Ohio Environmental Protection Agency

Feasibility Study for the Removal of the Gorge Dam

TETRA TECH

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Final Draft Report

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EXECUTIVE SUMMARY

The Gorge Dam was constructed on the Cuyahoga River in 1913 and produced hydroelectric power until 1958. The dam was then used until 1992 as a source of cooling water for a coal-fired power plant. However, the dam and its pool have not served any power generation purposes in the past 23 years and it is contributing to the impairment of aquatic life along the middle and lower segments of the river. Ohio EPA and other stakeholders are therefore pursuing the removal of the Gorge Dam to restore natural conditions to the Gorge and the Cuyahoga River.

The U.S. Environmental Protection Agency's Great Lakes National Program Office (U.S. EPA GLNPO) conducted a study of the sediment that has accumulated over the past century in the Gorge Dam pool. GLNPO found that the sediment may pose unacceptable risk to aquatic life, and U.S. EPA and Ohio EPA concluded that the contaminated sediment must be removed and disposed prior to the removal of the Gorge Dam.

Remedial action to remove the Gorge Dam and associated sediment will be a significant technical and financial undertaking. Since removal of the dam and safe disposition of the sediment will contribute toward delisting of the Cuyahoga River Area of Concern (AOC), Great Lakes Legacy Act (GLLA) funding could be used to fund part of the project (although the availability and contribution of GLLA funds is currently unknown). To access these funds, the State of Ohio and its non-federal partners would need to enter into a project agreement with the federal partner, U.S. EPA GLNPO. The use of GLLA funds would then provide up to 65 percent of the overall construction cost. The remaining 35 percent would be funded directly by the non-federal partners, or would be approved in-kind contribution. The removal of the sediment could be completed by GLNPO's pool of pre-qualified sediment contractors and the dam component could be completed by the non-federal partners.

To continue the process of securing the necessary technical and financial resources for future sediment and dam removal and disposal, Ohio EPA needs planning level cost estimates. Ohio EPA contracted with Tetra Tech Inc. (Tetra Tech) to assess feasible methods, propose construction activities, and develop planning level cost estimates for removal of the sediment and the dam. This report presents Tetra Tech's assessments and proposals.

Tetra Tech evaluated hydraulic and mechanical dredging for sediment removal with sediment dewatering and final disposal of dredge materials at a single site or sediment dewatering and final disposal at different sites. Two alternatives for dam debris disposal were evaluated: disposal at a commercial concrete crusher/recycler or at a landfill.

The preferred alternative is to hydraulically dredge during a single construction season with sediment dewatering, on-site weep water treatment, and dredge material final disposal at the former landfill along Peck Road in the Chuckery Area of the Cascade Valley South Metro Park. Dam demolition would occur during the same season and dam debris would be disposed of at a commercial concrete crusher/recycler. The preferred alternative costs $70 million (M), with approximately $57.5M for sediment removal/disposal and $12.5M for dam removal/disposal. Major costs include $19.3M for hydraulic dredging, $16.2M for sediment dewatering and dredge material disposal, and $7.8M for dam demolition. Contingencies of $8.2M are included in the total cost.

Additional surveys and studies will be necessary to ensure compliance with appropriate federal and state laws and regulations and to support future engineering and construction design. Studies will need to evaluate cultural resources, ecological resources, and hydrology and hydraulics (for flood plain management) to ensure compliance with appropriate laws and regulations. Additional engineering and construction design considerations include field reconnaissance and surveys (e.g., topography, bathymetry), collection of geotechnical borings, bench scale dewatering tests for dredging, and assessments of water treatment.

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
AOC	area of concern
AVS/SEM	acid volatile sulfide/simultaneously extracted metals
BUI	beneficial use impairment
CRCPO	Cuyahoga River Community Planning Organization
ESL	ecological screening level
GLLA	Great Lakes Legacy Act
GLNPO	Great Lakes National Program Office (U.S. Environmental Protection Agency)
HDC	Hardline Design Company
Metro Parks	Metro Parks Serving Summit County
NPDES	National Pollutant Discharge Elimination System
ODNR	Ohio Department of Natural Resources
OGS	Ohio Division of Geological Survey (Ohio Department of Natural Resources)
Ohio EPA	Ohio Environmental Protection Agency
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	probable effect concentration
POTW	Publicly-owned treatment works
RAP	remedial action plan
RM	river mile
SVOA	semi volatile organic analyte
TEC	threshold effect concentration
TMDL	total maximum daily load
TOC	total organic carbon
U.S. EPA	U.S. Environmental Protection Agency
VAP	Voluntary Action Program
VOA	volatile organic analyte

UNITS OF MEASURE

Unit	Definition
cy/d	cubic yard per day
mi^2	square mile

1.0 INTRODUCTION AND BACKGROUND

The Gorge Dam is on the Cuyahoga River in the city of Cuyahoga Falls in Summit County, Ohio. The dam was constructed in 1913 for hydroelectric power generation. Hydroelectric power was produced until 1958, and then the dam pool was used as a source of cooling water for a coal-fired power plant that generated power until 1992; the dam has not been associated with any type of power generation since 1992. In the 1990s and 2000s, the Ohio Environmental Protection Agency (Ohio EPA) concluded that the Gorge Dam, along with other dams on the Cuyahoga River, was contributing to the impairment of aquatic life along the middle and lower segments of the river. The middle and lower Cuyahoga River was also designated an Area of Concern (AOC) by the International Joint Commission (IJC) for impairments to 10 of 14 beneficial uses. The Cuyahoga River AOC begins at the Gorge Dam pool.

1.1 PROJECT AREA HISTORY

As American settlers moved into the Western Reserve, they founded new cities and towns along the rivers and streams in northeast Ohio which had waterfalls and rapids needed for the generation of hydropower (Ohio Geological Survey [OGS] 2004, p. 38). The Great Falls, in what is now the city of Cuyahoga Falls, were a sequence of three main falls and intervening rapids that formed on ledges of the Sharon Formation[1]. The Great Falls descended approximately 220 feet along a two-mile long segment of the Cuyahoga River known as the Gorge (OGS 2004, p. 38).

Source: Cuyahoga Falls Historical Society

Figure 1. Pre-1945 photograph of the Gorge Dam.

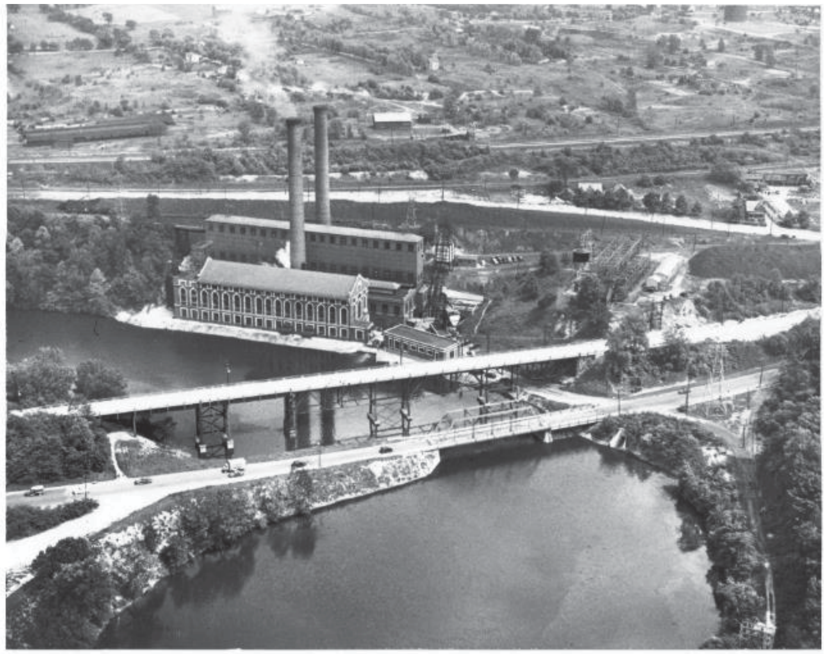
The town of Cuyahoga Falls (originally called Manchester) was founded in 1812 along the Great Falls because the falls were able to power grist-, saw-, and oil-mills. The first dam across the Cuyahoga River in the village was built in 1812 and, by 1881, five dams spanned the river (OGS 2004, p. 38). However, in March 1913, a flood destroyed many of the dams and also damaged the Ohio & Erie Canal (OGS 2004, p. 39; Hardline Design Company [HDC] 2011). As a result of the flood, several new concrete dams were built in the 1910s, including the Sheraton Dam and the LeFever Dam. As discussed in Section 2.0, these two dams were removed by the city of Cuyahoga Falls in 2013.

In 1913, the Ohio Edison Company built the 57-foot tall[2] and 450-foot long Gorge Dam across the Gorge. “The dam powered a 96-megawatt hydroelectric plant operated by the Northern Ohio Traction and Light Company from

[1] “The Sharon Formation is a quartz-rich sedimentary unit, consisting of interbedded conglomerate and medium to coarse-grained sandstones that were deposited in a braided stream environment. The Sharon Formation is resistant to erosion and forms prominent ledges.” (OGS 2004, p. 26).

[2] The Gorge Dam was reported as 62-feet tall by OGS (2004, p. 39) and as 57-feet tall by the Ohio Department of Natural Resources (ODNR 2010).

1913 until 1958." (OGS 2004, p. 39). Later, the hydroelectric power plant was replaced by a coal-fired power plant about a half-mile upstream of the dam that used the water in the Gorge Dam pool for cooling (OGS 2004). This plant stopped operating in 1992 and was decommissioned and razed in 2009.



Source: Cuyahoga Falls Historical Society

Figure 2. Photograph of Ohio Edison's Gorge Power Station.

The Gorge and Great Falls of the Cuyahoga River have a long legacy as a tourist destination due to the unique geology and hydrology of the area. In the late 1800s, recreational areas were developed along and within the Gorge. Visitors were drawn by the aesthetic, natural beauty of scenic outcrops during the summer and giant icicles in the winter. Popular sites were Mary Campbell's Cave (formerly Old Maid's Kitchen), Observation Rock, and the High Bridge. In 1882, the High Bridge Glens Amusement Park was developed, which included a Grande Promenade, dance hall, and rollercoasters (OGS 2004).Today, the Gorge is protected as part of the Gorge Metro Park; however, many of the scenic features that attracted visitors… are under the water impounded by the" Gorge Dam (OGS 2004, p. 43).

The Gorge Metro Park covers 155 acres and is part of the Metro Parks Serving Summit County (Metro Parks). The park was established in 1930 when the Ohio Traction and Light Company donated 144-acres to the Akron Metropolitan Park System, which later became the Metro Parks (OGS 2004, p. 44; Metro Parks 2015a). The Gorge Metro Park has three trails (Glens, Gorge, and Highbridge), a fishing dock upstream of the Gorge Dam, a shelter, picnic areas, and restrooms (Metro Parks 2015a).

1.2 PROJECT HISTORY

The United States is both "the most hydrologically controlled nation in the world" (with over 76,000 "large" dams and over 2 million "low-head" dams) and "the world leader in dam removal" (OGS 2004, p. 48). As dams across the United States age, people must consider the costs and benefits of maintaining or removing dams that may be economically or structurally obsolete and may be legal or financial liabilities. These considerations can be further complicated when sediments in the upstream reservoir or dam pool are contaminated, and the risk of downstream migration of remobilized toxic sediments must be addressed.

Dam removal has become a priority of the Ohio EPA and watershed stakeholders in the Cuyahoga River watershed. The Cuyahoga River from the Gorge Dam pool downstream to Lake Erie is a Great Lakes AOC; the removal of the Gorge Dam and mitigation of the contaminated sediments in the dam pool are long-term priorities to address the beneficial use impairments in the Cuyahoga River AOC. Similarly, Ohio EPA has developed total maximum daily loads for the upper, middle, and lower segments of the Cuyahoga River, and the middle and lower TMDLs called for the modification or removal of dams along the Cuyahoga River. Over the past decade, three low-head dams along the middle Cuyahoga River have been removed and one dam was modified. See Section 2.8 for further discussion of the Cuyahoga River AOC, TMDLs, and the previous dam removals.

The Gorge Dam is no longer used for hydroelectric or coal-fired power generation. Besides a demonstration project in 1999, and an attempt to restore hydroelectric power generation in the 2000s[3], the Gorge Dam and its pool have not served any power generation purposes in the past 23 years. During this timeframe, Ohio EPA, Metro Parks, and watershed stakeholders (notably the Friends of the Crooked River and Keel Haulers Canoe Club) have pursued the removal of the Gorge Dam to restore natural conditions to the Gorge.

Before the Gorge Dam can be removed, the sediment that has collected in the dam pool over the past century must be mitigated. The U.S. Environmental Protection Agency (U.S. EPA) Great Lakes National Program Office (GLNPO) funded a study to characterize the quantity and quality of sediment in the Gorge Dam pool. This study was the first comprehensive evaluation of sediment in the Gorge Dam pool. The results indicated that 832,000 cubic yards of sediment are present in the Gorge Dam pool (U.S. EPA 2012), which is significantly more than previously estimated. The study also indicated that anthropogenic pollutants could pose risks of toxicological effects to aquatic biota (U.S. EPA 2012, p. 66). The 2012 study served as a foundation to this feasibility analysis.

1.3 PROJECT OBJECTIVES

Ohio EPA contracted with Tetra Tech Inc. (Tetra Tech) to develop planning level cost estimates for the removal and disposal of sediments upstream of the Gorge Dam and for the removal and disposal of the Gorge Dam. Ohio EPA needs planning level cost estimates to continue the process of securing funds for eventual sediment and dam removal and disposal. As specified by Ohio EPA, this project focused upon issues and costs likely to have the greatest impact upon total project costs.

Tetra Tech coordinated with Ohio EPA, Metro Parks, the City of Akron, First Energy, and the Ohio Department of Natural Resources to perform the following tasks:

- assessment of feasible methods of sediment removal and dewatering;
- assessment of feasible methods of dam removal;
- identification of potential disposal sites and evaluation of material placement and management options;
- identification of potential regulatory requirements;
- and the development of concept level drawings of the existing site and proposed construction activities.

Coordination occurred through phone calls, email correspondence, and an agency meeting held April 27, 2015, and the results are summarized in this report. Sediment removal is discussed in Section 5.0, dam removal is discussed in Section 6.0, and the preferred plan is presented in Section 7.0.

[3] In the early 2000s, Metro Hydroelectric Company, LLC, proposed to restore hydroelectric power generation at the Gorge Dam. The proposal was opposed by more than 20 organizations (including Friends of the Crooked River, Keel Haulers Canoe Club, and Ohio EPA) for multiple reasons, including that the proposed project would only provide electricity for about 2,000 homes, would require the clearing of a few acres of forested land in the Gorge Metro Park, and would prevent the removal of the Gorge Dam. The Federal Energy Regulatory Commission (FERC) granted a three-year license for a feasibility study in 2005 as part of the integrated licensing process. However, the Metro Parks denied Metro Hydroelectric Company access to the Gorge Metro Park for the feasibility study because the company lacked the authority to develop the project on Metro Parks land (FERC 2007). The Metro Hydroelectric Company filed a lawsuit in federal court against the Metro Parks. While the federal district court for the Northern District of Ohio did grant an injunction to allow the Metro Hydroelectric Company to enter the Gorge Metro Park to conduct the feasibility study, the federal Sixth Circuit Court of Appeals overturned the district court's injunction and ordered the case to be dismissed. FERC terminated the permit for the integrated licensing process after the decision by the Sixth Circuit Court of Appeals. Since the Metro Hydroelectric Company could not access the Gorge Metro Park to complete the feasibility study, FERC terminated the permit for the integrated licensing process in 2007.

2.0 CHARACTERIZATION OF THE GORGE

The Gorge Dam project area is generally defined as the Gorge, including the upstream extent of the Gorge Dam pool at river mile (RM) 46.5 downstream to the Gorge Dam at RM 45.0. Sediment and dam removal operations will take place in the Gorge and dam pool (Figure 3). The project area will expand beyond the Gorge for such activities as sediment dewatering, permanent sediment disposal, and dam demolition disposal.

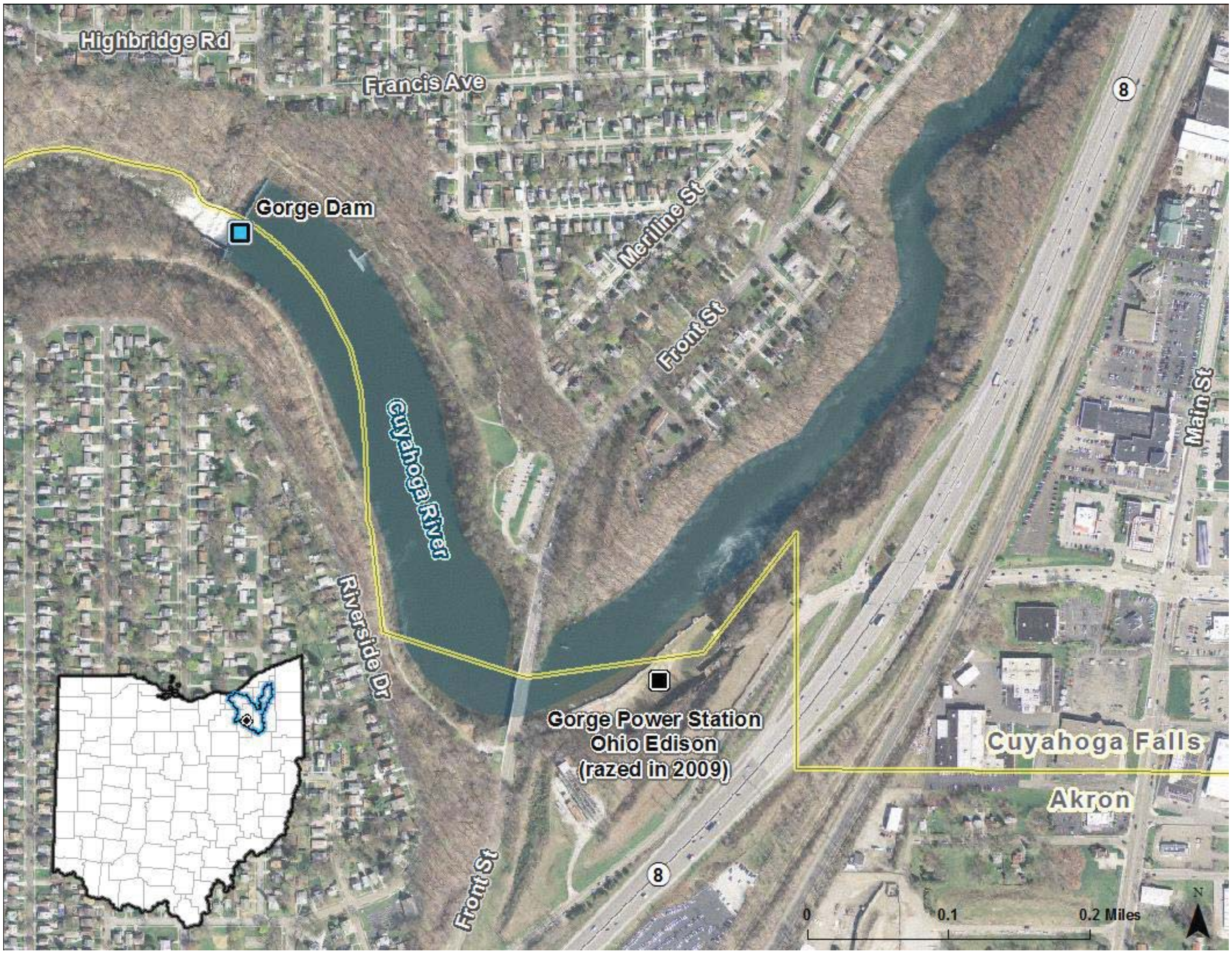


Figure 3. Map of the Gorge Dam and pool.

2.1 PROJECT SETTING

The Gorge Dam is approximately 0.5 miles downstream of the Front Street road bridge. The State Road bridge is the closest bridge downstream of the Gorge Dam, at RM 44.3. Much of the Gorge and both banks of the Cuyahoga River are contained within the Gorge Metro Park. The Cuyahoga River is essentially the boundary between the cities of Akron (left bank, south) and Cuyahoga Falls (right bank, north). High Bridge Road, in Cuyahoga Falls, runs along the north side of the Gorge downstream of the Gorge Dam. Riverside Drive, in the North Hill neighborhood in Akron, runs along the south side of the Gorge. State Route 8, a divided highway, runs along the Gorge Dam pool upstream of the Front Street road bridge.

