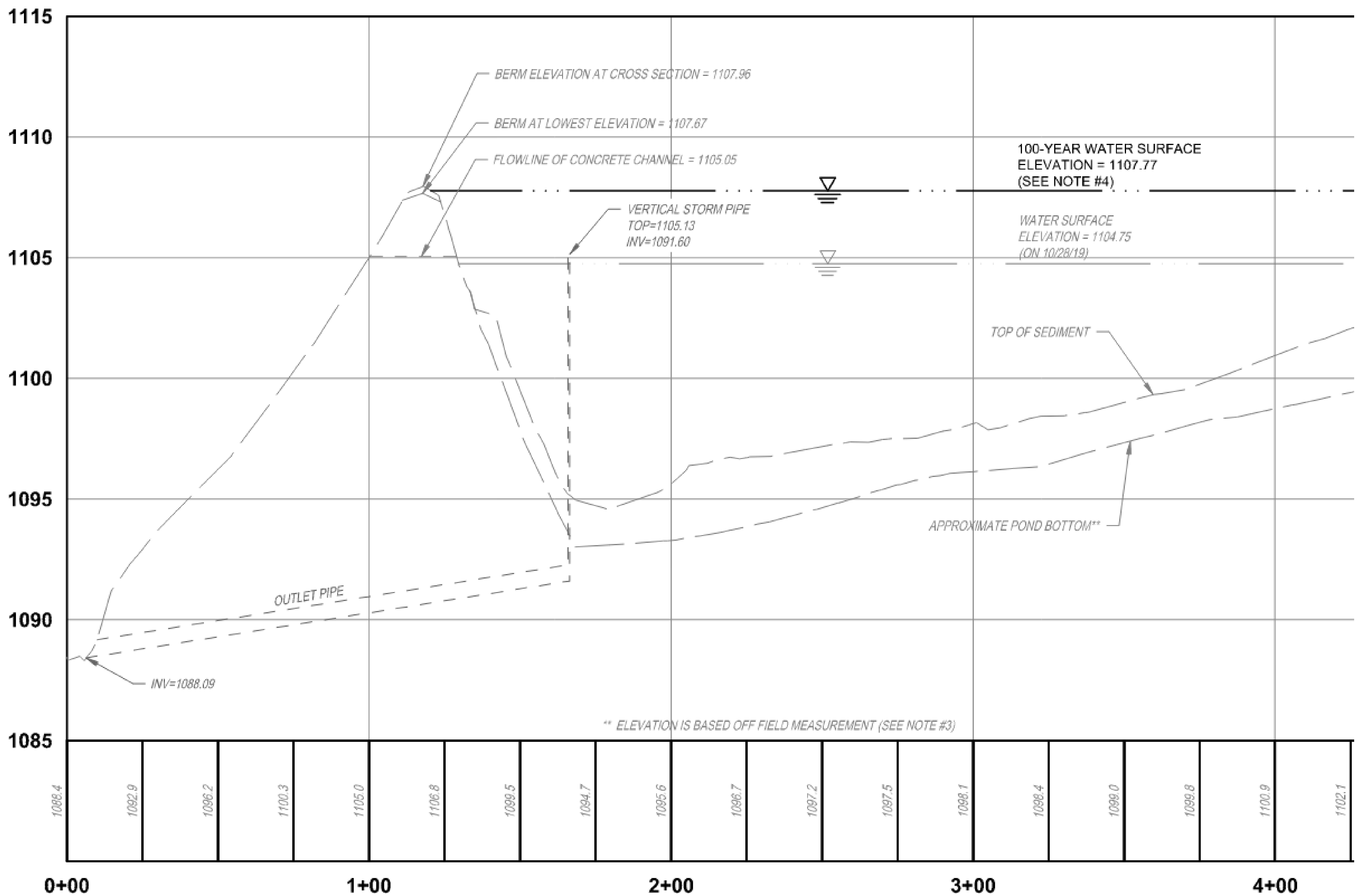

Figure 7 – Pond 1A (Knox Cattle Company Dam) Cross Section

Reference: **Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio**

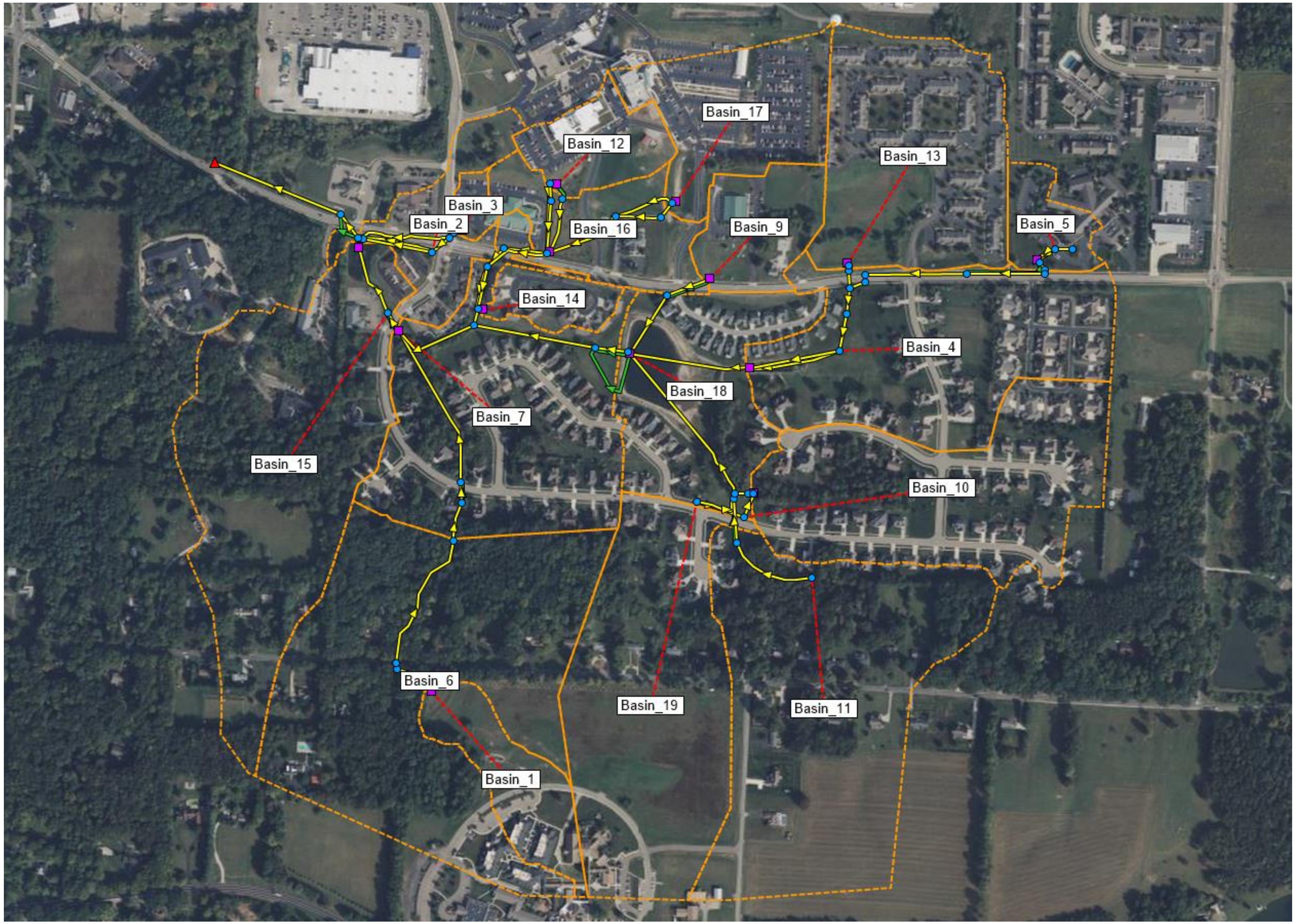

Figure 8 – PCSWMM Model Schematic

H&H MODEL SENSITIVITY ANALYSIS

Stantec completed development of the existing conditions H&H model of the Knox Cattle Company Dam watershed as described above. An H&H sensitivity analysis was then completed to estimate the impact to peak discharges due to variations in model inputs based on watershed-scale data sets. Stantec evaluated variations to the Curve Number, roughness, and depressional storage parameters in the model. The goal was to bracket the range of feasible model results produced by physical parameters that fall within typical ranges for the site conditions. Table 5 shows parameters that were tested during the sensitivity analysis and the range of values that were modeled.

