Lake Accotink Discovery

Report

Final Deliverable November 27, 2023

prepared for:

Fairfax County, VA

November 27, 2023

WSP

LimnoTech

Water | Scientists
Environment | Engineers

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prepared by:
LimnoTech and WSP

under contract to:
Fairfax County, VA

ACKNOWLEDGEMENTS
We would like to acknowledge the Lake Accotink Task Force who assembled the discovery questions, and Charles Smith, who served as our liaison throughout this project.

Note:
All materials in this report are based on high-level, rapid assessments and should be considered preliminary.

Introduction

The sections of this report are formatted to reflect the eight primary questions and sub-question posed in the Task Force's discovery scope document. The section headings of this deliverable report are direct quotes the questions posed by the Task Force. We tried to be comprehensive in our responses while still addressing each question individually; consequently, some of the responses are repeated from one section to the next.

1. WHAT WILL HAPPEN TO THE LAKE IF NOTHING IS DONE?

1.1 Will mud flat form?

- Will the lake fill in and become a mudflat and how long would that take?
- Will "mud flats" dry and become windborne?
- Under a managed wetland option, would mud flats ever develop?

In our experience, mud flats typically form via one of the mechanisms described below.

Saltwater Tides Inhibit Vegetation Growth

This will not be an issue for Lake Accotink.

Extreme Dry Conditions Cause Hard Pan Mud Flats

These are common in desert conditions and not anticipated in Lake Accotink.

Sediment Deposition Smothers Vegetation

Depositional mud flats are common in flash flood zones with high sediment transport rates. In this scenario, flash floods deposit large quantities of sediment in the floodplain. These types of mudflats are transient features that spur new vegetation growth. They are not likely to become a nuisance issue for Lake Accotink.

Shore Bird Herbivory Consumes Vegetation Faster Than It Can Grow

This type of mud flat requires a large shore bird population. If this were to become an issue there are simple deterrence that are proven effective, such string lines to interrupt landing flight paths. (See Figure 1-1)

Figure 1-1. Herbivory mud flat at Tifft Nature Preserve in Buffalo, NY

Water Level fluctuations May Expose Lakebed Sediments

If the water surface level in the lake were to go down, perhaps to a flash board breaking, some of the lakebed sediment may be exposed, leaving a mud flat. This is a transient phenomenon. In 2023, the water levels in Burke Lake were reduced by approximately one foot to facilitate a shoreline protection project. This exposed sediment at the upstream end of the lake and within a few months the mud flat had completely revegetated itself via volunteer seeding (See Figure 1-2).

Figure 1-2. Former Burke Lake Mud Flat (Photo taken 9/10/23)

1.2 Will there be quicksand that poses a risk to park users?

Quicksand is formed by confined aquifer whose groundwater bubbling to the surface. Since the groundwater and lake are at the same level, quicksand is not likely. In our investigation, we didn't find any evidence of quicksand near Lake Accotink. Infilling of the lake with sediment should not increase the likelihood of quicksand. (See Figure 1-3)

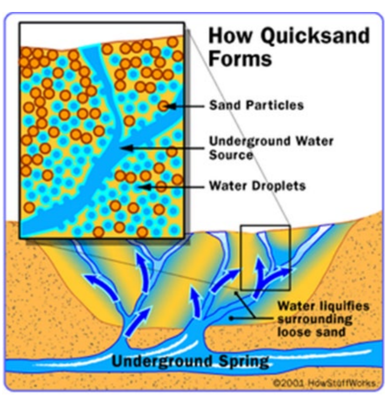


Figure 1-3. Quicksand Illustration (from How Stuff Works 2001)

Soft, sticky mud – which is often mistaken for quicksand – is present within the lake now and will likely continue to be present. The key difference between soft sticky mud and quicksand is that, as muck accumulates, it compacts the lower layers and makes it firmer; consequently, there is typically a limit to how far one sinks into soft, sticky mud. For this reason, it is often more of a nuisance than a safety hazard.

If soft, sticky mud is a concern, the planting of riparian vegetation often helps make soft sediments firmer.

1.3 Will there be nuisances such as mosquitos, odors, etc.?

1.3.1 Mosquitoes

Typically, wherever there is standing water, there will be mosquitoes. Mosquitoes are more common in small water bodies (pools and puddles). A one-gallon bucket of water left in a yard can grow mosquitos. To that end, shallow areas with emergent vegetation are more likely to contain mosquito larvae than open water lakes. On the other hand, more mosquitoes also mean more panfish, more dragonflies, more bats, and more insectivores in general that feed on mosquitoes and mosquito larvae. The food web and predator/prey interactions are complicated so it is difficult determine if the mosquito population will increase and even more difficult to define when/if they will be a nuisance.

In this author's personal experience, mosquitoes are more of a nuisance in the woods, where there is less wind. To that end, I would not anticipate a noticeable increase in mosquito "nuisance events" if the lake were allowed to infill with sediment or the percentage of wetland area were to increase.

1.3.2 Algae and odors

Algae and odors are two other potential nuisances which may be of concern. Shallow, stagnate water tends to produce algal blooms which can cause bad odors. Algal blooms and consequent odors tend to accumulate in shallow wind-blown bays. There is evidence of algal blooms and odors in Lake Accotink and the surrounding watershed (Figure 1-4).

Figure 1-4. Small algae-filled pond adjacent to Lake Accotink

If the lake were allowed to fill in via a ”Do Nothing” scenario, one can expect the frequency of algal blooms and odors to increase as the lake depth decreases. Several of the strategic intervention scenarios under consideration would promote the growth of emergent vegetation in shallow bays tht would counteract the risk of algal blooms and bad odors.

1.4 Will it become overrun with invasive species?

There is a high risk of invasive species under all scenarios. Whichever invasive species in the upstream watershed are a threat to Lake Accotink and several are readily identifiable around the lake (Figure 1-5).

Figure 1-5. Phragmites (left) and Purple loosestrife (right) found along the banks of Lake Accotink.

If the lake infills with sediment, the existing vegetation pallet will need to adapt to the new conditions. Changing conditions can create opportunities for invasive species to push out existing species. The same is true if the lake is dredged or some other strategic intervention is utilized.

The flash boards on the dam create a unique opportunity. In some cases, managing lake levels can help manage invasive species. For example, at the Tifft Nature Preserve in Buffalo, NY (Figure 1-5) they found that increasing lake levels would drown the phragmites along the water’s edge.

If the goal is to combat invasive species, then an invasive species management plan will be required. If a “Do Nothing” or management-only strategy is adopted, the site will require ongoing invasive species management. If the lake is dredged or a designed intervention strategy is adopted, then the constructed site will require at least 5 years of intensive invasives species management followed by ongoing management.

1.5 Will flood risk increase?

Lake Accotink and the surrounding areas are within the FEMA 100-year floodplain (Figure 1-6). The Lake Accotink Dam is a “run of the river” dam, meaning that it was not designed to capture, control, or attenuate flood waters. Consequently, the normal pool water level within the lake does not effectively contribute to flood storage or conveyance. Given this, the dam will behave similarly if the existing lake is full of water or sediment.

Figure 1-6. FEMA Floodplain Map for Lake Accotink and surrounding areas.

If an intervention that introduced large landforms to the lake were selected, they would need to be designed in such a way that they do not significantly increase flood risk.

2. IS MANAGING THE LAKE AS A WETLAND A VIABLE OR POTENTIALLY DESIRABLE OPTION?

2.1 What is a stream/wetland complex? How is it different than what we typically think of as wetlands?

A stream/wetland complex is also known as an anastomosing stream. This type of water system is a multi-threaded stream that has two or more channels. These channels weave together to form islands and dynamic waterways throughout the landscape. They are most common when the longitudinal slope of the channel is less than 0.5%. Two examples of anastomosing streams are provided in 2-1 and 2-2.

Figure 2-1. Backwater of the Mississippi (Photo by: Google Earth)

Figure 2-2. Lost Creek (Project by: The Nature Conservancy, Photo by: Richard Scott Nelson)

Because the dam has made Lake Accotink a nearly flat system, as the upstream end of the lake has infilled with sediment, it has taken on an anastomosing channel form (2-3). If the dam is removed or the crest lowered, the longitudinal slope of the stream will increase, and the channel could evolve into a single thread channel similar to what is present upstream and downstream.

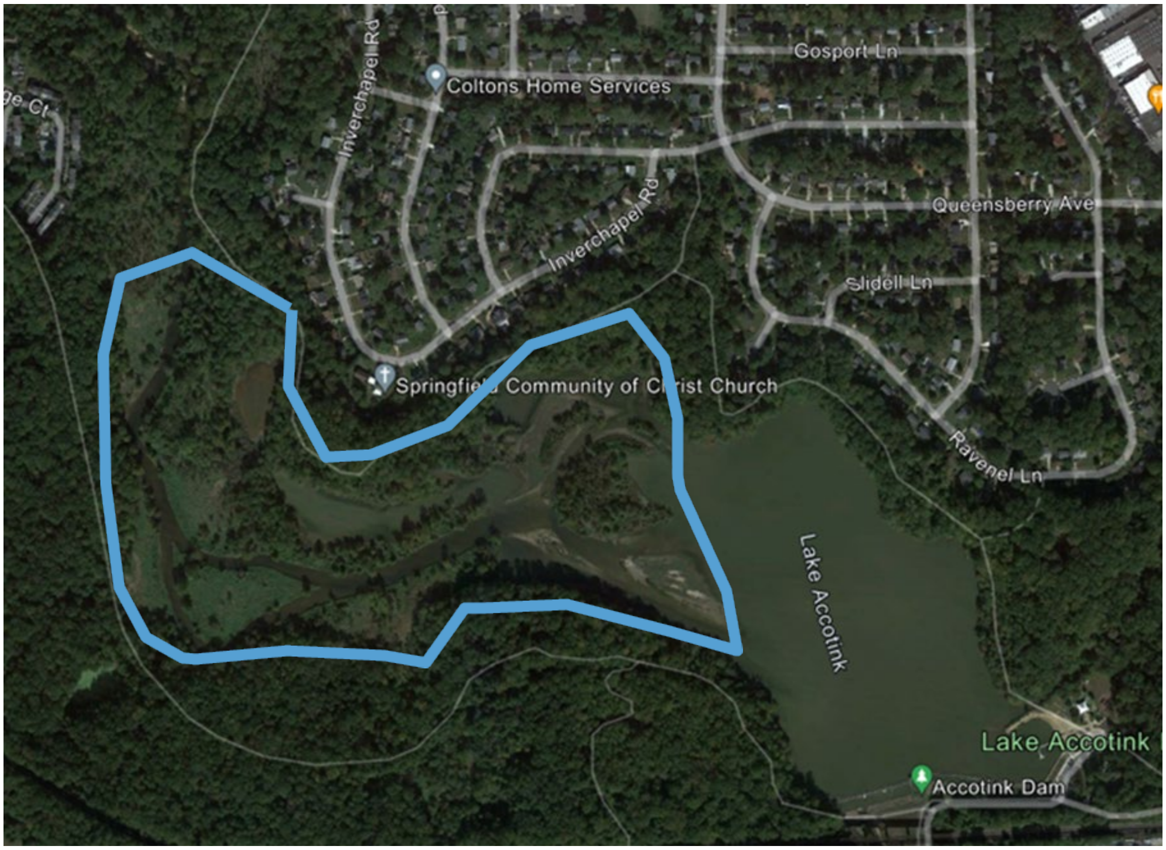


Figure 2-3. Lake Accotink aerial image showing anastomosing channel area (from Google Earth)

2.2 What is required to develop a plan to manage the lake footprint as a wetland?

An overall project implementation roadmap is provided in Figure 2-4. Given the complexity of the challenges faced by the community, a good strategy for developing a plan to manage the lake in a new/different way would be to start with a park master planning process.

The master planning process should:

- Seek community input on their vision for the park.
- Conduct feasibility analyses for the potential innervations and/or management strategies
- Identify potential funding mechanisms

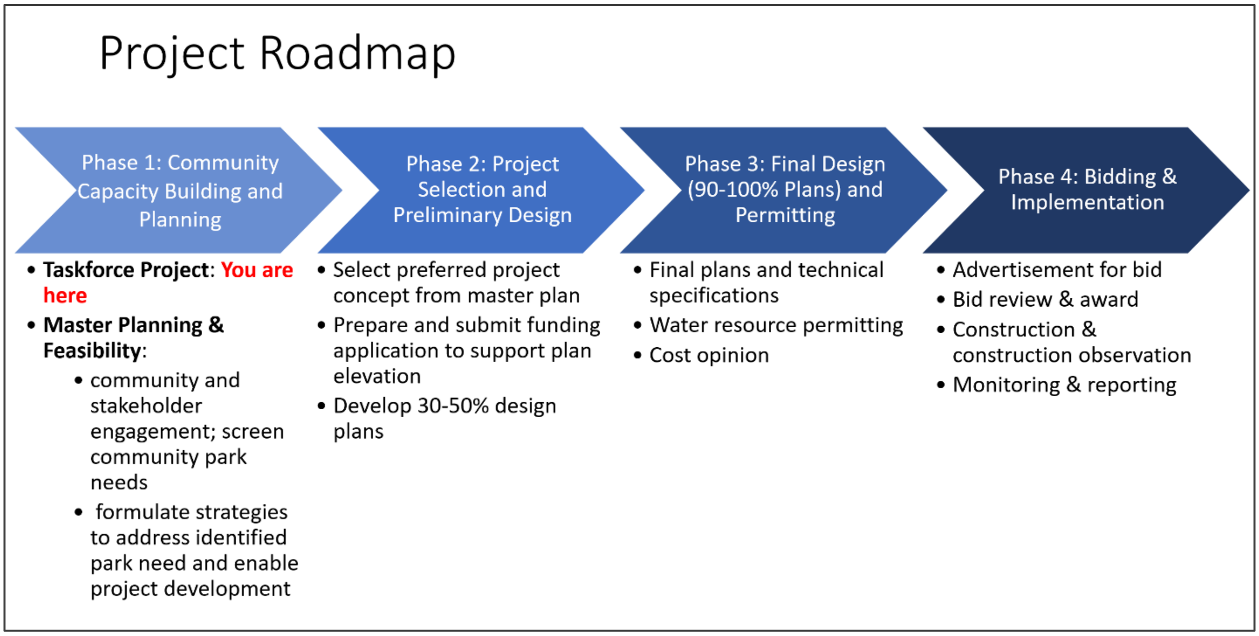


Figure 2-4. Project Implementation Roadmap

2.3 What might it look like?

The islands and wetlands that are naturally forming at the upstream end of the lake have a river delta appearance (Figure 2-3). If the lake were allowed to infill on its own, we can expect the delta to continue to grow downstream towards the dam. The ultimate condition would likely be an anastomosing stream with a layout similar to Figure 2-6. There are several partial dredge scenarios which include managed wetland options and will be discussed in Section 3.

Figure 2-5. 021 Aerial Image of the Lake Accotink Delta (image from Google Earth Pro)

Figure 2-6. Potential ultimate condition if the lake were allowed to fill in

2.4 How long will it take to create a managed wetland that is a community asset providing environmental and recreational benefits?

Infilling with No Interventions

The lake is infilling at a relatively rapid pace. To assess the potential timeline in which infilling may occur, we have divided the lake into 5 zones (Figure 2-7). Zone 1 is already a delta system and, for the purposes of this analysis, is considered fully filled. Zones 2-5 have been laid out using our best professional estimates of how the delta may grow in the future. The infilling timelines are estimated using to two methods:

Bulk Lake Sediment Retention Volumes From HDR's 2002 report "Lake Accotink Sediment Management Program Study"

- Estimated Retention Rate = 17,411 cubic yards per year
- This estimate is likely high and will decrease as the lake infills.
- The lower timelines in this analysis are likely lower than the true timeline.

Bedload Inflow Rates Only

- Assumes that all bedload is captured within the lake and all suspended loads pass through the lake.

- Total sediment load from HDR 2002 is 33,900 cubic yards per year and the bedload is estimated as ~13% of the total load.

- The upper timelines in this analysis are likely higher than the true timeline.

