



Versailles Lake Dam
Feasibility Study Report

December 8, 2021


Prepared for:

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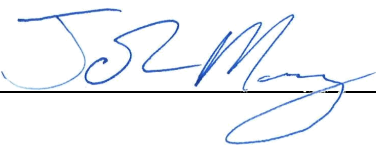
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Executive Summary

The Versailles Lake Dam was constructed in 1955-56 on Laughery Creek, a tributary to the Ohio River, in Ripley County, Indiana creating a 230-acre impoundment in Versailles State Park. The Versailles Lake Dam is approximately 56 feet in height and 960 feet in length between the abutments. A 240-foot-wide concrete ogee spillway makes up a portion of the total dam length. Indiana Department of Natural Resources is looking to address current issues with the dam associated with inadequate discharge capacity which could lead to overtopping at the Probable Maximum Flood (PMF) and high sedimentation rates in the impoundment that have resulted in loss of recreational value and storage capacity for Versailles Lake. Stantec was contracted to assess three possible alternatives to address these problems. Alternatives assessed include: 1) periodic dredging of the impoundment and construction of a roller compacted concrete emergency spillway to cover the downstream face of the earthen dam, 2) partial removal of the spillway and embankment and installation of a rock arch rapid in the dam footprint, and 3) full decommissioning of the dam and restoration of Laughery Creek through the former impoundment. Existing environmental, hydraulic, hydrologic, and anthropogenic conditions were assessed that could affect implementation of each alternative. Cost estimates for construction and long-term maintenance were also developed for each alternative.

Based on analysis of historical and current bathymetric data for Versailles Lake, it is estimated that the impoundment is currently storing 2.7 million cubic yards (CY) of sediment, resulting in a decrease in lake storage capacity of approximately 60 percent. Without sediment management or alteration of the dam facilities, the impoundment will completely fill with sediment within the next 20 to 25 years. Sediment concentrations in samples collected within the impoundment were lower than ecological and human health risk based screening values. Spillway and reservoir routing analyses conclude that the existing spillway can only pass approximately 50 percent of the PMF without the dam overtopping.

Our review of site conditions, regulatory considerations, and engineering elements suggest that all three alternatives assessed in this report are feasible. The major differences between them are the cost of sediment management, residual safety risks associated with leaving the dam in place, and recreational uses. All alternatives meet the IDNR dam safety requirements either by armoring the earthen dam or by partially or fully decommissioning the dam. Alternative 1 is the most expensive option due to the high cost of routinely dredging, dewatering, and hauling away stored sediment to an off-site disposal area. Alternative 1 most closely maintains the current recreational uses of Versailles Lake, while Alternative 2 and 3 result in loss of the lake and creation of riverine fishing opportunities and canoe/kayak passage.



Abbreviations

Cfs	Cubic feet per second
CN	Curve number
CWA	Clean Water Act
CY	Cubic yards
DOA	Department of the Army
DHPA	Division of Historic Preservation and Archaeology
ESA	Endangered Species Act
ESV	Ecological screening value
Ft	Feet
GIS	Geographic Information System
HMR	Hydrometeorological Report
HEC-HMS	Hydrologic Engineering Center Hydrologic Modeling System
IBI	Index of Biotic Integrity
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
IN SWMP	Indiana Stream and Wetland Mitigation Program
IPaC	Information for Planning and Consultation
ILF	In-lieu fee
kg	kilogram
LiDAR	Light detection and ranging
mg	milligram
Mi ²	Square miles



NHPA	National Historic Preservation Act
NLCD	National Land Cover Database
NRCS	Natural Resources Conservation Service
NWI	National wetland inventory
NWP	Nationwide Permit
OPCC	Opinion of probable construction costs
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PCN	Pre-Construction Notification
PMF	Probable maximum flood
PMP	Probable maximum precipitation
QHEI	Qualitative Habitat Evaluation Index
RSV	Refined screening value
SCS	Soil Conservation Service
SSURGO	Soil Survey Geographic Database
TSS	Total Suspended Solids
USACE	U.S. Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service
3DEP	Three-dimensional elevation program





1.0 INTRODUCTION

Stantec Consulting Services Inc. (Stantec) was contracted by the State of Indiana Department of Natural Resources (IDNR) to conduct a feasibility study to assess alternatives for rehabilitation or decommissioning of the Versailles Lake Dam.

1.1 PROJECT BACKGROUND

The Versailles Lake Dam was constructed in 1955-56 on Laughery Creek creating a 230-acre impoundment in Versailles State Park. The City of Versailles sourced their drinking water from the lake starting shortly after construction until the intake was abandoned due to sedimentation and water quality concerns. Visitors to Versailles State Park utilize the lake for various recreational opportunities including swimming, boating, and fishing, although the recreational value of the lake has diminished with the accumulation of sediments in the reservoir.

Based on the latest IDNR Dam Safety Inspection (2018), the dam is classified as “High Hazard” due to the potential for life loss should the dam fail. As a high hazard facility, State regulations require the dam spillway to pass the Probable Maximum Flood (PMF) with sufficient freeboard to prevent overtopping the dam. The inspection report estimates a PMF value of 50,000 cubic feet per second (cfs) which exceeds the reported spillway capacity at the dam crest of 35,000 cfs.

1.2 SCOPE

The analyses conducted in support of assessment of the project alternatives focus on a variety of environmental, hydrologic, hydraulic, and human environmental parameters. Key considerations include dam safety, sediment management, cost, recreational value, and ecological resources. Stantec assessed the capacity of the primary spillway and emergency spillway options to meet Indiana dam safety regulations by assessing the Spillway Design Flood hydrograph, spillway hydraulics, and flood routing through the reservoir. Sediment accumulation in the reservoir and resulting impacts to water quality and recreation were assessed through bathymetric survey, assessment of sedimentation volume, and sediment screening for potential contaminants.

The results of these analyses informed project alternatives regarding feasibility, costs, and benefits. Alternatives considered for the Versailles Lake Dam include full decommissioning of dam facilities, sediment management, and dam rehabilitation to safely pass the PMF. Planning level construction and life-cycle maintenance costs were developed for each alternative. Permits and agency coordination that could affect implementation of each alternative were reviewed and conceptual figures were created for each alternative.

1.3 PROJECT OBJECTIVES

The primary objectives of this study were developed in collaboration with IDNR and focused on minimizing public safety risks related to dam infrastructure while maintaining recreational value for visitors



to Versailles State Park. Each alternative was assessed relative to the potential to meet project goals. Specific project objectives are detailed in the sections below.

1.3.1 Recreational Value

Maintaining recreational opportunities at Versailles State Park is a primary objective of the project. The reservoir at Versailles State Park is used for recreational boating, fishing, and swimming. However, extensive sedimentation in the reservoir has reduced the feasibility of these activities in some locations. Each alternative will be assessed based on potential recreational opportunities for park visitors. Recreational opportunities may include enhancing fish habitat and angling opportunities, downstream canoeing/kayaking passage through Laughery Creek, swimming, and shoreline access.

1.3.2 Safety

As described previously, the dam is classified as a high-hazard dam and the spillway fails to pass the PMF. The dam also presents safety risk for state park visitors boating in the lake or walking on foot due to the hydraulic drop it creates and the potential for dangerous circulation patterns to develop downstream of the dam and stilling basin weir. Reduction or elimination of these hazards is a primary objective of the project.

1.3.3 Cost Effective

Construction and life-cycle costs were considered as a factor project feasibility. Long-term and routine maintenance costs of infrastructure upkeep are also an important component of project costs. For each alternative, construction costs were estimated to the nearest \$100,000 and a relative cost of maintenance was developed.

1.3.4 Other Considerations

Other factors that were considered in the development and assessment of alternatives include ecological resources and regulatory requirements. The current dam degrades aquatic habitat by acting as a barrier to upstream fish migration, transforming a lotic system to lentic, and reducing habitat diversity within the impounded reach. Sedimentation within the reservoir has reduced the diversity of substrates and impacted water quality. Aquatic habitat may be enhanced by restoring habitat connectivity, eliminating a barrier to movement of fish and other aquatic species, and increasing hydraulic variability. Alternatives will be assessed for their effects on aquatic habitat and ecological resources. Potential effects on special status species and associated regulatory requirements were assessed.

1.4 OVERVIEW OF ALTERNATIVES

Stantec assessed the following three alternatives relative to the aforementioned project objectives:

1. Rehabilitation of the dam and/or construction of auxiliary spillway to pass the PMF, maintenance of a sediment forebay within impoundment, and dredging of the impoundment to restore the recreational value of Versailles State Park Lake.



Existing Site Conditions

2. Partial decommissioning of the dam through lowering of the spillway crest and targeted grading of the stream valley through the impoundment.
3. Full drawdown of the impoundment and decommissioning of the dam.

2.0 EXISTING SITE CONDITIONS

2.1 PROJECT SETTING

The Versailles Lake Dam is located on Laughery Creek in Versailles State Park near the town of Versailles, in Ripley County, Indiana. The earthen dam is approximately 56 feet tall and 930 feet long. The water level of the lake is controlled by a concrete spillway with an elevation of approximately 789.5 feet (ft) (NAVD88). The crown elevation of the earthen dam was raised from an approximate elevation of 806 ft to 809 ft (NAVD88) during 1968 modifications to the dam (Figure 1). The contributing upstream watershed of Laughery Creek at the dam site is approximately 168 square miles (mi²). Two small tributaries enter directly into the lake: Falling Timbers Creek from the east (drainage area of 6 mi²) and Cedar Creek from the west (drainage area of 4.58 mi²). The drainage basin is primarily underlain by limestones and shales (Gray, 1972).

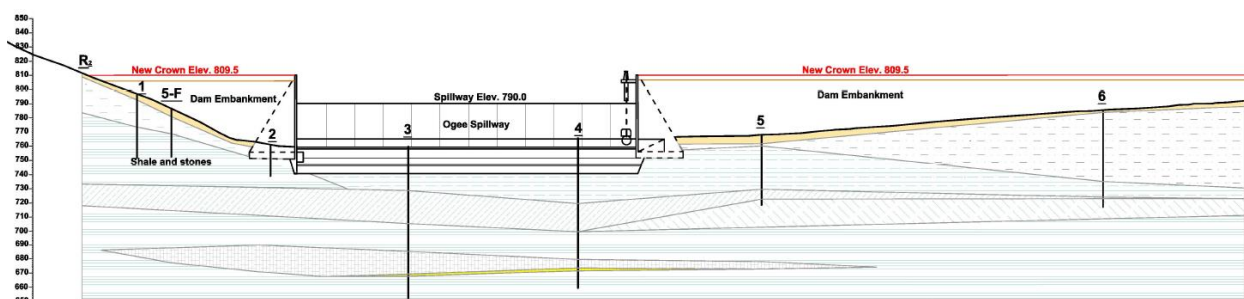


Figure 1. Geotechnical Profile along Versailles Lake Dam (IDNR, 2008)

2.2 LAND USE

Land use patterns provide important information regarding potential sources of impairment and erosion in the watershed. Land use data for the watershed was assessed using the National Agricultural Statistics Service (NASS) cropland data. The Laughery Creek watershed is 168 square miles and land use is split between agricultural (38 percent) and forested lands (41 percent) which account for a combined 80 percent of the watershed (Table 1). Pasture/hay, including animal feed lots, represent 12 percent of the watershed. Developed areas are limited and represent only 7 percent of watershed which primarily includes Batesville, Osgood, and Versailles.



Table 1. Land use types in the Laughery Creek Watershed

Land Use	Area (mi ²)	Percent
Agricultural Land	64.4	38
Developed Land	12.0	7
Forested Land	68.4	41
Hay/Pasture	20.9	12
Open Water	1.64	1
Shrub/Scrub	0.16	0.1
Wetlands	0.04	0.02
Total	167.5	100

2.3 EXISTING CONDITIONS OF DAM

Dam inspection reports and photographs from 1990 - 2018 document the structural condition and operational adequacy of the dam facilities. Specifically, the 1997 report indicated that the spillway could only pass 60 percent of the probable maximum flood (PMF) with 1.2 feet of freeboard and recommended additional hydraulic and hydrologic modeling to confirm the spillway capacity (IDNR, Earth Dam Visual Inspection Report, Versailles State Park Dam, 1997). No significant structural issues with the concrete spillway were noted in the inspection reports. Beginning in 1994, a small erosion gulley was observed along the left (north) abutment of the dam (IDNR, 1994). In the 2001 inspection report, it was noted that the drawdown structure gate had been vandalized and was inoperable (IDNR, 2001). The lake drain is inoperable as of the 2018 inspection report due to sedimentation and debris blockage, additional repair of fencing and the access gates to the valve pit were suggested (IDNR, 2018). Except for improvement of the spillway to pass the PMF, no significant maintenance activities are prescribed in recent inspection reports.

2.4 HYDROLOGY AND HYDRAULICS

2.4.1 Hydrologic Analysis

The Versailles Lake watershed is a 168 square mile area with predominantly agricultural and wooded land cover, as shown in Figure 2. A hydrologic analysis was performed to calculate the inflow design flood (IDF) for the reservoir following the IDNR General Guidelines for New Dams and Improvements to Existing Dams in Indiana (IDNR, 2001). The IDF for a high-hazard dam such as Versailles Lake Dam is the PMF. The United States Geological Survey (USGS) Streamstats web-based geographic information systems (GIS) application (USGS, Streamstats, 2021) was used to delineate the full contributing watershed, sub-basins, and flowpaths. Precipitation depths for the 24-hour and 6-hour probable maximum precipitation (PMP) were taken from Hydrometeorological Report (HMR) Numbers 51 and 52 (NOAA, 1978), and areal adjustments were made to account for the overall drainage basin size. The



Existing Site Conditions

SCS Type II and SCS Type B rainfall distributions were used for the 24-hour and 6-hour PMPs, respectively.