Table 5 – Sensitivity Testing Parameter Variations

Model Parameter	Lower	Upper
N-perv Urban	0.25	0.15
N-perv Rural	0.4	0.2
Dstore Imperv	0.075	0.05
Dstore Perv Urban	0.2	0.05
Dstore Perv Rural	0.3	0.1
Curve Number Condition	Good	Fair

The model was used to simulate 24-hour design storms to develop dynamic routing and establish hypothetical peak flow and water surface elevations for the 50%, 20%, 10%, 4%, 2%, and 1% annual chance exceedance (ACE) storm events. Peak flow rates were extracted from both sets of sensitivity test models at the outfall downstream of Pond 3 and near the intersection of Yauger Road and Woodlake Trail. Table 6 shows the resulting lower and upper range of peak discharges observed in the model at the watershed outfall location.

Table 6 – Sensitivity Analysis - Watershed Outfall Discharge Comparison

24-Hour Recurrence Interval	Stantec PCSWMM Model Lower Bound	Stantec PCSWMM Model Upper Bound
	Flow at Outfall Downstream of Pond 3 (cfs)	
2-Year	18	37
5-Year	35	64
10-Year	52	91
25-Year	81	132
50-Year	109	162
100-Year	137	206

Stantec then compared the outfall discharge results of the two PCSWMM sensitivity models with the results reported in the Kleingers study from 2020. The comparison between the three model scenarios is shown in Table 7.The results from the Kleingers study were significantly higher than the lower range of PCSWMM model results. The Kleingers study results were also higher than the upper range of PCSWMM sensitivity testing results for each of the recurrence intervals except for the 100-year event. Although the Kleingers

Reference: Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio

results were typically still higher than the high end of PCSWMM results, the peak discharges were generally more aligned when compared to the higher range of PCSWMM peak flows. The difference in peak flow rates between the two studies may be attributable to more storage and attenuation in the PCSWMM model compared to the Kleingers analysis. Field verification of stormwater basins and their associated outlet structures could be performed to confirm assumptions related to the modeled basins where the information provided Stantec regarding dimensions and configuration of the spillways was unclear.

Table 7 – Previous Study - Watershed Outfall Discharge Comparison Downstream of Pond 3

24-Hour Recurrence Interval	Kleingers Hydrology Study	Stantec PCSWMM Model Lower Bound		Stantec PCSWMM Model Higher Bound	
	Flow (cfs)	Flow (cfs)	Difference	Flow (cfs)	Difference
2-Year	68	18	-74%	37	-46%
5-Year	119	35	-71%	64	-46%
10-Year	145	52	-64%	91	-37%
25-Year	170	81	-52%	132	-22%
50-Year	191	109	-43%	162	-15%
100-Year	200	137	-32%	206	3%

STREAMSTATS

StreamStats is a Web application developed by the United States Geological Survey (USGS) that provides analytical tools that can be used for water-resources planning and management, engineering, and design. The map-based interface is able to delineate drainage areas for site-specific watersheds and generate estimates of flow statistics. While StreamStats information is produced assuming unregulated streams (no regulated basins, stormwater control, i.e. dams), the results can be used as an independent data point for comparison of peak flows in a watershed. The information produced by the StreamsStats application was compared to the results of the project's models developed for existing conditions.

Table 8 – Previous Study - Watershed Outfall Discharge Comparison Downstream of Pond 3

24-Hour Recurrence Interval	Kleingers Hydrology Study	Stantec PCSWMM Model Lower Bound	Stantec PCSWMM Model Higher Bound	StreamStats
	Flow (cfs)			
2-Year	68	18	37	64
5-Year	119	35	64	118
10-Year	145	52	91	163
25-Year	170	81	132	229
50-Year	191	109	162	284
100-Year	200	137	206	344

At this conceptual analysis phase, Stantec recommends using results from the PCSWMM model with parameters that produce the higher bracketing flows. The upper range of flows better aligns with results from the previous study and produces results that generate a more conservative estimate for infrastructure sizing.