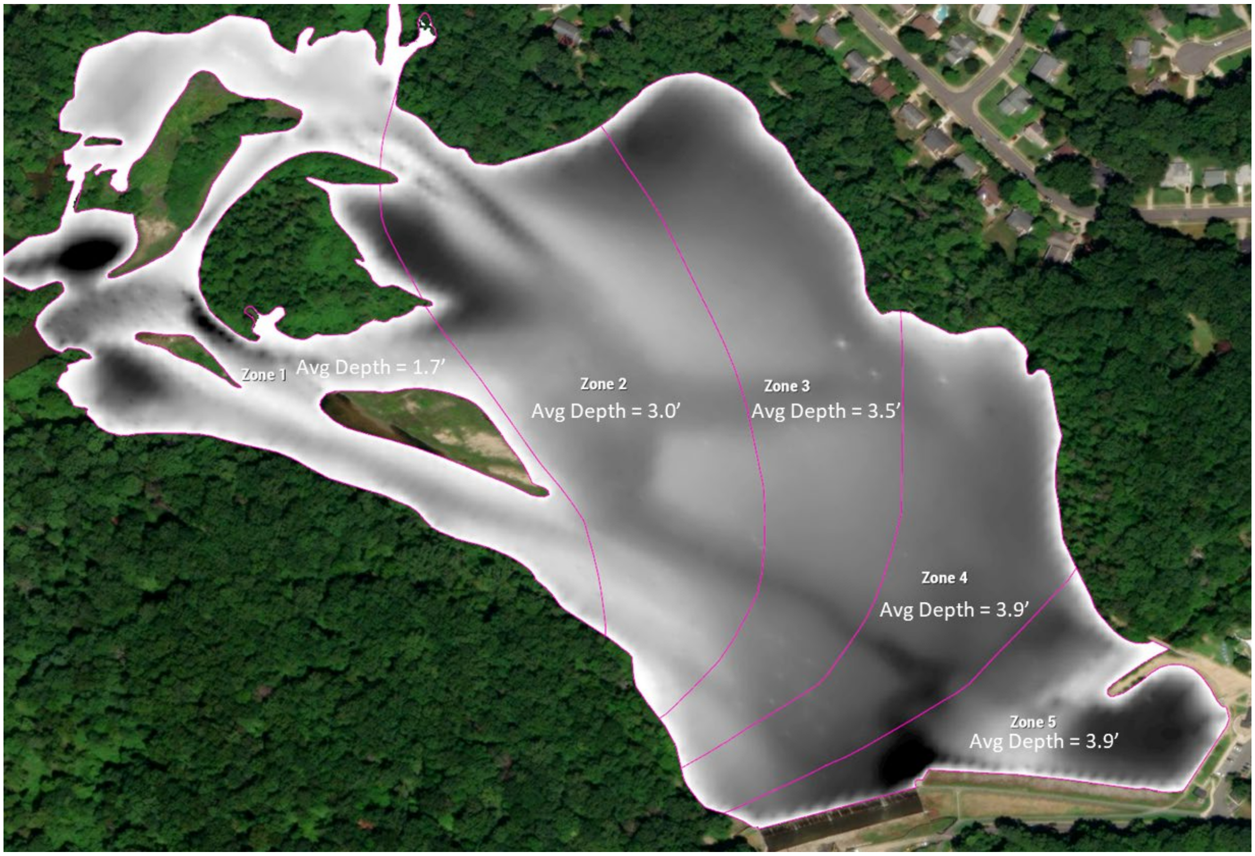


Figure 2-7. Lake Bathymetry with delta infilling zones identified.

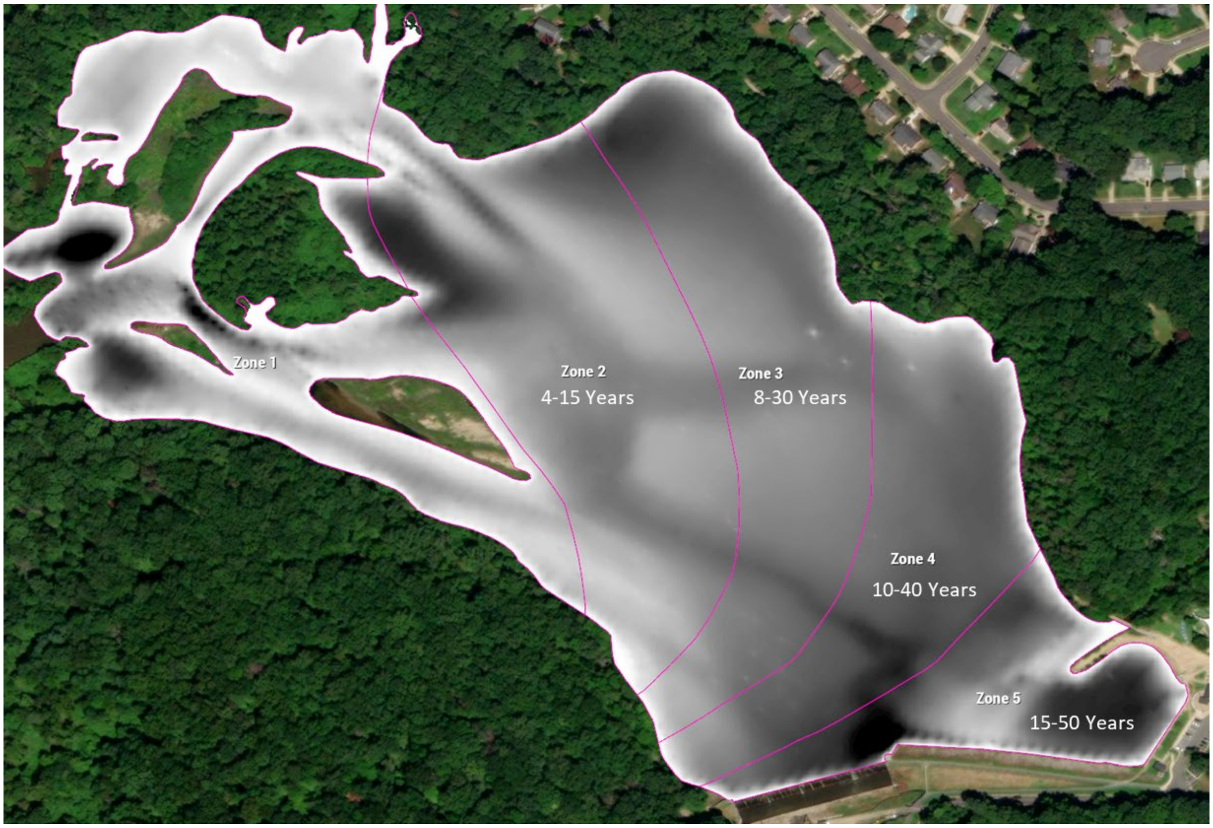


Figure 2-8. Lake bathymetry with potential infilling timelines for each zone.

Water Level Manipulation

Water level manipulation could help establish the riparian wetlands more rapidly. Lowering the crest of the dam, and consequently the surface elevation of the lake, would expose bed sediments. The sediments are likely nutrient rich and should readily grow wetland plants. Coupling the lake level lowering with an active planting/seeding project would help establish riparian wetlands even more quickly.

Figure 2-6 through Figure 2-9 provides bathymetric maps of Lake Accotink with its normal pool elevation as well as 1, 2, and 3 -food reduction is pond elevation. The 1 and 2 -foot crest reductions could be achieved by manipulating the flash boards along the crest of the dam. This project would likely take a few months and plant establishment could be achieved within 2 years. A 3-foot crest reduction would require altering the structure of the dam and would take at least 2 years; consequently, plant establishment could be achieved within 4 years.