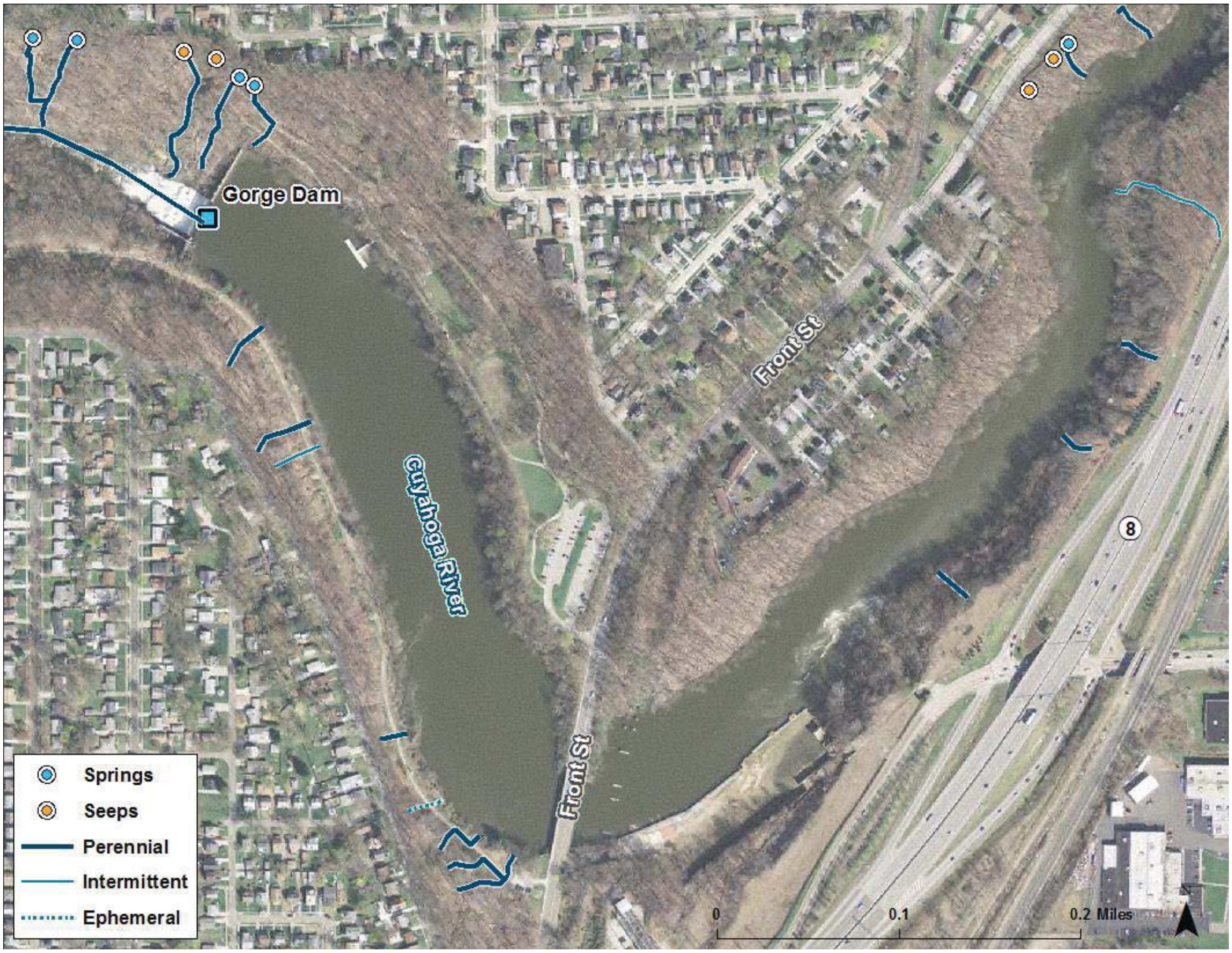
2.2 HYDROLOGY AND HYDROGRAPHY

The Cuyahoga River is a tributary to Lake Erie. The Cuyahoga River basin drains 813 square miles and includes 1,220 stream miles spanning parts of Geauga, Medina, Portage, Summit and Cuyahoga counties (Ohio EPA 2003, p. 12). Approximately 333 square miles (mi^2) drain to the Cuyahoga River at the Gorge Dam. No large perennial tributaries drain to the Gorge Dam pool or immediately upstream of the pool. Babb Run (RM 43.9), which is a primary headwaters tributary, and the Little Cuyahoga River (RM 42.6, 62 mi^2) are the nearest downstream named tributaries to the Cuyahoga River below the Gorge Dam; however, many small unnamed tributaries also drain to the Cuyahoga River (Figure 4).

Over 30 small tributaries along the Gorge Dam pool drain to the Cuyahoga River, and over two-thirds of such streams are perennial (Metro Parks 2015b). Many of these small tributaries are fed by seeps or springs (Figure 5). Of the 24 tributaries upstream of the Gorge Dam, the average length of a stream is 149 feet (range: 43 feet to 388 feet).

Groundwater seeps are prevalent throughout the rock outcrops and overhangs in the Gorge. Metro Parks identified six seeps and four springs in the Gorge between the Front Street bridge and the Gorge Dam (two seeps on the north side were outside of the Gorge Metro Park) and the agency identified three seeps and five springs along the Gorge Dam pool upstream of the Front Street bridge (Metro Parks 2015b). These seeps and springs feed perennial and interstitial streams.

Figure 4. Photograph of a small tributary of the Cuyahoga River downstream of the Gorge Dam.

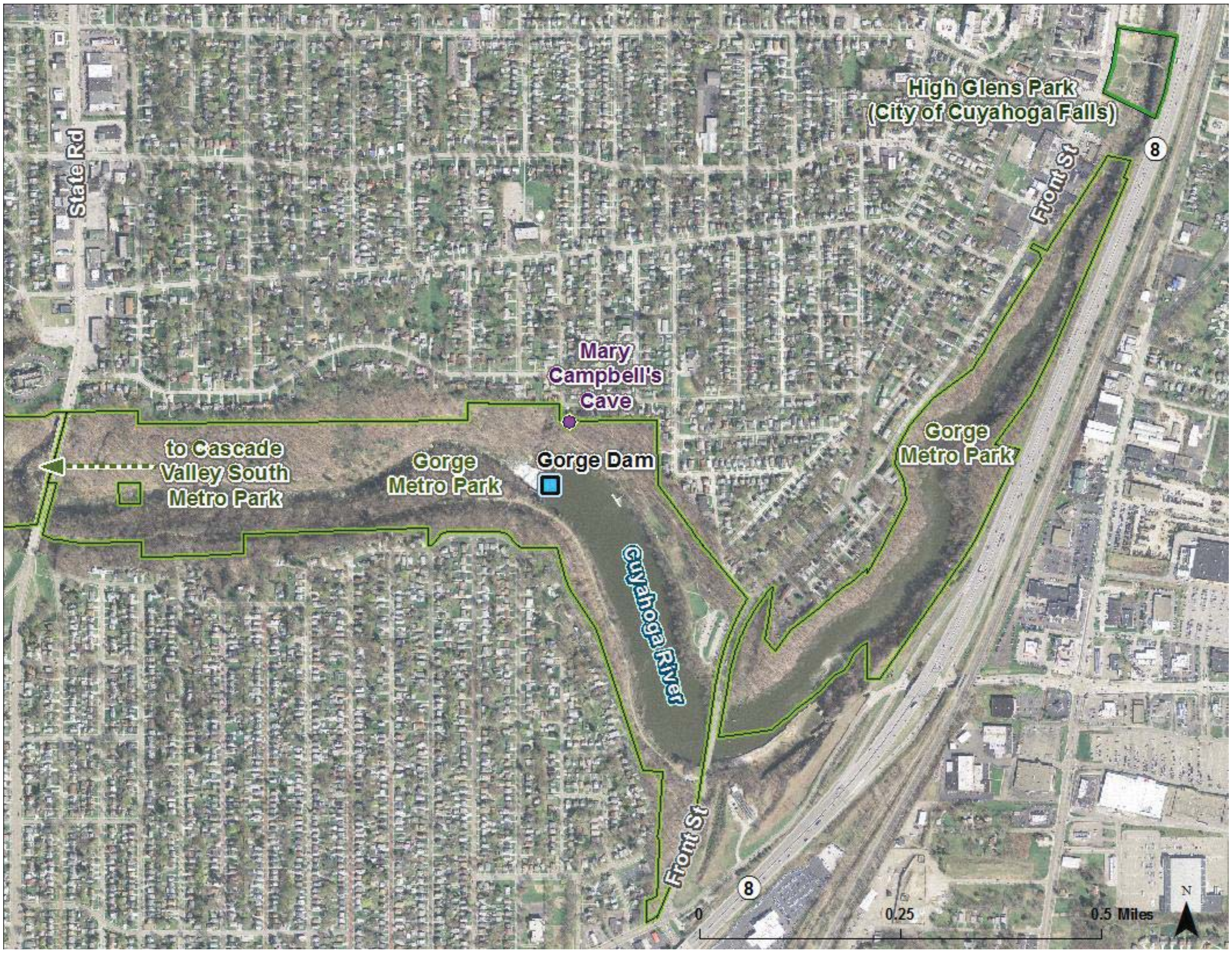


Source: Metro Parks 2015b.

Figure 5. Map of seeps, springs, and streams along the Gorge.

2.3 LAND USE AND LAND COVER

The "Gorge Metro Park is located in a predominantly residential and commercial, urban setting" (OGS 2004, p. 26). Large residential developments are north and south of the Gorge Metro Park (Figure 6). The Gorge Metro Park is mostly forested, except for a few areas that are impervious (e.g., parking lot, multi-purpose trail) or mowed grass.



Source: Metro Parks 2015b.

Figure 6. Aerial imagery of dominantly residential land use near the Gorge.

2.4 GEOLOGY AND GEOTECHNICAL ISSUES

Much of the Cuyahoga River basin, including the Gorge, is in the glaciated Appalachian Plateau (Ohio EPA 2003). “The river generally follows the course of the buried valleys, but does traverse a ridge of erosion resistant sandstone, resulting in the falls and cascades of Cuyahoga Falls” (Ohio EPA 2003, p. 12). The Gorge “formed after the termination of the last glaciation, about 12,000 years ago, and cuts through Pennsylvanian and Mississippian aged sedimentary rocks.” (OGS 2004, p. 26).

The topography generally varies from level plains to gently rolling hills in the project area; the relief typically ranges from 50 to slightly over 100 feet. The drainage divide between the Great Lakes basin and Ohio River basin runs through Summit County. In the northern portions of the county, the Cuyahoga River flows north to Lake Erie. Conversely, in the southern portions of the county, the Tuscarawas River flows south to the Ohio River after joining the Muskingum River.

Summit County was covered by both the Wisconsin and Illinoisan glaciers. The glacial till thickness varies across the county and project site depending on the location of the deposit. Within the buried valleys, the till may be absent, replaced by outwash deposits, or the till may overlie earlier outwash deposits. On the margins of the valley, the overburden becomes much thinner. In the Gorge, bedrock is evident in the sidewalls of the valley.

Figure 7. Photograph of the bedrock side walls along the Gorge.

As part of the feasibility study Tetra Tech reviewed available water well information in the area of the Gorge. Based on the ODNR Groundwater Resources Map for Summit County (ODNR 1979), the Gorge is an area where groundwater is obtained from shallow wells in shales and sandstones within the Cuyahoga Group. The area surrounding the Gorge is depicted as providing water from within the Sharon conglomerate, which lies below the Cuyahoga Group. The nearest water well to the Gorge that could be found was 0.8 miles to the southeast of the dam, on the east side of Main Street. This well was drilled to a depth of 50 feet but encountered rock at 14 feet. Because bedrock is visible in the Gorge banks, it is anticipated that rock is within 10 to 20 feet of the ground surface in the highlands surrounding the Gorge.

About 0.8 miles downstream of the dam, at the outlet of the Gorge, the Cuyahoga River follows a large buried valley that trends in a north-south direction. Bedrock depths in this buried valley can be in excess of 100 feet.

Based on the available information and Tetra Tech's site visit, there does not appear to be a significant risk of large or extensive bank instability. The soil cover on the bedrock is likely thin and could be unstable during construction or dewatering, but deep failures in the rock are not expected. However, these conclusions should be confirmed in subsequent design phases for the project based on a detailed field reconnaissance and, possibly, soil borings and additional analyses.

Based upon a review of groundwater resources maps and well logs obtained from ODNR, no evidence of shallow water wells were found in the area of the Gorge that would be impacted from lowering the pool. On the highlands above the Gorge, the development both north and south of the pool is residential and it is believed this development relies on piped water systems and not wells. The development on the east side of the upper half of the reservoir is typically commercial but it, too, relies on municipal water. However, a detailed well survey of the area should be made during subsequent design phases of the project to confirm this conclusion.

The adjacent infrastructure consists of the residential developments on the highlands to the north and south of the Gorge although there is some commercial development on the east side of the upper half of the pool. However, there does not appear to be any significant infrastructure within the Gorge with the exception of a CSO line that crosses the river upstream of the dam.

The demolition process should not negatively affect adjacent infrastructure based on the available information. However, because residential developments are nearby, blasting should not be allowed as part of the demolition work.

2.5 ECOLOGICAL RESOURCES

Important plant and animal species observed in the Gorge Metro Park are presented in Table 1 and Table 2, respectively (Metro Parks 2015b). These include a federally threatened plant species and state endangered, threatened, or potentially threatened plant species[4].

Northern wild Monkshood (*Aconitum noveboracense*) is a federally threatened plant species that is native to four states: Iowa, New York, Ohio, and Wisconsin (U.S. Fish and Wildlife Service 2015). Northern Monkshood is endangered in Ohio (Division of Natural Areas and Preservers 2014), and is found in only three locations in the state, including the Gorge Metro Park (OGS 2004, p. 42).

Table 1. Important plant species observed in (or immediately adjacent to) the Gorge Metro Park

Plant	Scientific name	Status [a]	Observed
American chestnut	*Castanea dentata*	noteworthy	2012
American prairie grass	*Panicum columbianum*	noteworthy	1981
Autumn coralroot	*Corallorhiza odontorhiza*	noteworthy	2009
Butternut	*Juglans cinerea*	noteworthy	1997, 1998, 2006[b]
Crinkled hairgrass	*Deschampsia flexuosa*	potentially threatened	2004
Drooping wood sedge	*Carex arctata*	endangered	2012
Flattened wild oat grass	*Danthonia compressa*	threatened	1979
Gray birch	*Betula populifolia*	noteworthy	1983, 1997, 2006
Long beech fern	*Thelypteris phegopteris*	potentially threatened	1997, 1998
Low sand sedge	*Carex tonsa*	noteworthy	2011
Northern monkshood	*Aconitum noveboracense*	endangered	2007
Northern wood reed	*Cinna latifolia*	endangered	2004
Mountain-fringe	*Adlumia fungosa*	threatened	1998, 2014
Round-fruited pinweed	*Lechea intermedia*	potentially threatened	1979, 1997*
Small-flowered evening primrose	*Oenothera parviflora*	noteworthy	2004

Source: Metro Parks 2015b.

Notes

a. Species identified as "endangered", "threatened", or "potentially threatened" are determined by ODNR (2014). Species identified as "noteworthy" are determined by MetroParks (2015b).

b Specimens were observed at multiple locations in the specified year.

All of the endangered, threatened, or potentially threatened plant species were observed at or upstream of the former Gorge Power Station and most were observed on the left bank (south side) of the Gorge.

[4] The designations "endangered species", "threatened species", and "potentially threatened species" are defined by ODNR (2014).

Table 2. Important animal species observed in (or immediately adjacent to) the Gorge Metro Park

Animal	Scientific name	Metro Parks status	Observed
Bald eagle	*Haliaeetus leucocephalus*	noteworthy	2013
River otter	*Lutra canadensis*	noteworthy	1976

Source: Metro Parks 2015b

2.6 CULTURAL RESOURCES

Metro Parks is developing a cultural resources survey and evaluation for the Gorge Dam removal project. For the purposes of this feasibility study, recreation on the Cuyahoga River and the National Register of Historic Places are briefly discussed.

2.6.1 Cuyahoga River Recreation

As discussed in Section 1.1, the Great Falls, the Gorge, and the Cuyahoga River are tourist destinations for both recreation and for experiencing the culture and history of the region. The Cuyahoga River is heavily recreated and the upper Cuyahoga River is designated a Scenic River[5]. The Cuyahoga River is also designated an American Heritage River[6] (Ohio EPA 2003, p. 13).

Much of the Cuyahoga River and its shores are used for recreation, including fishing, swimming, boating, hiking, and picnicking. Segments of the river are contained within reservations of the Cleveland Metro Parks[7], Summit County Metro Parks, and the Cuyahoga Valley National Park (Ohio EPA 2003, p. 13). The American White Water Association lists the Cuyahoga River from Broad Boulevard to Cuyahoga Street in Cuyahoga Falls as class III to class IV for canoeing and kayaking (Ohio EPA 2003, p. 18). The Gorge is within this segment, and with the removal of the Sheraton and LeFever dams in 2013, the Gorge Dam is the primary obstacle to this segment of the river rating as class V rapids.

2.6.2 National Register of Historic Places

As of April 21, 2015, 164 structures or sites were listed in the National Register of Historic Places in Summit County, Ohio. The Gorge Dam is not listed in the National Register of Historic Places, nor is any structure or site within the Gorge Metro Park. The dam itself is over 100 years old, and as such, is potentially eligible for listing on the National Register of Historic Places. Many of the iconic, historic structures (e.g., the High Bridge Glen Amusement Park, Gorge Power Station) no longer exist today. The nearest historic site listed in the National Register of Historic Places is the First Congregational Church of Cuyahoga Falls (75001538), which is 1.0 mile northeast of the Gorge Dam.

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[5] For more information regarding the Scenic River designation of the upper Cuyahoga River, refer to the Ohio Department of Natural Resources, Division of Watercraft's Scenic River program: http://watercraft.ohiodnr.gov/scenicrivers (accessed April 21, 2015).

[6] President William J. Clinton created the American Heritage Rivers program by executive order in 1997, and he designated 14 American Heritage Rivers in 1998. The American Heritage Rivers program improves coordination between federal agencies to support three objectives: natural resources and environmental protection, economic revitalization, and historic and cultural preservation.

[7] The Cleveland Metro Parks, the so-called "Emerald Necklace," are mostly in Cuyahoga County and are not affiliated with the Metro Parks Serving Summit County.

The Metro Parks are developing a cultural resources survey which will identify historic sites near the Gorge that are listed on the National Register of Historic places or are eligible for listing.

2.7 WATER QUALITY

Over the past three decades, numerous institutions have studied the water quality of the Cuyahoga River. The Ohio EPA has monitored and assessed the Cuyahoga River as required by Section 305(b) of the Clean Water Act and has published results of the assessments in multiple technical support documents (Ohio EPA 1994, 1999, 2008). The Agency has sampled portions of the Cuyahoga River basin for water chemistry, biology, habitat, or fish tissue in 1984-1992, 1996, 1997, 2004, 2005, and 2007. The National Center for Water Quality Research at Heidelberg University, National Park Service at the Cuyahoga Valley National Park, Northeast Ohio Regional Sewer District, city of Akron, and U.S. Geological Survey also maintain monitoring programs for the Cuyahoga River.

Biological community health, water quality, and habitat quality of the Cuyahoga River are presented in technical support documents (Ohio EPA 1993, 1999, 2000) and TMDL reports prepared by Ohio EPA (Ohio EPA 2000, 2003). Generally, biological community health improves below the Gorge Dam along free flowing reaches (Ohio EPA 1999). The removals of smaller dams on the Cuyahoga River upstream of the Gorge Dam have improved biological community health along those segments. Additionally, Ohio EPA concluded that conditions unique to the Gorge, including high gradient, exposed bedrock, and turbulent flow may “help to ameliorate potential water quality impacts from Akron combined sewers in this section” of the Cuyahoga River (Ohio EPA 1999, p. 12).

The only publicly available groundwater quality data are from a University of Akron study of seeps in the Gorge. A study of 37 seeps in the Gorge Metro Park found a dominance of sodium-chloride rich water that likely reflect the urbanization of the recharge area (OGS 2004, p. 27). The levels of sodium, chlorine, and bromine were evaluated with winter road management practices to determine that the sodium and chlorine were derived from dissolved halite applied as road salt. The authors also concluded that “the seeps are hydrologically isolated from each other” since the water chemistry between seeps and springs was highly spatially variable (OGS 2004, p. 31).

2.8 ENVIRONMENTAL ACTIVITIES

As discussed throughout Section 2.0, the Gorge is only a small, though unique, segment of the Cuyahoga River. However, federal, state, and local government agencies and public and private interest groups have been involved in a number of environmental activities that are directly relevant to this project. These are described below.

2.8.1 Cuyahoga River Area of Concern

The Cuyahoga River was designated in 1985 by the IJC as one of 43 AOCs in the Great Lakes basin and one of four AOCs in Ohio. The original Cuyahoga River AOC was defined as the lower Cuyahoga River from the Gorge Dam at RM 45 down to the mouth of the Cuyahoga River on Lake Erie, as well as the Lake Erie shoreline from Edgewater Park east to Wildwood Park (Cuyahoga River RAP 2013). When designated in 1985, the Cuyahoga River AOC was impaired for 10 of 14 beneficial uses. Later, Ohio EPA established delisting targets and milestones, first in 2005, and then revised in 2008 and 2014 (Ohio EPA 2014).

The Cuyahoga River Remedial Action Plan (RAP) Coordination Committee formed in 1992 to investigate the beneficial use impairments (BUIs), develop strategies to remediate the causes and sources of BUIs, and to eventually de-list the BUIs. The Cuyahoga River Community Planning Organization (CRCPO) organized by the Cuyahoga RAP Coordinating Committee in 1988 as a non-profit corporation with the objective of implementing the Cuyahoga River RAP. The Stage 1 report, to identify causes and sources of BUIs, was written in 1992. The report identified habitat loss, nonpoint source pollution, dams, and combined sewer overflows as the principle causes of BUI (Ohio EPA 2003, p. 38). The long-term goals associated with the Gorge Dam (referred to as the "Edison Dam" in the Stage 1 report) are to eliminate the accumulated sediment behind the dam and then to remove the dam (Cuyahoga River RAP 2008, p. 9).