MODEL RESULTS

EXISTING CONDITIONS – SUMMARY OF RESULTS

The existing conditions PCSWMM model is based on the upper range of sensitivity parameters tested and described above. This model was used to simulate 24-hour design storms to develop dynamic routing and establish hypothetical peak flow and water surface elevations for the 99.9%, 50%, 20%, 10%, 4%, 2%, and 1% annual chance exceedance (ACE) storm events.

The Knox Cattle Company dam maximum hydraulic grade line (HGL) is reported as 1107.81 feet (North American Vertical Datum of 1988 (NAVD88)) for the 1% ACE (100-year) event compared to 1107.77 feet identified in the Kleingers study. The total inflow into the Dam is reported as 300 cfs with a maximum outflow just downstream of Pond 1A of 131 cfs. The results of the existing conditions analysis indicate that the existing dam crest would overtop during the 24-hour, 100-year event. Table 9 (Pond 1A flow in and out), Table 10 (Basin 2 maximum water surface elevation).

Table 11 (Model Outflow) show results from notable locations from the Existing Conditions model.

Reference: **Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio**

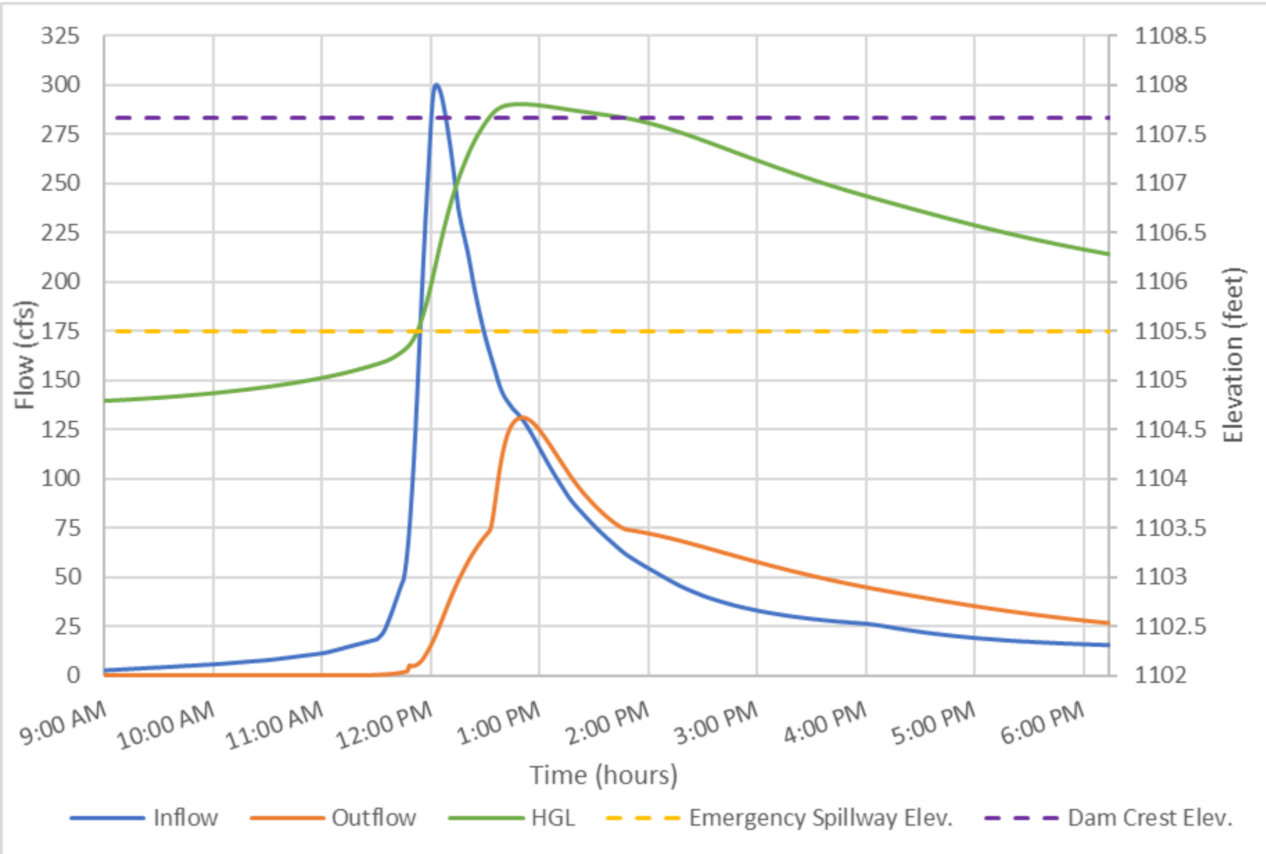

Figure 9 – Pond 1A (Knox Cattle Company Dam) – 100-year Reservoir Routing

Table 9 – Pond 1A – Existing Conditions Model Flow In / Flow Out

24-hour recurrence interval	Flow in (cfs)	Flow out (cfs)
1-Year	28	10
2-Year	50	16
5-Year	89	26
10-Year	132	36
25-Year	196	53
50-Year	244	69
100-Year	300	127

Table 10 – Basin 2 – Existing Conditions Model Hydraulic Grade Line

24-hour recurrence interval	HGL (ft)
1-Year	1083.2
2-Year	1083.8
5-Year	1084.7
10-Year	1085.4
25-Year	1086.5
50-Year	1087.3
100-Year	1088.8

Table 11 – Model Outfall – Existing Conditions Model Flow Out

24-hour recurrence interval	Flow out (cfs)
1-Year	23
2-Year	37
5-Year	64
10-Year	91
25-Year	132
50-Year	162
100-Year	206

DAM ALTERNATIVES ANALYSIS

The Client requested an H&H analysis be completed for Alternatives 2 and 3 as described in the Final Knox Cattle Company Dam Study (Stantec, July 2022) (the Study). To complete this analysis, Alternatives 2 (dam removal) and 3 (dam modification) were modeled separately based on the conceptual designs shown in the Study.