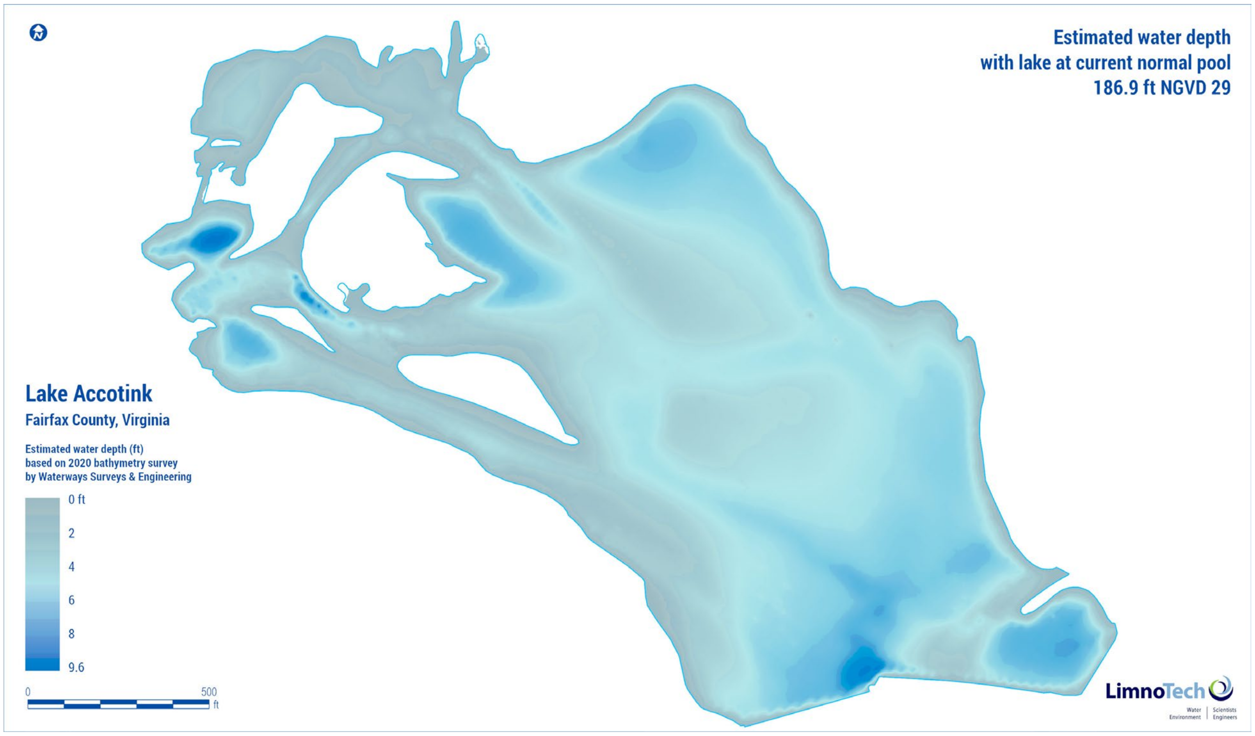


Figure 2-9. Lake Bathymetry based on 2020 survey data

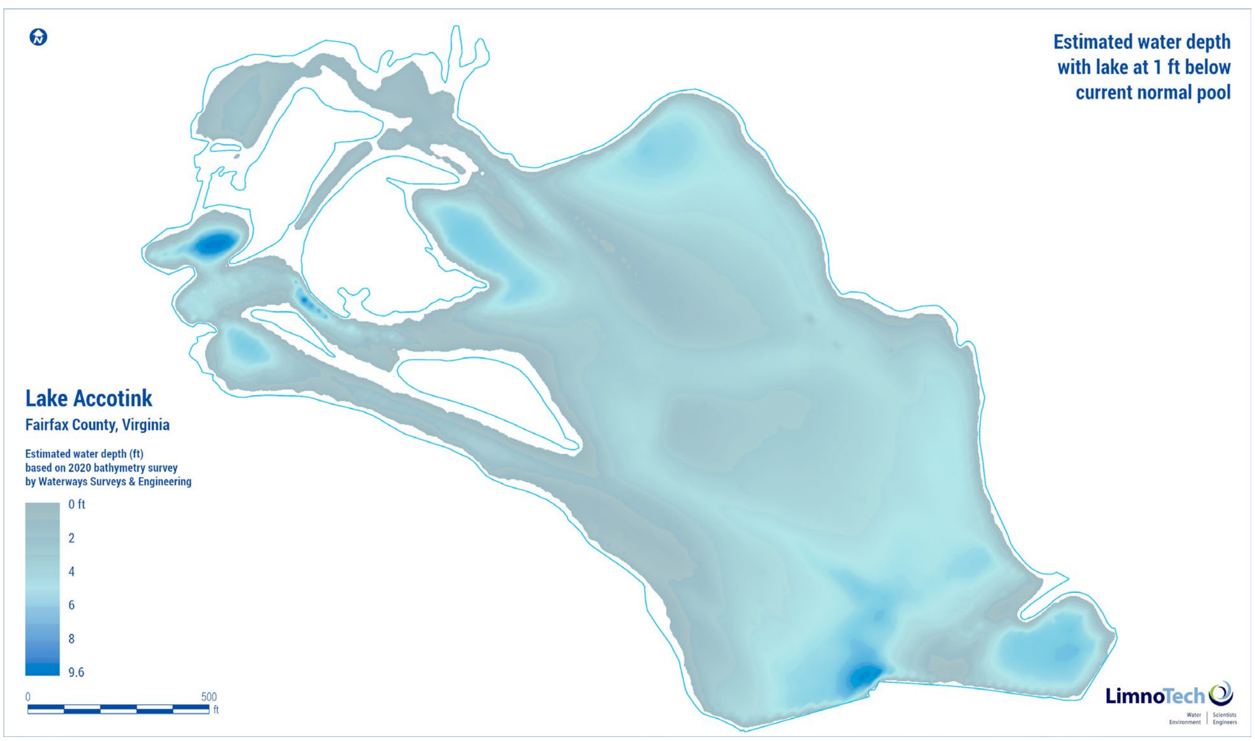


Figure 2-10. Lake Bathymetry with a 1-foot lowering of the dam crest

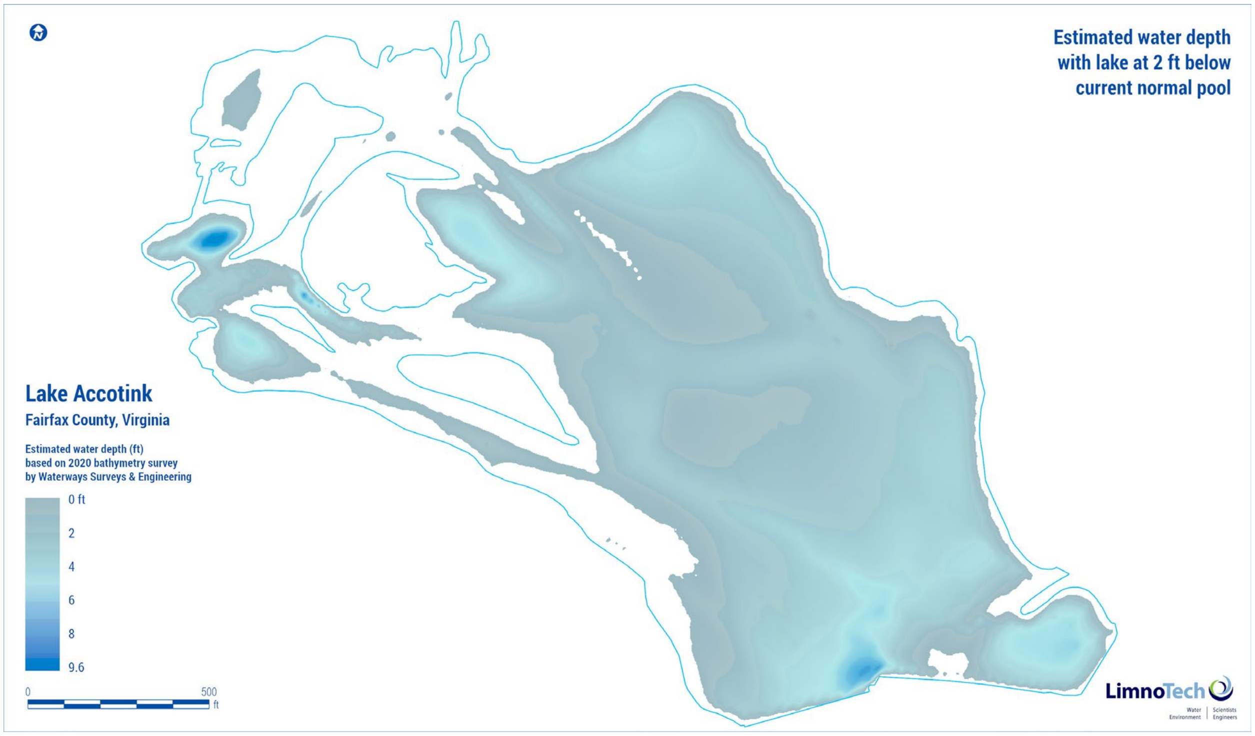


Figure 2-11. Lake Bathymetry with a 2-foot lowering of the dam crest

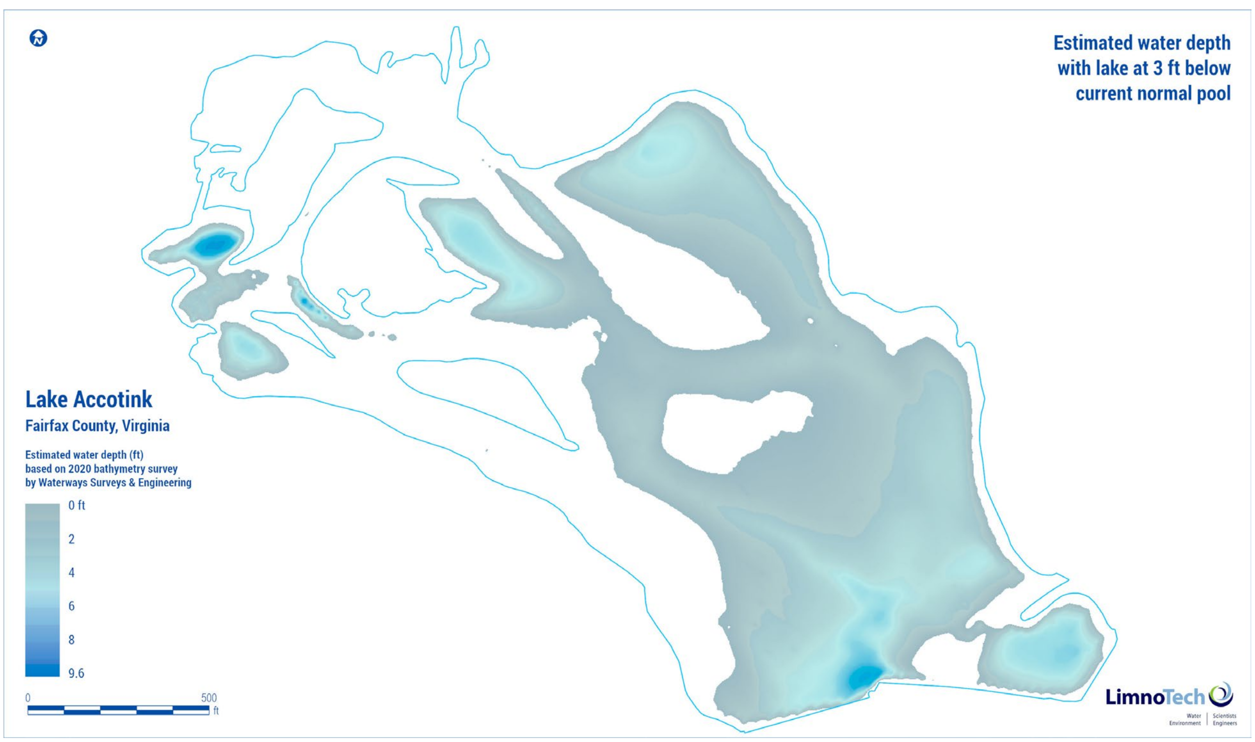


Figure 2-12. Lake Bathymetry with a 3-foot lowering of the dam crest

Intervention strategies

There are several partial dredge and open water strategies discussed on Section 3. These strategies will all likely take at least 5 years to implement and stabilize.

2.5 Will a managed wetland be "overcome" by storm pulses and sediment loading with emphasis on extreme events?

Introducing wetland vegetation into the shallow areas of the lake or via managed wetlands should reduce the risk of scour within the current reservoir footprint. The morphology (channel shape) of many stream/wetland complexes is largely controlled by the vegetation present. These types of systems tend to be relatively stable and resilient to storm flows.

Water and sediment from upper Accotink Creek will continue to flow into the Lake Accotink footprint in all scenarios; consequently, there will always need to be a creek channel through the site that is at least as large as upper and lower Accotink Creek is today.

2.6 Will a wetland have a less cooling effect on the environment than an eight-foot or more depth lake? Will a wetland create a heat island?

In this context, the primary cooling mechanisms are evaporation and transpiration (water uptake via vegetation). The lake will primarily experience evaporation only, but a wetland will experience both evaporation and transpiration; consequently, the wetland will likely have a greater cooling effect than the lake.

The primary heating mechanism in this system is direct solar radiation. Since wetland plants intercept and reflect direct solar radiation (i.e., they shade the water), one can anticipate less solar heating in a wetland than in a lake.

There are many nuances that govern heating and cooling in lake and wetland systems. A detailed investigation of these mechanisms would require more time than is available for this project, but it is reasonable to assume that most people won't be able to notice the temperature difference of the lake verses the wetland without the aid of a thermometer.

2.7 Would managed wetlands have different regulatory requirements than a lake, and if so, summarize them?

Please note: This section focuses on regulations pertaining to lake/wetland and construction regulations. Please see Section 4.5 for a discussion of the Accotink Dam regulations.

Both lakes and wetlands within Accotink Park are considered Waters of the US. As such, they both are subject to local, state, and federal regulations. While both are viewed slightly differently in the regulations, the protection goals are similar. A permit is required to modify either a lake or a wetland.

The easiest permits to obtain are for restoration activities that do not change the overall character of the waterbody, such as a permit for invasive species management. Permits for smaller restoration activities, such as shoreline habitat and short stretches of shoreline restoration (typically less than 500 ft), are also relatively easy to obtain.

Larger and more invasive restoration projects that change the morphology/shape of the waterbody require more to work to obtain. Placing fill in lakes and wetlands can be particularly challenging to get permitted. The intervention scenarios that include partially dredging the downstream end of the lake and placing the dredge spoils at the upstream end of the lake will require an extensive permitting process. Beneficial reuse of dredge sediments is feasible, but it is a relatively new regulatory process that few regulators have worked through in the past. Using the dredged sediment for wetland restoration will likely make onsite beneficial reuse of sediment a more straightforward permit application.

The most challenging permits to obtain are for projects that would effectively remove land from the Waters of the US. For example, filling the lake or wetland to the point where it is outside of the floodplain (or even the ordinary high-water mark) may actually require that you provide compensatory wetland mitigation in another location. In the extreme, filling in the lake to build a parking lot may not be permissible at all.

Of the scenarios presented under this study, the do-nothing scenario is the only one that would not require new permits. Of the remaining scenarios, the full dam removal and fish passage permits would likely be easiest to obtain, and the partial dredge and reuse permits would likely be the most difficult to obtain.

2.8 What is the cost to design, permit, and construct and maintain a managed wetland?

Overview of Estimating Methodology:

The Arcadis cost estimate was used as the basis for estimating the dredging cost for constructing and maintaining a managed wetland. The Arcadis cost estimate was compared to other recent dredging projects in the region to verify that the costs were reasonable. A summary of the comparison is provided in Table 2-1 below.

Project	Project Location	Project Status	Volume of Sediment Dredged (CY)	Type of Dredging	Estimated Project Cost	Estimated Cost/CY
Lake Accotink	Fairfax County, VA	Conceptual	500,000	Hydraulic	$67 - $143M	$134 - $286
Little Seneca Forebays	Montgomery County, MD	In Design	150,000	Mechanical	$26 - $40M	$173 - $266
Arrowhead Cove	Garrett County, MD	In Construction	15,000	Mechanical	$2.2M	$146
Lake Linganore	Frederick County, MD	Completed in 2021	150,000	Hydraulic	$21M	$140
Falling Creek Reservoir	Chesterfield County, VA	Construction Bids	112,000	Mechanical	$15-$22M	$134 - $196

Table 2-1 Local dredging project cost comparisons

The rough order of magnitude (ROM) costs for various Lake Accotink management scenarios presented in Table 2-2 are based on previous studies by Arcadis, annual contracts for stormwater improvements in Fairfax County, current contractor bids and pricing in the regional market, and best professional judgement. The ROM level costs are Association for the Advancement of Cost Engineering (AACE) Class 5 level and expected to have an accuracy range between -30% to +50%. Class 5 level estimates are generally prepared based on limited information, and subsequently have wide accuracy ranges. Given extreme fluctuations of commodities post-Covid shutdowns, energy price fluctuations due to the Russia/Ukraine War, global crises, workflow changes, etc., it is reasonable for the high-end costs to go beyond 50%. These estimates presented are based on current pricing in the regional market and should be used for general budgeting and evaluation and comparison of alternate schemes only. Scope and quantities of materials could vary considerably as result of new information and data collected during the engineering and design phase.

ROUGH ORDER MAGNITUDE (ROM) COST

Project: *Lake Accotink Task Force*
Date: *11/20/2023*

	DESCRIPTION OF WORK OR MATERIALS	UNIT	QTY	UNIT PRICE	VALUE	Unit Cost Reference and Assumptions
1	**Maintain entire open water area (Full Dredge)**				$95,300,000.00	
a	Base Dredge Event	LS	1	$95,300,000.00	$95,300,000.00	ARCADIS report dredge program cost. Removal of 500,000 CY
2	**Maintain 1/2 open water area (partial dredge and haul off)**				$28,349,557.00	
a	Dredging (Base)	CY	148,427	$46.00	$6,827,642.00	Based on Arcadis dredge program cost (1/2 open water (23 acres), dredged by 4 ft)
b	Dewatering	CY	148,427	$26.00	$3,859,102.00	Same unit cost as ARCADIS and dewatering assumptions
c	Material Processing / Transportation & Disposal	CY	148,427	$119.00	$17,662,813.00	Same unit costs as ARCADIS. Disposal of all material
3	**Lake as wetland (1/2 open water area - 1/2 dredge and reuse)**				$23,009,710.00	
a	Dredging (Base)	CY	148,427	$46.00	$6,827,642.00	Based on Arcadis dredge program cost (1/2 open water (23 acres), dredged by 4 ft)
b	Dewatering	CY	148,427	$26.00	$3,859,102.00	Same unit cost as ARCADIS and dewatering assumptions
c	Material Processing / Transportation & Disposal	CY	74,214	$119.00	$8,831,466.00	Same unit cost as ARCADIS. Keeping 1/2 of the material to construct and grade wetland features
d	Grading, conversion of dredged material to features (islands within the lake)	SY	111,320	$12.50	$1,391,500.00	Unit price for island creation for current project in Autsin, Texas +25%
e	Amenities / Trails, bridge, boardwalks, dock	LS	1	$750,000.00	$750,000.00	BPJ
g	Riparian Planting	LS	1	$350,000.00	$350,000.00	BPJ
h	Design/Permitting	LS	1	$1,000,000.00	$1,000,000.00	BPJ; Represented as approximately 5% of construction cost

Assumptions

1. THIS IS A ROM LEVEL COST (CLASS 5 ESTIMATE) TO BE USED FOR GENERAL BUDGETING AND COMPARATIVE PURPOSES ONLY. ROM COSTS NORMALLY HAVE AN EXPECTED ACCURACY RANGE BETWEEN -30% AND +50%.
2 GIVEN THE EXTREME FLUCTUATIONS OF COMMODITIES POST COVID, ENERGY PRICES FOLLOWING THE RUSSIA/UKRAINE WAR, GLOBAL CRISIS, WORKFLOW CHANGES, ETC., IT IS RESONABLE FOR THE HIGH END COST TO GO ABOVE 50%. THESE BEST ESTIMATES ARE BASED ON CURRENT PRICING IN THE REGIONAL MARKET.
3. THESE ARE NOT ENGINEERING ESTIMATES, SCOPE AND QUANTITIES MAY VARY CONSIDERABLY FROM THESE PRECONCEPTUAL ESTIMATES, PENDING FURTHER DESIGN STUDIES, AND UNIT PRICES ARE APPROXIMATE UNTIL PROJECT BIDS ARE OBTAINED.
4. COSTS ABOVE DO NOT IINCLUDE A CONTIGENCY AMOUNT. A 15% CONTINGENCY IS TYPICAL FOR CONSTRUCTION PROJECTS.
5. COSTS ABOVE DO NOT INCLUDE OPERATION AND MAINTENANCE COSTS. 4 FOOT OF DREDGING WOULD BE REQUIRED EVERY 5 YEARS. ANNUAL MAINTENANCE ACTIVITIES COULD INCLUDE VEGETATION SURVEYS, INVASIVE VEGETATION CONTROL, AND DEALING WITH UNPREDICATABLE WEATHER, HIGH WATER LEVELS, WILDLIFE DAMAGE, VANDALISM, ETC.
6. ARCADIS UNIT COSTS FOR DREDGING (191/CY) APPEAR PRACTICAL WHEN COMPARED AGAINST OTHER LOCAL DREDGING PROJECTS, MOST NOTABLY FALLEN CREEK RESERVOIR IN CHESTERFIELD, VA. BID OPENINGS FOR THIS PROJECT (11/16/2023) RANGED FROM 137-200/CY.
7. BASEFLOW CAN FLUCTUATE SEASONALLY AND WITH LOCAL WEATHER PATTERNS, THEREFORE IT WILL BE THE CONTRACTOR'S RESPOSIBILITY TO USE AN ADEQUATE PUMP SYSTEM BASED ON CURRENT FLOW CONDITIONS DURING THE WORK PERIOD. FOR GENERAL ESTIMATING PURPOSES, A TYPICAL PUMP SIZE IS BASED UPON 2 X BASEFLOW. BASEFLOW CAN BE ESTIMATED AS 500 GPM PER SQUARE MILE DRAINAGE AREA (500 GPM X 51 SQ. MI. X 2 = 51,000 GPM).

* ASSUMES REMOVAL OF A SECTION OF THE FLASH BOARDS. AS DISCUSSED IN PREVIOUS MEETINGS, THE REMOVAL OF A PORTION OF THE DAM WOULD NOT ADDRESS THE DAM HAZARD CLASSIFICATION ISSUE. WSP COULD NOT FULLY EVALUATE MODIFICATIONS TO THE SPILLWAY GIVEN OUR CURRENT SCOPE, THEREFORE THESE COSTS ARE NOT INCLUDED.

Table 2-2 Rough Order of Magnitude (ROM) costs and notes for Lake Accotink Management scenarios prepared by WSP

Entire Site as a Wetland

If the entire site were converted to a wetland, the construction costs could be as low as zero. Doing nothing and allowing the lake to in-fill with sediment would eventually convert they lake to a wetland (see Figure 3-2).

A partial dredge and wetland building scenario (Figure 3-5) could also eventually convert the entire lake to a wetland. This scenario would require several iterations of partial dredging without any offsite disposal. The first iteration of this scenario would cost approximately $23 million (Table 2-2). Future iterations would be in a similar cost range.

Annual operating costs for an open water area or managed wetland should be comparable and will vary based on the maintenance plan prepared. Comparable cost for Huntley Meadows Park is $50,000 per year and includes control of invasive species and vegetation surveys.

Half the Site as a Wetland and Half the Site as an Open Water Lake

The exact ratio of wetland area to lake area can be adjusted based on the desires of the community. Constructing the site to the correct ratios may require several iterations. The first iteration of this scenario would cost approximately $23 million (Section 3 of Table 2-2). Subsequent iterations would be in a similar cost range.

Once the wetland has been built out to the desired extents, the open water lake portion would continue to fill with sediment and would require maintenance dredging with off-site disposal. That maintenance dredging would cost on the order of $28.3 million per dredging cycle (Section 2 of Table 2-2). The frequency of maintenance dredging depends heavily on the ratio of wetland to lake area; however, we can expect that maintenance dredging will be required more frequently for a smaller open water lake than for the current lake size. This is because the total sediment load entering the lake is the same in both scenarios; consequently, the percentage of lake that is infilled in any given year will be higher for a smaller lake.

In addition to the dredging costs, the annual operating costs for an open water area or managed wetland should be comparable and will vary based on the maintenance plan prepared. Comparable cost for Huntley Meadows Park is $50,000 per year and includes control of invasive species and vegetation surveys.

Dam Maintenance Costs

None of the cost analyses included the inherent cost of maintaining the dam. The dam maintenance costs will be similar in all scenarios. The dam is nearing the end of its service life, so we can expect the maintenance costs for the dam to increase with time.

The fate of all dams is to either be removed, be replaced, or fail. All scenarios which include the dam can expect future maintenance activities which effectively replace the dam piece by piece over time. The timeline for such maintenance activities cannot be assessed within the available schedule for this analysis.

3. COULD A MANAGED WETLAND OPTION INCLUDE OPEN WATER AREAS?

All potential scenarios regarding the future configuration of Lake Accotink include open water areas. Since Accotink Creek flows through the site, at a minimum there will always need to be enough open water area to convey Accotink Creek flows through the site.

3.1 Where might open water be located?

If the site were managed as a stream and riparian wetland, the open water would extend in creek form throughout the length of the current lake footprint but would be appreciably narrower.

If all or a portion of the site were managed as a lake, the deepest portion of the lake would be at the down stream end near the dam or near a future outlet structure.