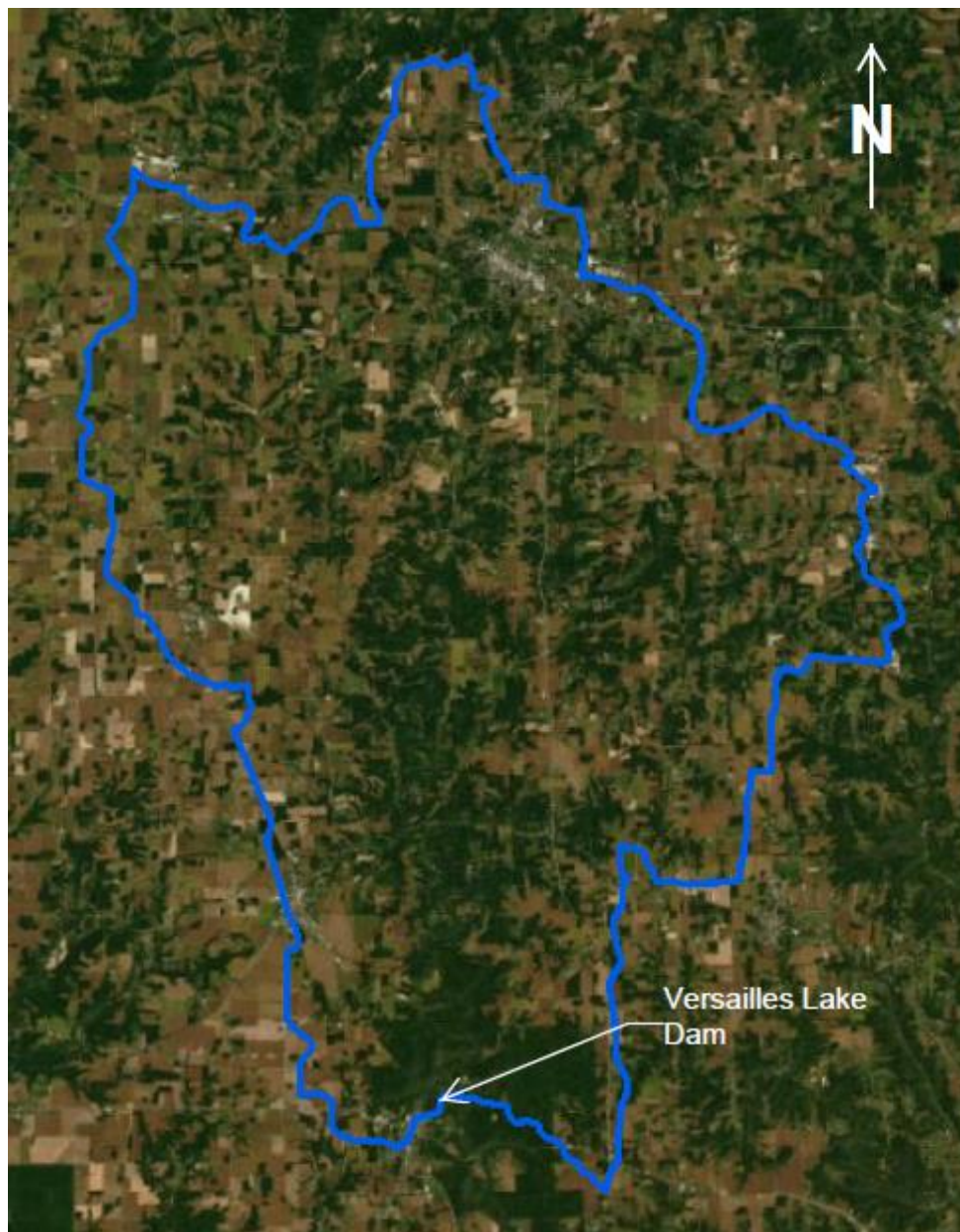


Figure 2 Versailles Lake Dam Watershed Map

The Soil Conservation Service (SCS) Technical Release 55 (TR-55) (USDA, 1986) curve number methodology was used to develop flow hydrographs for each sub-basin. The curve number calculations were based on Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database



(SSURGO) and the 2016 USGS National Land Cover Data (NLCD). Weighted curve numbers were calculated for each sub-basin based on the procedure outlined in the TR-55 manual, using the “CN Grid” processing tool in HEC GeoHMS for ArcGIS. The areas with dual hydrologic soil groups used the soil class with higher infiltration as they tended to be, per the SSURGO attributes, in well drained agricultural areas.

The longest flow paths were delineated by Streamstats, manually adjusted in ArcMap, and separated into overland flow, shallow concentrated flow, and open channel flow segments. Open channel flow velocities used to develop times of concentration were developed using bankfull depths and widths based on information obtained from Streamstats for each flow segment. Travel time was calculated using the methodology in TR-55, and basin lag was then determined for use in the HEC-HMS models.

The Muskingum Cunge reach routing method was used in the HEC-HMS model. Reach length, slope, and 8-point cross sections along flowpaths were estimated using the digital elevation model (DEM) developed from LiDAR data that was collected for Indiana in 2017 as part of the USGS 3D Elevation Program (3DEP) (USGS, 2017) in ArcMap. A celerity value of 5 feet per second was used based on guidance in the HEC-HMS tutorials and guides (USACE, 2021).

Peak discharge values for the 24-hour and 6-hour PMF storms, as well as 1-percent and 0.2 percent annual chance exceedance (ACE) events for comparison, are summarized in Table 2.

Table 2: Inflow Flood Peak Discharges

Storm	Peak Discharge (cfs)
1% ACE	28,000
0.2% ACE	39,000
6-hour	195,000
24-hour	209,000

2.4.2 Reservoir Routing

A reservoir routing and spillway analysis was performed using the HEC-HMS model. A stage-storage curve was developed using bathymetric data collected in March 2021 for elevations below the water surface level (790 ft) and LiDAR for elevations above the water surface and up to elevation 815 ft (USGS, 2017). The ESRI ArcGIS software’s 3D Analyst toolbox was used to calculate storage volume between



each reference elevation and the topobathymetric surface. The Versailles Lake area and storage capacity data is shown in Figure 3.

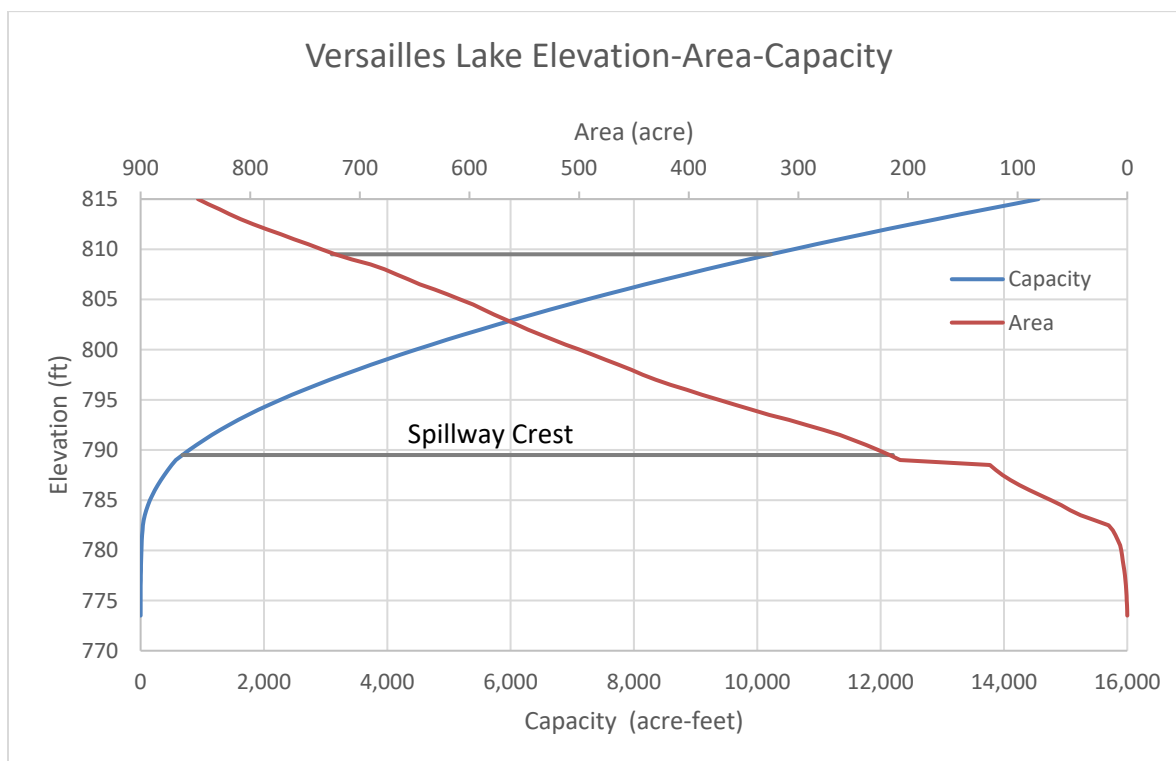


Figure 3 Versailles Lake Elevation-Area-Capacity Curve

The ogee spillway was modeled within HEC-HMS using the spillway function built into the software. The model accounts for changes in efficiency of the weir resulting from the level of sediment upstream of the spillway weir. The sediment elevation for current conditions was estimated from the bathymetric survey transect PP, as discussed in Section 2. The model was modified during the alternatives analysis to account for reservoir dredging upstream of the spillway, where applicable.

The results of the reservoir routing showed that the existing spillway is not capable of passing the PMF. Approximately 50% of the PMF, based on modeling a rainfall depth of 50% of the PMP, can be passed through the spillway without the dam overtopping.

2.4.3 Spillway Alternatives

Multiple spillway configurations were considered to develop potential spillway alternatives to pass the PMF, including lowering the existing spillway, armoring the dam for overtopping, or adding an auxiliary spillway. Results are discussed in section 3.2 and 3.3.



2.5 SEDIMENT ASSESSMENT

Since dam construction was completed in 1956, significant sedimentation in Versailles Lake has impacted the storage capacity and surface area of the lake (Renn & Arihood, 1991). Sedimentation volumes and resulting impacts to lake storage capacity between 1956 and 1988 are assessed in a 1991 study conducted by the U.S. Geological Survey (USGS) and the Indiana Department of Natural Resources (IDNR). For this study, current sedimentation rates and volumes are calculated by comparing bathymetric data collected in March 2021 to historical depth data from 1956 and 1988, as presented in Renn and Arihood (1991).

2.5.1 Sediment Volume

To estimate sediment storage in the lake, the study area was defined as the main open water area from the dam to island forming upstream of the boat ramp, approximately 150 acres and 6,300 feet upstream of the dam (Figure 4). Figure 5a and b presents the bed elevation of the lake in 1988 and 2021, respectively. Figure 6 shows the change in bed elevation in feet between 1988 to 2021. Upwards of 16 feet of sedimentation has occurred in some parts of the lake between 1988 and 2021. While Renn and Arihood (1991) noted significant sedimentation in the upstream and middle portions of the impoundment during the initial 32 years (1956 – 1988) following dam construction, current bathymetric data shows that sedimentation has continued in the downstream portion of the impoundment as the upstream areas begin to reach sediment storage capacity in the past 33 years (1988-2021).