The base Existing Conditions model geometry was used as a starting point to build in each of the alternative's infrastructure related to the Dam modifications. The Existing Conditions model geometry was modified to reflect changes in the upstream storage capacity of the Dam, changes to the spillway structures, and dam modifications. Additionally, the proposed Independent Living Neighborhood stormwater system at Ohio Eastern Star was incorporated into the alternative models. This proposed development, located in the upstream portion of Pond 1A's watershed, is anticipated to be constructed in a similar timeframe as the Knox Cattle Company Dam alternatives. Therefore, the drainage area modifications and additional upstream storage was included for each alternative evaluation. Plans for this proposed project were provided by the City of Mount Vernon.

After incorporating these concept geometries into Alternatives 2 and 3, a review of peak discharges and water surface elevations downstream of the project site was performed. The initial results from the base alternatives (model runs 1 and 3) indicated increased peak discharges and water surface elevations downstream of Pond 1A. Based on the model results, Stantec estimated the necessary additional storage capacity/attenuation that would be needed upstream of the Knox Cattle Company Dam (Pond 1A) to achieve the project's design criteria. Stantec evaluated additional conceptual variations to Alternatives 2 and 3 to mitigate increases in post-project peak discharges. Methods to reduce downstream peak flows included additional excavation of the existing basins, excavation of new basins, and/or modification to existing stormwater structures to create dry basins. The model runs and their variations are described below:

- Model Run 1 – Base - Dam Removal
- Model Run 2 – Dam Removal with two additional dry, upstream storage ponds
- Model Run 3 – Base - Dam Modification / Lowering (4' pond depth)
- Model Run 4 – Dam Modification (Dry Reservoir with no Permanent Pool)
- Model Run 5 – Dam Modification (4' pond depth) with two additional dry, upstream storage ponds
- Model Run 6 – Dam Modification (5' pond depth) with two additional dry, upstream storage ponds

Using the H&H model, Stantec evaluated each of the model runs listed above for the 1-, 2-, 5-, 10-, 25-, and 100-year, 24-hour precipitation events to determine benefits/impacts.