In 2010, following the 2009 GLNPO-funded assessment of the sediment in the Gorge Dam pool, the Cuyahoga AOC was expanded to RM 46.5 to include the Gorge Dam pool under the premise that remediating or removing the sediment behind the dam would require the resources of the Cuyahoga AOC and potential funding from the Great Lakes Legacy Act.

The Stage 2 report (Cuyahoga River RAP 2013) was prepared to develop strategies to remediate causes and sources of BUIs. The report includes detailed recommendations that will lead to BUI de-listing. Such recommendations, or identified delisting actions, include removal of contaminated sediments, habitat restoration projects, implementation of combined sewer overflow long term control plans, and green infrastructure projects (Cuyahoga River RAP 2013). The removal of the Diversion Canal dam and Gorge Dam is identified as an action that will support the delisting of the fish and benthos BUIs (#3 and #5, respectively) and the loss of fish habitat BUI (#14).

2.8.2 Cuyahoga River Total Maximum Daily Loads

Ohio EPA divided the Cuyahoga River into three sections (upper, middle, and lower) and developed TMDL submissions for each section. The Gorge Dam and project area are in the lower Cuyahoga River. Recent removals of smaller dams were on the middle Cuyahoga River.

Based on water quality data collected in the 1990s, Ohio EPA (2000) found the middle Cuyahoga River to be impaired by habitat and flow alteration, excessive nutrient levels, and low dissolved oxygen levels. The source assessment showed that the Munroe Falls, Kent, and Lack Rockwell dams altered the stream hydraulics of the Cuyahoga River "thereby decreasing the assimilative capacity of the stream and lowering the natural stream aeration" (Ohio EPA 2000, p. 15). Ohio EPA (2000, p. 25) concluded that the "elimination or modification of the dams would greatly improve habitat conditions and dissolved oxygen concentrations and would allow fish to migrate".

Following the approval of the middle Cuyahoga River TMDL in 2000, Ohio EPA developed the lower Cuyahoga River TMDL. The Agency determined that the causes of impairment to aquatic life uses in the lower Cuyahoga River were organic enrichment, nutrients, bacteria, flow alteration, toxicity, and degraded habitat (Ohio EPA 2003). During the TMDL assessment, Ohio EPA (2003, p. 87) evaluated the removal of the Canal Diversion Dam (also known as the Station Road dam or Route 82 dam, which is managed by ODNR and diverts water to the historic Ohio & Erie Canal, and recommended its removal to restore the Cuyahoga River to a free-flowing state in the lower 44 miles. The Agency also recommended the evaluation of other dams on the Cuyahoga River and its tributaries, including the Gorge Dam. Ohio EPA (2003, p. 91) concluded that biological communities will be improved and recreational opportunities will be enhanced and made safer by the assessment and removal of dams along the Cuyahoga River. Ohio EPA submitted the lower Cuyahoga River TMDL report to U.S. EPA Region 5 in 2003 and the report was approved in the same year.

2.8.3 Dam Removals on the Cuyahoga River

Based upon recommendations from water quality assessments and the Cuyahoga River TMDLs, four low-head dams along the Cuyahoga River upstream of the Gorge Dam were removed or bypassed in the mid-2000s in an effort to improve water quality and aquatic community health. The Kent Dam (RM 54.8) and Munroe Falls Dam (RM 49.9) were well upstream of the Gorge Dam (RM 45.0) while the Sheraton Dam (RM 46.5) and LeFever Dam (RM 46.8) are closer to the Gorge Dam (Figure 8). The Brecksville Dam (RM 20) is in the Cuyahoga Valley National Park and a draft Environmental Impact Statement has been completed for the removal of this dam.

The Munroe Falls Dam was removed by the city of Munroe Falls in 2006 through Clean Water Act Section 319(h) grants. The project also restored 510 linear feet of previously unstable stream bank and 3 miles of warmwater habitat in 2007 and 2008.

The Kent Dam was modified in 2005 and two miles of the Cuyahoga River were restored by the city of Kent through a Clean Water Act Section 319(h) grant. Since the Kent Dam was placed on the National Register of Historic Places, the dam was retained but modified to maintain compliance with the National Historic Preservation Act (Ohio EPA 2008). The project also restored 2,000 linear feet of riparian areas and established 600 feet of in-stream habitat and fish passage structures.

The Sheraton Dam[8] and LeFever Dam[9] were removed by the city of Cuyahoga Falls in 2013. The two dams were removed, adjacent buildings were stabilized, and segments of the stream channel were restored. These projects were funded by a Water Resource Restoration Sponsor Program grant for about $1 million.

[8] The Vaughn Machinery Company built the Henry Newberry Dam (hereafter referred to as the *Sheraton* Dam) in 1914, following the March 1913 flood that destroyed a previous wooden dam (Hardlines Design Company [HDC] 2011). The new concrete dam was used to support their steel, rubber, copper, and clay operations (HDC 2011). In 1990, the Sheraton Suites Hotel was constructed next to the old powerhouse foundation and Henry Newberry Dam.

[9] From 1914 through 1918, the Falls Hollow Saybolt Company, a division of the Walsh Paper Company, built a concrete dam to replace a previous wooden dam that was destroyed in the flood of March 1913 (HDC 2011); hereafter referred to as the *LeFever* Dam. The new dam was built upstream of the original wooden dam. At the time, it was the largest industrial hydroelectric dam on the Cuyahoga River (HDC 2011). This dam was formerly located behind the Saphira Restaurant. Burntwood Tavern is currently located at the site and remnants of the former dam can be seen from the dining areas.

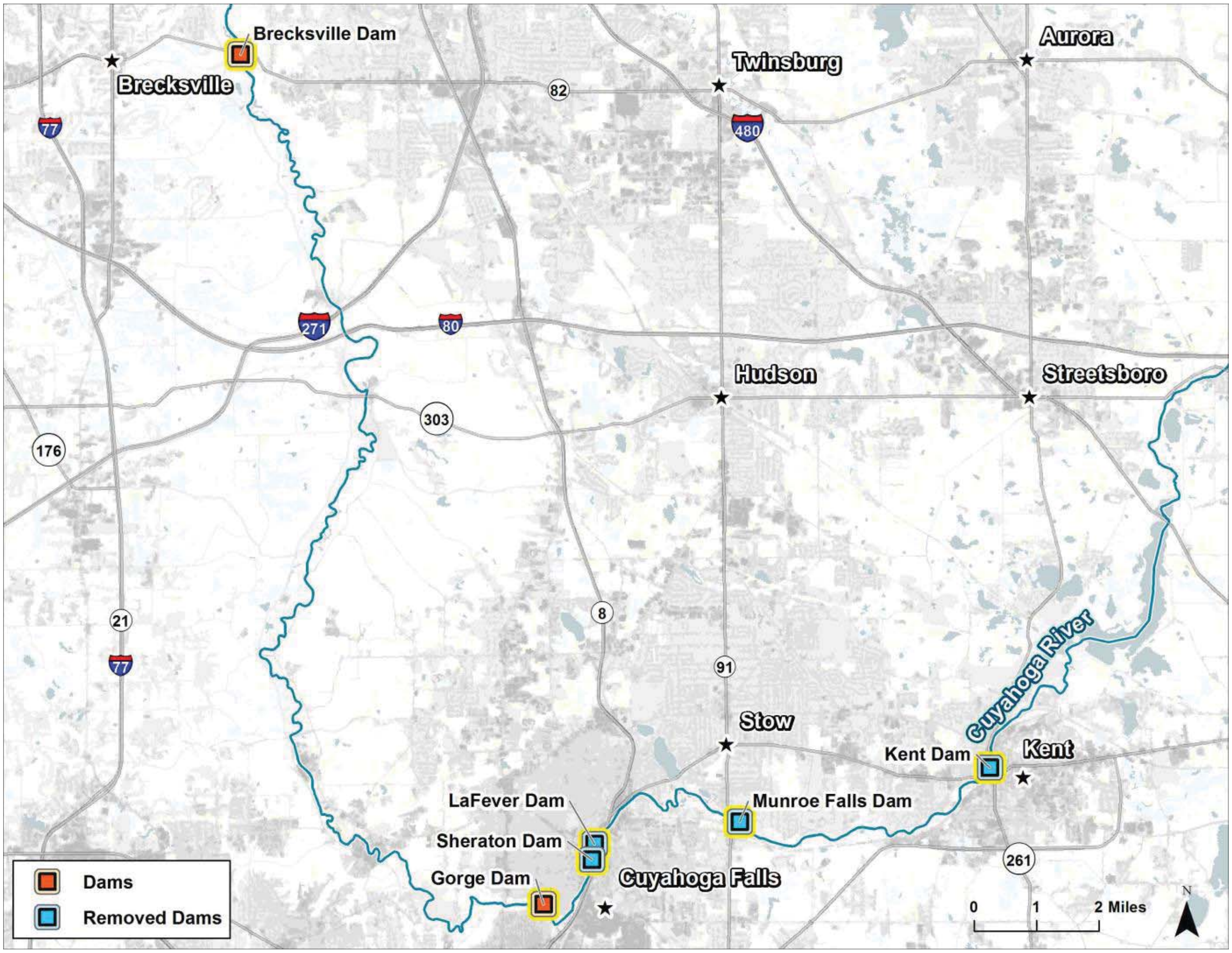
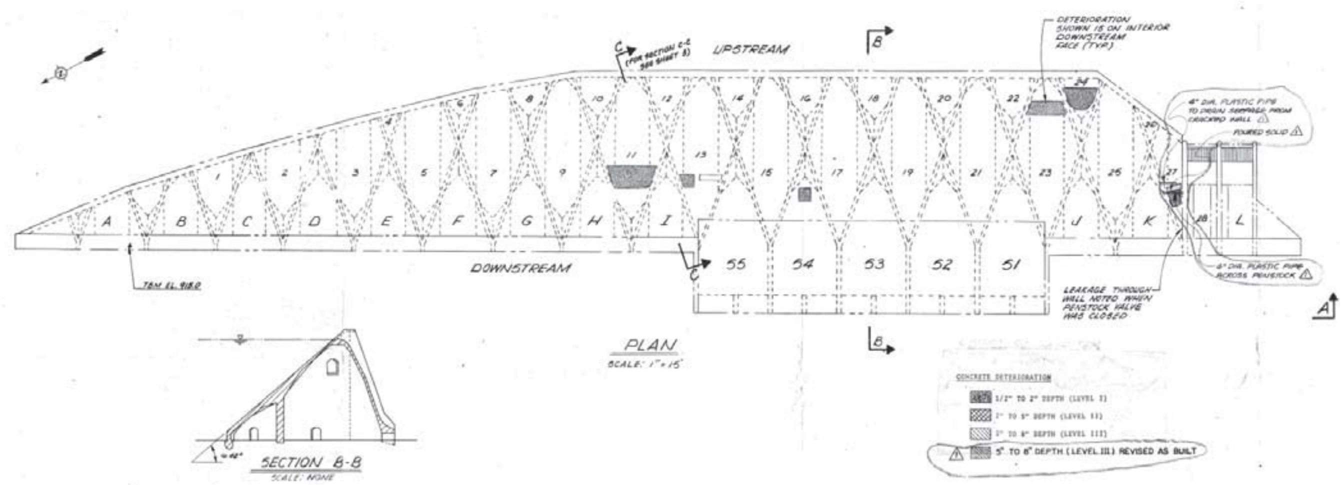


Figure 8. Dams near the Gorge Dam.

3.0 THE GORGE DAM

The Gorge Dam was designed by the Northern Ohio Power Company in 1911 and constructed in 1913. The dam is a 57-foot high, 420-foot long (including spillway), reinforced concrete, buttress-type structure that consists of an upstream inclined concrete face slab supported by one-foot thick concrete buttress walls (ODNR 2010). The buttress walls form an "X" pattern, in plan-view, beneath the face slab (Figure 9). The buttress vertices are spaced at approximately 24-foot intervals. The upstream face slab is inclined at approximately 45° to the horizontal.



Source: ODNR 2010

Figure 9. Gorge Dam schematic, in plan-view.

The dam has a 119-foot long, free overfall, reinforced concrete, ogee-crested spillway weir (located near the center of the dam) as its primary means of discharging excess runoff water (ODNR 2010). The spillway discharges onto a baffled, reinforced concrete apron at its base with energy diffusers, and then into the rock-lined natural river channel.

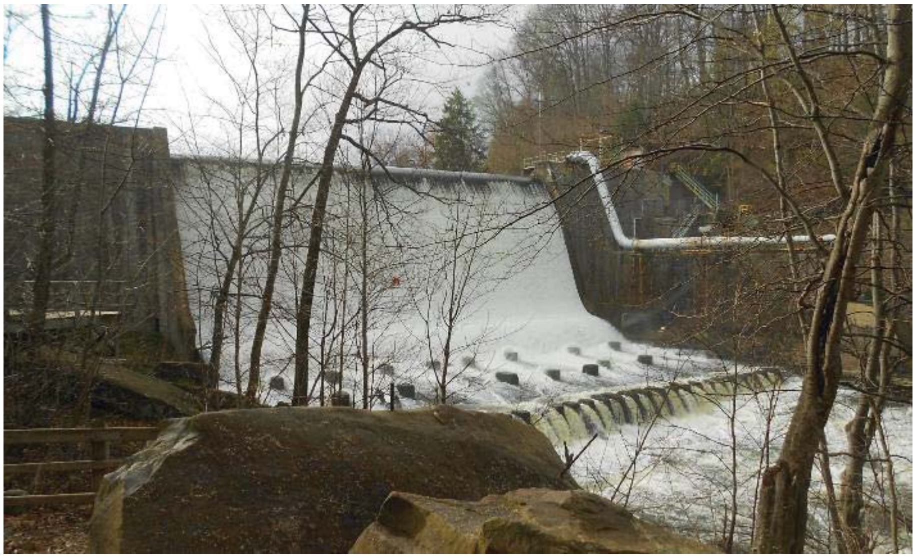


Figure 10. Gorge Dam Showing Ogee Spillway and Energy Diffusers.

According to available correspondence, the dam has been under periodic repair since the mid-1940s. Various materials such as coal dust, manure and loam were used over the years to patch cracks in the upstream face of the 45-degree slab. The underside of the slab and the buttress walls were patched by guniting prior to the early 1950's, and by concreting methods through the 1979's. The spillway appears to have been repaired several times since the mid-1940s. In the 1970's, it was determined that the dam did not meet current stability requirements. Consequently, the interior of the dam was pumped full with concrete in the mid-1980's to form a gravity structure.

4.0 SEDIMENT CHARACTERIZATION

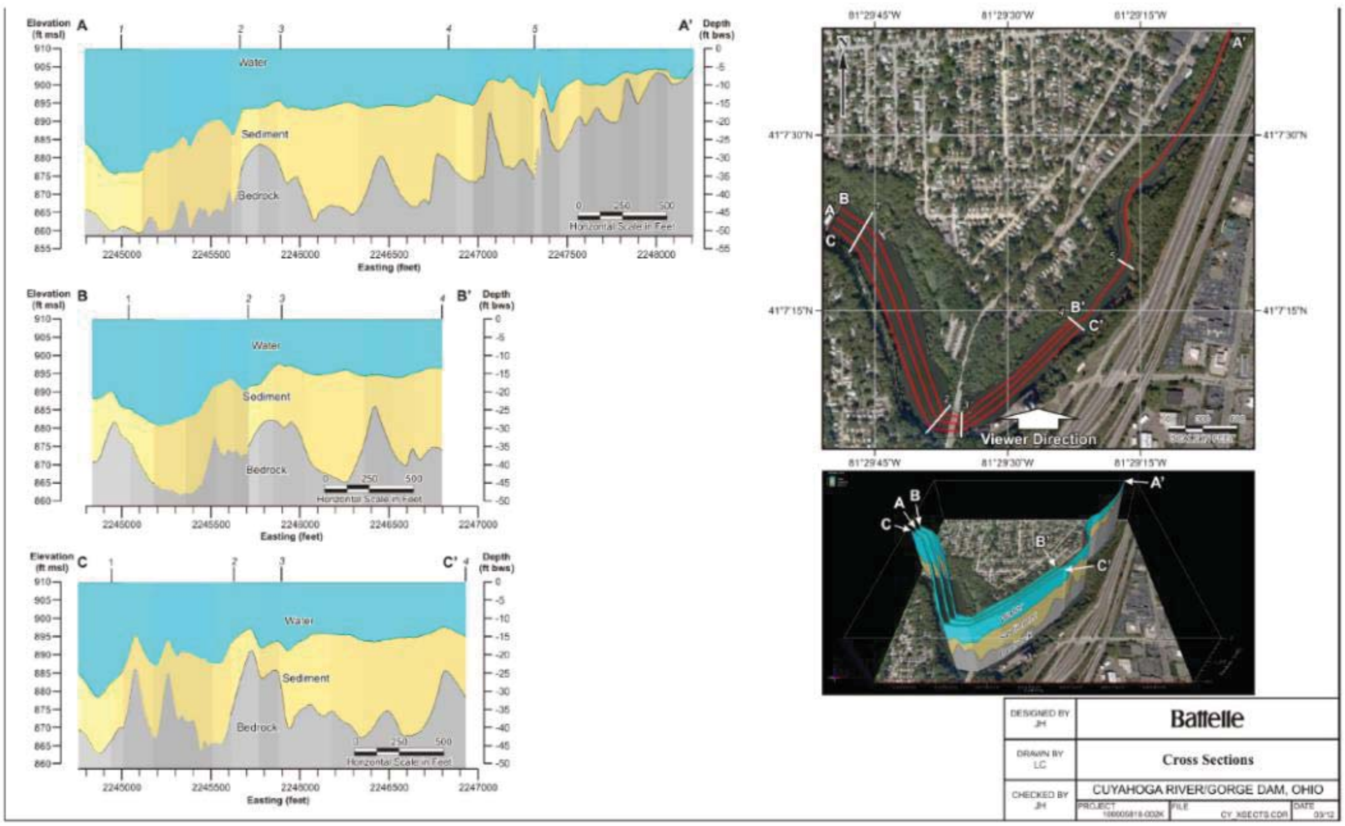
U.S. EPA GLNPO contracted with Battelle to characterize the quality of the sediment in the Gorge Dam pool. The results of this study are reported in *Task 2: Final Phase 1 and 2 Summary Report for Determination of the Nature and Extent of Potential Contaminant Concentration in Sediments within the Cuyahoga River Project Area* (U.S. EPA 2012). This study is the only comprehensive evaluation of sediment in the Gorge Dam pool, and thus, results pertinent to the development of this cost proposal are summarized in this section. Tetra Tech also evaluated the sediment chemistry data for risks posed to human health and those results are presented in this section.

4.1 QUANTITY

The sediment volume in the Gorge Dam pool was estimated to be 832,000 cubic yards based upon coring and poling performed in the summers of 2009 and 2011 (U.S. EPA 2012, p. 9). Sediment thickness was determined at 43 sediment coring sample locations and 154 sediment poling locations. The maximum sediment thickness encountered was 31.8 feet. Figure 11 provides a contour map of the data and Figure 12 presents cross-sections of the data (U.S. EPA 2012, p. 31-32).

Source: U.S. EPA 2012 (Figure 2-3, p. 31).

Figure 11. Estimated sediment thickness contour map of the Gorge Dam pool.



Source: U.S. EPA 2012 (Figure 2-3, p. 32).

Figure 12. Estimated sediment thickness cross-sections of the Gorge Dam pool.

4.2 QUALITY

Sediment core samples were collected, typically using vibracore equipment, during September 21-25, 2009 (first phase) and July 18-24, 2011 (second phase; U.S. EPA 2012). Sediment chemistry results indicated that organic and inorganic constituents exceed toxicological risk thresholds for benthic organisms. Based on this finding, Ohio EPA has determined that the sediment in the Gorge Dam pool must be dredged or otherwise removed prior to dam removal and cannot be discharged into the Cuyahoga River downstream of the dam. Analyses of sediment chemistry data also indicate that the dredge material may pose risks to human health (via direct contact); therefore, once permanently disposed of, deed restrictions will be necessary to prevent future human contact with the contaminated dredge materials.

4.2.1 Summary of Sample Collection and Laboratory Evaluation

Sediment core samples were collected at 25 locations, including duplicate samples directly adjacent to three locations, during the first phase. Sediment cores were segmented and discrete samples were collected and evaluated for volatile organic analytes (VOAs), semi volatile organic analyses (SVOAs), cyanide, acid volatile sulfides/simultaneously extracted metals (AVS/SEM)[10], total metals and mercury, polycyclic aromatic hydrocarbons (PAHs), pesticides, polychlorinated biphenyls (PCBs; as Aroclors), oil and grease, total organic carbon (TOC), total solids particle size distribution, and wet and dry bulk density (U.S. EPA 2012).

During the second phase, sediment core samples were collected at 22 locations, including duplicate samples at three locations. Sediment cores were segmented into 3-foot segments and discrete samples were collected that were evaluated for SVOAs, total metals and mercury, PAHs, pesticides, PCBs, oil and grease, TOC, and total solids (U.S. EPA 2012).