3.2 What type of open water could be maintained?

With enough money and political will, any type of open water (within reason) can be maintained. In this section we will present seven alternate open water scenarios and discuss the opertunities and challenges of each.

It should be noted that none of these scenarios have considered potential geotechnical challenges nor has a cut/fill analysis been conducted. If one or several of these scenarios is progressed forward, a master plan and feasibility study should be conducted.

Full Dredge Scenario (Figure 3-1)

This scenario would fully dredge the lake per the origional dredge plan. This option would restore the lake to its origional design condition. If this option were coupled with in-lake improvements and lake management strategies, it could temporarily improve the fishery. Re-dredging would likely be required every 5-15 years to maintain the lake's depth. Regular re-dredging could have detrimental effects on the fishery and aquatic ecosystems. This is likely the most expensive long-term option.

Do Nothing Ultimate Condition Scenario (Figure 3-2)

This scenario would allow the lake to fill in with sediment as discussed in Section 2.4. The ultimate condition of this scenario would likely be an anastomosing (multi-threaded) stream. In its ultimate condition all of the sediment load that enters from upstream will eventually be discharged to downstream; consequently, the long-term maintenance of the system would be limited to the maintenance of the dam. If maintained and managed during the infilling process, the ultimate condition has potential to be a rich and vibrant habitat.

The primary challenge to this scenario is the long duration and lake condition while the lake is filling with sediment (see Figure 2-5). While the lake is filling with sediment, the lake areas will remain shallow and continue to possess limited habitat. Furthermore, as the lake fills in, the downstream end may be more prone to algal blooms and bad odors.

Dam Removal Scenario (Figure 3-3)

This scenario would partially or completely remove the dam and restore Accotink Creek through the site. Removing the dam would increase the longitudinal slope of the creek and it would likely revert to a single-thread channel with a similar character as Accotink Creek both upstream and downstream of the lake.

This scenario would restore the sediment flow from the upper creek to the lower creek. This scenario has the highest long-term sustainability and lowest long-term costs.

Under this scenario, the park would lose the lake experience. Other unique experience (discussed in Section 5) would still be possible.

Partial Dredge Island Scenario (Figure 3-4)

A partial dredge scenario could dredge the downstream end of the lake and utilize the dredge spoils to build islands in the upstream end. The extent of the dredge zone and island zone will depend on the cut/fill balance of the sediment excavated.

The lake will continue to infill with sediment after the dredging and island building project; consequently, there could be multiple rounds of dredging and island building at gradually shift the site from more lake to more island. Eventually, regular maintenance dredging will be required to maintain an open water lake in a portion of the site.

The first round of island building will likely yield a smaller dredge/lake area than the first round of anastomosing stream building.

In this scenario, the presence of more water between the islands (as compared with the anastomosing scenario) means that there will continue to be sediment accumulation between the islands which would reduce navigability and bury aquatic habitat.

The ongoing maintenance cost of the dam may eventually become prohibitively expensive. If the next generation of park managers choose to remove the dam, this scenario would result in a more challenging and expensive dam removal scenario.

Partial Dredge Anastomosing Scenario (Figure 3-5)

A partial dredge scenario could dredge the downstream end of the lake and utilize the dredge spoils to build riparian wetland and an anastomosing stream at the upstream end. The extent of the dredge zone and stream zone will depend on the cut/fill balance of the sediment excavated.

The lake will continue to infill with sediment after the dredging and stream building project; consequently, there could be multiple rounds of dredging and stream building at gradually shift the site from more lake to more stream. Eventually, regular maintenance dredging will be required to maintain an open water lake in a portion of the site. Alternatively, once the stream zone fully covers the lake the system could be transitioned to a stream only complex.

The first round of anastomosing stream building will likely yield a larger dredge/lake area than the first round of stream building.

In this scenario, the narrower stream channels between the riparian zones/wetlands/islands would encourage sediment transport through the stream and towards the lake portion. This would help maintain navigability and aquatic habitat. On the other hand, more sediment transport through the stream zone would increase the infilling rate, and consequently dredge frequency, of the lake zone during the building phase.

The ongoing maintenance cost of the dam may eventually become prohibitively expensive. If the next generation of park managers choose to remove the dam, this scenario would result in a more challenging and expensive dam removal scenario.

Partial Dredge with Partial Dam Removal Scenario (Figure 3-6)

This scenario is a hybrid approach. It would likely yield a single-thread stream at the upstream end and a less dynamic stream channel with more stable riparian wetlands. The partial removal of the dam would expose more lakebed sediments and establish riparian wetlands more quickly (Figure 2-9). The partial removal of the dam would also make a fish passage structure more feasible.

This option would reduce the overall lake size and may require a greater dredging depth at the downstream and may provide less disposal area at the upstream end of the site.

This scenario may reduce the hazard classification of the dam but would likely not remove it from dam regulations entirely.

Partial Dredge Horseshoe Island Scenario (Figure 3-7)

This scenario would utilize dredge materials to construct horseshoe islands. The shape of the islands would promote sediment settling within the curvature of the horseshoes and may slow down the infilling rate of the dredged lake portion of the site. This scenario would utilize relatively little dredge volume when compared to the other partial dredge scenarios.

This scenario would likely be the most challenging to implement because the full sediment transport and depositional patterns will need to be vetted in order to properly design this scenario. It is also possible that the vetting process would ultimately deem this scenario infeasible.

The ongoing maintenance cost of the dam may eventually become prohibitively expensive. If the next generation of park managers choose to remove the dam, this scenario would result in a more challenging and expensive dam removal scenario.

Outlet relocation scenario (Figure 3-8)

This scenario could be coupled with most of the other scenarios. It would relocate the primary outlet of the lake closer to the beach area. The outlet would likely be a drop inlet structure with a concrete pipe that discharges downstream of the dam. The crest of the outlet would need to be at or below the current elevation of the dam crest and implementing this scenario may require slightly lowering the normal lake level.

The scenario would be designed to relocate the deepest area of the lake from the east end of the dam to the new outlet location. It should be noted that the current deepest portion of the lake is relatively small (see bathymetric map in Figure 2-6) and can be expected to be of a similar sized in this scenario.

This scenario would likely make a fish passage structure infeasible.