Results

The primary design criteria related to the H&H analysis included not increasing the magnitude or frequency of flooding of habitable structures upstream and downstream of the existing dam (based on comparison of existing and post-project conditions water surface elevations), for a range of recurrence intervals, and not materially increasing (more than 6-inches water depth) the frequency or severity of roadway overtopping during the 100-year discharge event. In the absence of a field survey of finished floor elevations, existing LiDAR information was used to estimate the elevations of habitable structures downstream of Pond 1A. Based on the extracted contour elevation data, structures downstream of Pond 1A are at an approximate elevation of 1090-feet.

Table 12 (Pond 1A flow in and out), Table 13 (Basin 2 maximum water surface elevation), and Table 14 (model outflow) shows the results from locations from the Alternatives models compared to the Existing Conditions model.

Reference: **Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio**

Table 12 – Pond 1A – Alternatives Model Flow In / Flow Out

	Existing Conditions		Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
24-hour recurrence interval	**Flow in (cfs)**	**Flow out (cfs)**	**Flow out (cfs)**					
1-Year	28	10	14	11	10	14	4	5
2-Year	50	16	31	12	24	20	7	8
5-Year	86	26	66	16	53	28	16	19
10-Year	132	36	94	39	84	34	35	42
25-Year	196	53	145	79	130	43	76	82
50-Year	244	69	181	119	178	93	113	123
100-Year	300	127	254	167	235	146	162	172

Table 13 – Basin 2 – Existing Conditions Model Hydraulic Grade Line

	Existing Conditions	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
24-hour recurrence interval	**HGL (ft)**						
1-Year	1083.2	1083.8	1083.7	1083.2	1083.4	1083.2	1083.2
2-Year	1083.8	1084.4	1084.3	1084.0	1084.0	1083.8	1083.8
5-Year	1084.7	1085.9	1085.1	1085.3	1084.8	1084.7	1084.7
10-Year	1085.4	1087.0	1085.7	1086.5	1085.6	1085.3	1085.3
25-Year	1086.5	1088.6	1086.6	1088.2	1086.4	1086.3	1086.8
50-Year	1087.3	1089.6	1088.1	1089.4	1087.2	1087.7	1088.2
100-Year	1088.8	1090.5	1089.5	1090.4	1088.9	1089.2	1089.6

Reference: **Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio**

Table 14 – Model Outfall – Existing Conditions Model Flow Out

	Existing Conditions	**Run 1**	**Run 2**	**Run 3**	**Run 4**	**Run 5**	**Run 6**
24-hour recurrence interval	**Flow out (cfs)**						
1-Year	23	34	31	23	28	23	23
2-Year	37	54	42	37	42	34	34
5-Year	64	102	69	84	71	55	55
10-Year	91	138	94	122	95	79	79
25-Year	132	186	134	173	130	121	138
50-Year	162	223	177	217	158	166	181
100-Year	206	254	229	252	212	218	231

Figure 10 shows the existing conditions 100-year water surface elevation extents in Basin 2 downstream of the dam. As shown, the extents of the 100-year event appear to approach the edge of some habitable structures in the area. A field survey was performed by Kleingers on June 22, 2022, to confirm the finished floor elevations of these structures and that the project design criteria can be met. Table 15 lists the surveyed properties and their corresponding finished floor elevations. The concepts in this report were developed prior to receiving the survey data. Model refinements will be made in detailed design to reduce the flooding impacts to structures and to inform possible localized mitigation strategies.

Reference: **Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio**

Table 15 – Surveyed First Floor Elevations (Kleingers)