Samples were not evaluated for VOAs and cyanide in the second phase because they were only detected in a few samples in the first phase; similarly, metal toxicity was determined in the first phase to be unlikely, thus AVS/SEM was not conducted in the second phase. Bulk density was not evaluated in the second phase because it was "relatively consistent across depth profiles" in the first phase (U.S. EPA 2012, p. 39). Similarly, particle size distribution was not evaluated during the second phase because the results "were relatively uniform with the sediment profile" (U.S. EPA 2012, p. 40).

4.2.2 Summary of Laboratory Results and Risk to Ecological Resources

Battelle (U.S. EPA 2012, p. 35) evaluated the risks to ecological resources using threshold effect concentrations (TEC; adverse effects are not expected to occur at concentrations below TECs) and probable effect concentrations (PEC; adverse effects are likely at concentrations above PECs). This section presents a summary of Batelle's findings (U.S. EPA 2012).

Detections and exceedances of PECs varied spatially. Total PAH concentrations were "consistent to a depth of 15 [feet], then decreased at depths below 15" feet. The concentration of 16 priority PAHs "decreased steadily with increasing depth" (U.S. EPA 2012, p. 43). One-half or more of individual PAHs were at or exceeded PECs in the 0-3 and 3-6 foot depth intervals, while significantly fewer samples exceeded below the 6-foot depth, and no samples exceeded PECs below 15-feet. However, between 83 percent and 95 percent of samples exceed the TEC for the 16 priority PAHs at each depth interval (U.S. EPA 2012, p. 43). Analysis of PAH toxicity to benthic organisms showed that samples at 15 of 25 sample locations may unacceptably affect benthic organisms, which includes the uppermost sediment segment (i.e., shallowest depths that benthic organisms likely inhabit) at 14 of those locations (U.S. EPA 2012, p. 45).

Samples were evaluated for 21 pesticides[11], and only two pesticides (alpha-BHC and methoxychlor) were not detected in any sample. The most often detected pesticides were 4,4'-DDT and its degradation products 4,4'-DDE and 4,4'-DDD (U.S. EPA 2012, p. 51). Six pesticides exceeded their PECs and TECs: 4,4'-DDD, 4,4'-DDE, 4,4'-DDD, dieldrin (only exceeded TEC), endrin (only exceeded TEC), and heptachlor epoxide. Pesticides were regularly detected at depths less than 15-feet and no pesticides were detected in the only four samples collected at over 18-feet of depth (U.S. EPA 2012, p. 53).

Four of nine PCB Aroclors were detected above the reporting detection limit: Aroclors 1242, 1248, 1254, and 1260 (U.S. EPA 2012, p. 53). Aroclors 1260 (129 detects in 182 samples) and 1254 (124 detects in 181 samples) were detected more often than Aroclors 1242 (47 detects in 177 samples) and 1248 (40 detects in 182 samples). Total Aroclors were detected and above the TEC at every depth level. Samples exceeded the PEC at 15-feet depth or less.

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[10] The AVS/SEM method can detect six metals: cadmium, copper, lead, nickel, silver, and zinc.

[11] Aldrin, alpha-BHC, alpha-chlordane, beta-BHC, 4-4'-DDD, 4,4'-DDE, 4-4'-DDT, delta-BHC, dieldrin, endosulfan I, endosulfan II, endosulfan sulfate, endrin, endrin aldehyde, endrin ketone, gamma-BHC (lindane), gamma-chlordane, heptachlor, heptachlor expoxide, methoxychlor, and toxaphene.

“Oil and grease were prevalent throughout” the Gorge Dam pool and were detected in almost every sample (U.S. EPA 2012, p. 56). Higher concentrations were typically detected at depths between 6-feet and 15-feet. Cyanide was not detected in over one-half of the samples collected during the first phase and never exceeded the PEC or TEC.

Samples were evaluated for 23 metals and every metal was detected in at least 4 samples and 12 metals were detected in all samples[12] (U.S. EPA 2012, p. 57). Eight metals exceeded their PECs and TECs: arsenic, cadmium, chromium, copper, lead, mercury, nickel (only exceeded TEC), zinc; exceedances of TECs ranged from 84 percent to 96 percent of samples. AVS/SEM analyses were conducted to evaluate potential metals toxicity of the sediment, with AVS/SEM results normalized by TOC in each sample[13]. Only discrete samples from the first segment of the first phase core samples were evaluated and the results indicate “that toxicity associated with metals concentrations in sediment is unlikely” (U.S. EPA 2012, p. 38).

Mean bulk density was estimated to be 0.8 grams per cubic centimeter (U.S. EPA 2012, p. 39). The average particle size distribution was 74 percent clay, 20 percent sand, 5 percent silt, and 1 percent gravel (U.S. EPA 2012, p. 40). “The mean total solids content was relatively consistent across the entire sediment profile [and] … percent solids increased slightly with increasing depth” (U.S. EPA 2012, p. 62).

4.2.3 Potential Risk to Human Health for Post-Disposal Exposure

Since the contaminated sediment in the Gorge Dam pool may have an unacceptable effect on aquatic life, the sediment will need to be removed prior to dam removal. Regardless of the methods of dredging and dewatering, the sediment will need to be permanently disposed of and future use of the permanent disposal site will be impacted by the contaminated dredge materials[14]. For this reason the contaminant levels of the sediment were evaluated to assess potential risk to human health from post-disposal exposure.

While Ohio does not have sediment or dredge material beneficial re-use chemistry standards, Ohio EPA has promulgated generic numeric standards for its Voluntary Action Program (VAP). These standards were developed for three exposure pathways (direct contact with soils, exposure to indoor air, and unrestricted potable use of groundwater) for three target populations: commercial or industrial workers, construction site workers, and residents. These standards are often used to assess risks to human health as part of property-specific risk assessments that are necessary for properties seeking a covenant not to sue from the VAP.

Permanently disposed of, dewatered dredge materials are essentially soil. Therefore, Tetra Tech evaluated the sediment chemistry data collected by Battelle (U.S. EPA 2012) with VAP generic numeric standards for direct contact with soils (Ohio EPA 2015). The VAP Chemical Information Database and Applicable Regulatory Standards from February 13, 2015 were compared with sediment chemistry results from each station for each sampled depth. About two-thirds of the sediment chemistry analytes (U.S. EPA 2012) have corresponding VAP standards. Results for one or more samples exceeded the VAP’s residential use standards for nine parameters.

[12] The following 12 metals were detected in all 225 samples: aluminum, arsenic, barium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, and zinc.

[13] TOC concentration was typically larger at shallower depth intervals (U.S. EPA 2012, p. 62).

[14] The dredge materials are not considered to be hazardous waste that is regulated under the Resource Conservation and Recovery Act.

Of 199 parameters[15] that were sampled, all sample results were less than VAP's commercial/industrial standards and all but one sample (for lead) was less than the construction standards. Sample results from nine parameters exceeded VAP's residential use standards[16].

It should be noted that the sediment chemistry results were only compared with generic numeric standards for single chemicals. A risk assessment to consider cumulative exposure to multiple chemicals was outside of the scope of the project and was not conducted.

[15] The 199 parameters include the following: oil and grease, total araclors, total of 16 PAHs, total of 34 PAHs, and 18 parameters that represent groups of hydrocarbons.

[16] The nine parameters that exceeded VAP's single chemical generic numeric standards for residential use (with the numbers of samples that exceeded) are: Aroclor 1254 (1), arsenic (214), bis(2-chloroethyl)ether (1), dibenzo(a,h)anthracene (3), benzo(a)pyrene (84), dinitro-o-cresol (1), lead (1), n-nitrosodi-n-propylamine (6), and thallium (203).

5.0 SEDIMENT REMOVAL AND DISPOSAL

Since the contaminated sediment in the Gorge Dam pool may unacceptably affect aquatic life, Ohio EPA has decided that they must be dredged and the dredge material must be disposed of permanently. This section discusses sediment dredging, dewatering and disposal of dredge materials, and the proposed plans for managing and removing sediment in the Gorge Dam pool.

5.1 SEDIMENT REMOVAL

"Dredging is the removal of sediments and debris from the bottom of lakes, rivers, harbors, and other water bodies" (NOAA 2014). Dredging is a common practice at ports and navigable waterways in the United States to ensure that the depth of the port or waterway is sufficient for boat and ship navigation. For example, the lower Cuyahoga River is dredged by the U.S. Army Corp of Engineers (USACE) to maintain the port of Cleveland. Dredging is also performed to remove contaminated sediments that threaten the health of humans and wildlife (NOAA 2014); this type of dredging is referred to as *environmental dredging*. Future dredging of the Gorge Dam pool will be environmental dredging.

The environmental dredging process is basically composed of five parts: dredging, transporting sediment, dewatering dredge materials, treating and discharging dewatering water, and disposing of dredge materials. These individual components vary based upon the type of dredging. The two major types of modern dredges are *hydraulic dredges* and *mechanical dredges*, which are briefly discussed with respect to environmental dredging in the following subsections. Dewatering and disposal are discussed in Section 5.2 and Section 5.3, respectively.

5.1.1 Hydraulic Dredging

"Hydraulic dredges work by sucking a mixture of dredged material and water from the channel bottom" (USACE 2015). The two main types of hydraulic dredges are *hopper dredges* and *cutterhead pipeline dredges*. Hopper dredges are larger vessels that collect the sediment in the onboard hold of the vessel (i.e., the *hopper*). Often, the dredge materials are transported to another location and dumped.[17] Cutterhead pipeline dredges are smaller vessels (without holds) that pump the sediment to shore. Due to the width and depth of the Cuyahoga River in the Gorge and the topographical constraints of the project area, only cutterhead pipeline dredges are feasible.

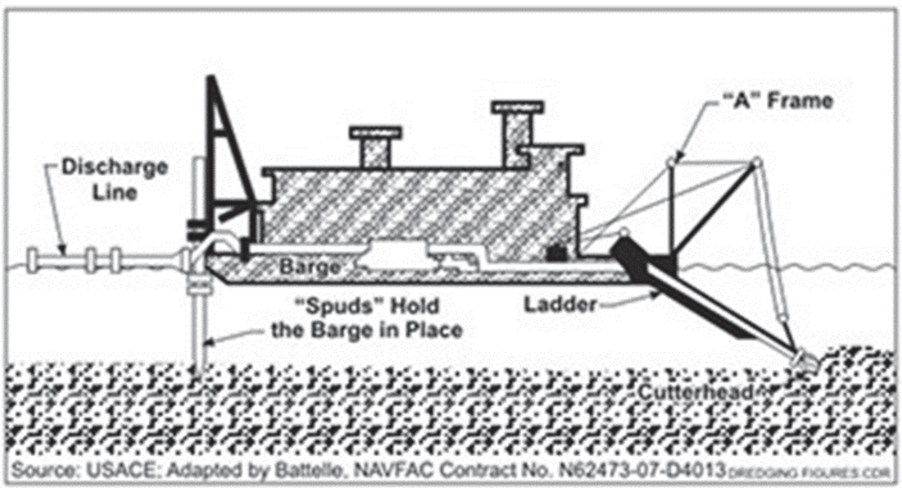

Figure 13. Hydraulic dredging.

When a cutterhead pipeline dredge is used (Figure 13), the

[17] While transporting and dumping dredge materials (through the doors on the bottom of the hoppers) is the most common type of hopper dredge, other types of hopper dredges pump the dredge material to a barge or to shore or use cranes to remove the dredge material from the hopper.

cutterhead[18] breaks up and loosens the bottom material that is then sucked up through the dredge, along with river water, and the mixture of dredged material and water is pumped through a discharge pipe to a dewatering location that is typically a nearby onshore site (USACE 2015). Often, the onshore dewatering site also serves as the permanent disposal site.

Portable hydraulic dredges are advantageous because they are smaller, transportable, and relatively inexpensive. Hydraulic dredging can be very cost efficient when the hydraulic dredge is operated continuously and the dredge is piped directly to the final disposal site (USACE 2015). Disadvantages include low sediment content (relative to river water) and slower pipeline velocities (Hayes 2006). Debris can also slow down dredging operations.

For the Gorge Dam project, cutterhead pipeline dredges would be able to navigate around the Front Street bridge and old bridge pylons (from a demolished bridge) once the pool water surface has been lowered. Smaller portable hydraulic dredges would also be relatively easy and cost-effective to deploy with the unique topography of the Gorge (e.g., steep Gorge walls, limited flat and open areas to launch). If a hydraulic dredging alternative is selected, the sediment slurry would be pumped in pipelines that run along the Cuyahoga River downstream to either the Chuckery Area of the Cascade Valley South Metro Park or to the Hardy Road Landfill, both of which are nearby in the city of Akron. The selected dewatering site would also serve as the permanent disposal site. These disposal sites are further discussed in Sections 5.4.4 and 5.4.5, respectively.

5.1.2 Mechanical Dredging

"Mechanical dredges remove material by scooping it from the bottom and then placing it onto a waiting barge or into a disposal area" (USACE 2015). The two main types of mechanical dredges are *dipper dredges* and *clamshell dredges*, both of which are named for the shape of their buckets.

With mechanical dredging, the dredge is secured to one barge and dredge material is placed on one or more disposal barges. The disposal barges, referred to as *scows*, transport the dredge material from the mechanical dredge to the dewatering location; multiple disposal barges are often used when the dewatering site is far from the dredging location. Dewatering sites must be selected in areas that are adjacent to the waterway that the disposal barges navigate. Dredge material may be disposed of at the dewatering sites or may be transported (often by truck) to a final disposal site.

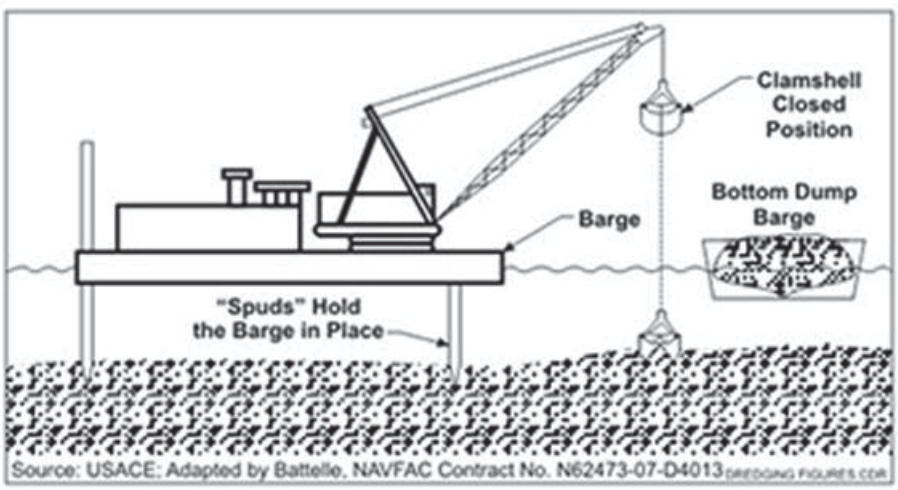

Figure 14. Mechanical dredging.

[18] "A cutterhead is a mechanical device that has rotating blades or teeth to break up or loosen the bottom material so that it can be sucked through the dredge" (USACE 2015).

The dredge materials collected by mechanical dredges contain higher concentrations of sediment (30 to 60 percent solids) than hydraulic dredges (Hayes 2006). USACE (2015) discussed how mechanical dredges are better for larger dredge materials:

> Mechanical dredges work best in consolidated, or hard-packed, materials and can be used to clear rocks and debris. Dredging buckets have difficulty retaining loose, fine materials, which can be washed from the bucket as it is raised. Special buckets have been designed for controlling the flow of water and material from buckets and are used when dredging contaminated sediments.

This is a disadvantage for the Gorge Dam project because GLNPO's contractor found that sediment in the Gorge Dam pool is typically composed of fine materials (i.e., silts and clays) (U.S. EPA 2012). While there are a few nearby, flat, open areas for dewatering mechanically dredged materials (e.g., the parking lots at Gorge Metro Park, the former Ohio Edison Plant), the dewatered dredge material would ultimately need to be trucked to a landfill or another approved upland disposal location for final disposal, which is discussed in Section 5.4.6. The operating landfill potentially available for use is 35 miles from the project area.

5.2 SEDIMENT DEWATERING

Dewatering methods will vary by dredging method. Since hydraulic dredging involves suction and pumping of both sediment pore water and river water, large volumes of water must be dewatered from the sediment slurry. Optimal hydraulic dredge slurries typically vary between 10 percent and 15 percent solids with the remaining 85 percent to 90 percent comprised of water. Mechanical dredging does not involve pumping and the dredge materials has far less water content than from hydraulic dredging. Regardless of dredging method, dredge materials will need to be dewatered prior to or as part of permanent disposal. Thorough dewatering is particularly critical if the sediment has to be transported by trucks.

5.2.1 Dewatering of Dredge Materials from Hydraulic Dredging

Dredged materials collected by hydraulic dredging are pumped to a contained dewatering site which, upon completion of the dewatering process, may also serve as the permanent disposal site. Large geotextile bags are typically used for dewatering for hydraulic dredging operations. Pipelines from the hydraulic dredge are connected to a piping manifold that distributes the sediment slurry into geotextile bags. After a geotextile bag is filled with sediment slurry, it is dewatered over time; water passes out through the walls of the geotextile bag and is collected in an underdrain system that discharges to a collection basin (Figure 15) [19]. The weep water is transported from the collection basin to a wastewater treatment plant. Wastewater treatment can be either onsite or at a municipal facility[20]. The weep water is treated and then discharged back to a surface waterway via an outfall permitted through the National Pollutant Discharge Elimination System (NPDES).

[19] The contractor will evaluate the need of and specifications of an underdrain system, along with the placement of geotextile bags, during project design.

[20] If the weep water is treated at a municipal facility, the weep water would need to meet the requirements of the municipal facility's industrial pretreatment program. Such requirements would likely include the analysis of constituents in the weep water.

Figure 15. Dewatering using geobags.

Due to the low solids content of the pumped dredge slurry, geotextile bags must be filled and dewatered repeatedly until geotextile bags are mostly full of solids. Crews must rotate through several geotextile bags and make adjustments to ensure that geotextile bags are constantly being filled during dredging operations and to ensure that the bags are not overfilled.

Hydraulically dredging areas with high percentages of fine grained sediments (like the Gorge Dam pool sediment) generally involve additional considerations and costs. During the past several years, the addition of polymers to separate and remove fine-grain sediments at a faster rate has become more common. The use of these polymers can greatly reduce the overall land area required for dewatering and can speed up the overall dredging operation.

Polymers are a class of chemicals that cause small, slow-settling particles to clump together into much larger, faster-settling agglomerates. They are injected into the pipeline from the hydraulic dredge and are mixed throughout the slurry. To be effective, the chemistry and dosage of a polymer must be matched through bench testing to the site-specific requirements of the sediment. When geotextile bags are used without the addition of polymers, the bags can quickly become overwhelmed by the volume of flow from the dredge and settlement/separation rates within the bags

5.2.2 Dewatering of Dredge Materials from Mechanical Dredging

Dredge materials collected by mechanical dredging are dewatered at a site close to the barge off-loading area(s). The general procedure for dewatering this material includes the following:

1. offloading wet soil/sediment from transport barges onto shore
2. transferring sediment from barges to temporary stockpiles
3. dewatering and allowing sufficient time to drain stockpiled material over some period of time
4. mechanically loading dewatered sediment onto trucks for offsite disposal.

Offloading of barges is largely a contractor-defined operation and can be accomplished by one of several methods. Each contractor will have their own preferences for unloading, which could include offloading barges using an excavator, the use of self-unloading hydraulic barges, or by other mechanical means like conveyors. Once sediment has been offloaded from barges, it would typically be placed in stockpiles positioned 100 feet or more from the water's edge.

Transport from shore-to-stockpiles could also be accomplished through several methods involving off-road trucks, conveyors, front-end loaders, or other means. Once material has been placed in stockpiles the material would be allowed to sit for several days or weeks, allowing time for it to drain before being loaded onto trucks for final disposal.

Dewatering is also considered a contractor-defined operation that could be accomplished by one of several methods. Dewatering via stockpiles is proposed herein. Contractors may also consider dewatering using plate and frame presses, or geotextile bags; contractors would then need to consider weep water treatment.

5.2.3 Water Treatment

Sediment weep water will be collected in basins or sumps at the sediment dewatering location. The basin will be large for the hydraulic dredging alternative to manage the large flows, while the mechanical operation will yield a much smaller quantity of water.

The planning assumption for the cost estimate is that sediment weep water would be treated at the disposal site and discharged directly to the Cuyahoga River. This approach would require a temporary NPDES permit and likely a more robust treatment plant than pre-treatment requirements for a publicly-owned treatment works (POTW). The contractor should evaluate water treatment capacity during the final design phase. It may be most efficient to operate multiple treatment trains (e.g., use three 3,000 gallon per minute treatment plants instead of one 9,000 gallon per minute treatment plant) to be able to increase or decrease capacity depending on dredging and dewatering operations.

Another option would be to send the sediment weep water to a POTW, such as the Akron Water Reclamation Facility on Akron-Peninsula Road, for final treatment and disposal. Water collected at the dewatering location will need to be treated to meet the POTW's pre-treatment requirements. Pre-treatment could include settling, filtration, and adsorption. Based on the physical and chemical composition of the sediment, the cost estimate assumes only settling will be necessary to meet pre-treatment requirements.