Existing Site Conditions



Figure 4. Sediment Assessment Study Area



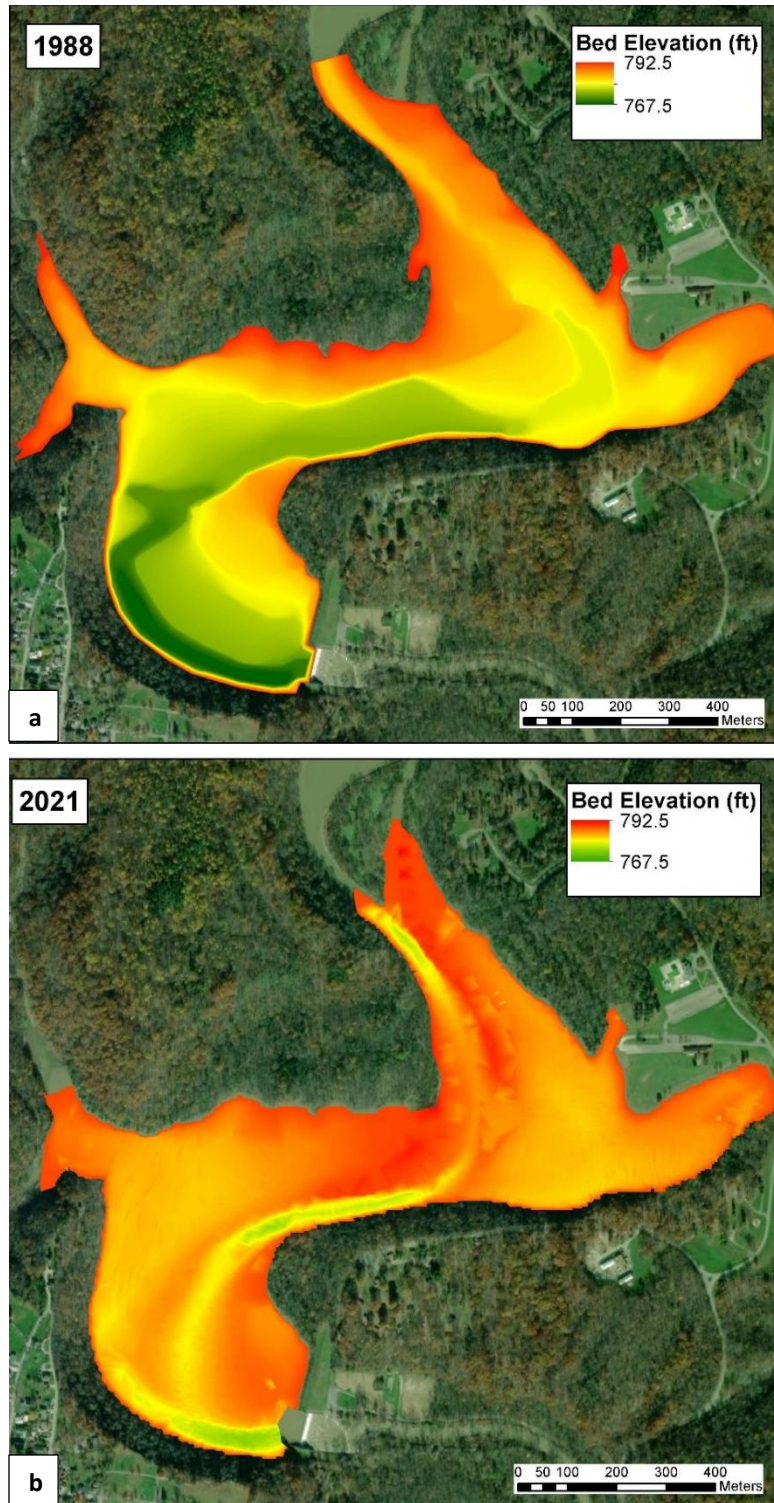


Figure 5. a and b, Bed elevation of Versailles Lake in 1988 and 2021



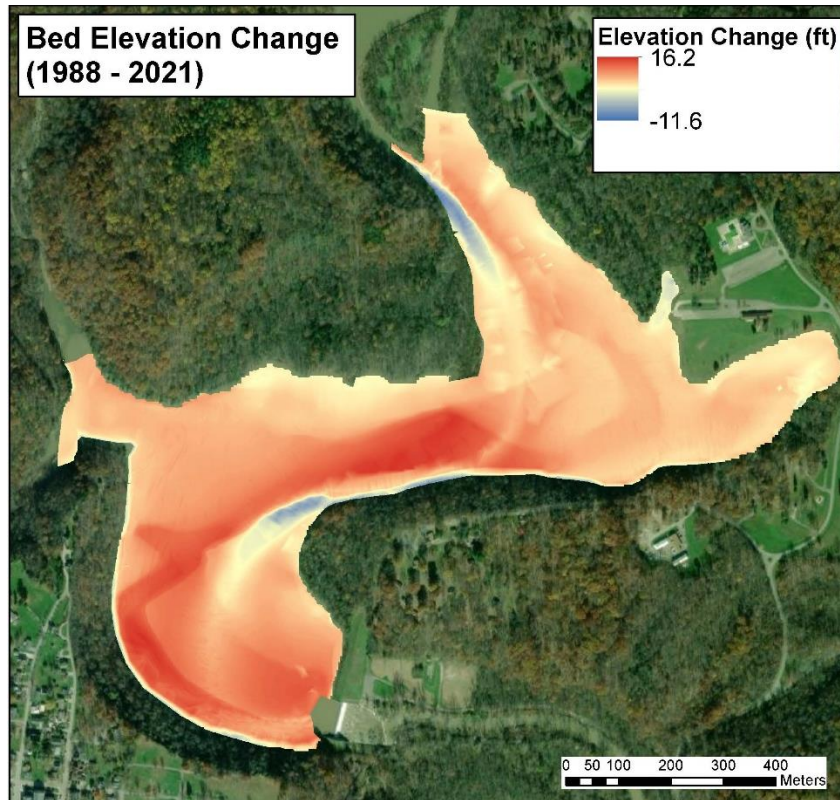


Figure 6. Change in bed elevation of Versailles Lake between 1988 and 2021

Sedimentation patterns are further illustrated by comparing cross-sectional profiles of the lakebed over time. While 40 cross-sections were assessed by Renn and Arihood in 1991, four were assessed for this study and are highlighted in Figure 7. Figure 8 shows cross-sectional data from 1956, 1988, and 2021 moving from downstream to upstream. Cross-sections are viewed in the upstream direction (i.e., from the west bank to the east bank of the impoundment). The 1956 depth data represents the initial impoundment elevations following dam construction. Cross-section PP is approximately 125 feet upstream of the dam and experienced the most significant sedimentation between 1988 and 2021, with upwards of 13 feet of accumulation during this time (Figure 8a). The historic thalweg of the channel is evident along the west bank of the impoundment (Figure 8a). Similar to cross-section PP, sedimentation along cross-section KK was greatest from 1988 - 2021 (Figure 8b). Between 1988 and 2021 a point bar formed along the west bank in the middle portion of the lake from continued sediment deposition. This sediment deposition is visible along cross-section HH (Figure 8c). Cross-section T is located near the upstream extent of the study area. Along this cross-section, sedimentation was greater in the period following dam construction between 1956-1988 than more recent years. Between 1988 and 2021, a mid-channel island formed along this reach as the channel reached storage capacity and the thalweg is deepening along the west side of this island (Figure 8d).



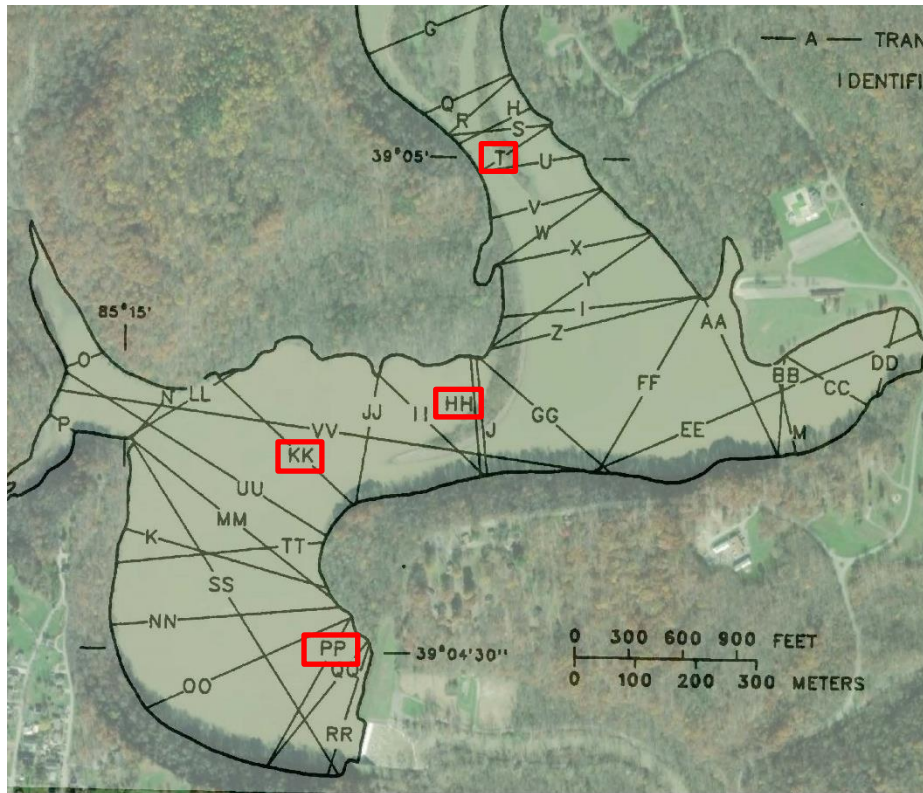


Figure 7. Location of historical transects



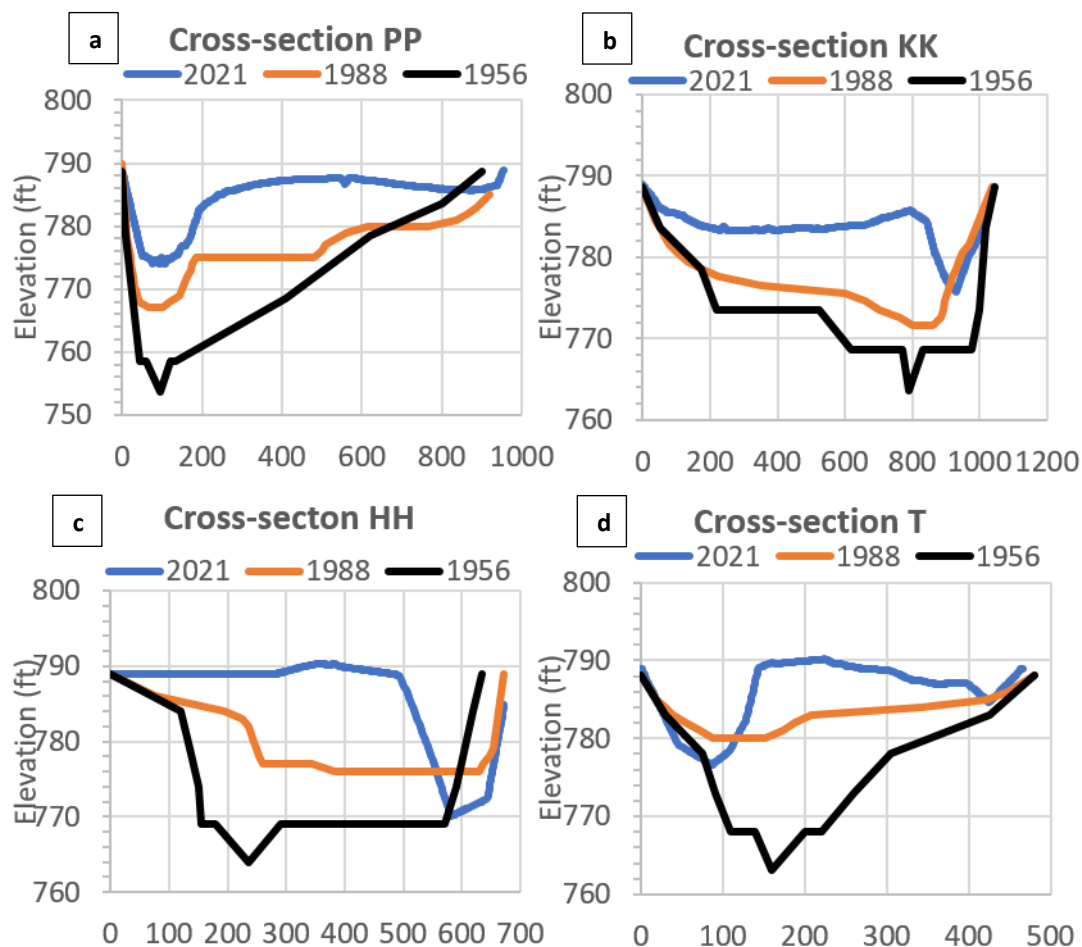


Figure 8. a through d, Comparison of Versailles Lake bed elevation cross-sections between 1956, 1988, and 2021. Cross-sections face upstream.

From 1956 to 2021, an estimated 2.7 million cubic yards (CY) have accumulated in the lake, resulting in a decrease in lake storage capacity of approximately 60 percent. From 1956 to 1988 and 1988 to 2021, the impoundment sedimentation rate was 48,000 and 38,000 CY per year, respectively. This suggests that while sedimentation rates may be slowing slightly, the lake continues to store fine sediment.

2.5.2 Sediment Chemistry

As described above, the Versailles Lake Dam contains a substantial volume of sediment. Dams may trap and store natural and anthropogenic constituents at concentrations that can pose risks to aquatic ecosystems and/or human health. A screening level assessment of sediment chemistry in the impoundment was conducted to assess the potential for contaminants in reservoir sediment following



EPA Region 4 Ecological Risk Assessment Guidance (US Environmental Protection Agency (EPA), 2018).

Sediment grab samples were collected in March 2021 at five locations along the impoundment (Figure 15, Appendix A). Sediment was collected with a Petite Ponar grab sampler from the sediment surface (< 0.5 feet). Samples were analyzed for 10 metals (Ba, Cd, Cr, Co, Cu, Pb, Hg, Ni, Se), PCB's, polycyclic aromatic hydrocarbons (PAHs), and total organic carbon.

The screening level assessment of the sediment compared measured concentrations of analytes to ecological screening values (ESV) and Refinement Screening Values (RSV). The concentrations are consensus-based values derived from published literature and, when exceeded, do not necessarily equate to effects. Instead, these values are intended to trigger more focused and definitive sediment sampling and analysis to better understand ecological and human health risks.

Table 4 in Appendix A compares the individual sediment sampling results against screening concentration values. No PCBs or PAH's were detected above the screening concentrations for any parameters or samples. All metals, except for Barium, were lower than the screening concentrations. All five samples exceeded the ESV (20 mg/kg) for Barium and two samples also exceeded the RSV (60 mg/kg). Barium is an alkaline earth metal that can be found in naturally occurring mineral deposits. Measured barium concentrations are lower than background concentration levels determined by the Ohio EPA (Ohio EPA, 2018). Background is the concentration of naturally occurring chemicals that are unaffected by any current or past activities involving the management, handling, treatment, storage, or disposal of chemicals.

2.5.3 Sediment Supply

Land use, riparian area impairments, and channel modifications all have potential roles in increasing erosion and sediment supply within the watershed resulting in significant sedimentation at Versailles Lake.

Streambank erosion is a potentially large source of sediment for the watershed. Streambank erosion is a naturally occurring process that is accelerated by a variety of human activities. Specifically, the removal of vegetation adjacent to the stream for crop or pasture fields makes streambanks more susceptible to erosion due to the loss of stabilization from plant roots. Extensive agricultural development could contribute to streambank erosion due to quicker delivery of rainfall to stream which results in higher stream velocities and shear stresses. Creation of impervious surfaces (e.g., parking lots, roads, etc.) can also increase stream velocities and bank erosion. Elevated total suspended solids (TSS) measured during high flow conditions suggests that significant loads of sediment are being produced by stream bank erosion (IDEM, 2020).

Sheet and rill erosion may also be contributing to sediment issues within the watershed. These types of erosion occur in areas with sparse vegetation as rain and water flow overland and remove soil particles. Plowing and planting of agricultural fields during spring and summer months may increase the potential for soil erosion during these seasons. The Natural Resources Conservation Service (NRCS) provides indices of land erodibility based on soil type and watershed characteristics. Seventy-six percent of the



Laughery Creek watershed is classified as highly erodible or potentially highly erodible, meaning the land is more susceptible to high rates of erosion (IDEM, 2020). All of the above factors could be contributing to the rates of sedimentation documented in Versailles Lake.

2.6 ECOLOGICAL RESOURCES

2.6.1 Wetland Inventory

The potential location of wetlands in the project area, a potential constraint for construction activities, was assessed using readily available digital data. This desktop assessment was conducted for planning purposes only and does not constitute a formal delineation of jurisdictional waters. The U.S Fish and Wildlife Service (USFWS) maintains a database of the extent and characteristics of wetlands potentially present in an area. National Wetland Inventory (NWI) data, while not suitable for regulatory purposes, do suggest a high likelihood that such features are present. Figure 9 shows NWI data in the vicinity of the Lake Versailles Dam and impoundment. Small freshwater forested/shrub wetlands are potentially present along tributaries upstream of the impoundment and downstream of the dam along the right descending bank. The mid-channel island forming along the upstream extent of the impoundment may also support wetlands.