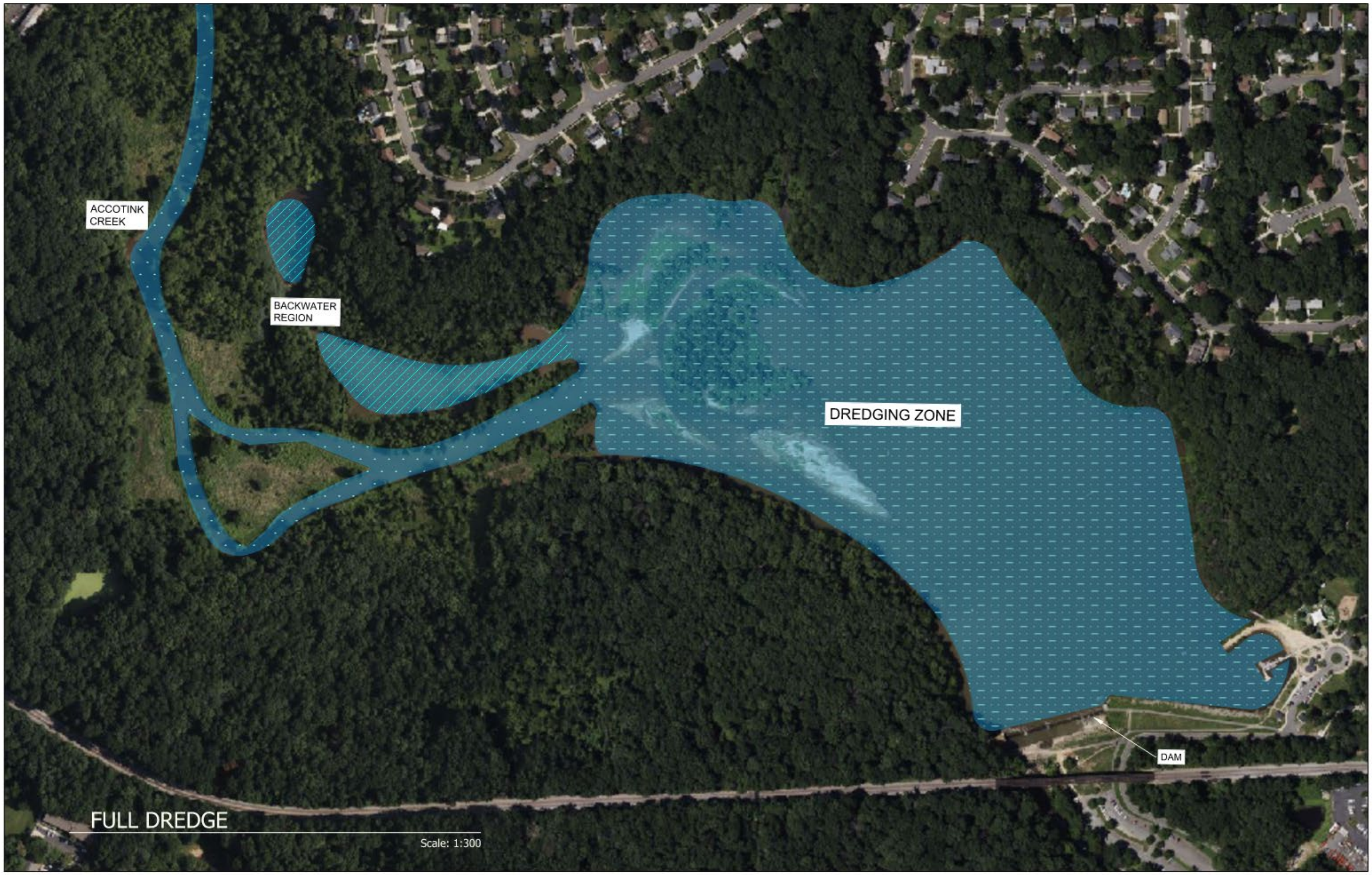


Figure 3-1. Full dredge scenario

Figure 3-2. Do nothing ultimate condition scenario

Figure 3-3. Dam removal scenario

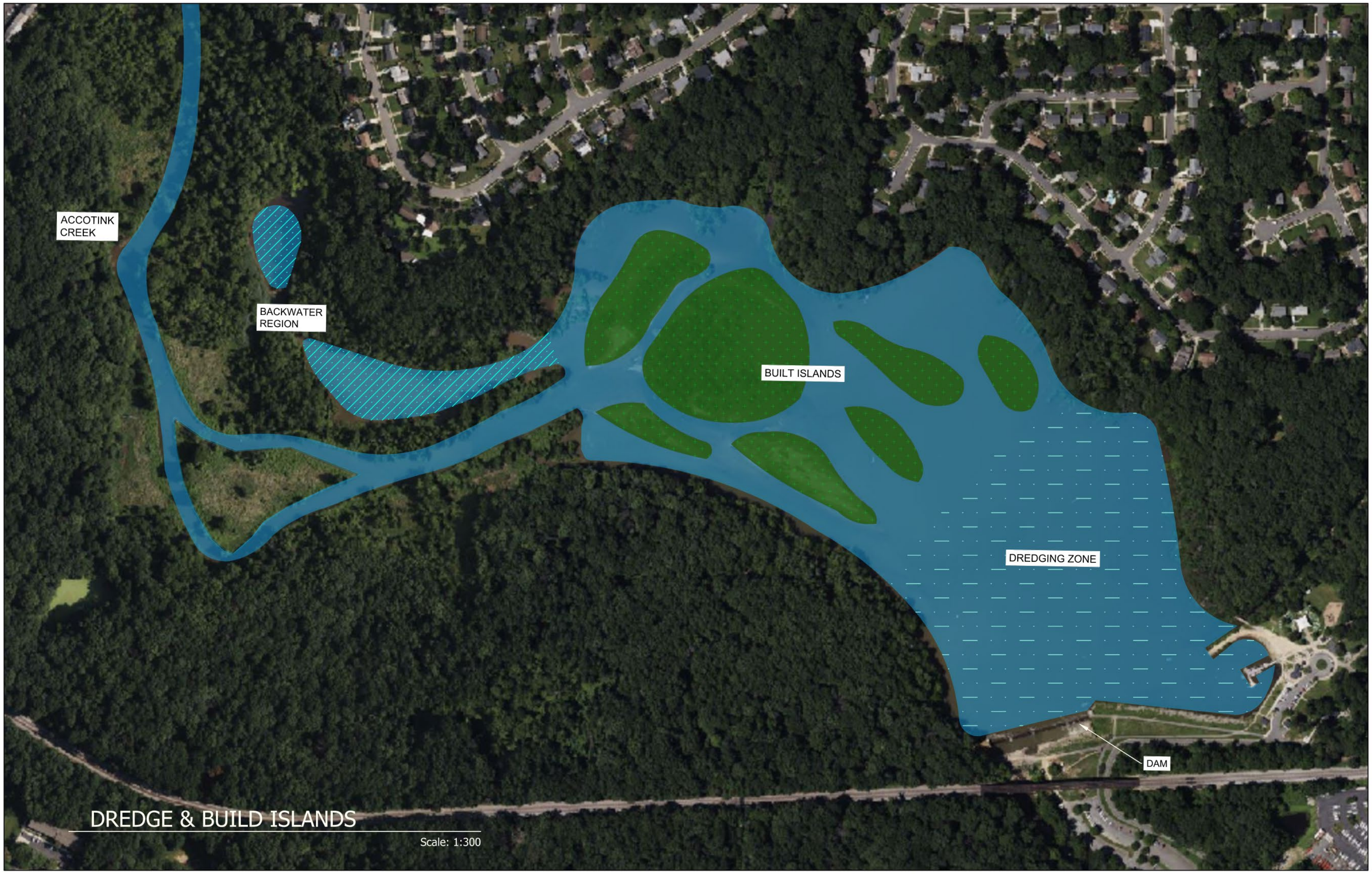


Figure 3-4. Partial dredge island scenario

Figure 3-5. Partial dredge anastomosing scenario

Figure 3-6. Partial dredge with dam modification scenario

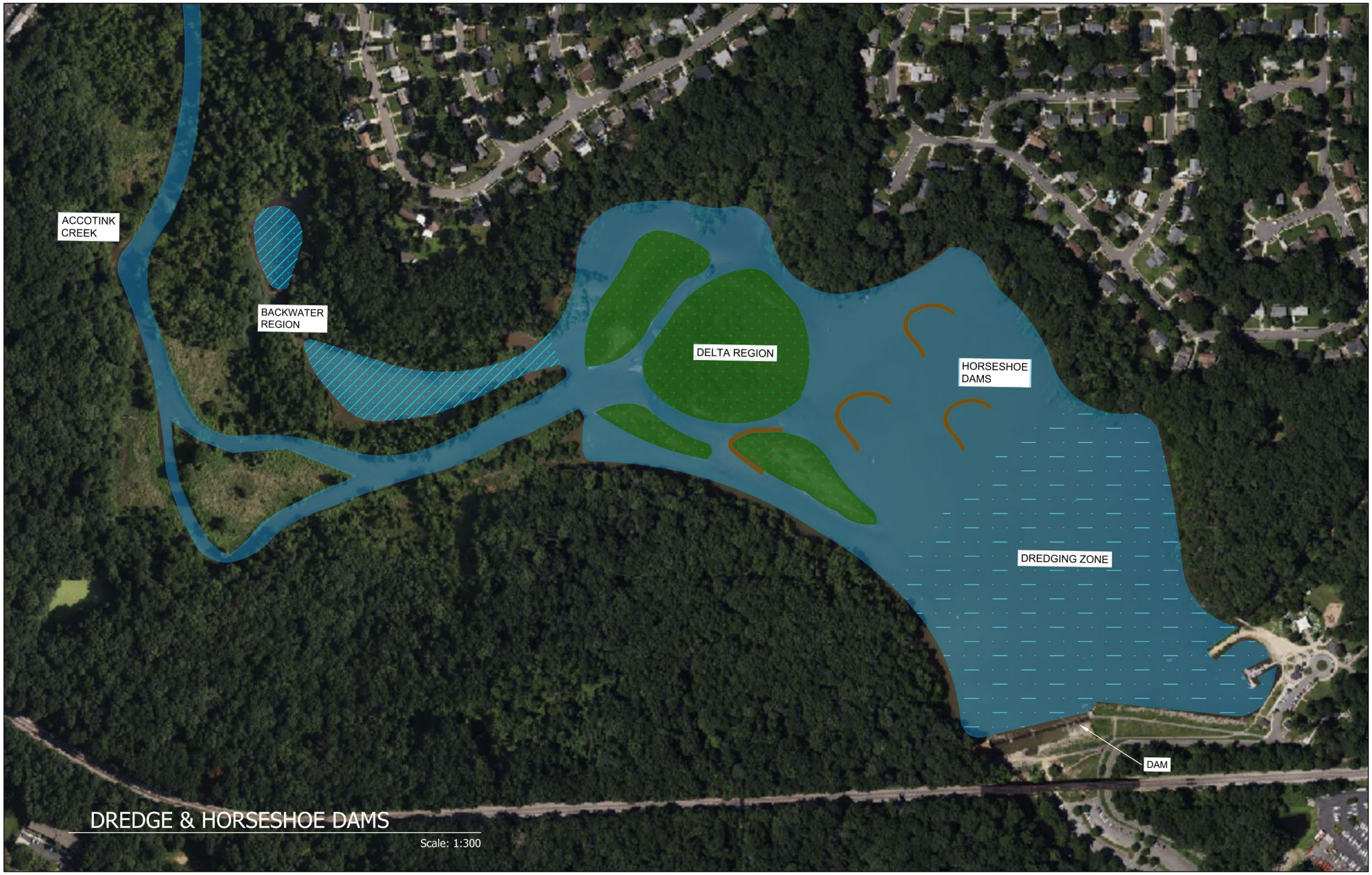


Figure 3-7. Partial dredge horseshoe island scenario

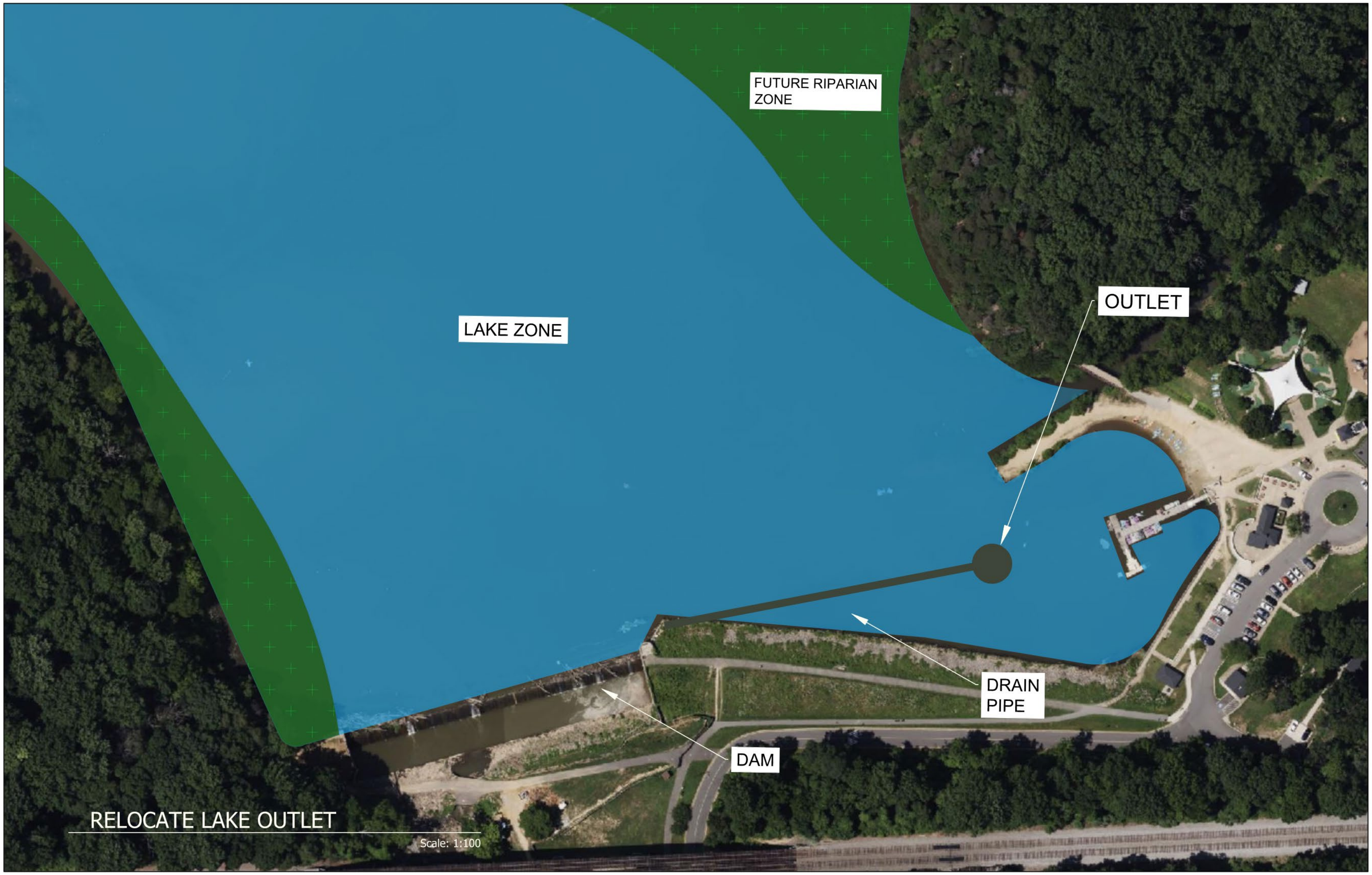


Figure 3-8. Outlet relocation scenario

3.3 How large and deep could an open water feature be?

If the goal is to avoid hauling dredge material offsite, the size of an open water feature is essentially a function of the proportions of deposited sediment and stored water within the lake. The desired lake depth is also a factor. For example, the average depth in Zones 2 and 3 are between 3.0 and 3.5 feet (Figure 3-9). If the goal is to dredge 3.0 – 3.5 feet from the downstream end of the lake, the total remaining open water area would be approximately half of what it is today. The open water area may be able to be increased slightly by raising portions of the wetland area 1-2 feet above the normal water surface elevation. That is an optimization exercise that could be included in a master planning study, if the community chooses to pursue a dredge reuse project.

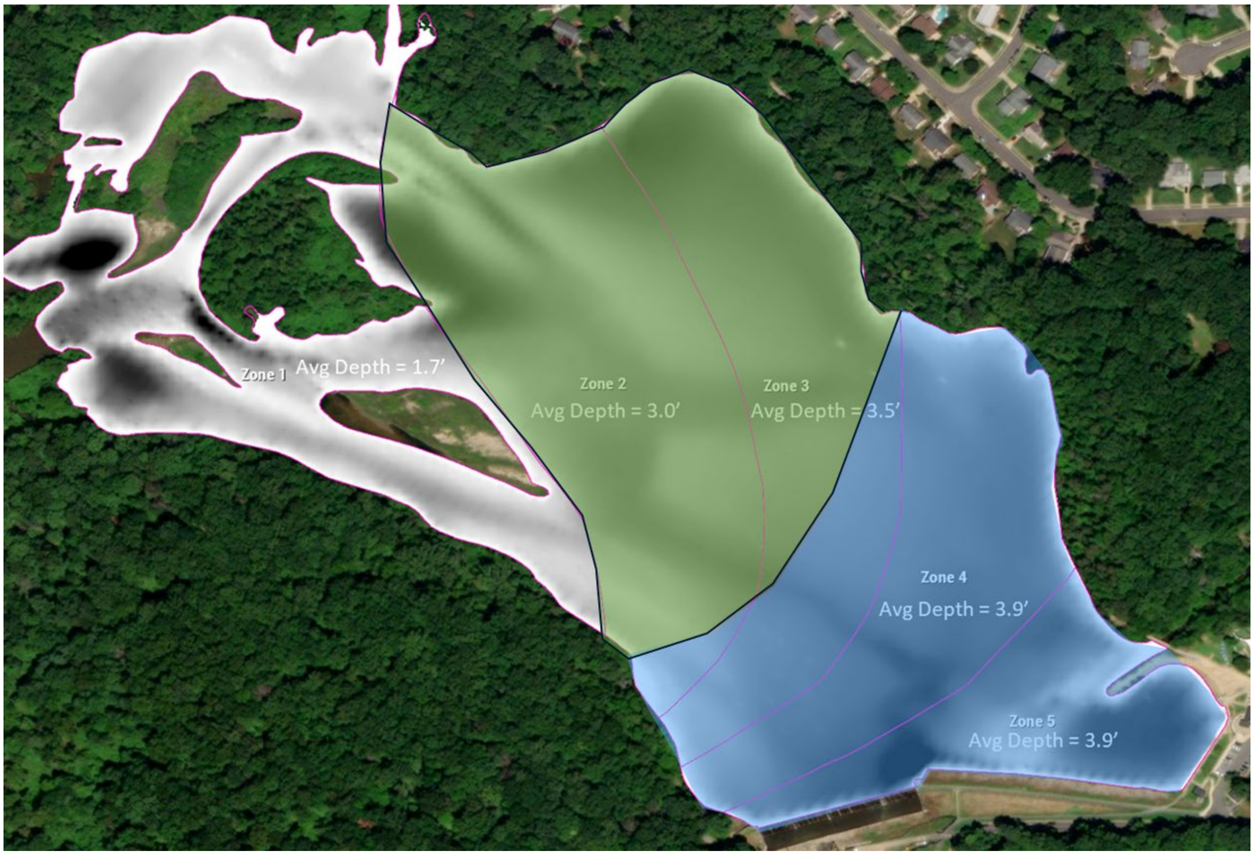


Figure 3-9 Example open water area and new wetland area for a target dredge depth of 3.0 - 3.5 feet

3.4 Would an open water feature need to be dredged periodically?

Yes. If the goal is to maintain an open water lake indefinitely, periodic dredging will almost certainly be necessary. It may be possible to maintain a deep pool in a riverine system, but a precedence has not been identified for this in Accotink Creek, and a deep riverine pool is likely not in the spirit of this question.

It should be noted that beneficial reuse of sediment should be considered a temporary strategy for reducing the cost of dredging in the lake. As the reuse sites are filled, the cost and challenges of beneficial reuse will increase. Eventually, dredging and offsite transport will be necessary to maintain a lake area.

There are research teams working on efficient sediment bypass systems which could, in theory, capture sediment from upper Accotink Creek and bypass it around the lake to downstream of the dam. This technology is quite young (i.e., still in the development stages) and Lake Accotink likely would not be a good candidate for this. Challenges to implementing sediment bypass include:

- Limited site space
- High suspended sediment concentrations
- The TMDL

3.5 How could an open water ("lake") area be sized to maximize the open water but minimize impacts from any necessary maintenance dredging operations to include:

i. Eliminate or reduce the need for pipelines and offsite processing areas,

ii. Utilize existing open spaces in Lake Accotink Park for operations,

iii. Maximizing the extent to which dredged sediment can be kept and used onsite, and

iv. Minimize impacts from trucking materials out?

The intervention strategy most conducive to optimizing open water space and dredge materials handling is the partial dredge anastomosing scenario (Figure 3-10). This scenario maximizes the reuse of dredge material in the smallest space manageable. There could be multiple rounds of utilizing this scenario for future maintenance dredging activities. The exact balance of wetland and open water would need to be optimized during a master planning effort or feasibility study. A long-term adaptive management strategy will likely be required as the wetland grows and the lake shrinks. If a large open water lake is desired, eventually hauling dredge spoils offsite will be necessary.

Figure 3-10 Partial dredge anastomosing scenario

3.6 What would it take to maintain an open water area and how much would it cost?

Note: We are assuming that "open water" in this context is referring to an open water lake. An open water creek will be necessary in all scenarios other than the full-dredge scenario.

Maintaining an open water lake indefinitely will require some level maintenance dredging. The cost of maintaining a lake depends on the exact ratio of wetland area to lake area. These costs are discussed in Section 2.8 and are repeated below.

The exact ratio of wetland area to lake area can be adjusted based on the desires of the community. Constructing the site to the correct ratios may require several iterations. The first iteration of this scenario would cost approximately $23 million (Section 3 of Table 2-2). Subsequent iterations would be in a similar cost range.

Once the wetland has been built out to the desired extents, the open water lake portion would continue to fill with sediment and would require maintenance dredging with off-site disposal. That maintenance dredging would cost on the order of $28.3 million per dredging cycle (Section 2 of Table 2-2). The frequency of maintenance dredging depends heavily on the ratio of wetland to lake area; however, we can expect that maintenance dredging will be required more frequently for a smaller open water lake than for the current lake size. This is because the total sediment load entering the lake is the same in both scenarios; consequently, the percentage of lake that is infilled in any given year will be higher for a smaller lake.

In addition to the dredging costs, the annual operating costs for an open water area or managed wetland should be comparable and will vary based on the maintenance plan prepared. Comparable cost for Huntley Meadows Park is $50,000 per year and includes control of invasive species and vegetation surveys.

4. HOW WOULD LAKE ACCOTINK DAM BE INCORPORATED INTO A MANAGED WETLAND OPTION?

4.1 Could the dam remain as is?

Yes, the dam can remain as is. Beyond normal dam maintenance, the primary consideration is the low-flow bypass built into that dam that is utilized to draw the lake for dredging and maintenance activities. In the scenarios which allow sediment to fill the lake up to the dam, this draw down system may need to be revised.

4.2 Could the dam be modified to improve wetland function and maintenance?

Yes, manipulating the water level of the dam is one strategy for managing a wetland. If the water level of the lake were drawn down 1-3 feet, the bed sediments would be exposed and wetland vegetation could be established. Figure 2-7 to Figure 2-9 indicate the approximate extent of potential new wetland zones under three draw down scenarios.

If the crest of the dam was lowered and the normal pool of the lake were reduced to create more riparian wetland, occasionally increasing the lake level is one strategy to help control invasive species.

4.3 Would management options be improved by removal of any portion of the dam?

Potentially, yes. Removing all or part of the dam could reduce the total number of management options you have; however, most of the remaining options would require less expensive long-term maintenance. Options that remove all or a portion of the dam shift the management regime from reservoir management to single-threaded stream management. A stream environment is more consistent with the historic, natural condition of the site and therefore should require fewer maintenance interventions.

4.4 How could fish passage be incorporated into dam/lake management options?

Fish passage design is easier for lower head obstruction, so naturally, full dam removal would be the most conducive to fish passage followed by partial dam removal. That said, fish passage can be incorporated into all of the lake scenarios.

The type of fish passage strategy depends on the target species, flow rates, obstruction height, and time of year. All of these would need to be considered.

Given the constrained nature of the site downstream of the dam, a fish passage structure would likely need to be asynchronous with the normal channel alignment (such as along the face of the dam, see Figure 4-1).

