Highland Lake Dredging Feasibility Study

Final Report, September 2015

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Executive Summary

Tetra Tech conducted a feasibility study to evaluate dredging and disposal options for Highland Lake. The study focused on Brasher Creek Bay and Sand Creek Bay, with the goal of improving recreational access in these areas. Both of these bays were dredged in or around 2000, but have since undergone sedimentation such that portions of the bays are less than two feet deep, making boat access difficult. The Highland Lake hydrographic survey conducted by Tetra Tech in 2014 was used to define the areas in need of dredging, and to estimate dredge volumes.

As part of this feasibility study, sediment samples were collected and analyzed to characterize the dredge material and inform decisions on dredging and disposal methods. Also, potential upland disposal sites adjacent to the lake were visited and evaluated with respect to capacity, current use, access, and other site constraints.

Different combinations of dredging and disposal options were evaluated for feasibility and cost. Dredging methods that were evaluated include mechanical and hydraulic dredging. Disposal options that were evaluated include open water disposal, upland disposal, and in-water land creation. The recommended plan, which is the most cost-effective option, includes mechanical dredging of Sand Creek Bay and Brasher Creek Bay, with open water disposal in nearby areas of the lake that are approximately 20 feet in depth. Dredging both bays in a single effort provides significant cost savings over dredging the two bays over two separate efforts.

The recommended option will require an Individual Section 404 permit from the U.S. Army Corps of Engineers (USACE). It will also require state water quality certification, which will be issued in conjunction with the USACE Section 404 permitting process. If proposed activities result in land disturbance equal to or greater than one acre, the project will also require a construction general permit from the Alabama Department of Environmental Management (ADEM).

1 Introduction

Highland Lake, managed by the town of Highland Lake, Alabama, has been undergoing sedimentation in several locations throughout the lake. This sedimentation has impacted recreation by limiting access to shallow areas, in particular near the marina at Brasher Creek Bay and in Sand Creek Bay. These two areas were previously surveyed and dredged in or about 2000. In 2014, Tetra Tech conducted a lake-wide hydrographic survey to create baseline bathymetry and to locate areas potentially impacted by sedimentation. The survey included intensive hydrographic surveys of the two bays to evaluate sediment impacts. The results of the survey are presented in the *Highland Lake Bathymetric Survey Final Report* (Appendix A).

The town of Highland Lake wishes to maintain boating access in the two bays and is considering dredging efforts that will provide a water depth to accommodate this access. This feasibility study assesses the environmental, engineering, and cost components that influence project feasibility for the purpose of recommending the most viable solution. Subtasks include: sediment characterization; evaluation of dredging, dewatering, and disposal options; a preliminary dredge plan; dredging cost estimate; and determination of necessary permits.

2 2014 Bathymetric Survey

The bathymetric survey conducted in 2014 used a single-beam sonar. Approximately 180,000 depth soundings were collected throughout the lake, with the two bays of Brasher and Sand Creeks surveyed at a higher density than the main lake body. The depth soundings were then processed into a Digital Terrain Model (DTM) of the lake bed. The DTM was then used to generate a depth contour map of each bay and of the entire lake. The 2014 bathymetric map showing the location of the bays within Highland Lake is shown in Figure 1. Bathymetric maps showing depth contours for Brasher Creek Bay and Sand Creek Bay are shown in Figure 2 and Figure 3, respectively.

The 2014 survey revealed that Highland Lake is over 50 feet deep in the deepest areas, and is shallowest on the North End and in the Long Hollow, Sand Creek, and Brasher Creek embayments. Sand Creek Bay and Brasher Creek Bay have filled in with sediment since they were last dredged in 2000. Though they have not filled in to the extent that was evident in the 2000 survey, both bays have experienced an increase in bed elevations that is impacting boating access. The central part of Brasher Creek Bay and the central and north-central areas of Sand Creek Bay have each undergone a 1 to 3 foot increase in bed elevation (sedimentation) since 2000.