Figure 9. National Wetland Inventory data in the vicinity of Versailles Lake Dam

2.6.2 Threatened/Endangered Species

An online review was performed using the USFWS Information for Planning and Consultation (IPaC) tool on February 2, 2021 to assess the potential for federally-listed species to occur within the project area. The assessment returned two species:

- Indiana Bat (*Myotis sodalis*) – Endangered
- Northern Long-eared Bat (*Myotis septentrionalis*) - Threatened

The state of Indiana threatened and endangered species list was also reviewed for Ripley County. Two mussel species of special concern are Kidneyshell (*Ptychobranchus fasciolaris*) and Little Spectaclecase (*Villosa lienosa*). It is unlikely that the impoundment contains habitat for Kidneyshell because this species generally occupies shoal habitat in rivers with sand and gravel (Williams et al. 2018). Little Spectaclecase is more likely to be found in finer substrates and slower moving currents. The complete list of state listed



species for the county can be found at https://www.in.gov/dnr/nature-preserves/files/np_ripley.pdf (IDNR, 2020).

2.6.3 Fish and Macroinvertebrate Community

A fish community survey of Versailles Lakes was conducted on June 4, 2018. Eighteen species of fish were recorded. A complete list of species, abundances, lengths, and weights can be found in Appendix C. The most abundant species was Gizzard Shad (*Dorosoma cepedianum*, [n = 453]), followed by Bluegill (*Lepomis machrochirus*, [n = 167], White Crappie (*Pomoxis annularis*, [n =123]), and Quillback (*Carpiodes cyprinus*, [n =122]). These species are commonly found in lakes, ponds, backwaters of streams, and slow-moving streams.

Fish and macroinvertebrate community sampling, as well as habitat quality assessments, were conducted by IDEM in August of 2019 at 24 sites in the Laughery Creek Watershed upstream of the Versailles Lake Dam. No survey sites were located downstream of the dam. Common species observed upstream of the Versailles Lake Dam impoundment included Bluegill, Golden Redhorse, Longear Sunfish, Northern Hog Sucker, and Bluntnose Minnow. Species richness for sites on the mainstem of Laughery Creek ranged from 20 to 27 species. Index of Biotic Integrity (IBI) scores for the watershed were primarily fair to good. Five of the 24 sites received poor IBI scores for fish and/or macroinvertebrates. Potential reasons for these biological impairments include elevated TSS levels resulting in low dissolved oxygen concentrations, increased stream temperatures, and impairment to fish growth and reproduction. Qualitative habitat evaluation index (QHEI) scores for the watershed ranged from 47 to 75 (IDEM, 2020).

2.6.4 Freshwater Mussels

Surveys conducted by IDNR in Laughery Creek documented the presence of thirteen live freshwater mussel species downstream of the dam (Appendix C). This includes records of Spike (*Eurynia dilatata*), a state of Indiana species of concern. An additional six species were found as shells, including the Kidneyshell (*Ptychobranhus fasciolaris*) and Little Spectaclecase (*Villosa lienosa*), both state species of concern. No live records of threatened or endangered species have been documented. Clubshell (*Pleurobema clava*), a federally endangered species, was found as a weathered shell as recently as 2005 but it is not thought to currently inhabit Laughery Creek (B. Fisher, personal communication, June 14, 2021). No known mussel surveys have been conducted within the reservoir.

3.0 ALTERNATIVES

3.1 ALTERNATIVE 0: NO ACTION

A “no action” alternative was considered to provide a baseline option for comparison of the other three alternatives. Alternative 0: No Action assumes that no modifications are made to the dam and no dredging of sediments in the impoundment occur. In this alternative, the remaining lake volume will fill



with sediment within approximately 20 to 25 years as Laughery Creek establishes a low gradient, high sinuosity channel and areas adjacent to the newly forming channel become shallow open water or emergent wetlands. As the lake continues to fill with sediment, recreational value and current uses of the lake will progressively decrease. Open water swimming and boating areas will be lost as water depths continue to decrease in all portions of the reservoir. Water quality and aquatic habitat will also degrade with further sedimentation.

Critically, although the lake volume will eventually become minimal, IDNR has indicated that the dam would still have a high hazard classification. The classification would not change if future dredging efforts would reestablish an open lake.

3.2 ALTERNATIVE 1: SEDIMENT MANAGEMENT AND DAM IMPROVEMENT

Alternative 1 has two primary goals: restoring the recreational value of a large portion of the existing lake and compliance with IDNR dam safety regulations for a high hazard dam. This alternative requires the most significant initial construction cost and will require the most significant ongoing maintenance.

To meet the safety requirements for a high hazard dam, the Versailles Lake dam must be retrofitted or replaced to provide a structure that can safely pass the PMF. The most feasible modification to the dam is construction of a roller compacted concrete (RCC) emergency spillway to cover the downstream face of the northern portion of the earthen dam (Figure 10). Only the longer, northern earthen embankment is shown with RCC armoring as the shorter, southern embankment is not wide enough to make RCC application economical. A concrete wall at the crest of the southern embankment will prevent overtopping of the unprotected dam face. RCC was chosen to armor the dam embankment due to the height of the dam and the expected overtopping depth based on the hydrologic analysis. RCC, along with mass placed concrete, is one of the more robust methods of dam embankment overtopping protection and has been used in numerous similar dam rehabilitation applications across the country.

A possible alternative to RCC for overtopping protection is the use of Articulated Concrete Blocks (ACBs). ACBs can be a cost-saving alternative to RCC in some situations. Typically, RCC is used when higher velocities and depths of overtopping are expected during design flood conditions, such as those anticipated at Versailles Lake Dam based on the hydrologic analysis presented here. However, ongoing improvements in the design and physical model testing of ACBs show that higher overtopping depths may be tolerated for some applications (Schweiger, Shaffer, & Nadeau, 2016). The hydrologic modeling results included as part of this feasibility study are not sufficient to determine if ACBs would be a viable alternative. Further modeling and analysis of the dam hydraulics, including the effects of improvements to the spillway, would be needed to determine if ACBs could be used in place of RCC.

This emergency spillway would activate at lake levels above 809.5', and the dam crest would be overtopped by several feet. The construction of this emergency spillway would require the removal of the existing parking lot and potentially limit parking options due to the need for energy dissipation features at the base of the dam.



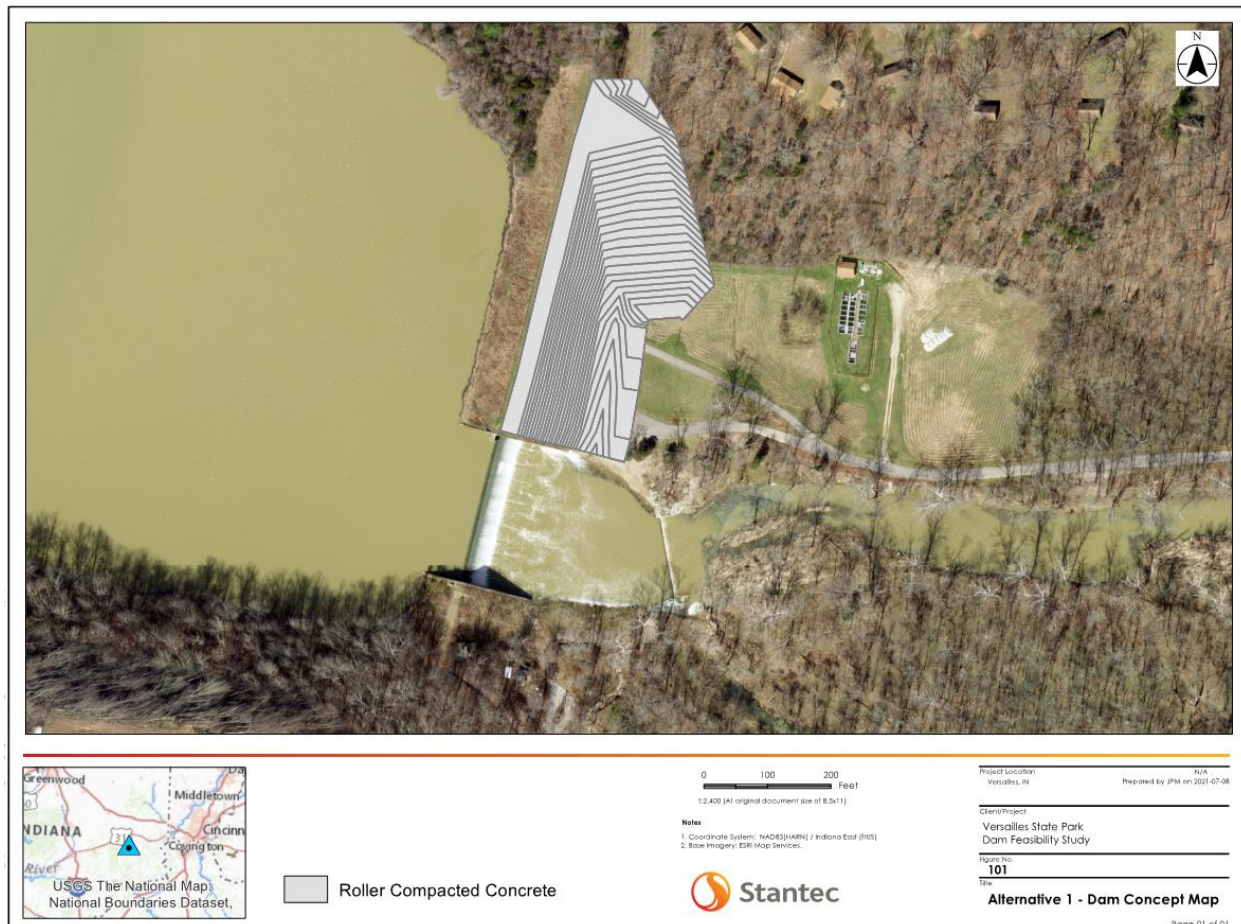


Figure 10. Alternative 1 Dam Concept Map

This alternative would include dredging of the lake to re-open and deepen the areas between the boat launch and the dam (Figure 11). The open lake footprint was assumed to be dredged to a minimum depth of 8 feet, assuming baseflow conditions. The total volume of dredge material to reach this minimum depth is approximately 425,000 cubic yards.

Ongoing maintenance dredging will be required. Sedimentation patterns and rates discussed Section 2.5 are likely to continue after dredging is complete. At a sediment inflow rate of 38,000 to 48,000 cubic yards per year, maintenance dredging could be required in as few as 5-7 years. The lake will have sedimentation levels close to current conditions within 9-12 years with no maintenance dredging. Estimated costs for maintenance dredging were assumed similar to present day costs and are presented in Appendix B. Control of sediment inflow into the reservoir is not feasible due to the size of the contributing watershed.

This alternative was further developed by considering the option to add an auxiliary spillway to the left of the dam embankment that would allow inflows to spill along a drainageway leading to Laughery Creek. The spillway was assumed to be 150-feet wide with a crest elevation of 790.0 (0.5 feet above the existing



Alternatives

spillway). These dimensions were chosen based on topographic site constraints and restricting the use of the auxiliary spillway to flood events that result in flow through the existing spillway. Hydraulic modeling showed that the addition of an auxiliary spillway would reduce, but not eliminate, the amount of overtopping on the armored dam section, which would still be substantial. The addition of an auxiliary spillway would lessen the flood load on the existing spillway and armored dam section, but would add the need to construct another structure, clear and maintain a channel from the auxiliary spillway to Laughery Creek, and possibly re-routing access roads or building bridge crossings over the auxiliary spillway channel to maintain vehicular access to the dam during a significant storm event.

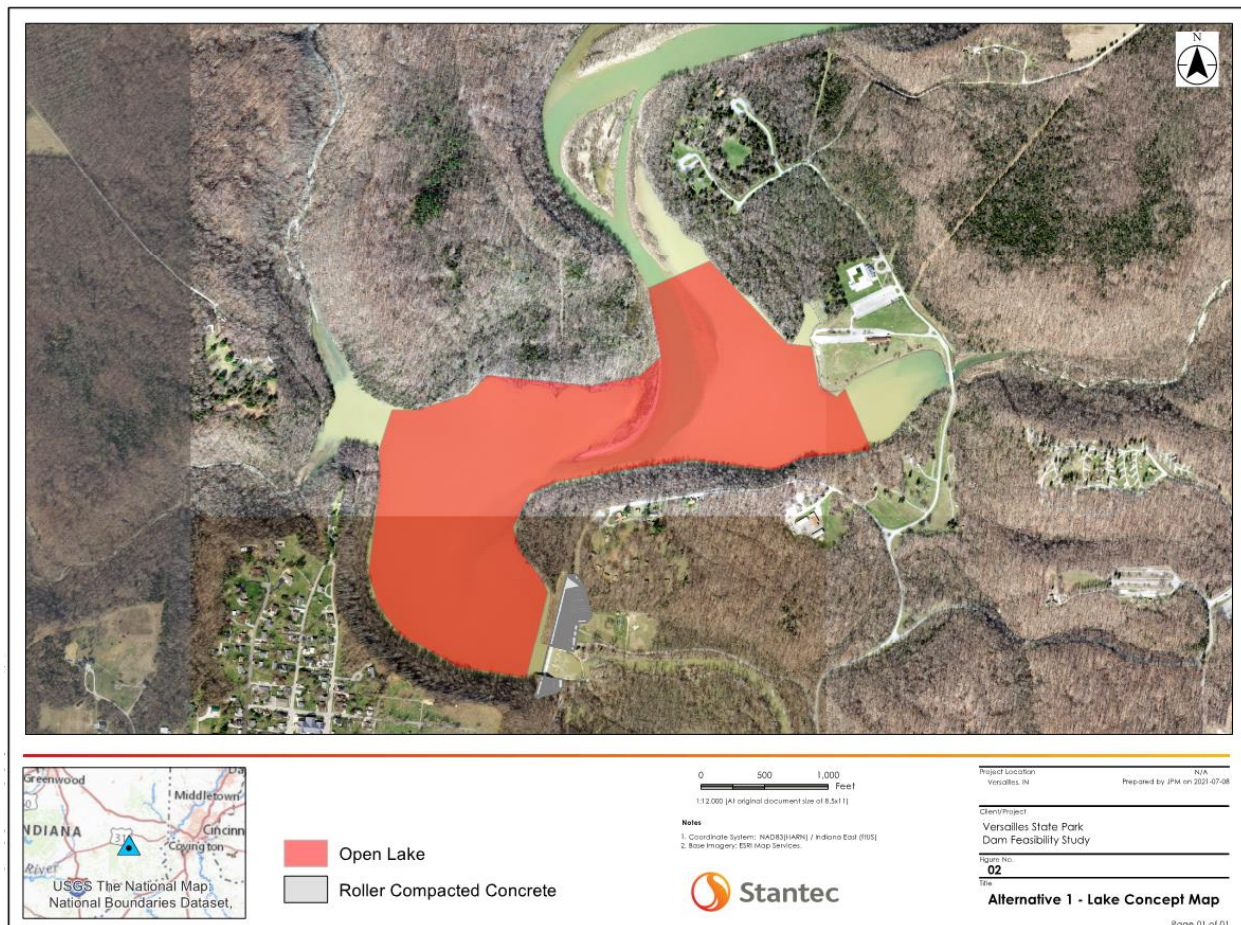


Figure 11. Alternative 1 Lake Concept Map

Because it maintains the lake as a viable, open water feature, this alternative best achieves IDNR's stated objective for recreational opportunities. Boating and fishing conditions, for lake tolerant species, would improve under this alternative.