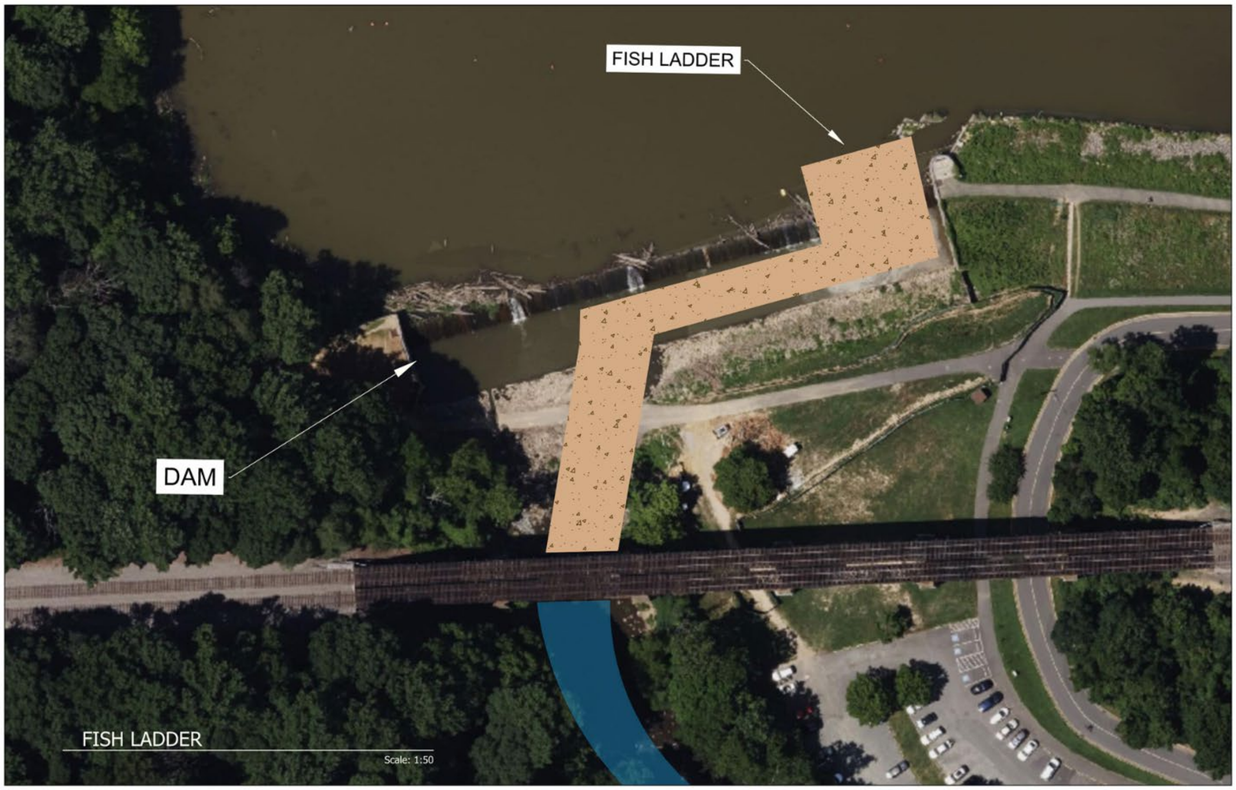


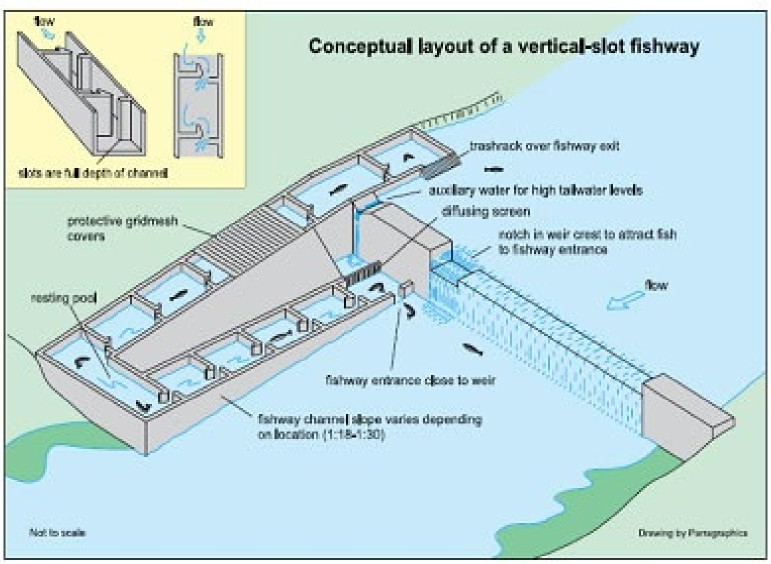
Figure 4-1. Potential fish passage structure layout

Rock ramps (Figure 4-2 and Figure 4-3) are often good passage options for panfish and bass, which have been observed in the lake. These types of structures mimic natural stream and can provide passage for other aquatic organisms, such as crawfish. The chaotic nature of the flows through rock ramps creates countless flow paths for an individual fish to navigate as they migrate upstream. The stone and sand substrate provide is an asset to the fish but can be more challenging to retain. The biggest challenge of these types of structures is that they tend to require more space.

Technical fishways (Figure 4-4) tend to be more appropriate for fish species with a strong drive to migrate upstream. These structures typically provide fewer flow paths, and are consequently, passable by a narrow range of fish species. These types of structures typically require less space than comparable rock ramp structures.

Figure 4-2. Little Creek rock ramp fish passage structure

Figure 4-3. Waterloo Park Riffle Run rock ramp fish passage structure



Vertical-slot fishway example. Image credit: Partgraphics

Figure 4-4. Technical fishway fish passage structure

4.5 How much would it cost to modify the dam under the scenarios in items b. and c. above?

Dam Modification for Improved Maintenance

Modifying lake level within the 2-foot elevation of the flash boards would be a relatively cost-effective manipulation. While this scenario hasn't been explicitly estimated, we would expect these costs to be within the $50,000 per year maintenance costs approximated in Section 2.8.

Partial Dam Removal for Improved Maintenance

As discussed in Section 4.3, a partial or full removal of the dam would result in a single-threaded stream system. Since this type of system has not been the focus of discussion, this scenario has not been included in the costs analysis.

Dam Modification for Fish Passage

For this estimate, it was assumed that a portion of the flashboards would be removed, and a fish passage rock ramp added to the dam. This rough order of magnitude (ROM) cost for a fish passage dam modification is $8.9 million.

Other Dam Maintenance Costs

As discussed in Section 2.8, none of the cost analyses included the inherent cost of maintaining the dam. The dam maintenance costs will be similar in all scenarios. The dam is nearing the end of its service life, so we can expect the maintenance costs for the dam to increase with time.

The fate of all dams is to either be removed, be replaced, or fail. All scenarios which include the dam can expect future maintenance activities which effectively replace the dam piece by piece over time. The timeline for such maintenance activities cannot be assessed within the available schedule for this analysis.

4.6 Describe the regulatory requirements for Lake Accotink Dam and potential impacts on sediment fate and transport downstream in Accotink Creek for the following scenarios:

i. No action is taken and the dam is left as is.

ii. A managed wetland is created and the dam is left as is.

iii. A managed wetland is created and the dam is modified.

iv. The dam is partially or wholly removed and Accotink Creek returned to a flowing stream.

Dam Regulation:

Please note: This section focuses on regulations pertaining to the Accotink Dam. Please see Section 2.7 for a discussion of Lake/Wetland regulations, as well as construction regulations.

The Lake Accotink dam is a composite structure, consisting of an earthen embankment section and concrete spillway section. The dam is approximately 100 years old and is classified as a high hazard dam. Currently, the Accotink Dam has a conditional Virginia Dam Safety Operation and Maintenance (O&M) Certificate since the spillway can only pass 0.6 times the Probable Maximum Flood (PMF), well below the 0.9 PMF spillway design flood (SDF) requirement for a high hazard dam.

Virginia DCR considers any sediment captured within the lake to be liquifiable material. Essentially, when calculating the volume of material stored upstream of the dam, captured sediment volume is counted the same as impounded water volume. Consequently, allowing the lake to fill in with sediment or dredging and reusing sediment to build wetland/island will not allow us to declassify the Accotink dam as a regulated dam. In short, regulation of the dam will not change due to Lake Accotink sediment management scenarios/ management of sediment within the lake.

Based on this assessment:

- There will be no changes or impacts on the regulation of the dam if no action is taken and the dam is left as it is because there will be no change to the effective capacity of the reservoir upstream of the dam.

- There will be no changes or impacts on the regulation of the dam if a managed wetland is created and the dam is left as is for the same reasons noted in the bullet above.

- There are unlikely to be changes or impacts on the regulation of the dam if a managed wetland is created and the dam is modified because it is unlikely that dam modification would be significant enough to delist the dam structure as a regulated dam. Doing so would require lowering the crest of the dam such that the impounding capacity no longer exceeds 50 acre-feet of combined volume of water and sediment (which would yield a dam height of only 1-2 feet). To delist the dam, the height of the dam would also need to be less than 25 feet.

- If the dam is removed and the river is restored, there will no longer be a dam to regulate. However, dam removal must satisfy its own set of conditions and requirements. Note that according to Virginia Department of Wildlife Resources, the dam is a high priority for removal to improve fish passage. This could make a dam removal permit easier to obtain.

Maintaining the Accotink dam as-is or in a modified condition would continue to subject the dam structure to ongoing inspection, maintenance, and tabletop analysis requirements. In addition, the dam would still require application for conditional certification from VA DCR. Through this process, an analysis by a certified Professional Engineer would determine the actions necessary to maintain the dam.

Sediment Transport in Lower Accotink Creek:

Rivers transport both water and sediment. Lanes Diagram (Figure 4-1) describes the general relationship between sediment and water flow. Most healthy streams that maintain a quasi-equilibrium have balanced sediment transport energy and water transport energy. When these two energies are out of balance, the stream will tend to degrade/erode or aggrade/deposit sediment.

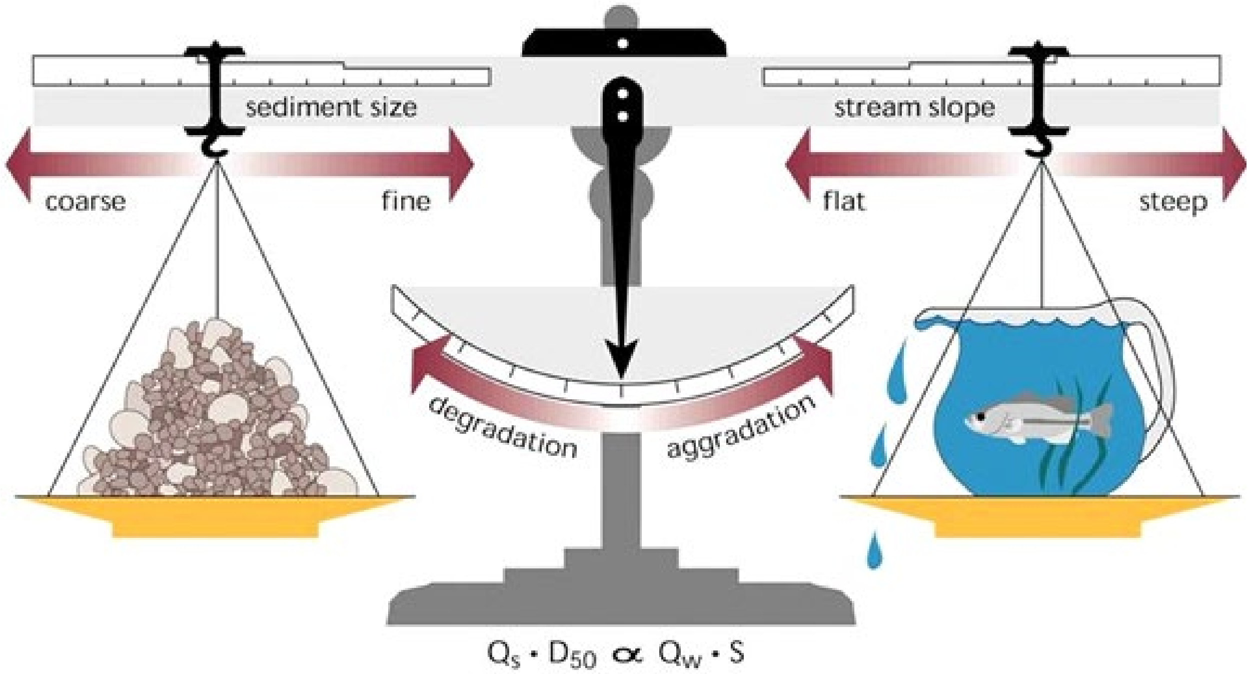


Figure 4-5 Lanes Diagram (Lane, 1955)

Urban development often disproportionately increases the water flow to a stream but not the flow of properly sized sediment. Consequently, the stream is sediment starved and degradation, incision, and erosion occur. This is a contributing factor to the historic degradation of upper Accotink Creek.

When upper Accotink Creek enters Lake Accotink, the opposite is true. The relatively flat water surface has less energy to transport sediment and some sediment accumulates within the lake.

Downstream of the dam, the balance flips yet again. The stream slope returns to its natural grade, but the sediment load has not returned, leading to stream degradation in lower Accotink Creek. This explains why there is larger creek substrate immediately below the dam – all of the fine material has washed through.

Given that the creek appears to be sediment starved downstream of the dam, leading to bed erosion, it is unclear if Lake Accotink is actually reducing the total load of sediment to the downstream waters. Unfortunately, there is not enough available data to assess this potential condition.

5. WHAT FEATURES/AMENITIES/BENEFITS/ IMPACTS WILL A MANAGED WETLAND PROVIDE/ HAVE?

To address this question, we will first provide a set of example images to illustrate the range of options to address Questions 5.a (aesthetic resources), 5.b. (water trails, pedestrian access/trails), 5.e (education), 5.f.i (recreation/boating), 5.f.ii (recreation/fishing), 5.g (water quality); and 5.h (habitat). We will then address several remaining specific questions in Sections 5.1 to 5.4.

Example Images of Features and Amenities

The task force's discovery questions have shown particular interest in the following features and amenities:

- Aesthetic resource
- Water trails, pedestrian access/trails
- Education
- Recreational boating
- Recreational fishing
- Water quality
- Bird habitat
- Aquatic and terrestrial habitat

This section provides 13 precedent images of features and amenities that could be adapted to the site in one or more of the future scenarios. Please note that most of the images are of built landscapes, so we can have confidence that they can be built again.

Figure 5-1 is a matrix of the precedent images along with the features and amenities listed above. The dots in the matrix indicate which features and amenities are readily visible in the precedent images.

Project/Site	Aesthetic resource	Water trails, pedestrian access/trails	Education	Recreational boating	Recreational fishing	Water quality	Bird habitat	Aquatic and terrestrial habitat
Lake Accotink Fish Habitat	●		●		●			●
Lake Accotink Bird Habitat	●		●				●	
Wellesley College Constructed Wetland	●					●	●	●
Clackamas River	●	●	●		●	●	●	●
Waterloo Greenway	●	●	●		●			●
The Wild Mile Vision Plan	●	●	●	●	●	●	●	●
Perrot State Park	●	●		●	●			
Garden of the Phoenix	●	●			●			
Chattahoochee Riverlands	●							
The Wild Mile boardwalk	●	●	●					●
Bush Presidential Center Prairie Trail	●	●	●			●	●	
Bush Presidential Center Boardwalk	●	●				●		
Lincoln Park	●	●	●			●	●	●

Figure 5-1. Features and Amenities Matrix

LAKE ACCOTINK FISH HABITAT

Image from Fishbrain.com

Correspondence from the VA Dept. of Game and Inland Fisheries indicates that the fish habitat is poor and has been for a long time. The dam also acts as a fish barrier.

"Great place to have a good day – 5 stars. So since I fish Burke a lot I thought that this lake was gonna be the exact same but it surprised me because you would literally catch 2 and 3 pounders easily. These fish are so aggressive and since it's spawning it's crazy"

Review from Fishbrain.com

"This lake is very shallow. Most of the lake is only a few feet deep. i was dragging bottum in a lot of the lake. Best fishing is done by kayak an Limited due to depth. though I have caught bass at the lake."