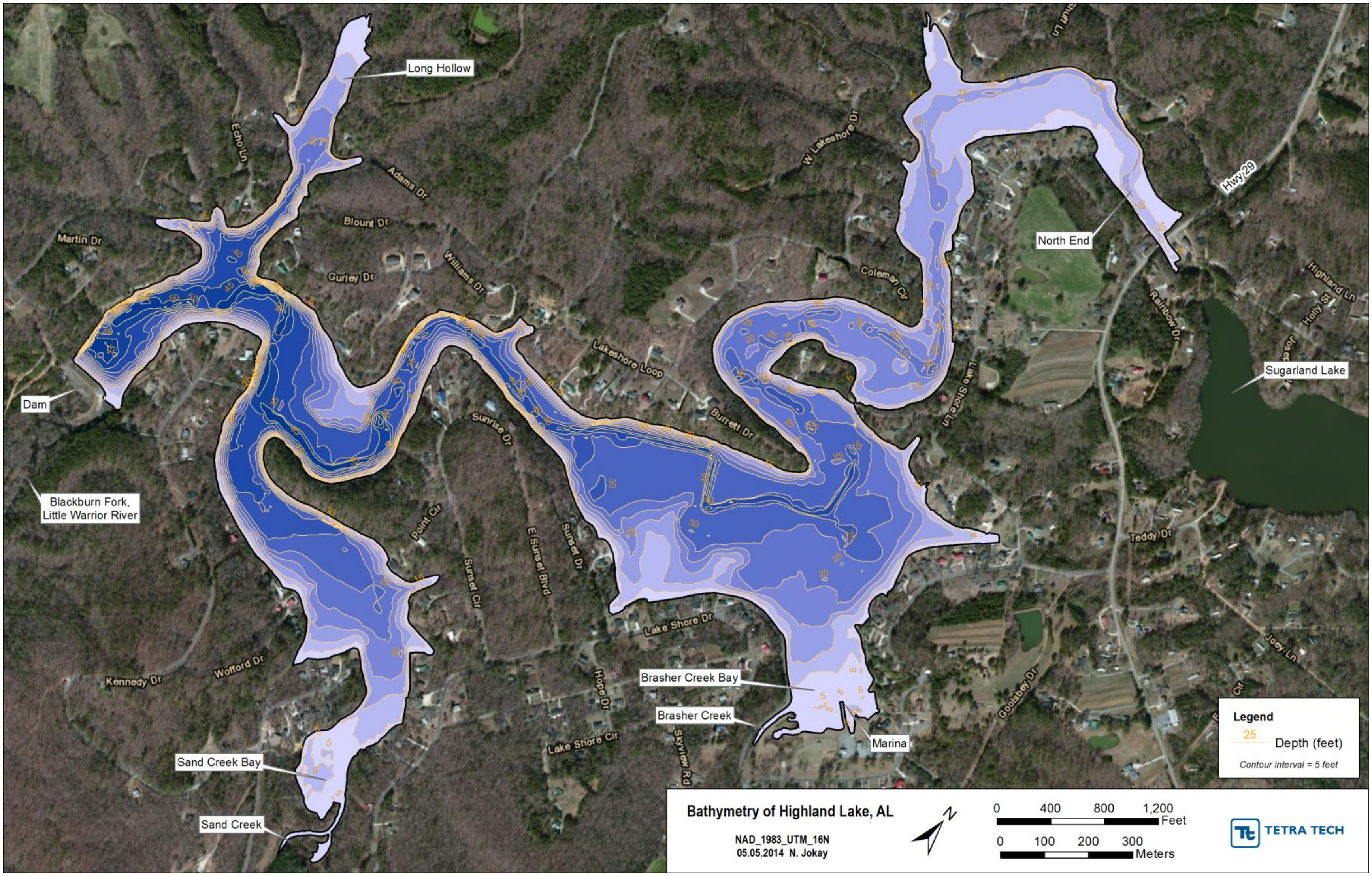

Figure 1. Location map showing 2014 bathymetry.