5.3 SEDIMENT DISPOSAL

This section of the document describes the issues associated with disposing of the sediment accumulated upstream of the Gorge Dam. Several options were evaluated as part of the feasibility study, including:

- Beneficial re-use of the sediment (e.g., use material to build an outdoor concert amphitheater, golf course, race track).
- Disposal of the sediment at a closed landfill or other similar property.
- Disposal of the sediment at an operating landfill.

Tetra Tech conducted a spatial analysis to locate publicly owned properties at various distances from the dam (Figure 16) and also contacted various potential partners to discuss disposal options. The results are summarized in the following sections.

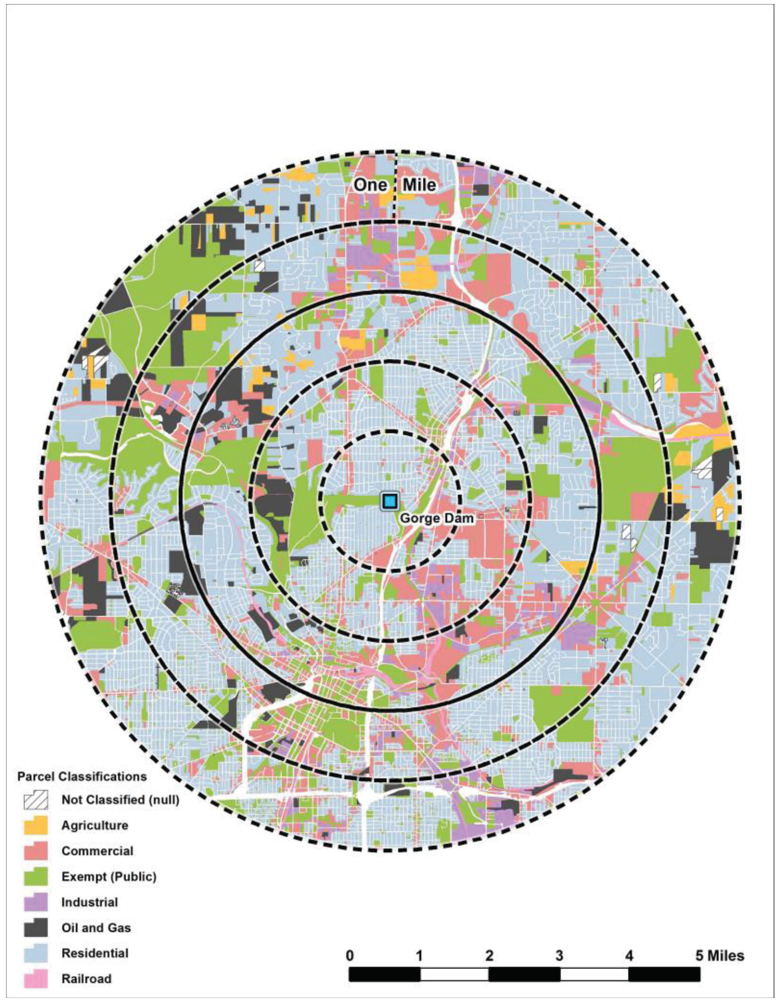

Figure 16. Analysis of property ownership type within the general vicinity of the Gorge Dam.

5.3.1 Beneficial Re-Use

Beneficial re-use is essentially finding a new use for an unused or discarded material. The dewatered dredge materials could be beneficially re-used as fill soil for any project where people would not have direct contact with the soil. Examples of such construction projects that could use dredge materials as fill soil include building golf courses, baseball diamonds, outdoor amphitheaters, and parks.

Due to the large volume of sediment (such as the 800,000 cubic yards to be dredged, which would cover an area of approximately 50 acres 10 feet deep), no beneficial re-use options were identified. As no partner or known entity was willing to accept dredge materials for beneficial re-use, this alternative became infeasible.

5.3.2 Closed Landfills

Two potential disposal sites were identified for receiving sediment directly from the Gorge Dam pool via hydraulic dredging; the locations of these sites are shown in Figure 17. These sites were not considered for final disposal of mechanically dredged materials due to transportation costs associated with more than 90,000 truckloads that would need to drive around, and not through, large residential areas between the dam pool and closed landfills.

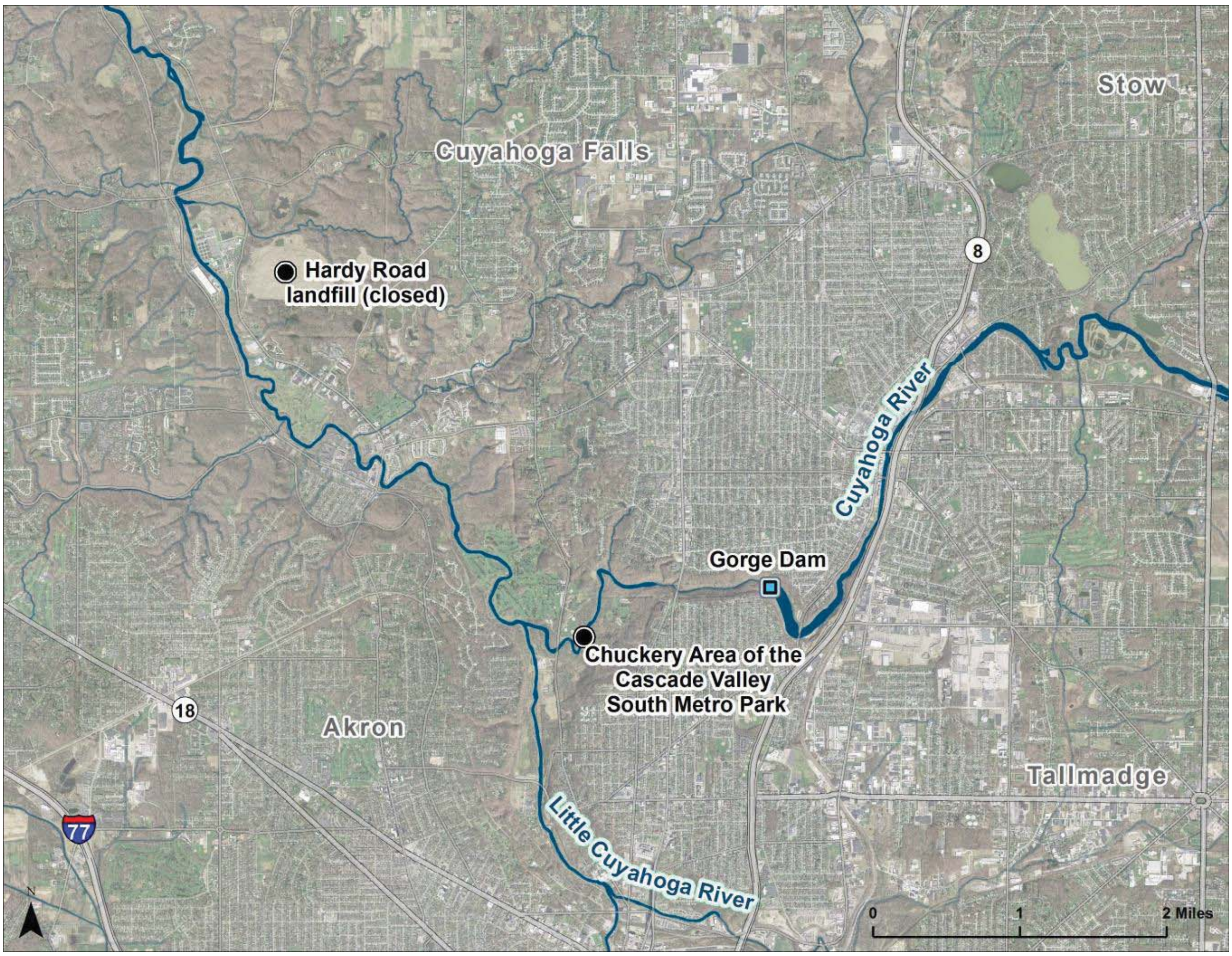

Figure 17. Location of the Chuckery Area of the Cascade Valley South Metro Park and the closed Hardy Road Landfill in relation to the Gorge Dam.

5.3.2.1 Chuckery Area of the Cascade Valley South Metro Park

The Chuckery Area of the Cascade Valley South Metro Park is 1.5 miles downstream of Gorge Dam along the east bank of the Cuyahoga River between Peck Road and Cuyahoga Street. An area of thirty five (35) acres lying outside the 100-year flood elevation has been identified in Figure 18 as a potential sediment disposal location. The parcel is owned by the city of Akron and is now overgrown by small brush and Shagbark Hickory trees. Previously, the site was used as a landfill, although details of its buried contents are not well-known. This closed landfill is not in a 30-year closure monitoring program and does not have a methane gas collection system. This parcel is particularly well-suited as a final disposal area for the sediment, both because of its proximity to the Gorge Dam and its relatively flat topography.

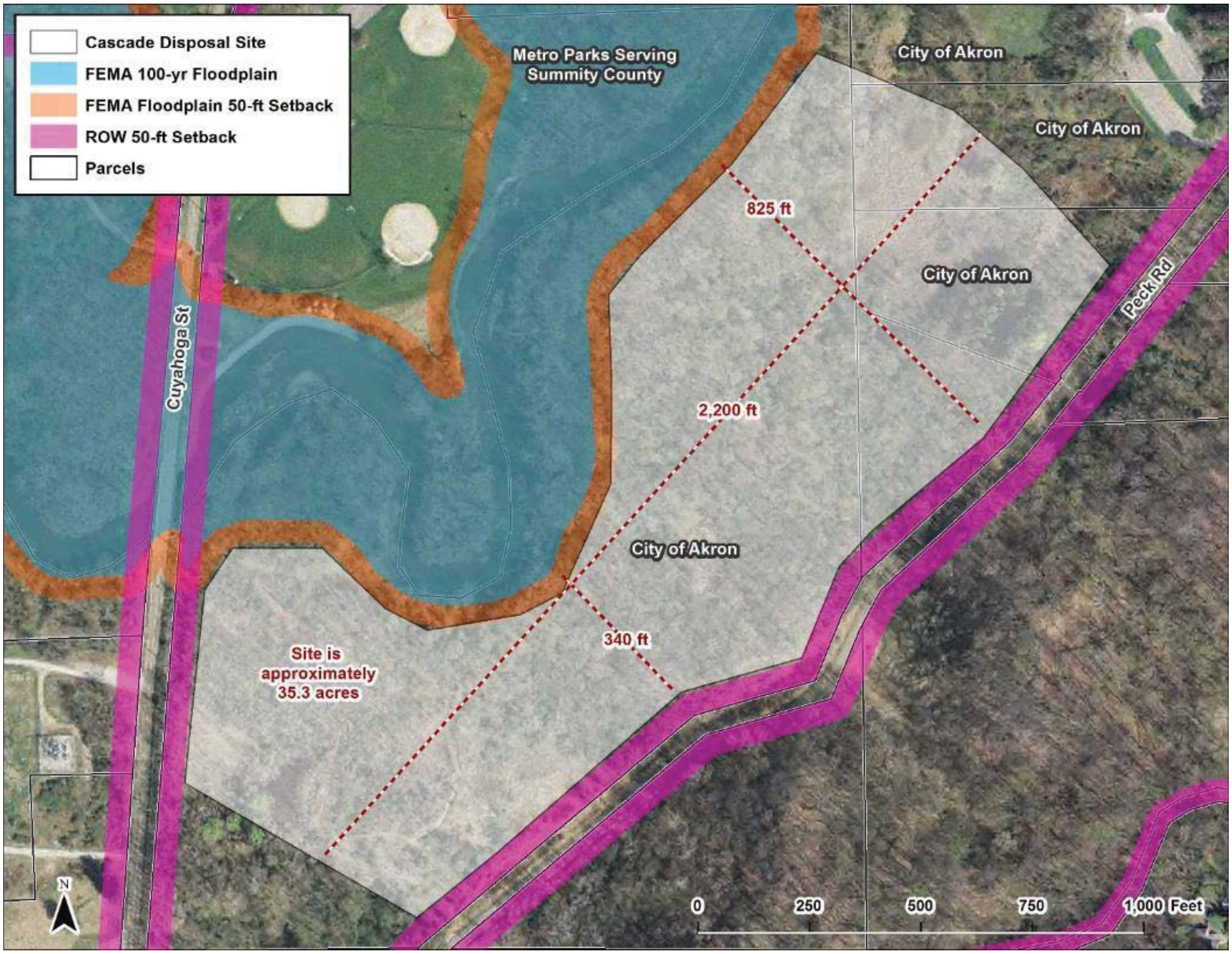

Figure 18. Potential disposal site in the Chuckery Area of the Cascade Valley South Metro Park

5.3.2.2 Hardy Road Landfill

The Hardy Road Landfill was identified as a second potential disposal site (Figure 19). The site is a sanitary landfill that was closed in 2002. This disposal site poses many challenges to hydraulic dredging but could be utilized if necessary. Sediment from hydraulic dredging would likely need to be pumped almost 6.1 miles to reach the landfill, following the riverbed. This extended pumping process would require the installation of multiple booster pumps along the pipeline.

This site is essentially a manmade “hill” rising about 100 feet above the surrounding natural topography. Below the “hill” is a capped, sanitary landfill, with provisions for methane gas collection, an impermeable cap, and seeded topsoil. As the landfill was recently closed, the property is still being monitored under a 30-year agreement. Use of this site involves several challenges, including its topography, the methane gas collection system, ongoing and continuing monitoring, and its status as a closed landfill.

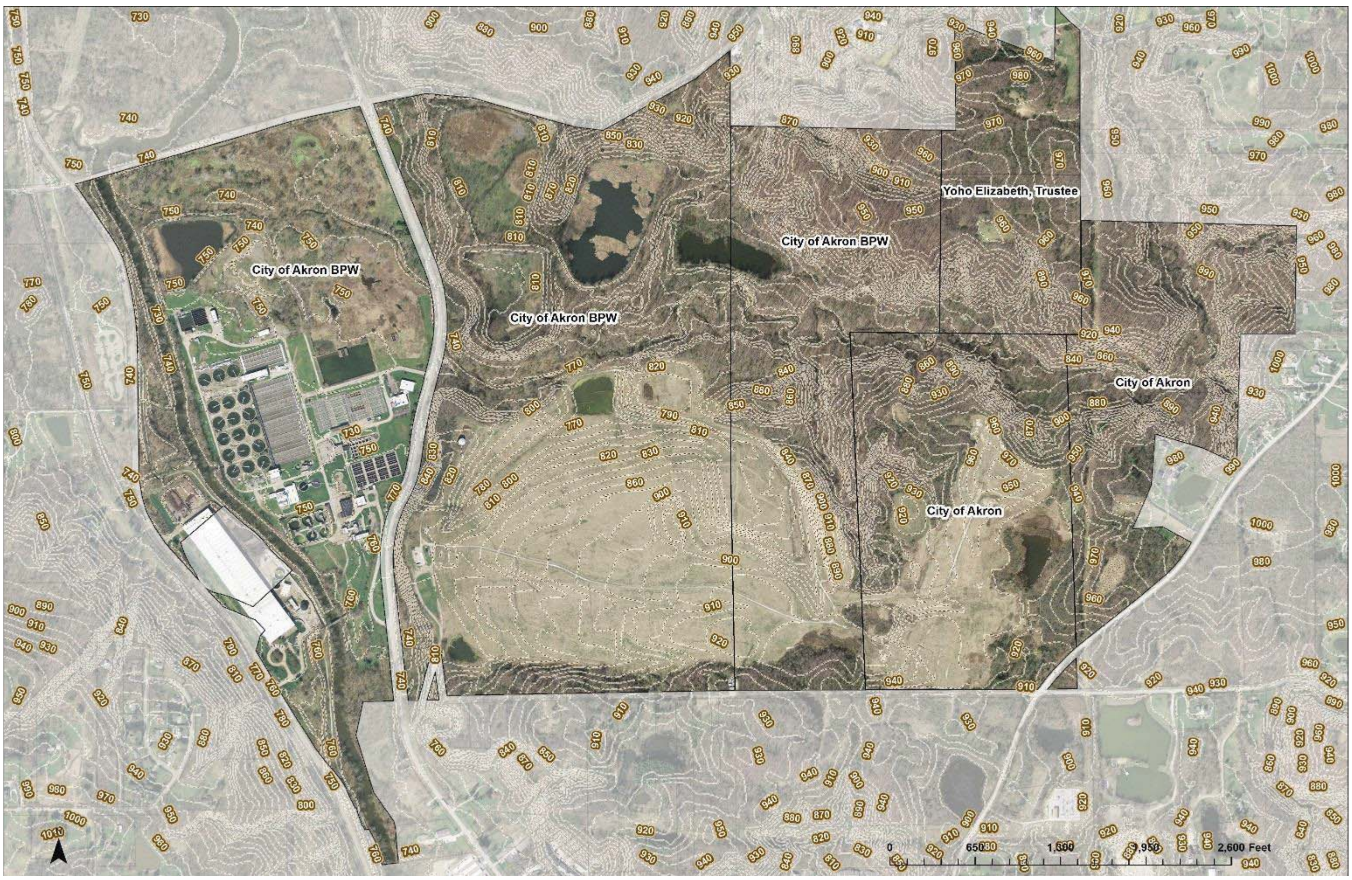

Figure 19. Potential disposal site at the Hardy Road landfill

5.3.3 Operating Landfill

Several licensed commercial area landfills are available within reasonable travel distance of the Gorge Dam site. No commitment has been obtained from any operating landfill that it could or would accept all or part of the Gorge Dam sediment. The volume of sediment, sediment characteristics, each landfill’s individual earthwork needs, and landfill tipping and handling fees, will be factors for consideration if landfill disposal is evaluated during final project design. To use landfill disposal, dredge materials would be collected by mechanical dredging and dewatered at the dam and then transported to the landfill by truck. Concerns with this approach include increased road traffic, noise, leakage, and costs (Hayes 2006). For preliminary cost estimates, a one-way trucking distance of 35 miles has been assumed.

5.4 SEDIMENT REMOVAL ALTERNATIVES

Cost estimates were developed for three alternatives for sediment removal, dewatering, disposal, and management. The three sediment removal alternatives are summarized in the list below:

- **Alternative 1a:** Hydraulic dredging with dewatering and disposal at the Chuckery Area along Peck Road
- **Alternative 1b:** Hydraulic dredging with dewatering and disposal at the closed Hardy Road landfill
- **Alternative 2:** Mechanical dredging with dewatering at both the Gorge Metro Park and former Gorge Power station and disposal at a nearby landfill or approved upland location

Sediment Removal Alternatives 1a and 1b utilize hydraulic dredges that would pump sediment slurry to disposal sites where material can be dewatered and deposited. Sediment Removal Alternative 2 uses mechanical dredging, one or more dewatering sites, with final disposal at an operating landfill or an approved upland location. Alternatives that were considered infeasible were removed from the analysis early in the process and are briefly describe below:

- Hydraulic or mechanical dredging with dewatering at various locations, and final disposal with an entity that would beneficially re-use dewatered dredge materials was not considered because no entity was willing to accept over 800,000 cubic yards of material.
- Hydraulic dredging with dewatering at either the Chuckery Area along Peck Road or the closed Hardy Road landfill with final disposal at an active landfill or other upload location was not considered due to (1) labor costs for moving the dewatered dredge materials to truck loading areas close to nearby roads, and (2) transportation costs associated with over 90,000 truckloads that must drive around large nearby residential areas.
- Mechanical dredging with dewatering at the Gorge Metro Park and former Gorge Power station, and disposal at either the Chuckery Area along Peck Road or closed Hardy Road landfill was not considered due to (1) transportation costs associated with over 90,000 truckloads that must drive around large residential areas, and (2) labor and equipment costs for moving dewatered dredge materials from truck offloading areas near public roads to the final disposal sites.
- Mechanical dredging in the dry after lowering the Gorge Dam pool to pre-pool depths was not considered for numerous reasons including (1) excavation, labor and transportation costs associated with removing the sediment within an active riverbed, (2) the need to isolate and maintain river flow throughout the excavation duration while minimizing sediment transfer, and (3) the need and difficulty to fully drain the dam pool level to streambed elevation.

5.4.1 Cost Basis

Because this is only a feasibility study, no final design engineering has been performed and, therefore, many design details have been assumed. For example, significant assumptions that were made to estimate project costs include:

1. Local partners would make property parcels available for sediment deposition and disposal;
2. Local partners would make parcels surrounding the dam and dam pool available during construction;
3. Suitable contractors with the necessary equipment will be available to perform the project;

4. There would be no unusual limits placed on the timing of construction activities (e.g., periods of the year when dredging could not occur);
5. There would be no unusual permit restrictions, treatment needs, or requirements;
6. There would be no requirements or non-restrictive affects for funding.

Each of these items will need to be fully assessed and addressed during the design phase of the project and will impact the final cost of the project.

Tetra Tech's proposed methods and suggested construction sequences are based upon past dredging project experience and conversations with dredging and demolition contractors with related experience. Tetra Tech assembled the most probable construction scenarios using this information; however, the proposed construction methodology is conceptual in nature. Modifications to the construction assumptions presented herein are probable and would likely reflect the future contractor's available equipment, labor skillsets and preferences, and issues that may arise during the project design phase.