Review from Fishbrain.com

LAKE ACCOTINK BIRD HABITAT

An American bald eagle sits on a log in Acadia National Park Pond in Acadia National Park, ME on September 30, 2020.Image credit: Will Newton/Friends of Acadia. https://www.nps.gov/acad/learn/nature/eagles.htm

WELLESLEY COLLEGE CONSTRUCTED WETLAND

Image credit: MVVA

Wellesley College Constructed Wetland
Wellesley, MA

CLACKAMAS RIVER

Pools and riffles in the restored river. Image credit: Inter-Fluve

Clackamas River
Clackamas, OR

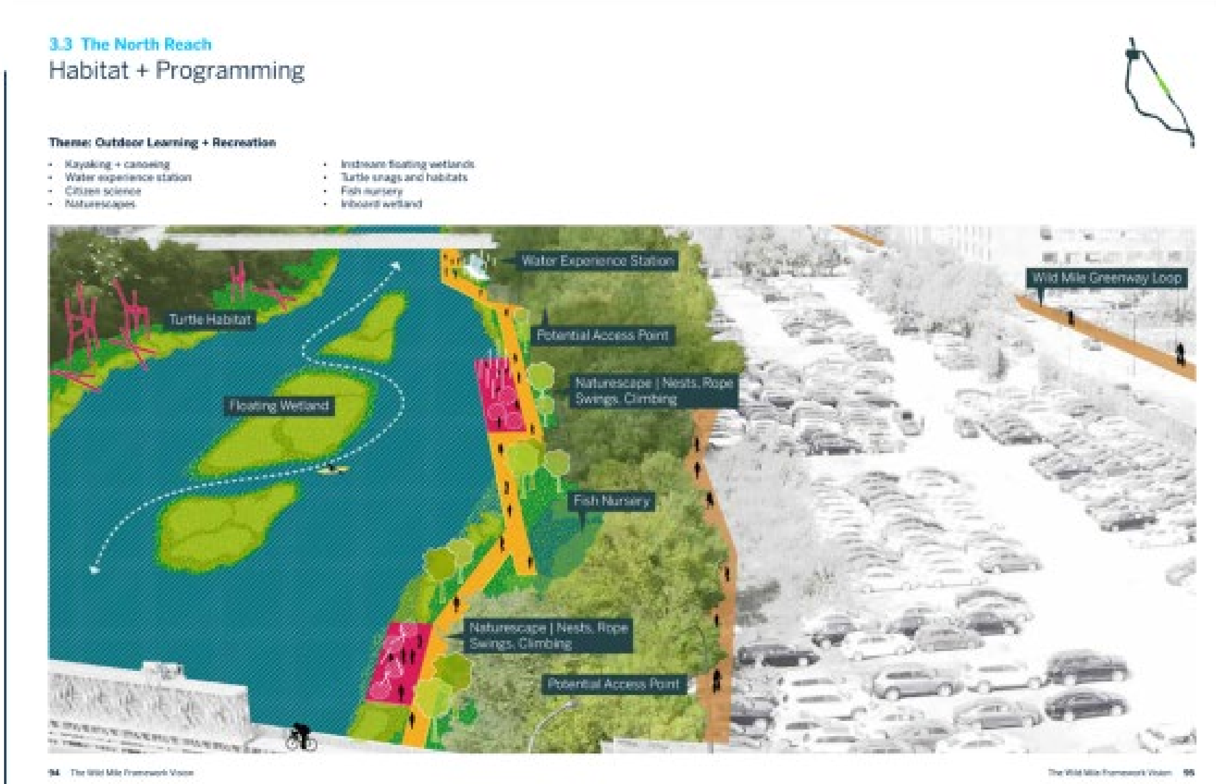
Strategically placed large wood in side channels mimic naturally occurring debris in the floodplain.
Image credit: Inter-Fluve

WATERLOO GREENWAY

Image credit: MVVA

The Confluence at Waterloo Greenway
Austin, TX

THE WILD MILE VISION PLAN



The Wild Mile Vision Plan, excerpt
Image source: https://drive.google.com/file/d/1-2r5WLF-TKCiqJSDW14tkKNzDvznWELo/view

The Wild Mile
Chicago, IL

PERROT STATE PARK

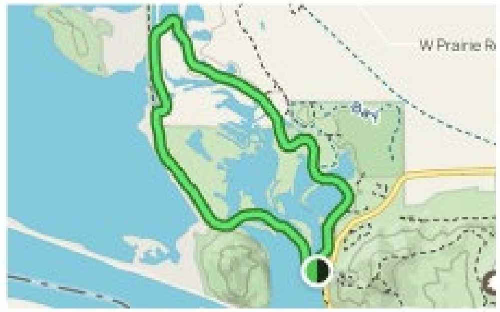


Photo By: Joshua Mayer, https://live.staticflickr.com/2828/9467327381_a2cb21cc7f.jpg, Water Trail Added

GARDEN OF THE PHOENIX

Garden of the Phoenix, Jackson Park, Chicago, IL
Image source: http://www.connectingthewindycity.com/2020/08/

CHATTAHOOCHEE RIVERLANDS

Image credits: SCAPE

Chattahoochee Riverlands Design Guidelines
Chattahoochee River, AL/GA/FL

THE WILD MILE BOARDWALK

Floating walks, gardens, and docks on the north branch of the Chicago River
Image credit: Dave Hampton

The Wild Mile
Chicago, IL

BUSH PRESIDENTIAL CENTER PRAIRIE TRAIL

Image credit: MVVA

George W. Bush Presidential Center
Dallas, TX

BUSH PRESIDENTIAL CENTER BOARDWALK

Image credit: MVVA

George W. Bush Presidential Center
Dallas, TX

LINCOLN PARK

Nature Boardwalk at South Pond, Lincoln Park, Chicago, IL
Image source: Dave Hampton

5.1 Aesthetic Resources

Aesthetics are truly a matter of personal opinion. All of the project examples provided include examples of aesthetic resources. Currently, Lake Accotink Park aesthetics include trees, water, woodland trails, a carousel, and the dam spillway. Other potential aesthetic resources could include: fishing piers, water access points, elevated walks/boardwalks, wetland plantings, and countless other options.

5.2 Trails and Access

A managed wetland will create new landscape that could include new pedestrian trail. These trails could include bog walks, board walks, and bridge segments that extend though or over the site.

The creation of a wetland with a multi-threaded channel would allow for new water trail programming similar to what is seen in the Perrot State Park example. A deeper single-threaded channel could also open the door for a kayak shuttle. Based on personal experience in recent years, programing around kayaking and paddle boarding has been more in-vogue than paddle boat programing.

5.3 Will a managed wetland change the usefulness/value of amenities (playground, picnicking, carousel, marina, etc.) in Lake Accotink Park as compared to having a lake?

Most of the existing park amenities will not be directly impacted by the various management scenarios. Park amenities may be in-directly impacted by the management scenarios. For example, if a selected management scenario incorporates new destination features, the park may draw more community members in general and results in greater utilization of the existing amenities. Similarly, new programing for potential new features could increase the utilization of existing amenities.

Under some of the management scenarios, in-lake or on-the-water amenities will change. For example, the types and locations of fishing opportunities may change. Boating opportunities may also shift from paddle boating to kayaking.

5.4 What would the community value of a managed wetland have as compared to having a lake?

All natural spaces provide community benefits; however, those benefits look a little different for each habitat type and from each person’s perspective. An exhaustive compare and contrast list would be infeasible to develop. Here are a few topics to consider when assessing the community value of a wetland vs a lake.

High-quality wetlands are often rare habitats that don’t receive the attention they deserve. In my experience, most people can name a few lakes that they have visited or are at least aware of, but few people can even name a high-quality wetland. From this perspective, having a high-quality wetland in your community is unique value.

Wetlands with pedestrian paths provide more accessible access to the site than lakes do. Wetlands with pedestrian paths and stream channels provide accessible access, boating opertunities, and more options for shore fishing.

A park with a lake, stream, and wetland would provide diverse habitat and more diverse opportunities to engage with nature.

5.5 Education

Most of the example sites include some type of educational programing even if it isn't immediately visible in the images. Similar educational programing can be implemented for lakes, wetlands, and stream. Examples include:

- Signage
- Outdoor classrooms
- Access to the water's edge
- Community events such as:
    - Tours,
    - "Take a kid fishing" programs,
    - Intro to bird watching stations,
    - 5k Fund Raisers, and
    - Light Hikes.

5.6 Recreation

Boating

In all managed wetland scenarios, there will still need to be a channel for Accotink Creek, and consequently, there will still be boating opertunities.

The creation of a wetland with a multi-threaded channel would allow for new water trail programming similar to what is seen in the Perrot State Park example. A deeper single-threaded channel could also open the door for a kayak shuttle. Based on personal experience in recent years, programing around kayaking and paddle boarding has been more in-vogue than paddle boat programing.

Recreational Fishing: Would the fishery improve/worsen? Would there be restrictions on fishing in any area?

Reports from The State of Virginia indicate that the fish habitat in the lake is poor. Most of the scenarios would seek to improve the fish habitat.

Scenarios that include dredging may temporarily improve the fishery, but frequent dredging can ultimately be detrimental to the fishery. A more riverine scenario will support more diverse fish habitat, but that habitat may not be the bass habitat that exists today. Overall, one can expect that the fishery will change under any of the scenarios, but whether that change is better or worse is a matter of opinion.

Fishing restrictions are typically imposed for reasons of safety or park etiquette. These types of restrictions are not likely to be significantly altered from their current condition in any of the scenarios.

5.7 Water Quality

Wetlands are often excellent mechanisms for promoting water quality. They promote groundwater-surface water interactions. They also promote vegetation with roots that penetrate into the groundwater This interaction in turn promotes nutrient cycling and capture.

5.8 Would a wetland support the family of nesting eagles and other birds of prey native to the Lake Accotink watershed ecosystem?

A managed wetland can maintain – and enhance bird of prey habitat with:

- Edge buffer zones which preserve existing trees often used for nesting. See **BLM guidelines** and **VA DWR Raptor guidelines**.
- Improved aquatic habitat (pond) as a food source.
- Logs, former beaver dams, woody debris, new nature-based solutions (NBS), process based restoration BMPs, and other perching areas can provide more locations for undisturbed feeding (photo above).

5.9 Would a managed wetland positively or negatively impact other aquatic and terrestrial wildlife in comparison to maintaining a lake? Would these impacts displace wildlife?

Managing for more wetlands will increase the diversity of the park. More diverse habitats support more diverse populations of aquatic and terrestrial wildlife. Higher diversity is generally considered a positive for natural systems.

Increasing over all species diversity may also decrease the abundance of an individual species that is currently dominant in the park, but this won't necessarily be the case. The reduction in abundance of an individual species could be view as a displacement, but it is a matter of opinion if that is a bad thing. For example, most people wouldn't view a decrease in mosquito population a bad thing.

6. WHAT MAINTENANCE WOULD BE NECESSARY FOR A MANAGED WETLAND?

6.1 What would be required to manage a wetland complex?

The main management effort will likely be invasive species management. Beyond that, a wetland complex can be managed similarly to a lake.

If a partial dredging and reuse strategy is utilized, then wetland restoration activities will be needed with each round of dredging.

6.2 What would maintenance cycles look like?

Invasive species management is typically an ongoing challenge with annual maintenance cycles. These may include chemical treatment, water level manipulations, and selective harvesting.

If a partial dredging and reuse strategy is utilized, the required dredging frequency will likely be anywhere from annual to decadal depending on the intervention strategy.

6.3 How much would maintenance cost?

Cost cannot be assessed with any degree of accuracy without a comprehensive operations and maintenance plan. The cost is largely a question of priorities, which direct the operations and maintenance plan.

For wetland establishment/restoration strategies, there will be higher levels of maintenance required during the establishment period. After that, it is reasonable to assume that the annual invasives maintenance costs will be similar in all scenarios.

Longer-term dredging operations can be expected to be the most expensive management option.

7. WHAT ARE THE SEDIMENT LOADS WITHIN ACCOTINK CREEK AND HOW WILL THEY CHANGE?

When considering sediment load into and out of Lake Accotink, the following must be considered:

- Estimating sediment transport rates is a very challenging undertaking,
- The physics of sediment transport is still not fully understood, and
- The available data for the Accotink watershed can only tell us part of the story.

> "IF YOU CAN ESTIMATE SEDIMENT TRANSPORT WITHIN A FACTOR OF FOUR, YOU ARE DOING PRETTY GOOD."
>
> Dr. Chris Paola, Professor of Geology & Geomorphology

7.1 What are the current sediment loads in Accotink Creek and what are the likely trends for sediment generation in the future?

The local USGS field office has been collecting flow and suspended sediment samples from Accotink Creek and Long Branch for many years. The USGS has processed their sample data to estimate annual suspended sediment data for each creek (Table 7-1). These annual summaries are modeled estimates based on the best available data for Accotink Creek and Long Branch, but there is no way to determine the exact "true" loads.

Water Year	Accotink Creek (WRTDS-K)	Long Branch (Surrogate)	Total load to Lake Acc
2014	27,700,000	2,945,876	30,645,876
2015	6,010,000	1,537,426	7,547,426
2016	8,960,000	1,351,470	10,311,470
2017	14,000,000	7,423,491	21,423,491
2018	31,300,000	11,027,030	42,327,030
2019	14,700,000	10,294,552	24,994,552
2020	11,900,000	7,233,527	19,133,527

Units are in pounds

Figure 7-1. Estimated annual suspended sediment load for Accotink Creek and Long Branch (Provided by the USGS)

The suspended sediment loads estimated by the USGS were averaged to estimate the typical annual suspended sediment loads delivered to Lake Accotink (Table 7-2). The suspended sediment load was then adjusted to approximate the total load by assuming 13% of the total load is bedload and 87% of the total load is suspended load.

Average Annual Loads Based on USGS Gage Data 2014-2020*	Suspended Sediment Load in lbs	SS Load in Tons	Cubic Yards @ 45 lbs/cf	Cubic Yards @ 94 lbs/cf
Average SS Load	22,340,482	11,170	18387	8802
Average Total Load	25,678,714	12,839	21,135	10,118

Figure 7-2. Annual suspended sediment and total load estimates

The 13% bedload assumption is consistent with the 2002 HDR report that reviewed several literature values; however, there is no available data to support this assumption and it could be highly inaccurate.

The sediment delivery volume has been estimated using unit weights of 45 lbs/cf and 94 lbs/cf. For lake infilling analysis we utilized 45 lbs/cf because the sediment has high concentrations of silt and clay. The mass balance calculations in Section 7.2 do not support the use of a unit weight of 94 lbs/cf.

Load Trends for the Future

The County is actively restoring reaches of upper Accotink Creek with the goal of reducing the overall suspended sediment loads delivered downstream. These efforts should lead to a declining trend in suspended sediment loads.

There are several observations of erosion and degradation in Long Branch. If left unchecked, continued degradation could lead to increasing trends in sediment loads, particularly courser bedloads.

7.2 What loads are leaving the lake in its current condition?

To estimate the loads leaving the lake, we first estimate the loads captured within the lake, and then utilize the inflow loads and the capture loads to estimate the exiting loads.

The loads captured within the lake were estimated by comparing two bathymetric surveys – one collected in May 2015, and one in November 2020. A map of the bathymetric changes is provided in Figure 7-3. During the 5.5 years between surveys, the lake infilled by as much as 7.2 feet, with a total infill volume estimate of 45.9 acre-ft (1,999,404 ft^3).

Based on these results, the average annual capture is:

- Weight = 16,358,825 Pounds
    - Assuming a unit weight of 46 lbs/ft^3.
- Volume = 363,529 ft^3 (13,464 CY)

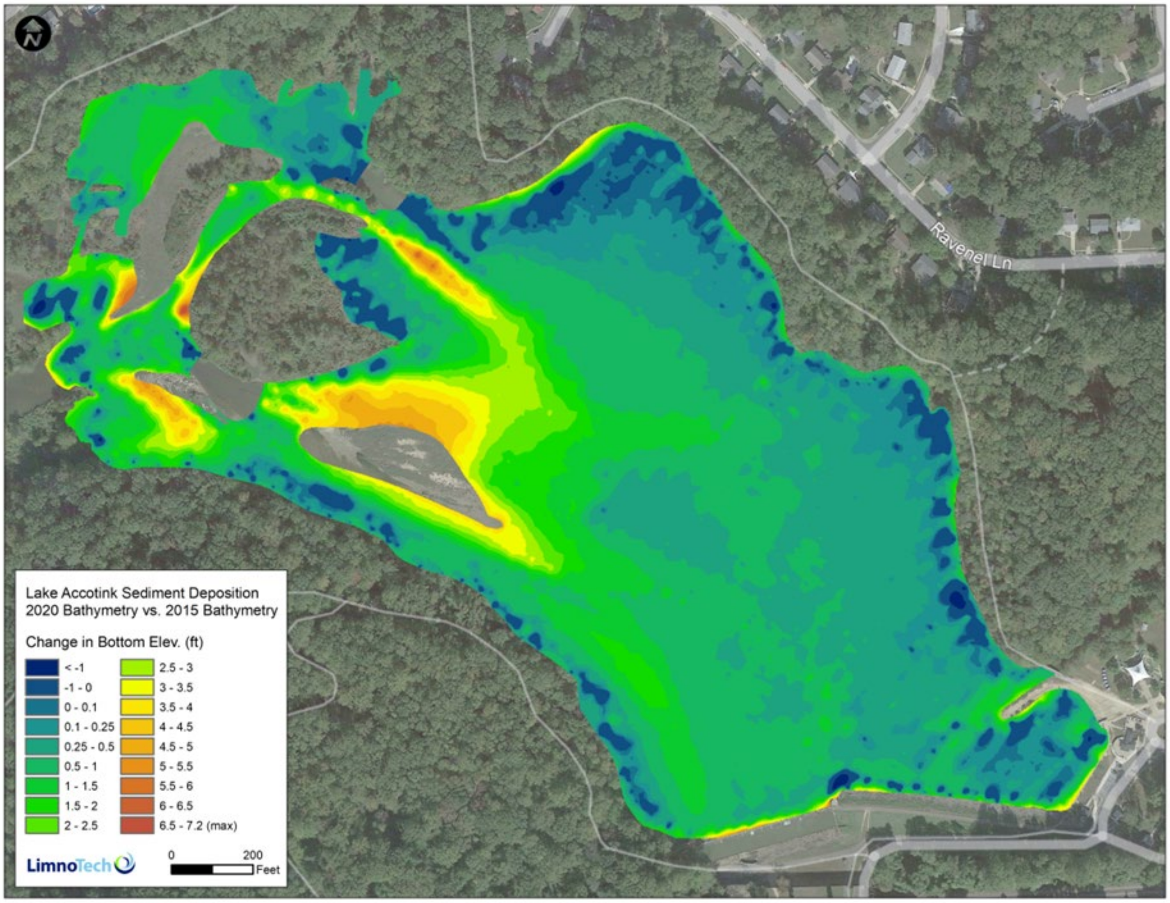


Figure 7-3. Bathymetric changes from May 2015 to November 2020

A comparison of the sediment capture rates and the sediment inflow rates yield an estimated load of approximately 4,700 tons of sediment transported to lower Accotink Creek and a capture efficiency of ~64% within the lake.