Property No.	Address	Finished Floor Elevation (ft)
1	40/38 Coventry Ct	1096.64
2	36/34 Coventry Ct	1094.02
3	43 Mallard Pointe	1115.56
4	41 Mallard Pointe	1111.76
5	39 Mallard Pointe	1107.31
6	37 Mallard Pointe	1104.99
7	35 Mallard Pointe	1100.53
8	33 Mallard Pointe	1096.59
9	31 Mallard Pointe	1095.10
10	29 Mallard Pointe	1092.57
11	32/30 Coventry Ct	1091.66
12	28/26 Coventry Ct	1100.73
13	16/14 Coventry Ct	1087.85
14	12/10 Coventry Ct	1096.04
15	27 Mallard Pointe	1091.76
16	25 Mallard Pointe	1090.97
17	23 Mallard Pointe	1090.47
18	8/6 Coventry Ct	1093.59
19	10 Woodlake Trail	1092.21
20	4/2 Coventry Ct	1087.02
21	14 Woodlake Trail	1093.01
22	21 Mallard Pointe	1090.36
23	19 Mallard Pointe	1090.63
24	18 Woodlake Trail	1089.82
25	15 Mallard Pointe	1090.32
26	22 Woodlake Trail	1096.59
27	13 Mallard Pointe	1090.42
28	24 Woodlake Trail	1100.53
29	11 Mallard Pointe	1091.99
30	9 Mallard Pointe	1093.20

Reference: Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio

[placeholder]