3.3 ALTERNATIVE 2: PARTIAL DAM DECOMMISSIONING AND STREAM VALLEY RESTORATION

Alternative 2 provides a middle approach between Alternatives 1 and 3, requiring only partial removal of the dam embankment and spillway structure and stabilizing most of the sediments in place. The vertical drop between the impounded sediments and the downstream reach of Laughery Creek would be achieved through construction of a cascade and riffle/rapid feature (Figure 12).

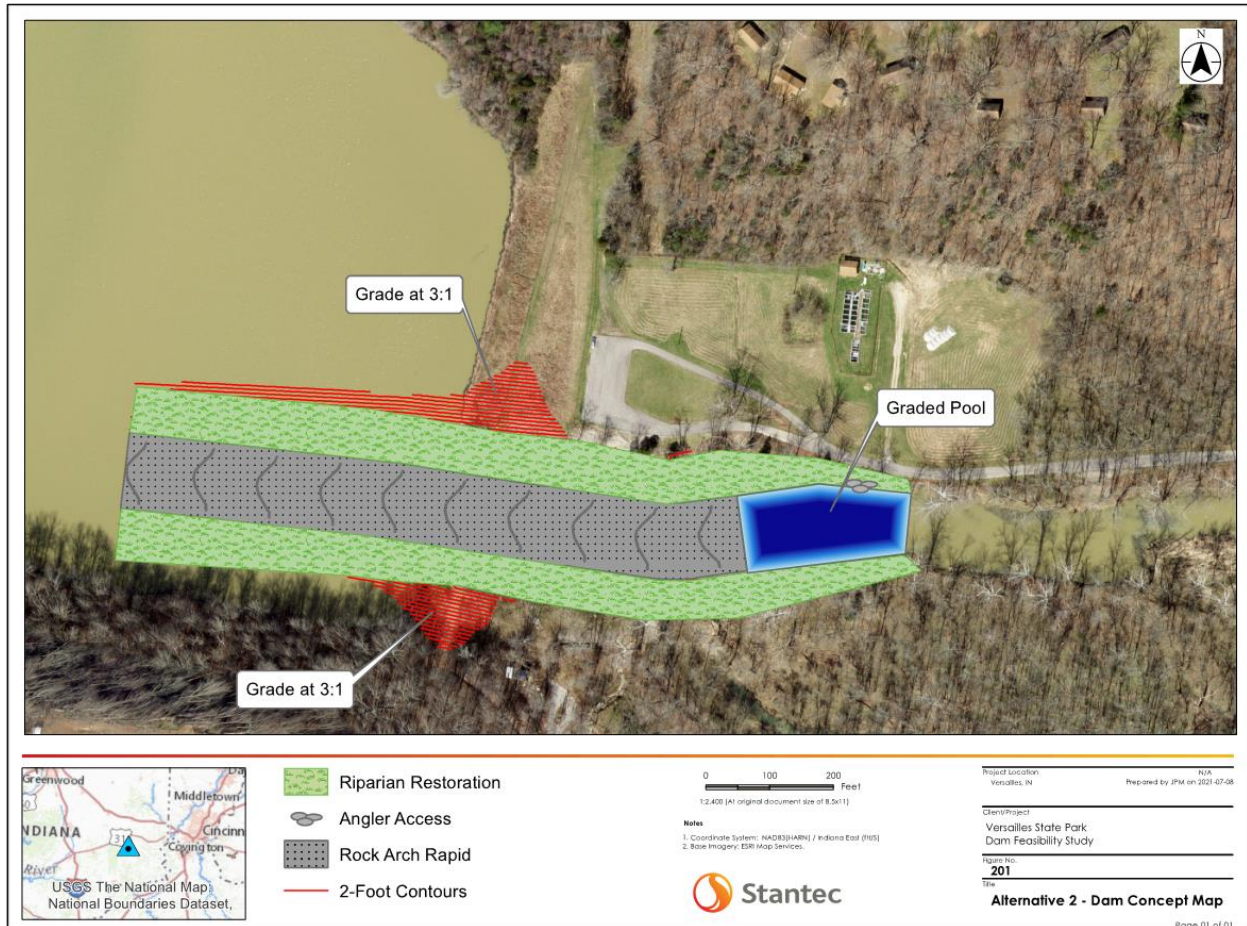


Figure 12. Alternative 2 Dam Concept Map

Stantec assessed options for this alternative where the existing spillway was lowered to a level which would allow it to pass the PMF or was replaced in a way which would allow most sediments to remain in place. Lowering the existing spillway crest could require significant structural improvements to the retaining walls separating the concrete spillway from the earthen dam. The structural integrity of the ogee spillway itself is also unknown and lowering could require significant structural stabilization. Hydraulic modeling shows that a spillway area wider than the existing spillway would be needed for this alternative. An option to replace the existing spillway with a cascade and rock arch rapids was chosen for structural



Alternatives

and safety reasons including risks associated with easier public access to the spillway from new land exposed in the drawn-down lake and stability of the adjacent concrete retaining walls.

Alternative 2 includes removal of the concrete spillway and retaining walls to an extent necessary to accommodate a rock arch rapid. The foundations of both the spillway and the retaining walls would remain in place below the rapid, decreasing the overall cost of demolition in Alternative 2. The rock arch rapid would have a slope of approximately 2-2.5% and would require approximately 850 linear feet of rapid to span the vertical difference between the impounded sediments and the downstream reach of Laughery Creek (approximately 18', from 774' to 756', based upon measured site conditions). Detailed modeling of the rock ramp will determine the final grades and dimensions to facilitate fish and boater passage.

Rough grading of impounded sediments is also recommended for this alternative. Construction mobilization for this alternative would occur in a single year and reservoir sediments can be expected to remain in their approximate current location. Rough grading would be used to move the new channel away from steep hill slopes, decrease occurrences of near-vertical slopes, and fill low areas to promote stream channel formation. This rough grading would produce a wide, flat valley with a sinuous stream channel. Open water features and emergent wetlands could be strategically graded to improve habitat (Figure 13).



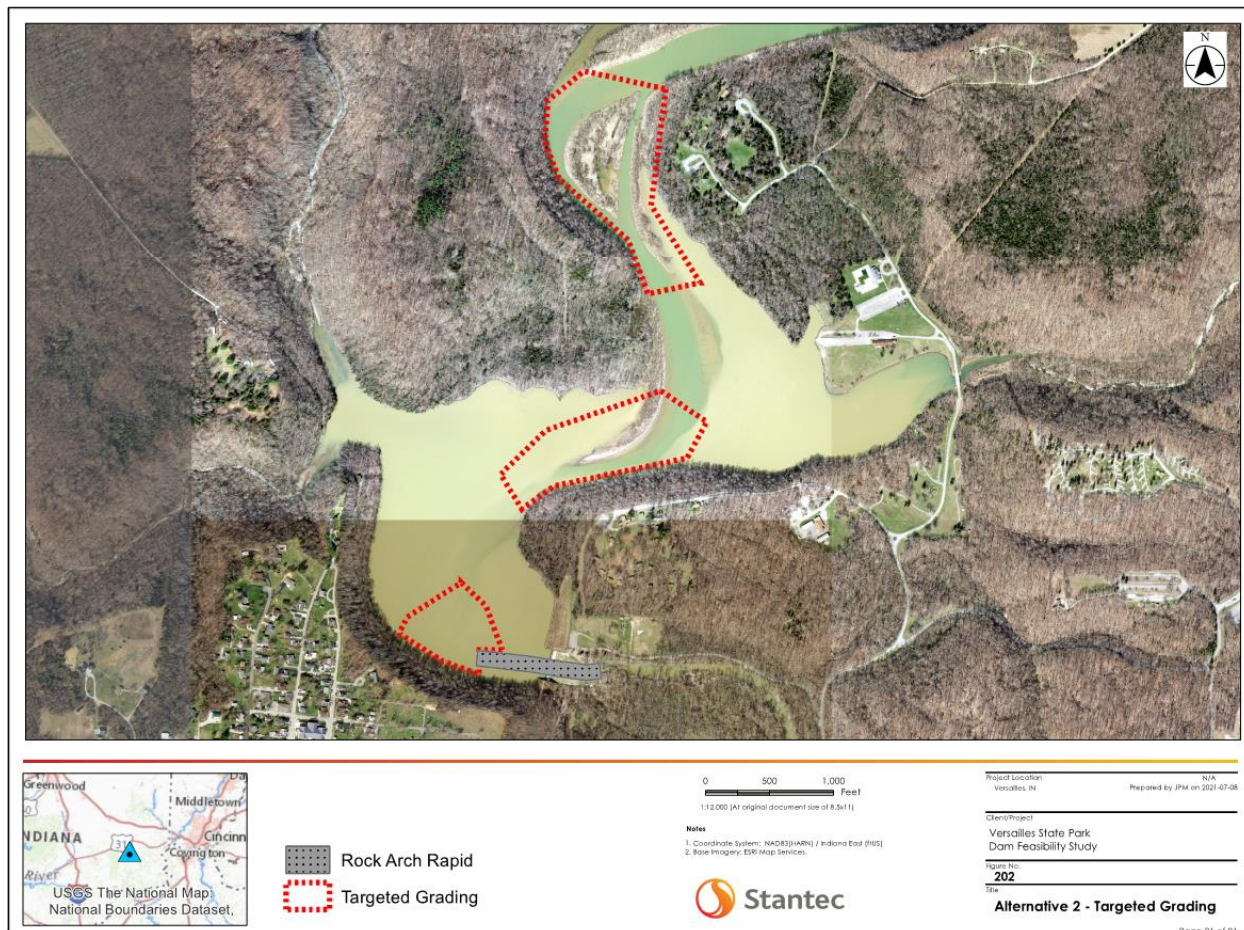


Figure 13. Alternative 2 Targeted Grading

Additional in-stream work could provide improved fishing opportunities for riverine species. Targeted fishing access would be difficult to install immediately after construction due to the “softness” of the likely saturated sediments of the former impoundment, but the pool at the downstream end of the rock arch rapid would provide a fishable stream feature. Future targeted restoration of Laughery Creek or development of new recreational amenities may be possible as the channel evolves, and sediments settle or erode. The rock arch rapids could also provide a canoe or kayak recreational feature, with the design accommodating both boater passage moving downstream and fish passage moving upstream.

3.4 ALTERNATIVE 3: FULL DAM DECOMMISSIONING

Alternative 3 includes removal of the full concrete spillway, retaining walls, and a large portion of the earthen dam. Alternative 3 relies on a passive approach to sediment management, using a multiple year construction window to allow Laughery Creek to mobilize and transport sediment in the impoundment at a rate that is appropriate for the stream system. The result of this approach would be a free-flowing Laughery Creek, which over time will evolve to occupy its historic valley.



Alternatives

Alternative 3 requires approximately 3-5 years of staged drawdown of Versailles Lake. This drawdown would be achieved by notching the concrete spillway to elevations which will allow staged mobilization and transport of sediment by the creek. Data collection and analysis will be required to estimate the appropriate annual sediment discharge and associated levels of dam notching.

A total “valley” width of approximately 400 feet will be graded through the earthen dam and concrete spillway. The remaining extents of the earthen dam will remain in place after construction. This valley width will reduce the potential for scour or sediment deposition caused by flow constriction.

Riffles and pools, designed with the goal of stability and aquatic habitat, will be constructed in the former footprint of the dam. These features will include stabilized angler access points to provide recreational opportunities and minimize erosion from foot traffic. Riffle features will also be designed to allow canoe and kayak passage (Figure 14).