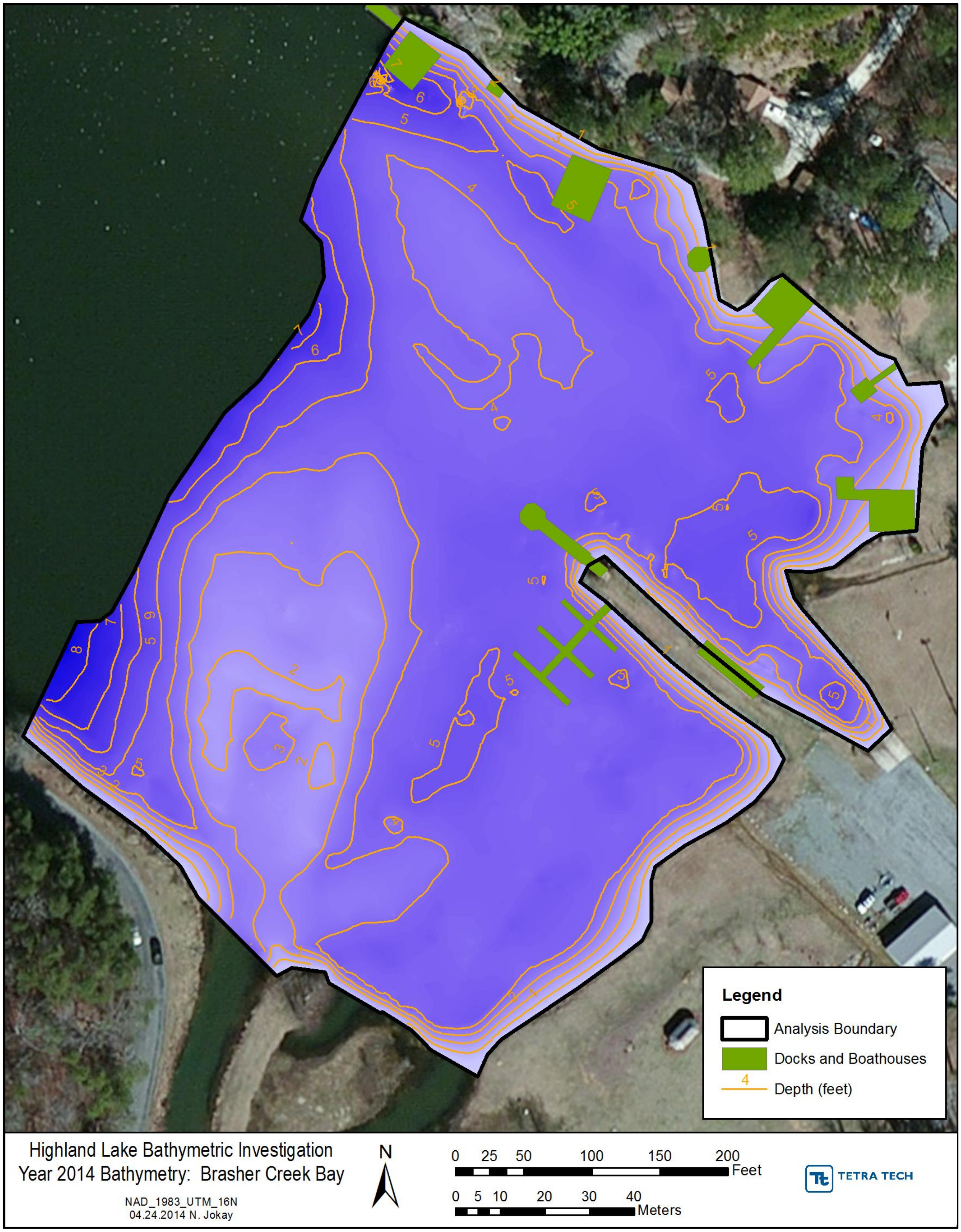

Figure 2. Brasher Creek Bay bathymetry surveyed in March 2014.