It should be noted that this analysis is entirely dependent on the percent bedload assumption, which we have little confidence in. The high deposition rates in the delta area that have higher shear stress and the lower deposition rates in the lower shear stress areas may indicate that that the percentage of bedload entering the lake is much higher than the assumed 13%. The observations of high erosion rates in Long Branch would further support a hypothesis that the bedload rates may be higher than assumed.

In summary, the bedload estimates/percentage is a critical assumption. This analysis should be considered our best guess at the loads leaving Lake Accotink. These values are only being reported because they are explicitly requested by the task force, and we would urge caution if using them to inform decisions about the future of the lake and dam.

7.3 How will these loads change if no action were taken?

If no action is taken, the lake will capture less and less sediment as it infills until it is completely full. Once full, the loads delivered downstream of the lake will be equal to the load entering the lake from upstream.

7.4 What would the loads leaving the lake be like if the lake were managed as a wetland?

As a partial wetland/partial lake system the loads delivered downstream of the dam will likely be slightly higher than the current loads. The smaller lake volume will likely be slightly less efficient at capturing sediment than the current lake is; however, some of this loss in efficiency could be made up by maintaining a deeper lake.

As a full wetland complex, the loads delivered downstream will be similar to, but possibly slightly less, than the loads currently delivered to the lake from upstream. Wetlands do have the ability to capture some sediment, but most of that occurs during floodplain overtopping events. Consequently, most sediment entering the wetland complex will pass through via the creek portion of the system.

7.5 What would the sediment loads be in Accotink Creek if the dam were removed?

If the dam were completely removed, the loads delivered downstream of the site will be equal to the load entering the site from upstream.

7.6 How will these loads affect downstream resources:

How will they impact instream fauna? (Mussels)

Most healthy streams need bedload sediment; consequently, restoring the bedload sediment to lower Accotink Creek should have a generally positive impact on the instream fauna.

Suspended sediment is often considered a pollutant and can have negative impacts on instream fauna; however, the suspended sediment loads in Accotink Creek are sufficiently high that the creek may already by dominated by suspended sediment tolerant species.

Mussel beds are common downstream of a dam, but habitat is often transient. Dams remove the fine sediment which can foul a mussel bed and allows mussel beds to thrive after a dam is installed. Dams also remove the bedload sand which is necessary to sustain mussel beds. The fact the sands take longer to wash out of the downstream reaches than the fine sediments is what creates the transient mussel habitat.

How much sediment could be expected to be captured by the floodplains?

Floodplains can capture large volumes of sediment during flood events; however, at the annual scale, floodplain capture of sediment is usually relatively small due to the fact that capture only occurs during flood events. A will connected floodplain can be expected to flood almost annually.

How might these loads affect Gunston Cove?

The total sediment load delivered to Gunston Cove may or may not be influenced by Lake Accotink. That cannot be determined with the available data (see the example in Section 4.5).

How could these effects be mitigated?

Suspended sediment leaving Lake Accotink could be mitigated by:

- Continually dredge the lake to remove collected sediment and prevent washout, or
- Target sediment management strategies elsewhere in the watershed

7.7 What regulatory implications are there for Fairfax County due to increased sediment loads downstream of Lake Accotink and how much could mitigating these increased loads cost?

The County does receive sediment reduction credits for Lake Accotink in the Chesapeake Bay TMDL. If management activities within the lake increase suspended sediment discharge to lower Accotink Creek, then those TMDL credits may be lost.

The County is actively perusing additional TMDL credits through other restoration activities and believes the additional cost to offset the Lake Accotink credits via other restoration activities is manageable.

Green infrastructure practices and stream restoration projects are often the most cost-effective strategies for mitigating suspended sediment loads at the community scale. This is because those practices are physically closer to the sediment sources and once implemented, the maintenance of those practices more manageable. Dredging is traditionally one of the most expensive sediment load reduction strategies because it needs to be done repeatedly.

8. OTHER:

8.1 Account for climate change in modeling and analysis of options.

The National Oceanic and Aerospace Administration (NOAA) provides an online tool for assessing climate change predictions at the county level across the United States (see link below). This tool was utilized to review climate predictions near Lake Accotink.

Future Climate Projections - Graphs & Maps | NOAA Climate.gov (**https://www.climate.gov/maps-data/dataset/future-climate-projections-graphs-maps**)

Overall, the temperatures are predicted to rise (Figure 8-1). Increasing temperatures will impact lakes, wetlands, and streams. Lake eutrophication (algal blooms) is directly tied to temperatures. Some may argue that shallow lakes will react to changing temperatures more readily than wetlands or streams, but it is difficult to make a direct comparison. Eventually, all three systems will begin to adjust to increasing temperatures.

While temperatures are predicted to increase nationwide, precipitation predictions are much less consistent. The NOAA online tool shows relatively stable precipitation predictions for this region. There is a slight increase in predicted overall annual precipitation (Figure 8-2) but the number days each year with over 3" of precipitation are predicted to remain relatively consistent (Figure 8-3). This suggests that climate change may not be a major factor when considering the flow balances into and out of the lake. In all likelihood, urban development and land management will have a greater impact on the lake water budget over the next 20 years.

That said, Super Storm Sandy demonstrated that the lake and sediment load within the watershed can be heavily impacted by storms of that magnitude, and there is an overall prediction that super storms and tropical storms may become more likely and more intense under future climate change scenarios. Those types of storms are driven by different climate factors than traditional flood producing storms in the county. It is easy to postulate that those storms will have an impact on the long-term function of the creek/lake/wetland system, but we can't yet predict what that impact will be.

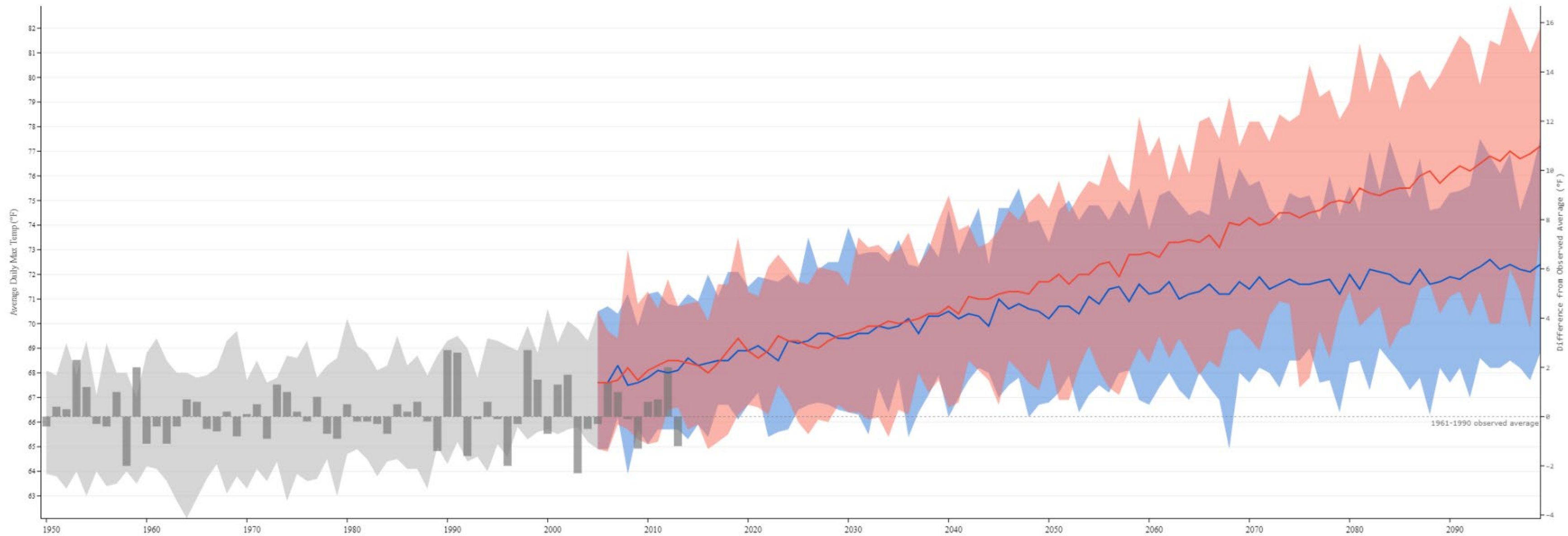


Figure 8-1 Temperature climate predictions for Fairfax, VA (for full-scale images please visit: Climate Explorer (nemac.org)**)**

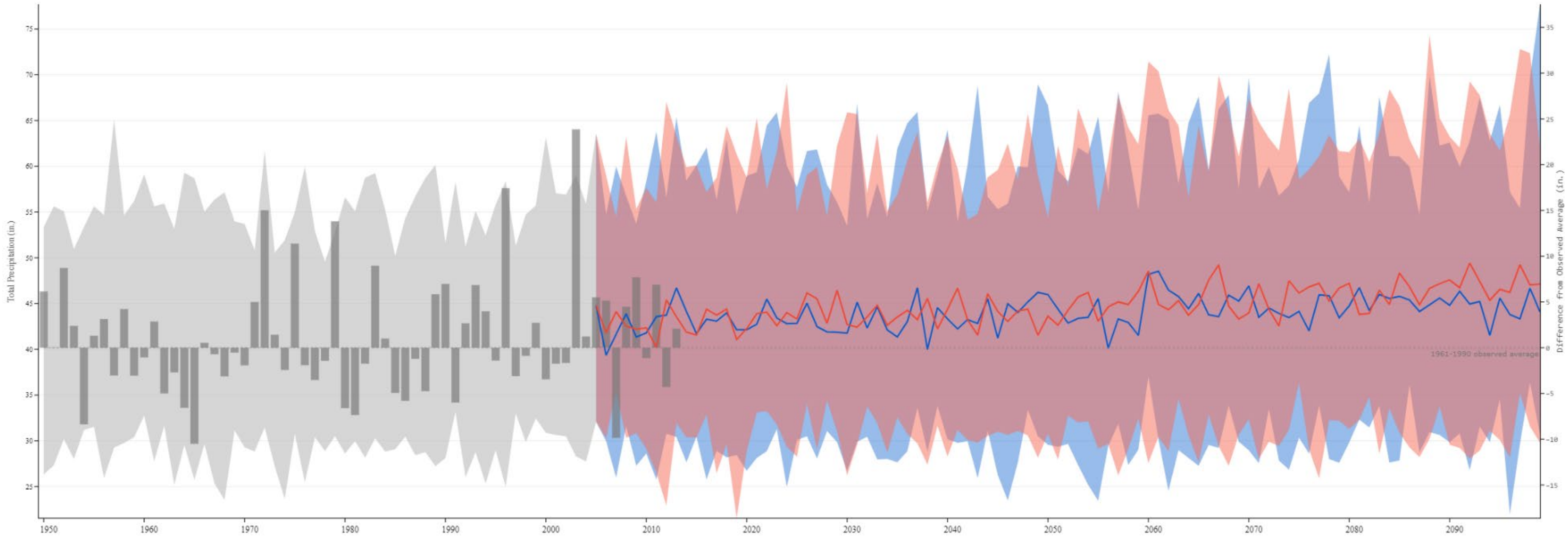


Figure 8-2 Annual precipitation climate predictions (for full-scale images please visit: Climate Explorer (nemac.org)**)**

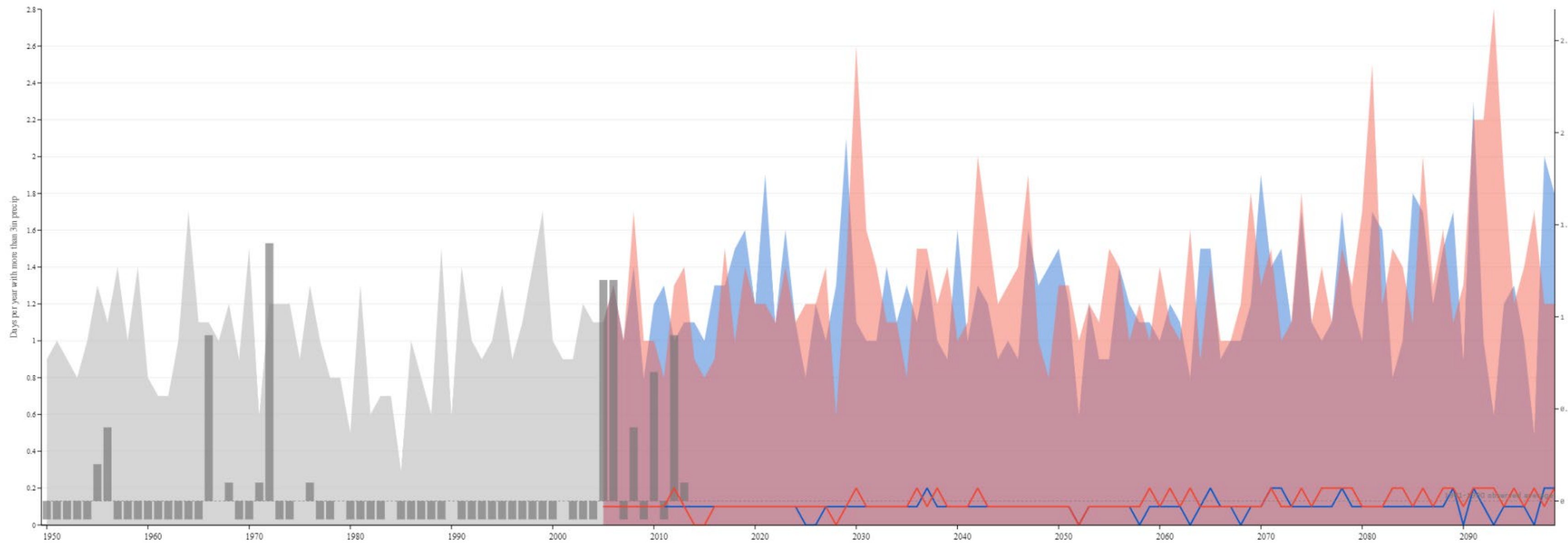


Figure 8-3 Days with >3" precipitation climate predictions (for full-scale images please visit: Climate Explorer (nemac.org)**)**

8.2 Conduct differential carbon footprint analysis of managed wetland, hybrid wetland – open water, and full dredge options.

There is a fair amount of confusion and misunderstanding regarding the role of wetlands on greenhouse gas emissions and carbon footprints. USGS reports from a decade ago suggested that wetlands were net emitters of greenhouse gases. While those studies were based on the best information at the time, they were based on modeling studies using older models and assumptions. There have been quite a few studies in the last decade that show that wetlands are as important as forests for landscape sequestration (see reference below).

Were, D., Kansiime, F., Fetahi, T., Cooper, A. and Jjuuko, C., 2019. Carbon sequestration by wetlands: a critical review of enhancement measures for climate change mitigation. Earth Systems and Environment, 3, pp.327-340) **https://www.researchgate.net/profile/Tadesse-Fetahi/publication/332623431_Carbon_Sequestration_by_Wetlands_A_Critical_Review_of_Enhancement_Measures_for_Climate_Change_Mitigation/links/5fff02c9299bf14088924875/Carbon-Sequestration-by-Wetlands-A-Critical-Review-of-Enhancement-Measures-for-Climate-Change-Mitigation.pdf**

In general terms, carbon entering a lake or wetland is either consumed by microbes to generate greenhouse gases (carbon dioxide, nitrous oxide, or methane) or buried in deep sediments. If the carbon is converted to greenhouse gases, they typically escape to the atmosphere where they contribute to climate change. However, they can also be transformed by other microbes to less potent forms (i.e., carbon dioxide) or trapped within the sediment by rapid burial. The key to permanent carbon sequestration in a system like the Accotink Creek/Lake/Wetland is to bury the carbon deep enough that microbes cannot readily generate greenhouse gasses or that generated greenhouse gasses cannot escape to the surface before they are trapped or transformed by soil microbes.

As described in the paper by Were et. al., wetlands are generally successful in sequestering carbon. Delta deposits, such as the one at the upstream end of Lake Accotink, can also do a good job sequestering carbon because they tend to deposit surface sediment relatively deep.

Due to the high deposition rates, Lake Accotink itself may sequester carbon; however, the fossil fuels burned during the dredging and the act of pulling carbon deposits back up to the surface likely severely diminish the benefits.