Significant factors affecting project cost include:

- construction timing
- fuel prices
- contractor and labor availability
- availability of property for use
- weather
- length of construction season

The project is heavily dependent on oil prices and other oil-derived products such as geotextile fabrics. Oil costs at the time of construction will influence fuel for dredge and pumping equipment, excavation equipment, sediment trucking costs, geotextile products, and bituminous pavements (where applicable). Current fuel pricing utilized in preparation of estimates vary between $2.55/gallon and $2.80/gallon in the Cuyahoga Falls area. Additionally, the actual timing for construction activities are unknown at this time and costs are expected to generally rise at the rate of inflation.

5.4.1.1 Effective Dates for Labor, Equipment, and Material Pricing

All costs of labor, equipment, and material are based on current (i.e., year 2015) conditions.

5.4.1.2 Estimated Production Rates

The construction of this project would require several specialty crews and equipment due to the unique construction techniques that are required. Conventional construction procedures, such as clearing and excavation work for sediment disposal, have been compared with RS Means data for this preliminary pricing. Production rates for the cost estimates presented herein assume that turbidity, water quality, and noise monitoring will not be required. As with any construction activities, actual production rates will be contractor-dependent and affected by the contractor's equipment, availability, work crew experience, weather, material availability, project timing, and other items.

Production rates for hydraulic dredges have been assumed to be 3,000 cubic yards per day (cy/d), 16-to-17 hour workdays 7 days/week with all sediment dredging performed during one construction season. Dredging rates exceeding 3,000 cy/d will be limited by geotextile bag filling operations at the disposal site.

Similarly, a mechanical dredging rate totaling 2,000 cy/d has been assumed and would be performed during 9 to 10-hour workdays. Reaching this volume will require the use of two mechanical dredges operating simultaneously over two seasons with sediment offloading/transfer on both the north shore parking lot (right bank, south of Front Street) and the former Gorge Power Plant on the southerly shore (left bank, east of the Front Street road bridge).

5.4.1.3 Project Markups

Construction contingencies of 15 percent are included for Alternatives 1a and 2. A higher contingency of 20 percent is used for Alternative 1b due to potential complexities and unforeseen issues (e.g., additional monitoring) that could arise during the placement of sediment over a portion of the recently closed Hardy Road Landfill.

5.4.2 Pre-Mobilization Activities

Prior to mobilization and site preparation, additional studies and activities will need to be performed to support sediment removal and disposal. These studies and activities are beyond the scope of this feasibility study; they are briefly summarized in Section 7.0.

Access limitations will vary by alternative. For all three sediment removal alternatives, Metro Parks will need to restrict public access to the Gorge Dam pool and portions of the Gorge Dam Metro Park. Alternative 1a would also likely require access restrictions to Peck Road and the parking lots in the Chuckery Area of the Cascade Valley South Metro Park. Alternative 2 would likely require Metro Parks to close down the entire Gorge Metro Park.

Construction contractor(s) would need to prepare a site-specific health and safety plan that would address public access to the project area. Such a plan may call for security fencing and for visitors to be escorted through restricted areas.

5.4.3 Post-Demobilization Activities

Cost estimates for each sediment removal alternative include $300,000 for river monitoring following the completion of construction activities. In the case of Alternative 1b, costs associated with a three-year post-construction landfill monitoring program ($3,000,000) are also included. For all three sediment removal alternatives, the estimated costs do not consider the management of dredge residuals that may remain after dredging; such costs could include confirmation sampling or for the maintenance of sediment soil covers or caps.

5.4.4 Sediment Removal Alternative 1a

In Sediment Removal Alternative 1a, one portable hydraulic dredge with ±200 cubic yards/hour capacity, would be used and the sediment slurry would be pumped in a single pipeline[21] along the Cuyahoga River to a single dewatering and final disposal site along Peck Road in the Chuckery Area of the Cascade Valley South Metro Park[22]. An actual dredge volume of 800,000 cubic yards (±96% removal of total material) was assumed for preliminary pricing[23]. The mobilization and equipment needs (Section 5.4.4.1), construction sequence (Section 5.4.4.2), and costs (Section 5.4.4.3) are presented in the following subsections.

5.4.4.1 Equipment and Mobilization Needs

Mobilization will simultaneously occur at the Gorge Dam pool and at the Chuckery Area along Peck Road. The hydraulic dredges and associated equipment and watercraft will be mobilized to the former Gorge Power Station

[21] In the event that more than one hydraulic dredge would be operated in the Gorge Dam pool, the two or more pipelines would connect into a single pipeline at the Gorge Dam, which would be placed along the Cuyahoga River.

[22] The address of the Chuckery Area of the Cascade Valley South Metro Park is 837 Cuyahoga Street, Akron, Ohio 44313. Peck Road intersections Cuyahoga Street near this address, on the east side of Cuyahoga Street.

[23] The contaminated sediment volume was estimated as 832,000 cubic yards based upon data collected in 2009 and 2011 (U.S. EPA 2012). The volume will likely change by the time dredging occurs several years into the future.

along Front Street. A hydraulic discharge line with a booster pump will be deployed along the Cuyahoga River in the Gorge Metro Park and the Cascade Valley South Metro Park. Earth moving equipment will be mobilized to the dewatering and disposal site area, within the Chuckery Area along Peck Road in the Cascade Valley South Metro Park. Major equipment and materials necessary for Alternative 1a are presented in this section; refer to Appendix A for more detailed information for these and other equipment and materials.

The major equipment needed for Sediment Removal Alternative 1a are:

- One 10” or 12” hydraulic dredge
- One hydraulic discharge line with one unmanned booster pump
- Polymer feed equipment
- Earth moving equipment at Peck Road

The major materials needed for Sediment Removal Alternative 1a (to be used at the dewatering site) are:

- Granular fill, soil, and washed drain stone
- High density polyethylene liner and cushion geotextile fabric
- Underdrain tile and stone bedding
- Geotextile bags
- Piping manifold: main line, feeder lines, pipe fittings and connectors, valves, etc.

5.4.4.2 Construction Sequence

The Sediment Removal Alternative 1a construction sequence begins with mobilization and preparation at the Gorge Dam pool and at the Peck Road dewatering and disposal site (Table 3). The hydraulic dredge would be deployed at the former Gorge Power Station. To facilitate dredge deployment, a temporary boat launch would be constructed at the former Gorge Power Plant. A pipeline from the dredge would be deployed along the Cuyahoga River from the Gorge Dam downstream to the Chuckery Area of the Cascade Valley South Metro Park (refer back to Figure 17).

While the equipment access ramp is constructed and the pipelines are deployed, the Peck Road site would also be prepared. The 35 acre area would first be cleared of vegetation and then graded. As the dewatering and disposal site is prepared, Metro Parks will need to restrict public access to the Chuckery Area of the Cascade Valley Metro Park, including access to Peck Road and the Chuckery Trail. Preparations would continue at the Peck Road site with the construction of a berm and collection basin along the perimeter of the disposal site and with the construction of a temporary pump station transferring runoff to a municipal sanitary sewer, or by constructing a temporary water treatment facility.

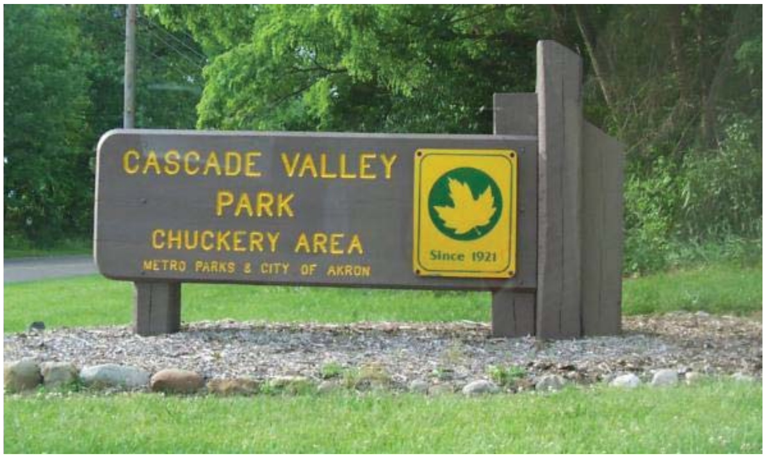

Figure 20. Photograph of the Peck Road entrance to the Chuckery Area of the Cascade Valley South Metro Park.

After all of the construction is completed and equipment has been mobilized, the system would be tested. The testing will also allow for the optimization of polymer additives. After testing the system, dredging and dewatering operations would begin (Table 4). The hydraulic dredge would begin in the Gorge Dam pool upstream of the Front Street bridge. The vessel would dredge beginning at the upper dredge limits of the pool and would work its way downstream. The pool elevation will need to be lowered using the lake drain in the dam to allow passage of the dredge under the Front Street Bridge. Dredging operations would continue until all sediment has been removed. Two work shifts working 7 days/week have been assumed with dredging work taking about 9 months.

Crews at the Peck Road site would monitor the dewatering and make adjustments and rotate geotextile bags as necessary. Assuming a rate of 3,000 cubic yards of sediment per day, with operations continuing 16 hours per day for seven days per week, the dredging should be completed in around 39 weeks.

After dredging operations are completed, the dredges and equipment would be demobilized. The temporary equipment launch ramp and pipelines would be removed (Table 5). At the Peck Road site, the geotextile bags would continue to be dewatered and any remaining water would be treated. Geotextile bags would be left in place. After the piping manifold, water treatment facility, and other temporary equipment are removed, the perimeter berm would be bulldozed into the collection basin and soil would also be graded over the sediment-filled bags, mulched, and re-vegetated. Erosion control measures would also be implemented. Achievement of the design elevation is assumed sufficient for agency acceptance of the dredge materials management units (i.e., no confirmation sampling to evaluate the chemistry of disposed dredge material is required). The site would be covered, re-vegetated, and essentially restored.

5.4.4.3 Costs

The estimated cost for Alternative 1a is $57,400,000. The major costs and assumptions with labor, equipment, and materials are presented in Appendix A. Construction costs are estimated at $45,488,600, which includes a 15 percent contingency of $6,830,100. The total cost includes allowances for a disposal site geotechnical and environmental report ($400,000), project engineering design ($909,700), construction phase engineering ($3,411,600), and river monitoring program ($300,000). Costs do not consider management of dredge residuals that may remain after dredging nor do they consider evaluation of the chemistry of disposed and buried dredge materials.

Labor for dredging operations is the single largest labor cost at $12,150,000 for operating at 16 hours per day and dredging 3,000 cy/d. The estimated costs for crews filling geotextile bags is $1,300,000.

The polymer for hydraulic dredging is the most expensive material cost, with $4,400,000 for the polymer and $2,080,000 for the associated feed equipment and associated work. The second most expensive material is the geotextile bags ($4,400,000). Soil for construction of the berm at the dewatering site and for final grading will cost $1,944,000.

Table 3. Mobilization and preparation for Sediment Removal Alternative 1a

Gorge Dam pool and Cuyahoga River	Peck Road dewatering and disposal site
1. Prepare shoreline erosion control measures.	1. Prepare disposal site erosion control measures.
2. Construct temporary launch for dredges and equipment.	2. Clear and grub disposal site of trees and brush. About 35 acres for dredge material disposal, a temporary construction yard and storage.
3. Install temporary hydraulic pump line(s) from upper pool to Peck Road disposal site generally following the bed of the river, with a maximum distance of 2.6 miles.	3. Grade disposal site to flat condition, filling as necessary. Remove all protruding concrete, stumps, and such.
--	4. Construct a temporary berm and collection basin around the perimeter of dewatering and fill area.
--	5. Spread 6 inch sand layer on the bottom of the dewatering and fill area. Place a 40 mil HDPE liner over the sand bedding. Then, cover the liner with a 6 inch layer of washed stone for geotextile bags to be placed upon.
--	6. Install temporary treatment plant[a] to treat dewatering runoff and to remove sediment prior to discharge.
--	7. Spread out geotextile bags [b] along disposal site.
--	8. Construct discharge route from sedimentation basin(s) to outlet, including erosion control measures.
9. Mobilize dredge(s) to the Gorge Dam pool (upstream of the Front Street road bridge), including discharge pumps and booster pumps. Connect dredging equipment to discharge line.	9. Connect piping manifold go geotextile bags. Pipeline(s) will run from dredge(s) and discharge pumps to the piping manifold to fill the geotextile bags.
10. Test the dredge and pipeline setup.	
11. Using bench test information for polymer optimization.	--

Notes
a. The temporary treatment plant is assumed to have a peak flow capacity of 6,000 gallons per minute.
b. The geobags are assumed to have dimensions of a 120 foot circumference and 200 feet long. They will be 9 feet tall once filled and 7 feet tall after complete dewatering.

Table 4. Dredging and dewatering operations for Sediment Removal Alternative 1a

Gorge Dam pool and Cuyahoga River	Peck Road dewatering and disposal site
12. Commence hydraulic dredging operations, pumping and transporting sediment slurry to the disposal area and into the geobag network.	
--	13. Provide staff at disposal site (1) to monitor filling of the geotextile bags (including the rate of filling), (2) to make any adjustments to piping, (3) to operate valves, and (4) to rotate the bags being filled.
14. Continue with hydraulic dredging operations for 24 hours per day and six days per week.	
--	15. Fill bags to roughly 7 feet of depth. As bags are filled and dewatered, a second tier of bags is to be added above the first bag layer.
16. When dredging upstream of the Front Street road bridge is complete, mobilize the smaller dredge downstream of the bridge.	--
17. Dredging operations are completed.	

Table 5. Demobilization and restoration Sediment Removal Alternative 1a

Gorge Dam pool and Cuyahoga River	Peck Road dewatering and disposal site
18. Demobilize the dredges, pipelines, pumps, and such.	18. Disconnect and remove geobag filling piping manifold. Remove treatment plant and other appurtenances.
19. Remove temporary boat launch.	19. Following stabilization of sediment in the lagoon cell(s) and treatment/removal of any remaining flows, grade out excess soil material from the perimeter berms to cover filled geotextile bags and to facilitate surface drainage.
--	20. Seed and mulch the disposal location to establish vegetation.
--	21. Install permanent erosion control measures.
--	22. With vegetation established, abandon and restore any remaining disturbed areas.
23. Install new plantings.	
24. Remove temporary erosion control measures.	

5.4.5 Sediment Removal Alternative 1b

Similar to Sediment Removal Alternative 1a, Alternative 1b assumes one hydraulic dredge operates 7 days/week with 2 work shifts. However, under Alternative 1b the sediment slurry is to be pumped along the bed of the Cuyahoga River to a single dewatering and permanent disposal site at the Hardy Road landfill[24]. The mobilization and equipment needs (Section 5.4.5.1), construction sequence (Section 5.4.5.2), and costs (Section 5.4.5.3) are presented in the following subsections.

5.4.5.1 Equipment and Mobilization Needs

Mobilization will simultaneously occur at the Gorge Dam pool and at the closed Hardy Road landfill. The hydraulic dredges and associated equipment and watercraft will be mobilized to the former Gorge Power Station along Front Street. A hydraulic discharge line with an unmanned booster pump will be deployed along the Cuyahoga River in the Gorge Metro Park downstream to the landfill. Earth moving equipment will be mobilized to the dewatering and disposal site area, within the closed Hardy Road landfill. Major equipment and materials necessary for Alternative 1b are presented in this section; refer to Appendix A for more detailed information for these and other equipment and materials.

The major equipment needed for Sediment Removal Alternative 1b are:

- One 10” or 12” hydraulic dredge
- One hydraulic discharge line with five booster pumps
- Polymer feed equipment
- Earth moving equipment at Hardy Road

The major materials needed for Sediment Removal Alternative 1b (to be used at the dewatering site) are:

- Soil and washed drain stone
- High density polyethylene liner and cushion/bedding
- Geotextile bags
- Piping manifold: main line, feeder lines, pipe fittings and connectors, valves, etc.

5.4.5.2 Construction Sequence

The Alternative 1b construction sequence begins with mobilization and preparation at the Gorge Dam pool and at the Hardy Road landfill dewatering and disposal site (Table 6). Similar to Alternative 1a, the hydraulic dredge would be deployed from the former Gorge Power Station. To facilitate dredge deployment, a temporary launch ramp would be constructed at the former Gorge Power Station. A pipeline would be deployed along the bed of the Cuyahoga River from the upper end of the Gorge Dam dredge area downstream to the Hardy Road landfill site; additionally booster pumps will need to be installed along the pumping route because of the longer distance compared to the Alternative 1a site. One booster pump per mile is assumed.[25]

At the Hardy Road landfill both a dewatering site and disposal site must be prepared. At the dewatering site, a relatively flat area near the landfill hill needs to be cleared of vegetation. Weep water from the geotextile bags would be collected in an existing sedimentation basin and pumped through a temporary water treatment plant (to

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[24] The closed Hardy Road landfill is east and southeast of the Akron Water Reclamation Facility at 2460 Akron-Peninsula Road, Akron, Ohio 44313.

[25] The use of booster pumps considering elevation changes along the Cuyahoga River channel will be evaluated during the final design phase.

be constructed) to meet the pre-treatment requirement prior to discharge to the City of Akron's nearby Water Reclamation Facility (Table 6).

The disposal site at the Hardy Road landfill would be prepared simultaneously with upper pool preparations. The existing methane gas recovery piping system would need to be modified and protected (Table 6). The existing topsoil placed over the landfill mound would be salvaged and stockpiled for reuse. The existing clay cap material would be left in-place and a new synthetic landfill liner would be installed over the clay cap as an additional measure to minimize seepage from sediment overburden into the closed landfill cells.

After all upper pool and disposal site preparatory work is complete and all equipment and geotextile dewatering bags have been mobilized, the system would be tested. The testing will also allow for the optimization of polymer additives. After testing the system, dredging and dewatering operations would begin (Table 7). As with Alternative 1a, a hydraulic dredge would begin in the Gorge Dam pool upstream of the Front Street bridge and would remove sediment as it moves downstream.

Crews at the Hardy Road site would monitor the dewatering operations, filling several of the ±200' x ±50' x ±7' large geotextile bags simultaneously while making flow adjustments as necessary. As geotextile bags become filled with sediment, they would be isolated from new flow and allowed to dewater (Table 7). Following an extended dewatering period estimated at 3 weeks, the geotextile bags would be split open and the dewatered sediment would be moved using earthmoving equipment and spread out over a designated disposal fill area. Assuming a rate of 3,000 cubic yards of sediment per day, with operations continuing 16 hours per day for seven days per week for each dredge, the dredging should be completed in around 39 weeks.

When dredging operations are completed, the dredge and other equipment would be demobilized at the Gorge Dam pool. The temporary launch ramp and pipelines would also be removed (Table 8). At the Hardy Road site, the geotextile bags would continue to be dewatered and any remaining water would be treated. After all the geotextile bags are dewatered, opened, and the dredge material transported to the disposal site, the pre-existing methane gas collection system at the landfill would be re-installed and the site would be re-seeded.

5.4.5.3 Costs

The estimated cost for Alternative 1b is $77,100,000. The major costs and assumptions with labor, equipment, and materials are presented in Appendix A. Construction costs are estimated at $55,888,800, which includes a 20 percent contingency of $11,289,200[26]. The total cost includes allowances for a disposal site geotechnical and environmental report ($750,000), project engineering design ($1, 806,000), construction phase engineering ($4,192,000), and a river monitoring program ($300,000). Since the disposal site is a closed landfill that must meet closure requirements, an additional allowance has been estimated to monitor the landfill post-construction for three additional years ($3,000,000).

Labor for dredging operations is the single largest labor cost at $12,960,000. This cost includes dredging for 16 hours per day and dredging 3,000 cy/d, as well as a crew to monitor and maintain the five booster pumps. As with Alternative 1a, the estimated costs for crews filling geotextile bags in Alternative 1b is $1,300,000. With Alternative 1b, an additional $12,000,000 in labor is necessary to open the geotextile bags and move the dredge materials to their final disposal sites at the landfill.

Similar to Alternative 1a, the polymer for hydraulic dredging is the most expensive material cost for Alternative 1b, with $4,400,000 for the polymer and $2,080,000 for the associated feed equipment. The second most expensive material is the geotextile bags ($4,400,000). Unlike in Alternative 1a, topsoil will not be trucked into the closed Hardy Road landfill because existing soil at the landfill will be stripped and stockpiled for replacement over the

[26] A larger contingency was selected because the disposal site is a closed landfill that must meet closure requirements

landfill following sediment placement. However, additional topsoil will be needed to supplement final cover and grading ($348,000).