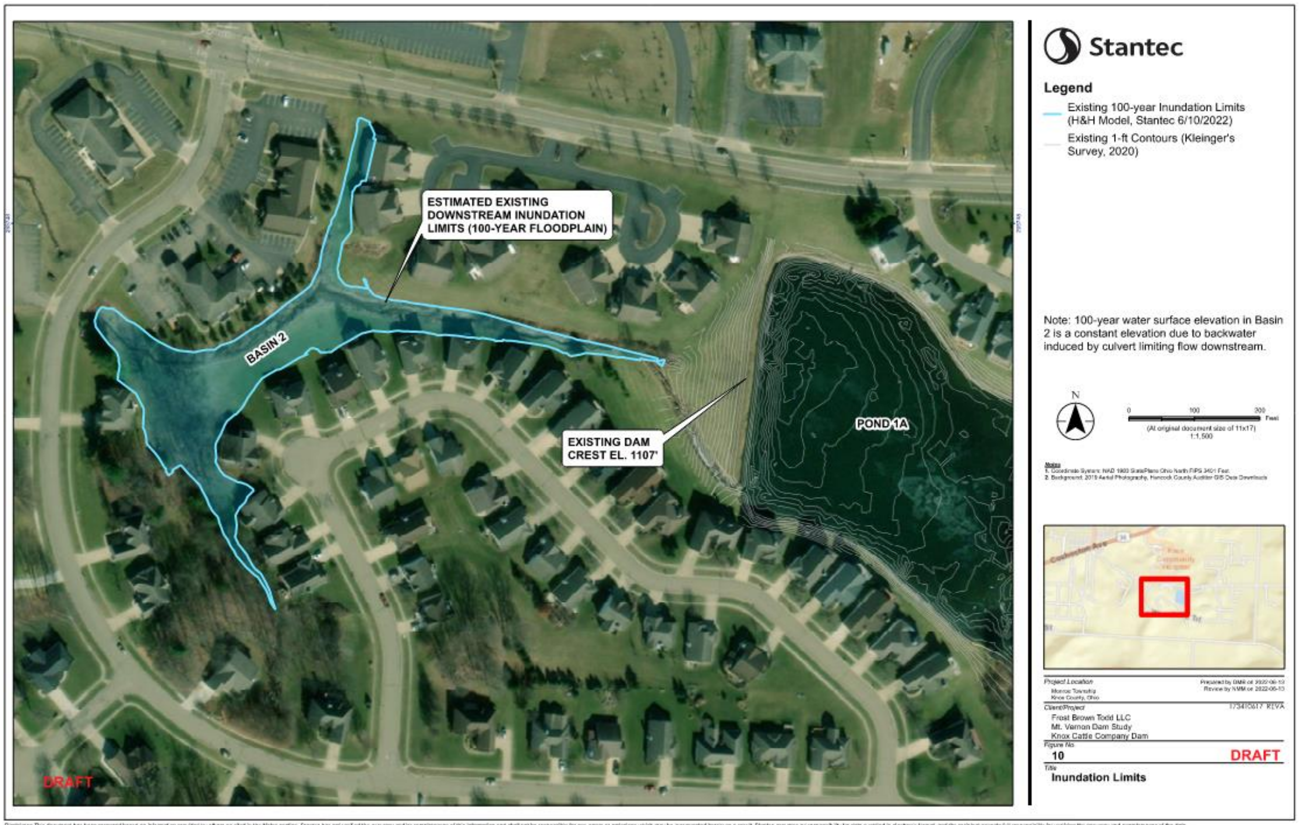

Figure 10 – Pond 1A (Knox Cattle Company Dam) – 100-year Reservoir Routing

The Existing Conditions model shows 17 cfs overtopping Yauger Road during the 100-year event, which translates to a depth of 0.2 feet. Alternative 2 (Dam Removal) shows 4 cfs (0.1 feet) of overtopping during the 25-year event and 53 cfs overtopping (0.5 feet) during the 100-year event. The other alternatives models do not overtop for the 25-year event, but do show overtopping across the roadway ranging between 21 cfs and 51 cfs (between 0.2 and 0.5 feet deep).

Alternatives 2a, 3b, 3c, and 3d are generally meeting the H&H hydraulic criteria for the project. Alternatives 2 and 3a show flowrates downstream of Pond 1A that cause increased water surface elevations and the potential to increase flooding at habitable structures downstream during the 100-year precipitation event. The alternatives described in this report are based on conceptual level design. The selected alternative should be further evaluated for hydraulic efficiencies and reservoir routing as the design is advanced.

Critical Storm

The City of Mount Vernon requires new developments to include stormwater control measures to the critical storm event, specifically that the peak discharge rate of runoff from the critical storm and all more frequent storms occurring under post-project conditions shall not exceed the peak discharge rate of runoff from a one-year, 24-hour storm occurring on the same development under pre-development conditions. Storms of less frequent occurrence than the critical storm, up to the 100-year storm shall have peak runoff discharge rates no greater than the peak runoff compared to pre-development conditions. Pre-development conditions are defined as the site conditions at the time of adoption of the City's Stormwater Ordinance, December 1989. (Mount Vernon, OH Codified Ordinance §920.19).

Hydrologic and hydraulic models representing pre-development conditions are outside of Stantec's scope. Stantec relied upon the pre-development discharge rates reported in the Kleingers study (page 4) to determine the peak flow rates. Pre-development run-off volumes were not reported in the Kleingers study. The key elements of the critical storm are presented in Table 16. Existing conditions flow rates were compared against post-project flow rates for Alternatives 2, 3A, and 3B. Resulting flow rates are extracted at the downstream end of the hydraulic model (outflow of Pond 3) for consistency with the pre-development flow rates reported in the Kleingers study.

Reference: **Knox Cattle Company Dam Study – H&H Analysis – Mount Vernon, Ohio**

Table 16 – Critical Storm Evaluation – Pond 3 / Watershed Outlet

Column ID	1	2	3	4	5	6	7
24-hour recurrence interval	**Watershed Outflow (cfs) (pre-developed)**	**Run Through Area Outflow (cfs) (Site Only)**	**Allowable Discharge (cfs) (Site Only)**	**Total Allowable Discharge (cfs)**	**Alt. 2 Proposed Concept Discharge (cfs)**	**Alt. 3A Proposed Concept Discharge (cfs)**	**Alt. 3B Proposed Concept Discharge (cfs)**
1-Year	70	40	30	70	34	23	28
2-Year	85	49	30	79	54	37	42
5-Year	156	90	30	120	102	84	71
10-Year	195	112	83	195	138	122	95
25-Year	247	142	105	247	186	173	130
50-Year	301	173	128	301	223	217	158
100-Year	323	186	137	323	254	252	212

1. Undeveloped/predevelopment condition flow rate (Kleingers)
2. Discharge through the project site (Pond 1A) from off-site drainage areas
3. Allowable discharge contributed by the project site for the 1-year to Critical Storm (5-year)
4. Total discharge measured at Pond 3 allowable.

According to the model, when using the previously developed (Kleingers) critical storm discharge limits, each of the three alternatives (2, 3A, 3B) satisfy the peak discharge rate reduction as measured at the outlet of Pond 3.

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Attachment: Attachment

c. Nick Mueller – Stantec

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