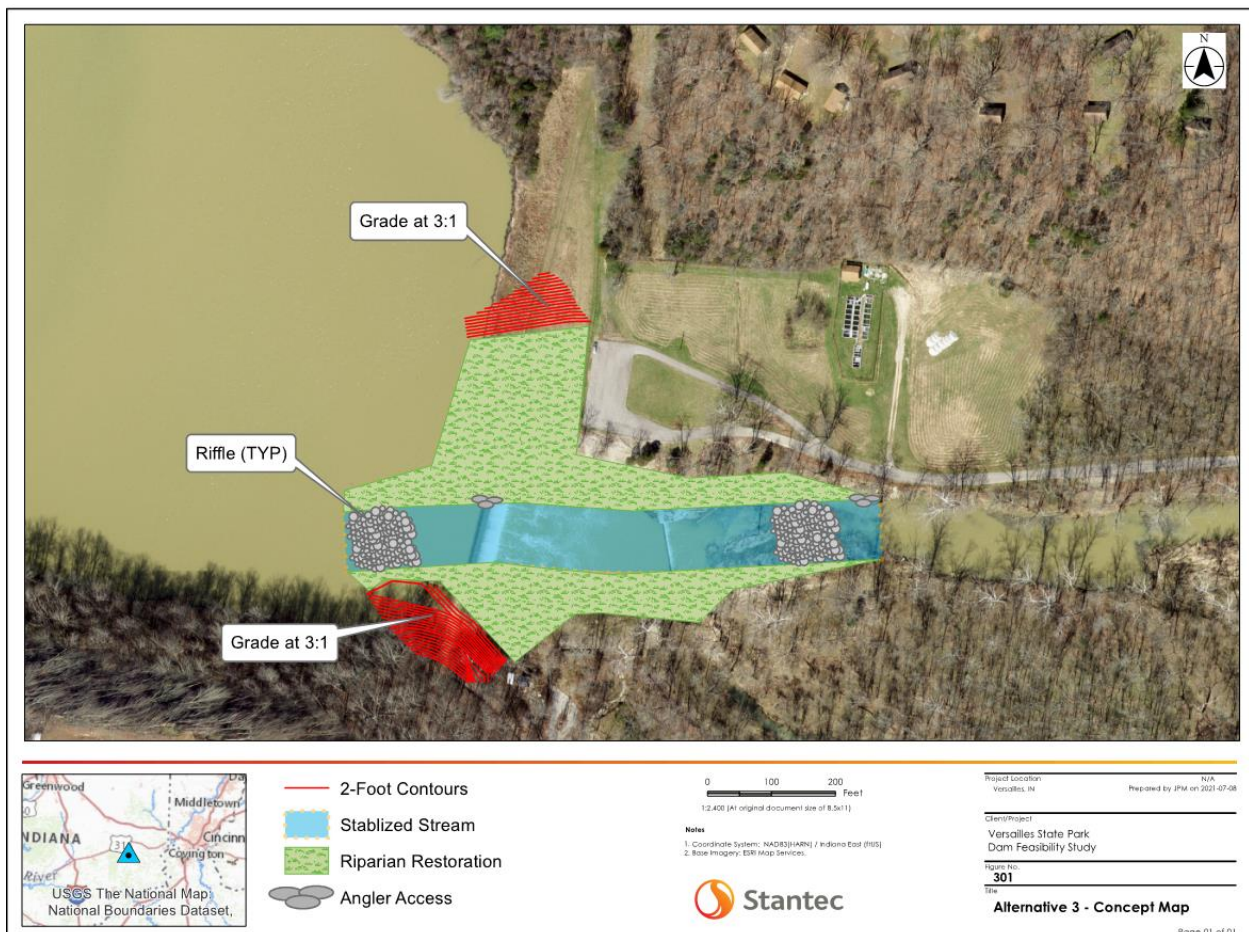


Figure 14. Alternative 3 Concept Map

Minimal grading of impounded sediments, to provide a smooth transition from the current lake footprint to the downstream reach of Laughery Creek, will be required.



4.0 ASSESSMENT AND COMPARISON OF ALTERNATIVES

4.1 RECREATIONAL VALUE

Each alternative offers unique recreation opportunities, either in the form of a maintained Versailles Lake or a restored, free-flowing Laughery Creek.

Alternative 1 most closely resembles the initial recreational layout of Versailles Lake, dredging and reopening most of the lower lake between the boat launch and the dam. This alternative would target maintenance of approximately 115 acres of open lake to allow for boating, swimming, and fishing in this area. The lake would be dredged to a minimum depth of 8 feet in this open lake footprint, with some areas in the south and west of the lake remaining deeper.

Alternatives 2 and 3 would change the viable fishing and boating recreation activities available in the former lake footprint. Both alternatives would be designed to be passable by both fish and canoes or kayaks during certain flow conditions. Both alternatives could be designed to create changed (riverine) fishing opportunities. Habitat structures to ensure bank and stream bed stability can also be designed to provide improved holding habitat for fish and provide angler access. Alternative 3 offers more opportunities to design a stream restoration component that would improve the value of Laughery Creek as a fishery in the vicinity of the decommissioned dam. Alternative 2 requires most of the area in the dam footprint to become the constructed riffle, leaving the end pool as the highest potential option for fishing focused amenities. Additional active restoration in the existing lake footprint after full or partial dam removal could create additional targeted fishing opportunities.

Both Alternative 2 and Alternative 3 also provide possibilities for canoe or kayak paddling recreation. Alternative 2 provides a potentially more challenging kayaking design, with the rock rapid offering the potential for creating more challenging features. Stantec did not assess flow data as part of this study to assess the seasonal viability of the stream to support paddling.

4.2 ECOLOGICAL EFFECTS

Both alternatives 2 and 3 will provide ecological uplift within the current footprint of the lake and for the larger Laughery Creek system through improved sediment transport and restoration of fish passage through the current dam footprint. The impoundment currently creates a monotypic pool habitat which cannot support a large diversity of fish species. The fishery would likely shift from a lentic system that supports species like crappie to a lotic one where species like smallmouth bass are targeted. Restoration of the stream through the current impoundment length would likely result in an improved fish community similar to the riverine species observed in upstream reaches (Section 2.6.3). Riffles would also enhance in-stream aquatic habitat quality. The need for active stream restoration along the full length of the impoundment is unlikely as the sediment is erodible and should not preclude natural channel evolution. However, spot treatments may be necessary.



Impacts to downstream aquatic habitat would occur from pulses of sediment delivery into the downstream reach of Laughery Creek as sediment is released from the impoundment. The location and depths of accumulated sediment in Laughery Creek following drawdown of the impoundment would depend on many factors, including flows following dam removal. Qualitative assessment of impoundment sediment indicates that the majority of the sediment is comprised of material finer than sand that would be transported as suspended load during high flow events. This would likely minimize accumulation of sediment shoaling in the downstream reach as base and high flows will continue to flush sediment further downstream. Therefore, impacts to mussel and fish habitat from sediment releases will likely be short-term. For Alternative 3, additional sediment transport analysis may be needed to quantify expected suspended sediment concentrations and transport rates through the downstream reach. Downstream sediment impacts are expected to be marginal for Alternative 2 as targeted grading and plantings in the impoundment will be used to stabilize most of the sediment in its current position.

The timing and sequencing of dam decommissioning will be fundamental to reducing risks to aquatic resources from the release of sediment. Conducting a multi-stage drawdown over a period of up to five years will slow down the rate of sediment mobilization while allowing more time for impoundment sediments to stabilize. Additional study of the sediment transport capacity of the channel downstream of the dam is needed to inform a drawdown rate that is appropriate for the stream system.

For Alternatives 2 and 3, existing wetlands that have developed along mid-channel islands and impoundment boundaries may no longer be maintained following drawdown of the impoundment. It is expected that most, if not all, of these wetlands will slowly revert to upland habitat types. Simultaneously, the potential for the development of these in-stream wetland systems is enhanced and new wetlands will likely form at a lower elevation coincident with the new floodplain. Open water features and emergent wetlands could be strategically graded to improve habitat. Native plantings will also promote the development of wetland plant communities.

4.3 SAFETY

Alternative 0 represents the highest safety risk of the three alternatives. The dam still risks failure during high flow events, as overtopping would still occur during the PMF, and scour could cause failure of the earthen dam. As the reservoir continues to silt in, park visitor access to the existing concrete ogee spillway may become possible. This easy access could cause a safety hazard if visitors approach the spillway crest.

Alternatives 1, 2, and 3 all meet the IDNR dam safety requirements either by armoring the earthen dam or by partially or fully decommissioning the dam. Long-term risks still exist with Alternative 1, requiring ongoing active monitoring of the dam's primary spillway and the roller compacted concrete emergency spillways and repair of any deficient parts of the structure. The depth of water overtopping the roller compacted concrete is significant, meaning any infrastructure immediately downstream of the dam may be damaged by water as energy dissipates at the base of the dam. Both Alternative 2 and Alternative 3 are anticipated to remove the classification of the remaining berm as a dam.



All alternatives assessed as part of this study assume that the spillway, retaining walls, and earthen dam are structurally and geotechnically sound. None of the alternatives include costs associated with structural stabilization, removal and replacement, or geotechnical stabilization of existing structures.

4.4 PROBABLE COSTS

4.4.1 Construction Costs

A planning level opinion of probable construction cost (OPCC) was prepared for each of Alternatives 1-3. These costs assume that all dam structures are stable and that no modifications or replacement of the earthen or concrete portions of the dam will be required. All costs are in 2021 dollars, and escalation is not factored into the costs as no timeline for implementation is suggested by this study. Each planning level OPCC includes known major project components, a 5% other/miscellaneous allowance, a 30% planning level contingency, and an approximate estimate of survey, design, and permitting professional services. All costs are rounded up to the nearest \$100,000. Detailed cost estimates are presented in Appendix C.

Alternative 1 is the most expensive of the alternatives. The total project construction cost estimate is \$66,500,000. Direct dam improvements represent approximately \$11 million of the total planning level construction cost. The primary driver of high costs for this alternative is the need to dredge, dewater, and haul stored sediments to an off-site dredge disposal area. While hydraulic dredging alone may cost as little as \$8-12 per cubic yard of material, this generally assumes that dredge materials may be disposed of by dumping into a receiving water. An example of this would be dredging of a harbor, with dredged materials being deposited in deeper offshore waters. In this case, there are no deeper offshore areas available for sediment disposal. A nearby disposal location was assessed for viability of a confined disposal facility, but elevation and site constraints made this infeasible (see Appendix D for detailed discussion). Construction of a dewatering facility, and subsequent loading, hauling, unloading, grading, and stabilization of sediments at a disposal location account for over 80% of the per cubic yard cost of dredging for this alternative. The quantity of dredged sediments represents less than 15% of the total sediment contained within the impoundment. While increasing the volume of sediment removed would yield some per-unit cost savings as the equipment mobilization costs and construction of a dewatering facility would remain the same, most of the costs per unit of sediment dredged remain fixed.

Alternative 2 is the second most expensive alternative. The total project cost estimate is \$12,300,000. The benefit of Alternative 2 is that construction could occur in a single mobilization but would require that most of the sediment within the impoundment be stabilized in place. The rock arch rapid, which allows the PMF to pass safely, but keeps most sediments in place, accounts for approximately \$2,100,000 of the total project cost. Cost of the rock arch rapid assumes that clean, broken concrete from dam demolition can be recycled as material for the base of the rapid. Demolition of the dam to below the finished grade of the rapid accounts for an additional \$3,000,000.

Alternative 3 is the least expensive of the three alternatives. The total project cost estimate is \$9,400,000. Alternative 3 requires several mobilizations over a period of 3-5 years to notch the spillway, allowing



sediment to mobilize and be transported downstream through natural processes. Stream stabilization and restoration is limited to the dam footprint and immediately upstream and downstream of the dam.

Alternatives 2 and 3 are the most likely to be eligible for grant funds whereas fewer grants are available for dam repair. The Versailles Lake Dam is the only IDNR regulated dam on the mainstem of Laughery Creek. Removal of the fish passage barrier could have significant impacts on watershed health upstream of the dam, for both fish and for freshwater mussels.

4.4.2 Maintenance Costs

Alternatives 2 and 3 are designed to minimize ongoing maintenance costs. Costs will likely be limited to adaptive management during the first 2-3 years following dam decommissioning as the new Laughery Creek channel establishes.

Alternative 1 will require active monitoring of the roller compacted concrete, with potential significant ongoing costs as the concrete spillway or the roller compacted concrete emergency spillways age. The most easily defined operational cost of Alternative 1 is the need to periodically dredge sediment. Maintenance dredging an inflow of sediment between 38,000 and 48,000 cubic yards per year volume every 5-7 years, for example, would require that approximately 200,000 cubic yards of sediment be dredged. The approximate cost to dredge, dewater, haul, dump, grade, and stabilize that volume of material is approximately \$16,000,000 in 2021 dollars.

4.5 REGULATORY CONSIDERATIONS

This project is subject to a combination of federal, state, and local regulations aimed to protect human health and the environment. The following section describes the permits and regulatory processes that may be required by regulatory agencies as they relate to project design elements and impacts. Table 2 provides a summary of the possible permitting pathways and regulations applicable to each alternative.

Table 3. Possible regulatory and permitting considerations for project alternatives

Regulatory Item	Alternate 1	Alternate 2	Alternate 3
CWA Section 404 General Permit	General permit unlikely	NWP 27 (Aquatic Habitat Restoration) unlikely	NWP 27 (Aquatic Habitat Restoration) possible
CWA Section 401 Individual Permit	Yes	Yes	Yes



Section 7 – Endangered Species	informal consultation likely for freshwater mussels and bats	informal consultation likely for freshwater mussels and bats	informal consultation likely for freshwater mussels and bats
Section 106	Historical review process with SHPO, Phase I Cultural Resources survey possible due to public lands	Historical review process with SHPO, Phase I Cultural Resources survey possible due to public lands	Historical review, process with SHPO Phase I Cultural Resources survey possible due to public lands
Waters of the U.S or State Mitigation	Mitigation costs for 1) any impacts at disposal locations, 2) impacts to the stream at dredging sites, and 3) stream and wetland features in the vicinity of dam construction.	Likely for any wetland and stream impacts if individual 401 WQC required	Likely for any wetland and stream impacts if individual 401 WQC required

Clean Water Act 404 Permit

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 Department of the Army (DOA) through the U.S. Army Corps of Engineers (USACE). DOA permits can be divided into two basic groups; General Permits and Individual Permits. General Permits are issued for small impacts and Individual Permits are issued for projects with greater impacts or those with classes of actions not authorized under NWP. The USACE has developed a Nationwide Permit (NWP) program that authorizes approximately 54 specific activities. The program has a list of general conditions that must be met by all NWP’s. In addition, each NWP has its own list of specific conditions and authorizations. If a proposed activity can be conducted within the constraints of the general and specific NWP conditions, a permit is issued.

Alternatives 2 and 3 may be eligible for authorization under NWP 27 Aquatic Habitat Restoration, Establishment, and Enhancement Activities if ecological lift can be demonstrated through the project design. Alternative 3 has more opportunity for ecological enhancement through in-stream habitat structures, constructed riffles, and other natural channel design features.