Table 6. Mobilization and preparation for Sediment Removal Alternative 1b

Gorge Dam pool and Cuyahoga River	Hardy Road dewatering and disposal sites
1. Prepare shoreline erosion control measures.	1. Prepare disposal site erosion control measures.
2. Construct temporary launch for dredges and equipment.	2. Prepare landfill "hill" for future material placement. Preparation to include removal and stockpiling of existing clay cap material, installation of a new synthetic landfill liner to isolate "new" soil from the existing landfill waste, modification and protection of the existing methane gas recovery piping system.
3. Install temporary hydraulic pump line(s) from upper pool to Hardy Road disposal site generally following the bed of the river. Install approximately 4 booster pumps.	3. Clear and grub proposed dewatering land area of trees and brush adjacent to and beyond the base of the landfill "hill". This dewatering area needs to be relatively flat for placement and filling of geotextile bags.
--	4. Install dewatering site piping necessary to fill geotextile bags including manifolds, feed lines, valves, and collection piping.
	5. Use the existing sedimentation basins at the Hardy Road landfill site to collect geobag runoff before flow is sent to a temporary treatment plant or to Akron's Water Reclamation Facility.
	6. Install temporary pumping system to convey collected geobag runoff from the existing sedimentation basins to a temporary treatment plant or the nearby Akron Water Reclamation Facility for final treatment.
--	7. Install layer of geotextile bags and connect piping feed lines on prepared disposal area. Geotextile bags may need to be stacked to accommodate the small area available for dewatering.
8. Mobilize dredge(s) to the Gorge Dam pool (upstream of the Front Street road bridge), including discharge pumps and booster pumps. Connect dredging equipment to discharge line.	8. Connect piping manifold go geotextile bags. Pipeline(s) will run from dredge(s) and discharge pumps to the piping manifold to fill the geotextile bags.
9. Test the dredge and pipeline setup.	
10. Using bench test information for polymer optimization.	--

Notes
a. The temporary treatment plant is assumed to have a peak flow capacity of 6,000 gallons per minute.
b. The geotextile bags are assumed to have dimensions of between 90-foot and 120 foot circumference and 200 feet long. They will be 9 feet tall once filled and 7 feet tall after complete dewatering

Table 7. Dredging and dewatering operations for Sediment Removal Alternative 1b

Gorge Dam pool and Cuyahoga River	Hardy Road dewatering and disposal sites
11. Commence hydraulic dredging operations, pumping and transporting sediment slurry to the disposal area and into the geobag network.	
--	12. Provide staff at disposal site (1) to monitor filling of the geotextile bags (including the rate of filling), (2) to make any adjustments to piping, (3) to operate valves, and (4) to rotate the bags being filled.
13. Continue with hydraulic dredging operations for 24 hours per day and six days per week.	
--	14. Fill bags to roughly 7 feet of depth. As bags are filled, additional tiers of bags are to be added above the first bag layer.
--	15. As geotextile bags become filled, the filled bags will be isolated from new flow and will drain for a few weeks. After this extended "drying" period, the bags can be split open and the "dry" material removed to the landfill "hill" for spreading and final disposal.
16. When dredging upstream of the Front Street bridge is complete, mobilize the smaller dredge downstream of the bridge.	16. Continue filling the geotextile bags and wasting the "dry" sediment as work progresses.
17. Dredging operations are completed.	

Table 8. Demobilization and restoration Sediment Removal Alternative 1b

Gorge Dam pool and Cuyahoga River	Hardy Road dewatering and disposal sites
18. Demobilize the dredges, pipelines, pumps, and such.	18. Disconnect and remove geobag filling piping manifold.
19. Remove temporary boat launch.	19. When all geotextile bags have been emptied and "dry" sediment has been spread on the "hill", the graded sediment on the "hill" is to be seeded in accordance with BMP requirements.
--	20. Complete any piping modifications to the methane gas collection system.
--	21. Remove treatment plant (if used), wasted geotextile bags, etc.
--	21. Install permanent erosion control measures.
--	22. Restore any remaining disturbed areas.
23. Install new plantings.	
24. Remove temporary erosion control measures.	

5.4.6 Sediment Removal Alternative 2

In Sediment Removal Alternative 2, two mechanical dredges, each with material transfer barges, would be used to transport the dredged material to shore. The dredge material would then be dewatered in the north parking lot of the Gorge Metro Park and in available flat, open areas at the site of the former Gorge Power Station. After dewatering, dredged sediment would be loaded onto trucks and transported to a regional landfill for final disposal. Areas damaged in the Gorge Metro Park would be repaired and restored. The mobilization and equipment needs (Section 5.4.6.1), construction sequence (Section 5.4.6.2), and costs (Section5.4.6.3) are presented in the following subsections.

5.4.6.1 Equipment and Mobilization Needs

Figure 21. Photograph of Ohio Edison's former Gorge Power Station.

Mobilization will simultaneously occur at the former Gorge Power Station (Figure 21) and the Gorge Metro Park's north shore parking lot. Two mechanical dredges, associated equipment and watercraft will be mobilized to the former Gorge Power Station along Front Street along with earth moving equipment mobilized to facilitate temporary stockpiling and dewatering at each shore location. Major equipment necessary for Sediment Removal Alternative 2 are presented in this section; refer to Appendix A for more detailed information for these and other equipment and materials. No significant materials are necessary with this alternative.

The major equipment needed for Sediment Removal Alternative 2 are:

- Two portable sectional barges with an excavator for dredging
- Two transport barges for each dredging barge
- Two work boats
- Two front end loaders
- Two bulldozers
- Many trucks for hauling soil to the final disposal location(s)

5.4.6.2 Construction Sequence

The construction sequence begins with mobilization and preparation at the Gorge Dam pool and at the Gorge Metro Park main parking lot (north lot) and the former Gorge Power Station (Table 9). A temporary launch ramp would be constructed at the former Gorge Power Plant. At the same time, the north shore parking lot at Gorge Metro Park would be prepared for sediment dewatering. An offloading dock would be constructed on the right bank near the main parking lot. As the dewatering and disposal site is prepared, Metro Parks will need to restrict public access to the Gorge Metro Park.

After site preparation at the former Gorge Power Plant and the Gorge Metro Parks parking lot, dredging and dewatering operations would begin (Table 10). A hydraulic excavator or clamshell hoe mounted on a barge would dredge sediment and place it on additional transfer barges that will transport dredge material to the dewatering site(s) along each shoreline. Additional front end loaders or off-road trucks would shuttle dredge material from the transport barge to a dewatering area away from the water's edge; a bulldozer or front end loader would move the dredge material around the site. Assuming an excavation rate of 1,000 cubic yards of sediment per day for each mechanical dredge, with operations continuing ±10 hours/day, six days per week, the dredging should be completed in about 88 weeks. Mechanical dredging would likely require two construction seasons.

As dredging continues, some of the dredge material piles at the dewatering site would dry out sufficiently for removal[27]. Dewatered dredge material would then be loaded onto dump trucks (using front end loads or backhoes) and transported an estimated 35 miles to an area landfill. After the dewatered dredge material in one area was transported to the landfill, dewatered dredge material in another area would be ready for transport. Dredging operations would then temporarily stockpile additional dredged materials into an area where dewatered dredge materials had been removed.

Almost 93,000 truckloads would be necessary to transport approximately 800,000 cubic yards of dredge materials. Transporting dewatered dredge materials to a nearby landfill would include the following additional costs: truck fuel, truck drive labor, landfill fees, and parking lot and road repairs. The truck traffic and dredge material dewatering would be assumed to damage the existing parking lots and roads at the Gorge Metro Park; the parking lots and roads would need to be repaired or replaced (Table 11).

5.4.6.3 Costs

The estimated cost for Alternative 2 is $63,500,000. The major costs and assumptions with labor, equipment, and materials are presented in Appendix A. Construction costs are estimated at $52,989,000, which includes a 15 percent contingency of $7,112,700. The total cost includes allowances for project engineering design ($1,059,700), construction phase engineering ($1,854,600), and a river monitoring program ($300,000). Unlike Alternatives 1a and 1b, no allowance is necessary for a hydro-geotechnical/environmental report of the disposal site because the dredge materials would be transported to an upland, active landfill.

Labor for dredging operations is the single largest labor cost at $14,400,000 for operating two crews for 16 hours per day and dredging 2,000 cy/d. Offloading dredge materials from the transport barges will cost $4,800,000, while moving the dredge materials from the offloading areas to the dewatering areas with front end loaders and bulldozers will cost $1,200,000.

Similarly, after de-watering, front end loaders and bulldozers will be used to load dewatered sediment onto trucks ($1,200,000) that will then haul the dredge materials to their final disposal site ($14,400,000). A "tipping fee" or disposal cost may also need to be paid to the landfill operator for accepting the sediment ($16,000,000).

Restoring the former Gorge Power Station to pre-construction conditions, replacing the Gorge Metro Park's north parking lot, and restoring the area around the north parking lot are relatively minor items and will cost less than $300,000.

[27] Dewatering is considered a contractor-defined operation that could be accomplished by one of several methods. Dewatering via stockpiles exposed to ambient air is proposed herein. Contractors may also consider dewatering using plate and frame presses or dewatering using geotextile tubes with a slurry box.

Table 9. Mobilization and preparation for Sediment Removal Alternative 2

Gorge Dam pool	Gorge dewatering sites
1. Prepare shoreline erosion control measures.	1. Prepare disposal site erosion control measures.
2. Construct temporary launch for dredges and equipment.	2. Prepare onshore sediment dewatering areas, including stockpile areas, haul routes, and surface drainage measures.
--	3. Construct temporary offloading dock for offloading sediment transfer barges.
--	4. Construct temporary sedimentation basin(s) to improve discharge water quality from spoil offloading area.
5. Mobilize dredge(s) to the Gorge Dam pool (upstream of the Front Street road bridge), including barged-mounted dredges and sediment transfer barges.	

Table 10. Dredging and dewatering operations for Sediment Removal Alternative 2

Gorge Dam pool	Gorge dewatering sites
6. Launch work barges with excavators to provide mechanical dredging. Launch additional barges for transfer of excavated material to shoreline offloading docks.	
7. Dredge sediment with backhoe, place on transport barges, move transport barges to shoreline for unloading.	7. Unload and temporarily stockpile spoil onshore to dewater.
8. Continue with mechanical dredging operations for 10 hours per day and six days per week.	
--	9. Once the dredge material is dewatered, load it onto trucks and transport it to the disposal site at a regional landfill.
--	10. Unload trucks at the disposal site(s) at the landfill.
11. Dredging operations are completed.	

Table 11. Demobilization and restoration Sediment Removal Alternative 2

Gorge Dam pool	Gorge dewatering sites and landfill disposal site
12. Demobilize the dredge, barges, and such.	12. Transport remaining dewatered dredge materials to the regional landfill
13. Remove temporary boat launch.	13. Remove temporary offloading dock
--	14. Repair or replace parking lots used as dewatering sites and restore any remaining disturbed areas
15. Install new plantings	
16. Remove temporary erosion control measures	

6.0 DAM REMOVAL AND DISPOSAL

The anticipated dam demolition and removal sequence was developed to minimize the amount of sediment that is released downstream. Therefore, as much sediment as possible should be removed from the Gorge Dam pool before the dam is completely breached. Initial dam demolition will proceed with barge-mounted hydraulic excavators with breaker hammers. Barges will also be used to transport demolition debris to the former Gorge Power Station for temporary marshalling and for truck access. The pool will be drawn down (first using the lake drain, then using dewatering notches) as the top of the dam is demolished.

Eventually, as the pool is drawn down, the pool level will become too shallow for barges to operate. Prior to such shallow pool levels, demolition equipment will be moved onto the partially demolished dam and the barges will be demobilized. Haul roads will be constructed along the shores of the former pool to haul and remove demolition debris to Front Street. Temporary stone cofferdams will be installed to allow for the demolition of the Gorge Dam foundation in dry working conditions.

The generalized construction sequence is presented in Table 12. The pool drawdown (Section 6.1), dewatering notches (Section 6.2), cofferdams (Section 6.3), and demolition sequence (Section 6.4) are then discussed in more detail. This section concludes with discussions of the volume of demolition debris (Section 6.5) and the dam debris disposal alternatives (Section 6.6).

Table 12. Gorge Dam demolition sequence.

Gorge Dam pool and Cuyahoga River
1. Mobilize equipment to the former Gorge Power Station, Gorge Metro Park north parking lot, and Gorge Dam.
2. Install erosion control at barge launch areas.
3. Lower pool using existing lake drain.
4. Mobilize barge with hydraulic excavator and concrete breakers for dam notching
5. Begin dam concrete demolition.
6. As material is demolished, a wider work area will be created on top of the structure. Move concrete demolition equipment to the top of the dam and continue demolition.
7. Install erosion control for southern temporary haul road.
8. Construct temporary haul road along south shore within the former dam pool.
9. Construct temporary cofferdam to divert flow to northern half (right bank) of river.
10. Continue with and complete demolition of the southern half of the dam and spillway.
11. Remove observation deck.
12. Construct temporary haul road along north shore within the former dam pool.
13. Remove temporary cofferdam.
14. Continue with and complete demolition of the northern half of the dam.
15. Truck out demolition debris to commercial concrete crusher/recycler or landfill.
16. Dispose of non-concrete debris to landfill using roll-off dumpsters.
17. Remove temporary haul road and dispose of road material.
18. Restore disturbed areas

6.1 DRAWDOWN

The lowering of the Gorge Dam pool should be controlled as much as possible to reduce the risk of drawdown instability around the edges of the lake. Detailed studies of the geologic conditions and slope stability evaluations of the reservoir rim should be performed in subsequent design phases. This work would include a detailed field reconnaissance of the reservoir rim and geotechnical investigations and evaluations to evaluate the impact of the lake drawdown on the existing river banks and slopes.

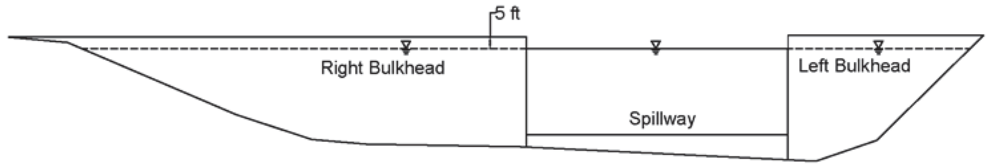
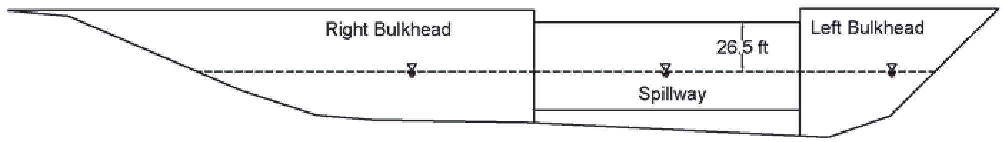
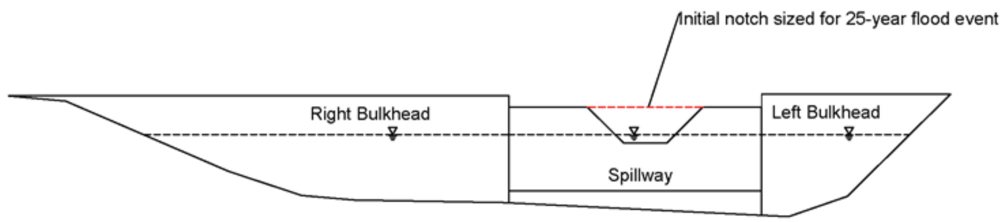
A field reconnaissance performed in 2011, for a geotechnical literature review of the Northside Interceptor Project, indicated no significant instability in the area of the Gorge Dam pool. However, during the 2011 reconnaissance, a landslide was observed approximately 2,000 feet downstream of the dam on the left bank, above the river. Consequently, landslides and other instabilities are present within the valley.

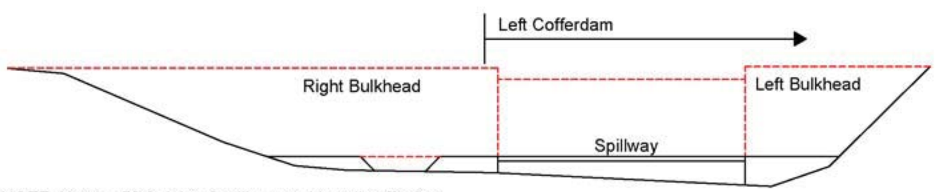
Based upon Tetra Tech's experience, a drawdown rate of 2 to 3 feet per week can be performed with a relatively small risk of causing instability. A greater drawdown rate may be acceptable for the lower portion of the reservoir where the bank and channel slopes are flatter. However, this drawdown rate should be confirmed in subsequent design phases based on the results of a detailed field reconnaissance and further geotechnical explorations and evaluations.

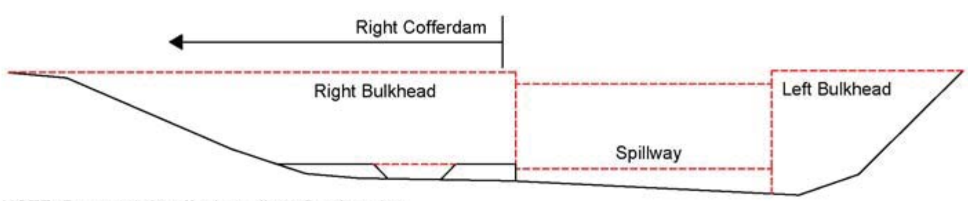
6.2 DEWATERING NOTCHES

Notches will have to be cut into the crest of the dam to lower the pool as the demolition progresses. Early in the demolition process, the notches should be sized so that the dam doesn't overtop for a relatively frequent storm event, say a 25-year event. However, as the demolition progresses and the crest is lowered, at some point the remaining structure will tolerate an overtopping event and the notches can be sized to facilitate the construction schedule. A detailed structural analyses and sliding/overturning evaluation would be needed to determine the crest elevation at which the structure can safely withstand an overtopping event.

For the initial demolition work, the notches can be excavated using the barge-mounted equipment. However, as the dam crest is lowered and the dam section becomes wider, it is anticipated that the notch excavation will be performed by equipment on the crest starting at the downstream face of the dam and working in an upstream direction. Figure 22 shows the recommended notching sequence to lower the pool and divert flows during the demolition process.

<table>
<tr><td>Pre- construction conditions</td><td>
</td></tr>
<tr><td>Lower the dam pool with the lake drain</td><td>
</td></tr>
<tr><td>Construct drainage notch and begin demolition</td><td>

NOTE: Flows to be maintained at all times. Notch invert to be maintained at ~2 ft below pool level as demolition continues.</td></tr>
<tr><td>Divert flows around spill way</td><td>

NOTE: Notch ~50 ft right of spillway and install cofferdam on laft side to divert flows around stilling basin. Remove remaining spillway, stilling basin and left bulkhead.</td></tr>
<tr><td>Divert flows to river channel</td><td>

NOTE: Remove left cofferdam, divert flow into river channel, install right cofferdam, and remove remaining right bulkhead. Remove right cofferdam at completion.</td></tr>
</table>

Note: These figures are conceptual. The dam demolition contractor will propose the notching sequence, extent, and such during the engineering construction design phase.

Figure 22. Recommended notching sequence to lower the pool and divert flows

6.3 LEFT AND RIGHT COFFERDAMS

Cofferdams will be needed as the pool nears the bottom of the reservoir to temporarily divert flows and to allow demolition of the lower portions of the dam to be performed in the dry. Due to the bedrock in the streambed, a sheet pile cofferdam is not feasible. As a result, it is recommended that the cofferdams be embankments constructed of granular material that can be placed into standing water.

The granular material used to construct the cofferdams should be a well-graded sand and gravel such as ODOT Item 304. Visqueen or another type of seepage barrier can be placed on the upstream slope of the embankment. The seepage barrier can be protected from damage by placing a geotextile and larger stone (ODOT No. 2 Stone or Type A Rock Channel Protection) over the barrier on the upstream slope.

However, because of the permeability of the granular material and the bedrock surface, it is anticipated that significant seepage will occur through the cofferdam. Therefore, a dewatering and pumping system will likely be required immediately downstream of the cofferdam embankment to maintain a dry working area.

6.4 DAM DEMOLITION

6.4.1 Initial Activities During Sediment Removal

Dam demolition should occur after the majority of the sediment is removed from the Gorge Dam pool. During sediment removal, any salvageable items can be removed from on top of the dam structure and the following work items can be completed:

- The pool should be lowered using the existing lake drain on the left abutment; this will lower the pool to a level approximately 7 feet below the spillway crest. A lowered pool may be necessary for barges to pass beneath the Front Street bridge immediately downstream of the former Gorge Power Plant.
- Clear and grub to create access and a work area along downstream face of dam for equipment travel.
- Remove the floating fishing pier from the north shore, and also the timber deck observation structure downstream of the dam (north shore) to provide work and storage area downstream of the dam.
- Construct a temporary aggregate roadway along downstream face of dam.
- Create a marshalling area for temporary stockpiling and loading the concrete demolition waste. This marshalling area should be located above flood stage; the former Gorge Power Plant location could be considered for this marshalling area.

6.4.2 Dam Demolition with Barge-Mounted Equipment

It is recommended that one or more hydraulic excavators with breaker hammers, positioned on barges, be used to initially remove the dam concrete. The first notch should be located just north but outside the main river channel to route flows around the spillway pad.

The spillway section should be notched in the center to keep the discharges near the middle of the channel and reduce the potential for erosion. As the pool lowers, the exposed portions of the dam can be demolished using breaker hammers working on and across the top of the dam structure. The demolition waste should then be hauled away from the site and properly disposed of in a construction debris landfill or at a commercial crushing operation.

The demolition should continue until the dam is about 15' above the foundation. This depth will be the minimum depth of water needed to float the barges upstream for demobilization. However, before the barges are removed from the pool, one or more excavators with concrete breakers should be placed on top of the remaining dam structure to continue the demolition operations. The barges can then be removed from the pool.

6.4.3 Dam Demolition with Equipment on the Dam Crest

The concrete demolition can be continued while working from the top of the remaining portions of the dam. The top of the dam should be notched roughly 50' right of the spillway to temporarily divert river flow around the spillway and stilling basin. In addition, a small, temporary cofferdam (left cofferdam) should be constructed upstream of the spillway and left bulkhead to offset/divert channel flow to the notch 50' right of the spillway. This would allow the remaining portions of the left bulkhead, the spillway, and the stilling basin to be removed in the dry. The concrete should be completely removed to the bedrock surface.

Once the left bulkhead, the spillway, and the stilling basin are completely removed, the left cofferdam can be removed and flow can be diverted to the main river channel. A second cofferdam (right cofferdam) can then be installed so that the remaining portions of the right bulkhead can be removed in the dry. As mentioned above, the concrete should be completely removed to the bedrock surface.

A boring (BH-5) drilled for the Preliminary Geotechnical Data Report for the Northside Interceptor Tunnel was located on top of the bluff above the left abutment of the dam. The ground surface of this boring was at elevation 984.7 and it was drilled to a depth of 230.5 feet, or to elevation 754.2. The location of this boring and a log of this boring are presented in Appendix B.

The dam foundation in the river is at approximately elevation 860 feet above sea level. At this elevation, boring BH-5 encountered soft to medium hard shale with siltstone interbeds to elevation 857.9 feet. Below this elevation, the boring encountered medium hard to hard sandstone, which is believed to comprise most of the dam foundation. The RQD of the sandstone was 100 percent and the recovery of the rock core was 100 percent, indicating high-quality rock. Based on the hardness and competency of this sandstone, any required excavations or removals of this rock may require significant effort and may not be able to be accomplished with conventional excavation equipment.

6.5 QUANTITY ESTIMATES

The quantities of the concrete to be removed were based on the original construction drawings and subsequent modifications to the structure in the 1980s. When the dam was constructed in 1916, it was originally designed to be hollow with reinforcing walls to give the structure stability. However, in the 1970s it was decided that the dam did not meet stability requirements. Consequently, to improve stability, the dam was filled with concrete in three construction phases in the early 1980s.

The calculated volume of concrete in the dam was 24,365 cubic yards. A 10% contingency was added to this value for a total volume of 26,802 cubic yards. The volume calculations of the dam are presented in Appendix C.

It should be noted that no independent surveys or measurements of the dam were performed to verify the dimensions shown on the drawings. Consequently, it is recommended that additional surveys and field measurements of the dam be performed for subsequent design phases of the project.

As mentioned above, it is assumed that all of the concrete rubble will be removed from the site to a construction debris landfill or to a commercial concrete crushing operation for recycling. Consequently, some initial clearing and improvements to the site will be needed for ingress and egress to the dam to haul away the rubble. The design of these improvements should be performed during subsequent design phases of the project.

6.6 DAM DEBRIS DISPOSAL ALTERNATIVES

Two alternatives for dam debris disposal were evaluated. Both alternatives use the same dam demolition sequence; the differences are the final disposal sites for the dam debris. Both alternatives exclude any activities at the disposal site after the demolition debris is transported to the disposal site. The two dam debris disposal alternatives differ by the destination of the dam demolition debris:

- **Alternative 1:** Commercial concrete crusher/recycler
- **Alternative 2:** Landfill

6.6.1 Dam Debris Disposal Alternative 1

The estimated costs for Dam Debris Disposal Alternative 1 is $12,554,000. The major costs and assumptions with labor, equipment, and materials are presented in Appendix A. Construction costs are estimated at $9,278,000, which includes a 15 percent contingency of $1,392,000. The total cost includes allowances for project engineering design ($694,000), post-construction phase engineering ($800,000), and a river monitoring program ($300,000).

Dam demolition and debris transport are the most expensive costs ($7,150,000). Materials costs are relatively minor; the most expensive material costs are $157,500 for 6,300 tons of aggregate for temporary haul roads and $176,300 for 7,050 tons of cofferdam material cost.

For each alternative, 26,000 cubic yards of dam demolition debris will be transported to a final disposal site. In Dam Debris Disposal Alternative 1, the debris are transported to a commercial concrete crusher/recycler ($368,000).

6.6.2 Dam Debris Disposal Alternative 2

The estimated costs for Dam Debris Disposal Alternative 2 is $13,291,000. The major costs and assumptions with labor, equipment, and materials are presented in Appendix A. Construction costs are estimated at $9,840,000, which includes a 15 percent contingency of $1,476,000. The total cost includes allowances for project engineering design ($736,000), post-construction phase engineering ($849,000), and a river monitoring program ($300,000).

As with Dam Debris Disposal Alternative 1, dam demolition and debris transport are the most expensive costs ($7,150,000). Materials costs are relatively minor; the most expensive material costs are $157,500 for 6,300 tons of aggregate for temporary haul roads and $176,300 for 7,050 tons of cofferdam material cost.

For both alternatives, 26,000 cubic yards of dam demolition debris will be transported to a final disposal site. In Dam Debris Disposal Alternative 2, the debris are transported to a landfill ($611,000), which includes a landfill tipping fee ($338,000).

7.0 DESCRIPTION OF PREFERRED PLAN

The costs for the three sediment removal alternatives are presented in Table 13 and the costs for the two dam removal alternatives are presented in Table 14. Because the environmental benefits of each alternative are the same (i.e., removal of contaminated sediment and improved hydrologic and water quality conditions in the river), the preferred plan is the one that costs the least. In this case, that is the combination of Alternative 1a for sediment removal (hydraulic dredging and Peck Road site) and Alternative 1 for dam removal (commercial concrete crusher/recycler). The combined cost of these two alternatives is approximately $57 million.

Additional details of the Preferred Plan are provided in Appendix D, including conceptual site plans and cross-sections. This plan emerged as the Preferred Plan for several reasons, including the following:

- Hydraulic dredging is much cheaper than mechanical dredging because of the reduced labor and trucking costs.
- The Peck Road site is located along the Cuyahoga River and much closer to the dam than is the Hardy Road landfill, thus reducing pumping costs.
- The Peck Road site is owned by the City of Akron, who is open to considering the site for final disposal of the sediments (as stated during an April 27th agency meeting).
- The Peck Road site was previously used as a landfill, although details of its buried contents are not well-known.
- Only limited environmental consequences (e.g., wetland mitigation, possible contamination cleanup, final restoration needs) are associated with the Peck Road site.
- Use of the Hardy Road site is complicated by its status as a closed landfill in a 30-year closure monitoring program, existing methane gas reclamation, and a relatively small available working area for construction activities.

Table 13. Summary of sediment removal alternative costs.

Cost	Alternative 1a	Alternative 1b	Alternative 2
Major costs (rounded to the nearest millions of U.S. dollars)			
Dredging	$19.3	$20.8	$19.9
Dewatering	$16.2 [a]	$21.6	$1.2
Disposal		$13.5	$31.9
Construction costs	**$45.5**	**$55.9**	**$53.0**
Contingency	$6.8	$11.2	$7.1
Design and monitoring	$5.1	$10.0	$3.4
Total costs	**$57.4**	**$77.1**	**$63.5**
Unit cost per cubic yard of sediment (U.S. dollars, rounded to the nearest cent)			
Construction cost	$56.86	$69.86	$66.24
Total cost	$71.75	$96.38	$79.38

Note a: For Sediment Removal Alternative 1a, the Peck Road area is used for both dewatering and final disposal.

Table 14. Summary of dam removal alternative costs.

Major costs	Alternative 1	Alternative 2
Demolition	$8,807,700	$8,807,700
Dam debris disposal	$470,700	$1,081,700
Construction costs	**$9,278,000**	**$9,889,000**
Construction plus contingency	$10,670,000	$11,372,000
Total costs	**$12,554,000**	**$13,354,000**

7.1 ENVIRONMENTAL COMPLIANCE AND REGULATORY (PERMITTING) CONSIDERATIONS

Removal of the Gorge Dam would need to be performed in compliance with appropriate state and federal laws and regulations, including but not limited to the: Archaeological and Historic Preservation Act; the Clean Air Act; the Clean Water Act; the Endangered Species Act; the National Environmental Policy Act; the National Historic Preservation Act; Executive Order 11988, Floodplain Management; and Executive Order 11990, Protection of Wetlands. Additional technical analyses to support compliance with these laws and regulations include the following.

7.1.1 Cultural Resources

The potential impacts of the Gorge Dam removal will need to be evaluated with respect to cultural resources. The scope of this assessment will also need to include the areas for dredge material dewatering and final disposal. For example, the final disposal site for Alternative 1a, which is in the Chuckery Area of the Cascade Valley South Metro Park, would need to assess any potential impacts to the Signal Tree.

The Metro Parks Serving Summit County will perform a cultural resources survey and publish a report that evaluates the potential impacts of the Gorge Dam removal upon local cultural resources.

7.1.2 Ecological Resources

The potential impacts of the Gorge Dam removal, including the lowering of the dam pool, will need to be evaluated with respect to threatened and endangered species. The scope of this assessment will also need to include the areas for dredge material dewatering and final disposal.

No state or federally threatened or endangered animal species live in the Gorge Dam pool. Northern monkshood (*Aconitum noveboracense*) is the only federally endangered plant species in the Gorge Metro Park and no federally threatened species are present. Northern monkshood is also state endangered plant species found in the Gorge Metro Park, as are drooping wood sedge (*Carex arctata*) and northern wood reed (*Cinna latifolia*). Flattened wild oat grass (*Danthonia compressa*) and mountain fringe (*Adlumia fungosa*) are state threatened plant species.

Alternatives 1a and 1b involve significant disturbance; therefore, prior to mobilization and site preparation, ecological resources will need to be evaluated for potential impacts to listed plant and animal species from dewatering and disposal site activities. Alternative 1a would involve the clearing of vegetation across a 35 acre area along Peck Road in the Chuckery Area of the Cascade Valley South Metro Park. A future ecological resources evaluation would need to determine what animal and plant species are present in this area and what the impacts would be. For example, the potential impacts upon the Indiana bat (*Myotis sodalis*), which is federally and state endangered, may need to be considered if the trees to be cleared are potential bat habitat.

7.1.3 Hydrologic and Hydraulic Study

An assessment of the post-dam Cuyahoga River hydraulics will need to be performed as part of or in conjunction with Gorge Dam removal work. This assessment will need to ensure that removal of the dam does not cause any rise in the existing flood elevations. Federal Emergency Management Agency (FEMA) flood-mapping updates will also be required.

7.2 ENGINEERING CONSIDERATIONS

Additional surveys and studies will be necessary to support future engineering design and construction engineering design for dredging, dewatering, and disposal operations.

7.2.1 Surveys

Detailed field reconnaissance and surveys of the Gorge, valley walls, highlands, Gorge Dam, Gorge Dam pool, and dewatering/disposal site along Peck Road will be necessary for future design work. In addition to topographic surveys performed by professional surveyors, the bathymetry of the Gorge Dam pool should be further mapped. Additional sediment delineation will be necessary to update Battelle's sediment survey (U.S. EPA 2012).

7.2.2 Geotechnical Borings Collection

Two sets of geotechnical borings are recommended. Borings near the Gorge Dam may be necessary to evaluate site stability for dam demolition operations. Borings at the dewatering and disposal site may also be necessary to evaluate the stability of the former landfill where more than 800,000 cubic yards of dredge material will be disposed. As discussed in Section 6.1, proposed drawdown rates should be assessed to ensure slope stability.

7.2.3 Dewatering Tests

A bench-scale dewatering test should be performed for both hydraulic and mechanical dredging sediment removal alternatives. A hanging bag test should be performed for the preferred Sediment Removal Alternative 1a. If Alternative 1b is selected, a hanging test should still be performed. However, if Alternative 2 is selected, a stabilization test is necessary prior to mechanical dredging.

Bench testing will also be needed to determine the most effective chemistry and dosage of polymer additives. These polymers are estimated to cost over $4,000,000; site-specific testing is necessary to account for site-specific characteristics of the Gorge Dam pool sediment.

7.2.4 Water Treatment Assessment

A bench-scale evaluation of water treatment will be necessary to determine what level of treatment will be necessary to meet pre-treatment requirements for the Akron Water Reclamation Facility or another facility if an existing POTW is used to treat weep water from dewatering following hydraulic dredging. If a project-specific temporary water treatment facility is constructed, tests will need to be performed to ensure that NPDES requirements are met.

Treatment capacity will also need to be evaluated. Hydraulic dredging will likely operate at faster speeds than dewatering and water treatment such that multiple geotextile bags will likely be filling simultaneously. As discussed in Section 7.2.3, dewatering speed and capacity need to be assessed. Similarly, the water treatment speed and capacity should be assessed to ensure that water treatment occurs at a sufficient speed so as to not impede hydraulic dredging.

8.0 ROLES AND RESPONSIBILITIES AND FUNDING SOURCES

Remedial action to remove the Gorge Dam and associated sediment will be a significant technical and financial undertaking. Since removal of the dam and safe disposition of the sediment will contribute toward delisting of the Cuyahoga River AOC, Great Lakes Legacy Act (GLLA) funding could be used to fund part of the project (although the availability and contribution of GLLA funds is currently unknown). To access these funds, the State of Ohio and its non-federal partners would need to enter into a project agreement with the federal partner, U.S. EPA GLNPO.

The use of GLLA funds would provide up to 65 percent of the overall construction cost. The remaining 35 percent would be funded directly by the non-federal partners, or would be approved in-kind contribution. Examples of non-federal direct funding may include for the design of the sediment and dam removal components, part of the removal construction activity, and oversight during construction. In-kind contribution may include time spent by the non-federal partners on the project, a credit for using property for sediment disposal instead of sending the material to a commercial landfill, and treatment of the weep water at the Akron WWTP. Based on the current cost estimate and internal capabilities, a reasonable distribution of effort would be for GLNPO to fund the sediment removal and the non-federal partners to fund the dam removal.

Upon completion of the feasibility study, the non-federal partners would take the following actions:

- Confirm that they have the capacity to provide the anticipated non-federal share of the project cost;
- Confirm with GLNPO that the project would qualify for GLLA funding and would have a high likelihood of receiving GLLA funding;
- Pursue a project agreement with GLNPO. Approved non-federal partner costs to implement the project would be credited toward the non-federal share.

Once the design for the sediment component is complete, the non-federal partners will provide the design package to GLNPO. GLNPO will then solicit bids from its pool of pre-qualified sediment contractors. The completion of the design and procurement should be completed to allow mobilization of the sediment contractor in early spring to maximize the construction window. The non-federal partners will complete the dam removal design component and award the dam removal construction contract. Dam removal procurement should be scheduled to allow the selected contractor to start prior to the completion of the sediment phase. A general time line is provided in Table 15.

Table 15. Potential time line for the removal of the Gorge Dam

Task	Number of Months after Project Agreement with GLNPO
Design for Sediment and Dam Removal Components	15
Procurement of Sediment Contractor	20
Procurement of Dam Removal Contractor	26
Completion of Sediment Removal	30
Completion of Dam Removal	40

9.0 REFERENCES

Akron. 2011. *Geotechnical Literature Review – Northside Interceptor*. Prepared by BBC&M Engineering, Inc., for the City of Akron, Department of Public Works, Bureau of Engineering, Akron, OH. July 2011. Provided to Tetra Tech on a CD transmitted by postal mail on June 16, 2015.

———. 2012. *Preliminary Geotechnical Data Report – Northside Interceptor Tunnel*. Prepared by S&ME, Inc., for the City of Akron, Department of Public Works, Bureau of Engineering, Akron, OH. February 2012. Provided to Tetra Tech on a CD transmitted by postal mail on June 16, 2015.

Cuyahoga Falls Historical Society. 2013. *Aerial view of the plant taken prior to 1945*. [JPEG file]. April 2013. http://cuyahogafallshistory.com/wp-content/uploads/2013/04/SCAN0007.jpg. Accessed April 20, 2015.

Cuyahoga River RAP (Cuyahoga River Remedial Action Plan). 2008. *A Community Guide for Restoring the Cuyahoga River: The Cuyahoga Delisting Action Plan*. http://www.cuyahogaaoc.org/assets/2008_delisting_action-plan.doc. Accessed April 20, 2015.

———. 2013. *Cuyahoga River Remedial Action Plan. Stage 2 Report. Remedial Strategies For Area of Concern Restoration and Protection*. Cuyahoga River RAP Coordinating Committee. http://www.cuyahogaaoc.org/assets/stage-2-final.docx. Accessed April 3, 2015.

FERC (Federal Energy Regulatory Commission). 2007. *Order Denying Rehearing. Metro Hydroelectric Company, LLC. Project No. 12484-002.* October 18, 2007. https://www.ferc.gov/whats-new/comm-meet/2007/101807/H-2.pdf. Accessed April 20, 2015.

Hayes, D.F. 2006. *Dredging Contaminated Sediments*. University of Utah, Department of Civil and Environmental Engineering. http://www.epa.gov/region1/ge/publiceventsandmeetings/ccc_041206/249941_dredging.pdf. Accessed May 15, 2015.

HDC (Hardlines Design Company). 2011. *Phase I History/Architecture Evaluation of Two Concrete Dams on the Cuyahoga River*. HDC 1158. Columbus, OH. August 5, 2011. https://cfo.cityofcf.com/web/sites/default/files/imce/engineering/upload/Phase%20I%20History-Architecture%20Evaluation%20of%20Two%20Dams%20on%20the%20Cuyahoga%20River.pdf. Accessed April 20, 2014.

Metro Parks (Metro Parks Serving Summit County). 2015a. *The Gorge*. http://www.summitmetroparks.org/ParksAndTrails/Gorge.aspx. Accessed April 3, 2015.

———. 2015b. Geographic information system files of cultural resources, geologic features, rare animal and plant species, sensitive areas, streams, and wetlands. Metro Parks, Akron, OH. Provided by Robert Curtis (Metro Parks) via electronic mail on March 16, 2015.

NOAA (National Oceanic and Atmospheric Administration). 2014. *What is dredging?* U.S. Department of Commerce, NOAA, National Oceanic Service. http://oceanservice.noaa.gov/facts/dredging.html. Accessed May 15, 2015.

ODNR (Ohio Department of Natural Resources). 2010. *Dam Safety Inspection Report: Gorge Plant Dam*. File no. 1013-003.ODNR, Division of Soil and Water Resources, Columbus, Ohio.

———. 2014. *Rare Native Ohio Plants Status List*. ODNR, Division of Natural Areas and Preserves. December 15, 2014. http://naturepreserves.ohiodnr.gov/rareplants. Accessed April 2, 2015.

Ohio EPA (Ohio Environmental Protection Agency). 1994. *Biological and Water Quality Study of the Cuyahoga River. Geauga, Portage, Summit and Cuyahoga Counties, Ohio. Volume 1*. Technical Report EAS/1992-12-11. Ohio EPA, Division of Surface Water, Columbus, OH. August 19, 1994. http://www.epa.state.oh.us/portals/35/documents/cuyahg91.pdf. Accessed April 2, 2015.

———. 1999. *Biological and Water Quality Study of the Cuyahoga River and Selected Tributaries. Geauga, Portage, Summit, and Cuyahoga Counties (Ohio). Volume 1.* Ohio EPA, Division of Surface Water, Columbus, OH. August 15, 1999. http://www.epa.state.oh.us/portals/35/documents/cuyvol1.pdf. Accessed April 2, 2015.

———. 2008. *Cuyahoga River Aquatic Life Use Attainment Following the Kent and Munroe Falls Dam Modifications Portage and Summit Counties*. Biological and Water Quality Report NEDO/2008-08-01. Ohio EPA, Division of Surface Water, Columbus, OH. August 6, 2008. http://www.epa.state.oh.us/portals/35/documents/MiddleCuyahoga2007final-amended2.pdf. Accessed April 2, 2015.

———. 2014. *Delisting Guidance and Restoration Targets for Ohio Areas of Concern.* Ohio EPA, Division of Surface Water, Lake Erie Program. May 2014. http://epa.ohio.gov/portals/35/lakeerie/Ohio_AOC_Delisting_Guidance.pdf. Accessed November 25, 2014.

———. 2015*. Ohio EPA Voluntary Action Program Chemical Information Database and Applicable Regulatory Standards (CIDARS)*. [Excel file]. Ohio EPA, Division of Environmental Response and Revitalization, Columbus, OH. February 13, 2015. http://www.epa.state.oh.us/portals/30/rules/CIDARS_021315.xlsx. Accessed April 6, 2015.

OGS (Ohio Division of Geological Survey). 2004. *Pennsylvanian Sharon Formation, past and present: sedimentology, hydrogeology, and historical and environmental significance*. Guidebook 18. Edited by A.M. Foos. Ohio Department of Natural Resources, Division of Geological Survey. 2004. 93 pp.

USACE (U.S. Army Corps of Engineers). 2015. *About Dredging*. http://dqm.usace.army.mil/Education/Index.aspx. Accessed May 15, 2015.

U.S. Fish and Wildlife Service. 2015. *Threatened and Endangered Species*. U.S. Department of the Interior, U.S. Fish and Wildlife Service, Environmental Conservation Online System. http://ecos.fws.gov/ecos/home.action. Accessed April 2, 2015.

U.S. EPA (U.S. Environmental Protection Agency). 2003. *Ecological Screening Levels*. U.S. EPA, Region 5, RCRA. August 22, 2003. http://www.epa.gov/region5/waste/cars/esl.htm. Accessed November 22, 2013.

———. 2012. *Task 2: Final Phase 1 and 2 Summary Report for Determination of the Nature and Extent of Potential Contaminant Concentration in Sediments within the Cuyahoga River Project Area*. Prepared for U.S. EPA GLNPO, Chicago, IL. Prepared by Battelle, Columbus, OH. June 2012.