Clean Water Act 401 Permit

Section 401 of the CWA requires state agencies to certify that a federally issued Section 404 CWA permit



will not result in a violation of state water quality standards. Each individual state has the option of placing restrictions on usage of the NWP's under its 401 CWA authority. This authority is administered by the IDEM. The selected alternative may qualify for NWP 27 only if it will have a minimal effect on water quality. A minimal effect is defined by IDEM as an activity that permanently impacts 0.1 acres or less of Waters of the United States, permanently affects 300 linear feet or less of stream, and does not result in any permanent secondary effects to Water of the United States. It is likely that all alternatives will exceed these impact limits and require preparation of an individual 401 WQC.

A 401 WQC application requires additional information not involved in a 404 Pre-Construction Notification (PCN). The application includes discussion of avoidance and minimization measures. The applicant is responsible for issuing a public notice of the application after determination by the IDEM that the application is complete. The Individual 401 WQC application review process may require up to 120 days to complete, prolonging the project implementation schedule.

Section 7 of the Endangered Species Act

The Federal Endangered Species Act (ESA) [16 U.S.C.1531 et seq.] became law in 1973 and provides for the listing, conservation, and recovery of endangered and threatened species. The U.S. Fish and Wildlife Service is the agency responsible for protecting and monitoring populations of listed endangered species. Section 7(a) (2) of the ESA states that each Federal agency shall insure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of listed species, or result in destruction or adverse modification of designated critical habitat. A federal action includes approval of a permit or license, including Section 404 permits under the CWA. Coordination under this statute will likely be resolved through informal consultation with USFWS. Federal and state listed threatened and endangered species potentially present in the Project area are described in Section 2.5.2.

Should suitable summer bat roosting habitat be present and tree clearing be required, a presence/absence surveys could be needed. If trees are cleared between October 1 and March 31, any effects to bats will be discountable and surveys will not be needed. It is possible that the impoundment may contain suitable habitat for the certain mussel species. For Alternatives 2 and 3, mussels may be directly or indirectly impacted by physical crushing from heavy equipment in the dam construction footprint. Mussels may be stranded on exposed substrates or entrapped within the substrate as the dam pool is lowered. For Alternatives 1 and 2, dredging or grading of sediment may also impact mussels. It may be necessary to conduct a presence/absence survey for mussels prior to Project construction. See Section 4.2 for more details on anticipated effects on mussels.

National Historic Preservation Act

Section 106 National Historic Preservation Act (NHPA) requires Federal agencies to identify historic properties potentially affected by undertakings, and to seek ways to avoid, minimize, or mitigate any adverse effect on these properties. In cases where the project may have the potential to cause effects to properties listed, or eligible for listing, in the National Register of Historic Places, the activity is not



authorized until the requirements of Section 106 of the NHPA have been satisfied. The Division of Historic Preservation and Archaeology (DHPA) is the official historic preservation agency of the state of Indiana. For all Alternatives, a complete inventory of the National Register of Historic Places database will need to be conducted for the Project area to identify historic and archaeological resources potentially impacted by the Project. Additionally, a Phase I Cultural Resources Survey may be required since the Project involves public land. The dam structure itself could be considered a historic structure due to its age. A Phase I investigation generally involves a literature review of site records, aerial photographs, maps, and other relevant cultural resources records. If potential impacts to historic features are identified, coordination with DHPA will determine what mitigation measures are required.

Waters of the U.S. Mitigation and Monitoring

As described above in Section 4.2, existing wetlands along the current dam impoundment would be indirectly impacted by drawdown of the impoundment under Alternative 2 and 3. However, new wetlands may form along the new impoundment extended. Targeted grading and native plantings can be used to enhance the establishment of new wetland plant communities and promote wetland hydrology. Compensatory wetland mitigation and monitoring may be required as stipulations as the issued 404 Permit from USACE. It is anticipated that onsite mitigation through development of wetlands along the newly established floodplain will be sufficient to fulfill such requirements.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) process begins when a federal agency develops a proposal to take a major federal action. These actions are defined at [40 CFR 1508.1](#) and includes actions that are funded used federal grants. The environmental review under NEPA can involve three different levels of analysis: 1) Categorical Exclusion Determination, 2) Environmental Assessment (EA)/Finding of No Significant Impact, and 3) Environmental Impact Statement (EIS). A categorical exclusion is applied when the lead federal agency concludes that the action does not have a significant effect on the human environment. If the federal agency decides that a categorical exclusion does not apply to the proposed action, then an EA is prepared. The purpose of the EA is to determine if the action will cause significant environmental impacts, in which case a more detail analyses of project environmental effects are conducted through the EIS process. The EIS is a more rigorous document than the EA and is published for public review and comment for a minimum of 45 days.

State Permitting

For all alternatives, a Construction in a Floodway permit will be required from the IDNR Division of Water.

4.6 OTHER CONSIDERATIONS

For both alternatives, actively grading and restoring the stream could cost an additional \$1-3 million but could likely be offset in part by grant programs. Grant funds are likely more readily available for



“restoration” approaches such as Alternative 2 and Alternative 3 which return Laughery Creek to a free-flowing condition.

Public outreach will need to be a critical consideration of all three alternatives. Change in the primary recreational use of the impoundment footprint will significantly impact long-term operations at the park. Although Alternative 1 does maintain an open lake between the boat launch and the dam, this open lake has a smaller footprint than the lake immediately after construction of the dam and will require regular dredging maintenance that will impact use of the lake.

Each of the alternatives includes assumptions related to existing conditions and sediment transport during the construction of each alternative. Alternative 1 has the highest risk of increased construction and professional services costs. The cost estimate developed for this study assumes that the earthen dam and all concrete structures are sound and do not require replacement or repair. Geotechnical and structural investigations included in the professional services line item would inform the need for repairs or replacement of existing structures and confirm that the volume of concrete assumed is adequate. The dredging cost line item in the Alternative 1 cost estimate could also be volatile, as it requires trucking of materials to a dredge disposal facility (which was assumed to be located on Indiana DNR property).

4.7 COMPARISON OF ALTERNATIVES

Table 3 summarizes how each alternative presented above does or does not meet the project objectives and the associated impacts.

Table 4. Summary comparison of project alternatives

Item	Alternative 0 (No Action)	Alternative 1 (Sediment Management with Dam Improvement)	Alternative 2 (Partial Dam Decommissioning)	Alternative 3 (Full Dam Decommissioning)
Safety	High-hazard dam remains	High-hazard dam remains	Reduction in hydraulic drop	Elimination of dam safety risks
Recreational Value	Lake for boating and swimming lost	Open-water boating, swimming, and fishing are maintained	Canoe/kayak passage possible with riffle/rapid feature, fishing	Canoe/kayak passage, river fishing
Habitat	No improvement	No improvement for riverine species	Fish passage possible	Fish passage, In-stream habitat structures possible



Construction Cost	\$0	\$103,500,000	\$13,200,000	\$9,800,000
Maintenance	Long-term maintenance of dam facilities	Periodic dredging of forebay, long-term maintenance of spillways	Minimized, 2-3 years of adaptive management	Minimized, 2-3 years of adaptive management

5.0 SUMMARY AND CONCLUSIONS

Stantec’s review of available data and studies, existing site conditions, regulatory considerations, and engineering considerations suggests that all three alternatives are feasible. The major differences between them are the cost of sediment management and residual risk.

The concept designs presented in the study are meant to be planning level decision tools. Cost estimates represent best available data for 2021 prices. Alternative 1 has the highest risk of cost increases, as future investigations could significantly increase the modifications required at the dam and future changes in trucking or hydraulic dredging cost rates could increase the per unit cost of dredging the lake. Alternative 1 was estimated to cost approximately \$103,500,000, with dredging activities costing over half of the total project cost. Alternative 2 was estimated to cost approximately \$13,200,000 and Alternative 3 was estimated to cost approximately \$9,800,000. Both Alternative 2 and 3 assume minimal handling of impounded sediments.

Alternatives 2 and 3 significantly alter the recreational uses available to park visitors. Both alternatives would result in loss of the existing lake at Versailles State Park. While fishing and boating opportunities would still be available, they would be in the form of canoe or kayak use and riverine fishing. There are likely seasonal limitations on viability of Laughery Creek as a paddling stream.

Alternative 1 does not remove the ongoing need to comply with regulations associated with a High Hazard classified dam. Alternative 1 also requires periodic dredging as there are no feasible means of decreasing the sediment inflow from the larger Laughery Creek watershed.

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Appendix A - SEDIMENT DATA



Figure 15. Sediment grab sampling locations for screening analysis



Table 5. Versailles Lake Dam Sediment Ecological Screening Results, March 2021

Chemical	Units	Ecological Screening Value (ESV) ¹	Refinement Screening Value (RSV) ¹	S01	S02	S03	S04	S05	Arithmetic Mean
PCBs, Total	mg/kg	59.8	676	< 0.34	< 0.3	0.82	1.4	0.84	1.0
PCB-1016	mg/kg			< 0.31	< 0.27	< 0.24	< 0.27	< 0.26	
PCB-1221	mg/kg			< 0.34	< 0.30	< 0.26	< 0.3	< 0.29	
PCB-1232	mg/kg			< 0.24	< 0.21	< 0.18	< 0.21	< 0.2	
PCB-1242	mg/kg			< 0.14	< 0.12	< 0.11	< 0.12	< 0.12	
PCB-1248	mg/kg			< 0.24	< 0.21	< 0.18	< 0.2	< 0.2	
PCB-1254	mg/kg			< 0.29	< 0.25	0.82	1.4	0.84	1.0
PCB-1260	mg/kg			< 0.28	< 0.24	< 0.21	< 0.24	< 0.23	
ICP Metals									
Barium	mg/kg	20	60	79	65	47	57	49	59
Cadmium	mg/kg	1	5	0.18	0.17	0.11	0.13	0.12	0.14
Chromium	mg/kg	43.4	111	13	12	7.8	9.6	8.4	10
Cobalt	mg/kg	50		7.6	6.4	4.3	5.4	5.1	5.8
Copper	mg/kg	31.6	149	11	9.9	5.8	8.3	8	8.6
Lead	mg/kg	35.8	128	14	12	7.7	9.9	10	11
Mercury	mg/kg	0.18	1.1	0.13	0.042	0.027	0.038	0.039	0.055
Nickel	mg/kg	22.7	48.6	13	11	6.7	8.7	8.3	9.5
Selenium	mg/kg	0.72	2.9	0.3	0.25	0.21	0.24	0.2	0.24
Zinc	mg/kg	121	459	50	43	27	36	35	38
PAHs									
Anthracene	µg/kg	57.2	845	< 7.9	< 5.3	< 7.6	< 3.5	22	22
Benzo(a)anthracene	µg/kg	108	1050	< 14	11	< 13	12	72	32
Benzo(a)pyrene	µg/kg	150	1450	< 13	18	16	15	84	33
Chrysene	µg/kg	166	1290	< 17	18	19	17	87	35
Dibenz(a,h)anthracene	µg/kg	33	135	< 20	< 13	< 19	< 8.8	19	19
Fluoranthene	µg/kg	423	2230	16	31	32	31	210	64
Fluorene	µg/kg	77	536	< 6	< 4.0	< 5.8	< 2.7	11	11
Napthalene	µg/kg	176	561	< 6	< 4.0	< 5.7	< 2.7	< 3.7	
Phenanthrene	µg/kg	204	1170	< 8.2	10	13	11	100	34
Pyrene	µg/kg	195	1520	15	23	25	25	150	48
Total Organic Carbon	mg/kg			23000	180000	190000	22000	22000	

¹ESV and RSV from U.S. EPA Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update)



Appendix B – COST ESTIMATE



Versailles Dam Feasibility Study

Alternative 1 - Conceptual Cost Estimate (2021 Dollars)

Number	Item	Est. Quantity	Unit	Unit Cost	Extension
1	Mobilization	1	LS	\$2,500,000	\$2,500,000
2	Construction Layout & Staking	1	LS	\$40,000	\$40,000
3	Soil Erosion and Sediment Control	1	LS	\$50,000	\$50,000
4	Aggregate Access/Staging & Storage	1	LS	\$50,000	\$50,000
5	Clearing & Grubbing	3	AC	\$15,000	\$45,000
6	Demolition (Parking, Drive, Etc.)	1	LS	\$100,000	\$100,000
7	Dam Embankment Excavation	14,000	CY	\$30	\$420,000
8	Concrete Sub-Grade & Drainage	14,000	SY	\$50	\$700,000
9	Roller Compacted Concrete	30,000	CY	\$250	\$7,500,000
10	Concrete Training Walls	1,700	CY	\$950	\$1,615,000
11	Dredge, Dewater, Haul Sediment	425,000	CY	\$75	\$31,875,000
12	Revegetation	3	AC	\$8,000	\$20,000
13	Other Misc.	1	LS	\$2,300,000	\$2,300,000
Base Construction (Nearest \$100,000)					\$47,300,000
Construction Contingency (30%)					\$14,200,000
Construction Upper Bound					\$61,500,000
Survey, Design, Permitting, Construction Administration					\$5,000,000
Total Project Cost Estimate					\$66,500,000

Versailles Dam Feasibility Study

Alternative 2 - Conceptual Cost Estimate (2021 Dollars)

Number	Item	Est. Quantity	Unit	Unit Cost	Extension
1	Mobilization	1	LS	\$450,000	\$450,000
2	Construction Layout & Staking	1	LS	\$30,000	\$30,000
3	Soil Erosion and Sediment Control	1	LS	\$25,000	\$25,000
4	Aggregate Access	1	LS	\$5,000	\$5,000
5	Dam Demolition	1	LS	\$3,200,000	\$3,200,000
6	Dam Embankment Bulk Grading	25,000	CY	\$20	\$500,000
7	Bulk Sediment Excavation	100,000	CY	\$14	\$1,400,000
8	Cascade Riffles	2	EA	\$30,000	\$60,000
9	Straw Mat Erosion Control Fabric	2,200	SY	\$12	\$26,400
10	Bulk Rock (Rapid)	18,000	TN	\$85	\$1,530,000
11	Structure Boulders (Rapid)	2,700	TN	\$225	\$607,500
12	Angler Access	1	EA	\$15,000	\$15,000
13	Revegetation	5	AC	\$10,000	\$50,000
14	Other/Misc.	1	LS	\$450,000	\$450,000
Base (Nearest \$100,000)					\$8,400,000
Contingency (30%)					\$2,600,000
Construction Upper Bound					\$11,000,000
Survey, Design, & Permitting					\$1,300,000
Total Project Cost Estimate					\$12,300,000

Versailles Dam Feasibility Study

Alternative 3 - Conceptual Cost Estimate

Number	Item	Est. Quantity	Unit	Unit Cost	Extension
1	Mobilization	1	LS	\$500,000	\$500,000
2	Construction Layout & Staking	1	LS	\$30,000	\$30,000
3	Soil Erosion and Sediment Control	1	LS	\$25,000	\$25,000
4	Aggregate Access/Staging & Storage	1	LS	\$5,000	\$5,000
5	Dam Concrete Demolition	1	LS	\$4,200,000	\$4,200,000
6	Dam Embankment Bulk Grading	25,000	CY	\$20	\$500,000
7	Channel Stabilization	800	LF	\$500	\$400,000
8	Bulk Sediment Excavation	25,000	CY	\$14	\$350,000
9	Angler Access	2	EA	\$15,000	\$30,000
10	Revegetation	4	AC	\$10,000	\$40,000
11	Other Misc.	1	LS	\$300,000	\$300,000
Base Construction (Nearest \$100,000)					\$6,400,000
Construction Contingency (30%)					\$2,000,000
Construction Upper Bound					\$8,400,000
Survey, Design, Permitting, Construction Administration					\$1,000,000
Total Project Cost Estimate					\$9,400,000

Appendix C – FISH AND MACROINVERTEBRATE COMMUNITY

Table 6. Species and relative abundance of fish collected in Versailles Lake, June 4, 2018

Common Name*	Count	Percent	Length Range(inches)	Weight (pounds)	Percent (by Weight)
Gizzard Shad	453	42.7	2.5 - 10.4	72.46	16.1
Bluegill	167	15.8	2.5 - 7.1	16.64	3.7
White Crappie	123	11.6	4.8 - 11.5	16.62	3.7
Quillback	122	11.5	10.3 - 16.0	126.34	28.0
Golden Redhorse	53	5.0	8.6 - 16.1	55.70	12.4
Brown Bullhead	43	4.1	3.6 - 10.7	13.76	3.1
Spotted Sucker	24	2.3	8.8 - 12.3	11.45	2.5
Channel Catfish	22	2.1	14.0 - 26.1	47.42	10.5
Largemouth Bass	15	1.4	5.1 - 20.3	22.82	5.1
Common Carp	14	1.3	17.1 - 22.2	44.49	9.9
Longear Sunfish	13	1.2	2.5 - 4.7	0.57	0.1
Warmouth	3	0.3	3.9 - 4.7	0.18	<0.1
Black Crappie	2	0.2	6.7 - 6.8	0.25	0.1
Yellow Bullhead	2	0.2	4.4 - 8.0	0.29	0.1
Bigmouth Buffalo	1	0.1	32.0	21.00	4.7
Golden Shiner	1	0.1	6.1	0.09	<0.1
White Sucker	1	0.1	9.4	0.31	0.1
Redear Sunfish	1	0.1	6.9	0.21	<0.1
Total	1,060			450.60	

*Common names of fishes recognized by the American Fisheries Society.



Table 7. Mussel species found in Laughery Creek downstream of Versailles Lake

Common Name	State Status	Federal Status
Threeridge		
Spike	Special Concern	
Wabash Pigtoe		
Plain Pocketbook		
Fatmucket		
White Heelsplitter		
Flutedshell		
Fragile Papershell		
Pink Heelsplitter		
Giant Floater		
Deertoe		
Paper Pondshell		



Appendix D – ALTERNATIVE 1 DESIGN DISCUSSION



Reference: Versailles Lake Dam Feasibility Study Report

Dredging of the Versailles State Park Lake by hydraulic means and transportation of dredged material through a pipeline network to a confined disposal facility (CDF) was assessed during development of Alternative 1. A property owned by the State of Indiana was identified as a site for the CDF (Figure D1). This site is approximately 144 total Acres and has several valley/ravine features in the south and west sides of the parcel.

Stantec performed a desktop assessment of two possible pipe routes from the lake to the proposed disposal site and conducted preliminary designs of a CDF at the site. Both alignments require significant booster pump and backflow prevention system use as the disposal site is significantly higher in elevation than the disposal site. The topography and potential cultural resources at the disposal site add additional feasibility concerns. Assessed piping alignments are shown in Figure D1.

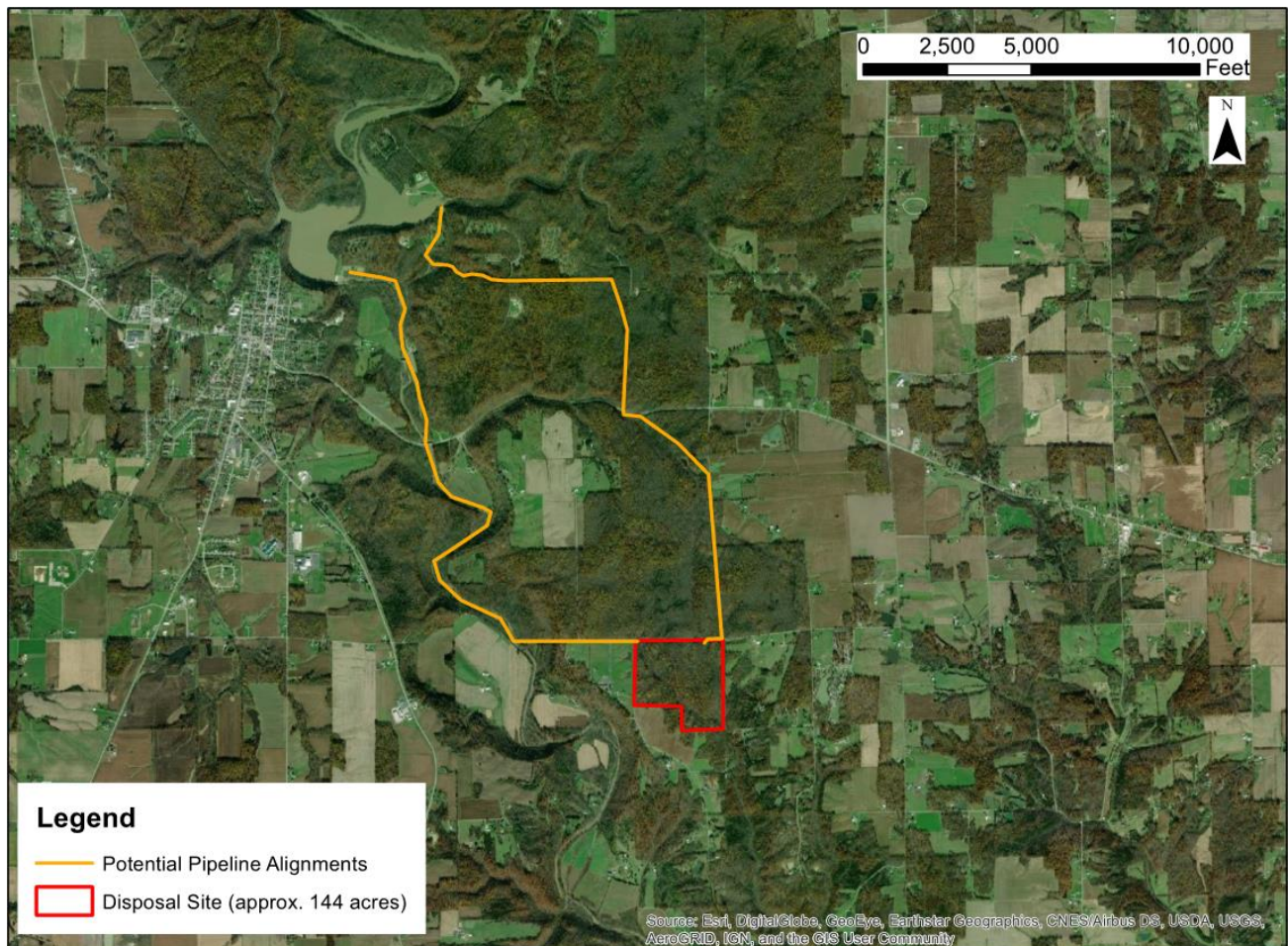


Figure D1 Pipeline Alignments

The first route follows roads and trails within the park, beginning near the boat house parking lot and using an existing box culvert underpass to bypass U.S. Route 50. This route is approximately 3.5 miles long, with a maximum vertical lift from the lake surface of approximately 190 feet. This route requires some clearing of forested park land and has several locations where “valleys” are crossed (pipeline must traverse downslope

Reference: Versailles Lake Dam Feasibility Study Report

then back upslope). These changes in vertical profile create risks for pipe clogging and for pipe pressure related issues.

The second route presents a “best-case” scenario for pumping of hydraulically dredged sediments. This alignment follows Laughery Creek to an apparent public right of way labeled County RD-250. This route is approximately 3.75 miles long. By following the profile of the stream, booster pumps are not required until the final segment following County RD-250. The vertical difference between the disposal site and Laughery Creek at this location is approximately 240 feet.

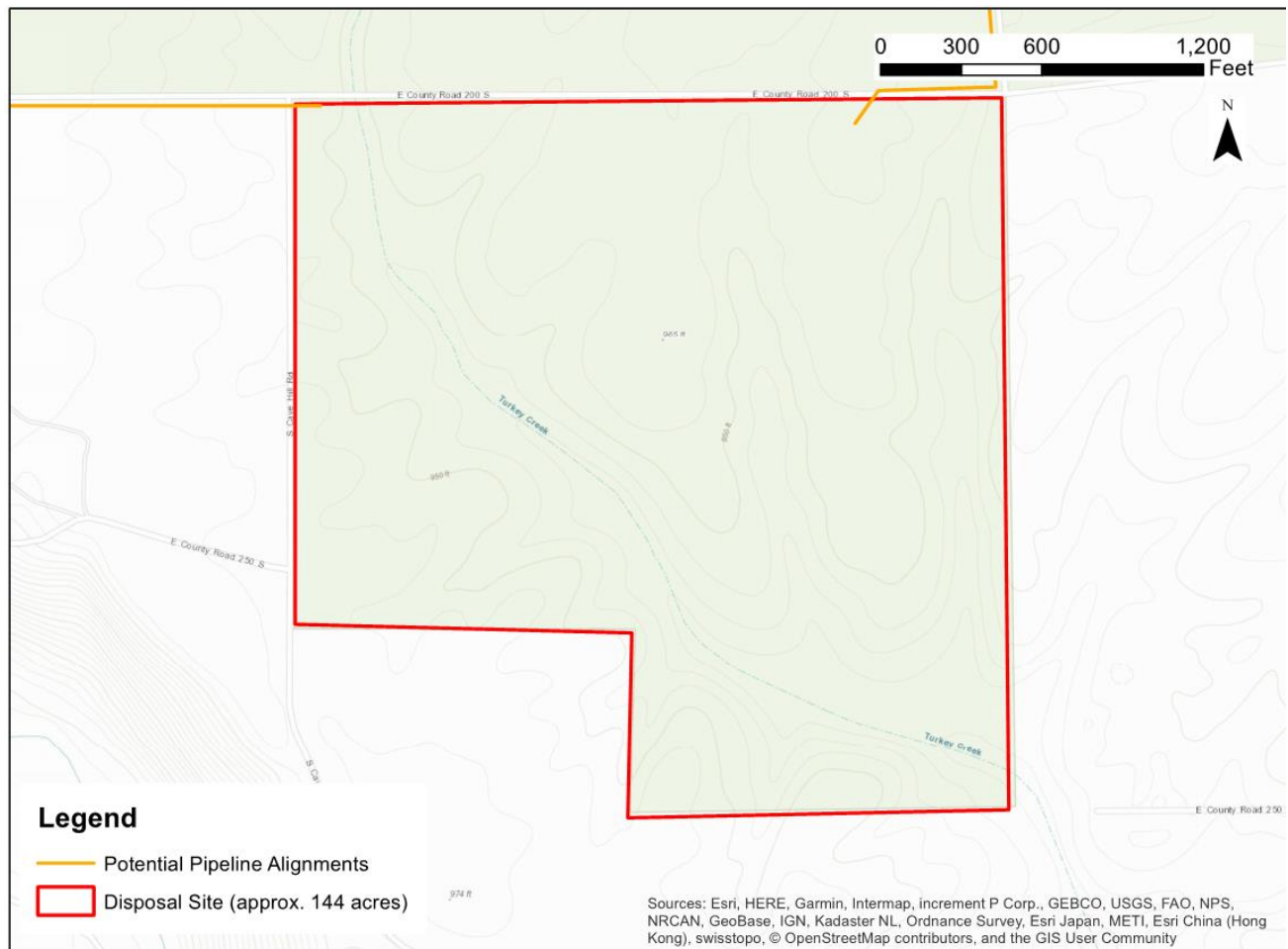


Figure D2 CDF Site Map

A stream, noted as Turkey Creek, flows across the southwestern side of the parcel. Four small, unnamed tributaries to Turkey Creek are shown within this parcel as well. The United States Geological Service (USGS) Milan, IN Topographic Quadrangle also notes a cemetery (Wilson Cemetery) as being located on this parcel. Impacts to these streams and this cultural resource, if delineated as shown in the USGS map, could add significant permitting burden and mitigation costs to the project if this site is used for a CDF.

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Reference: Versailles Lake Dam Feasibility Study Report

The valley containing Turkey Creek is up to 60 feet deeper than the surrounding, flatter topography (Figure D2). The simplest means of developing a CDF at the proposed site is to dam the valley of Turkey Creek and use the resulting impoundment as the CDF. Creating a berm that does not impact the mainstem of Turkey Creek is likely not economically feasible, as the depth of slurry placement required for the volume to be stored would require berms of significant height making this approach cost prohibitive and likely spatially infeasible.