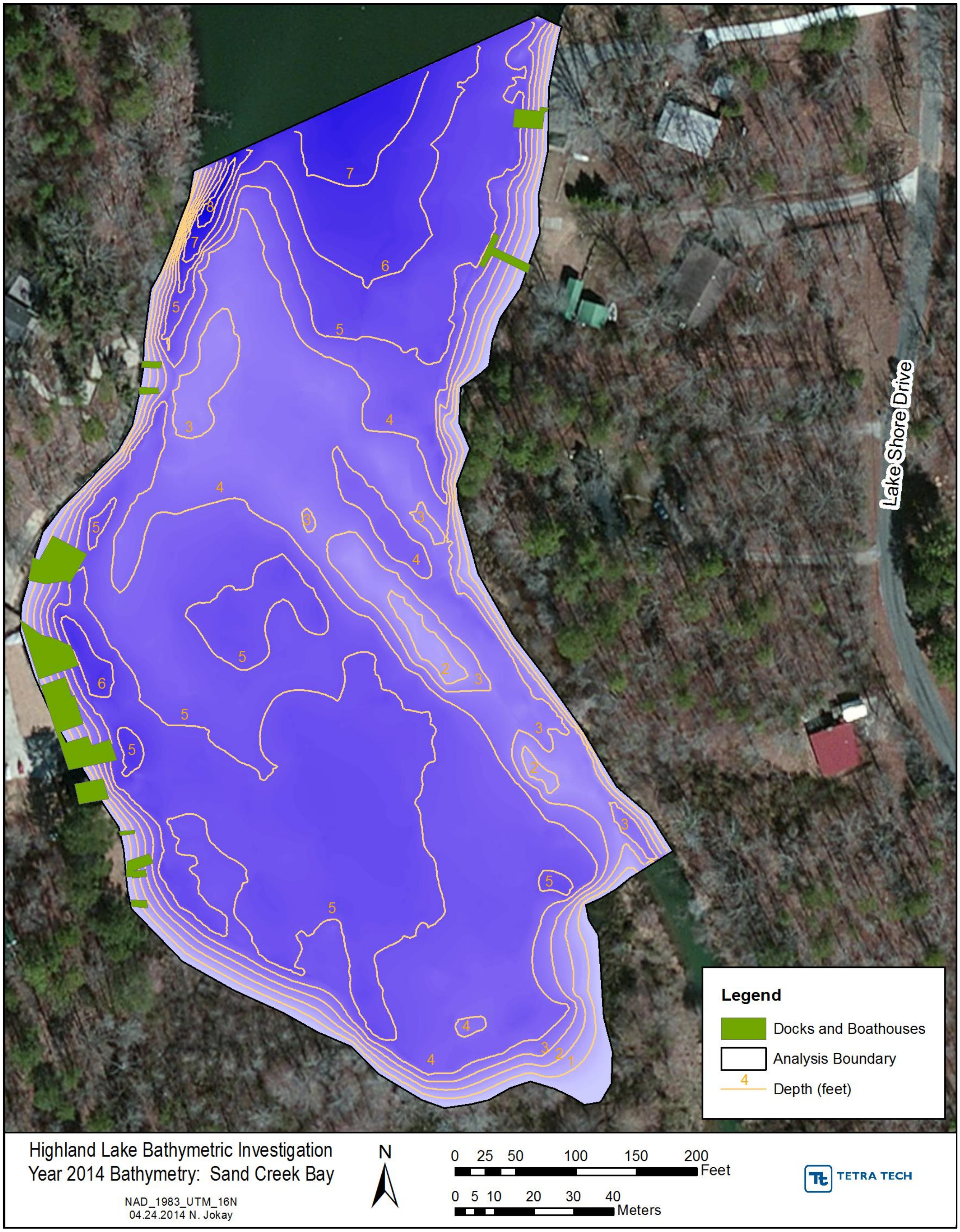

Figure 3. Sand Creek Bay bathymetry surveyed in March 2014.

3 Proposed Dredge Areas

Proposed dredge areas are shown in Figure 4 for Brasher Creek Bay and in Figure 5 for Sand Creek Bay, including the water depths in each of the dredge areas. These dredge areas were selected for evaluation in this feasibility study by the Town of Highland Lake based on the results of the 2014 hydrographic survey.

Two dredge areas are proposed in Brasher Creek Bay:

- A channel that extends north/northwest from the mouth of Brasher Creek to the present 7-foot depth (approximately 0.31 acres).
- An area around the marina that includes access to boat ramp, the boat docks on the west side of the peninsula, and an area extending northward to the present 7-foot depth (approximately 1.51 acres).

One dredge area is proposed in Sand Creek Bay:

- An area from the mouth of Sand Creek across the bay that is less than 4-feet deep out to the present 5-foot depth (approximately 1.13 acres).

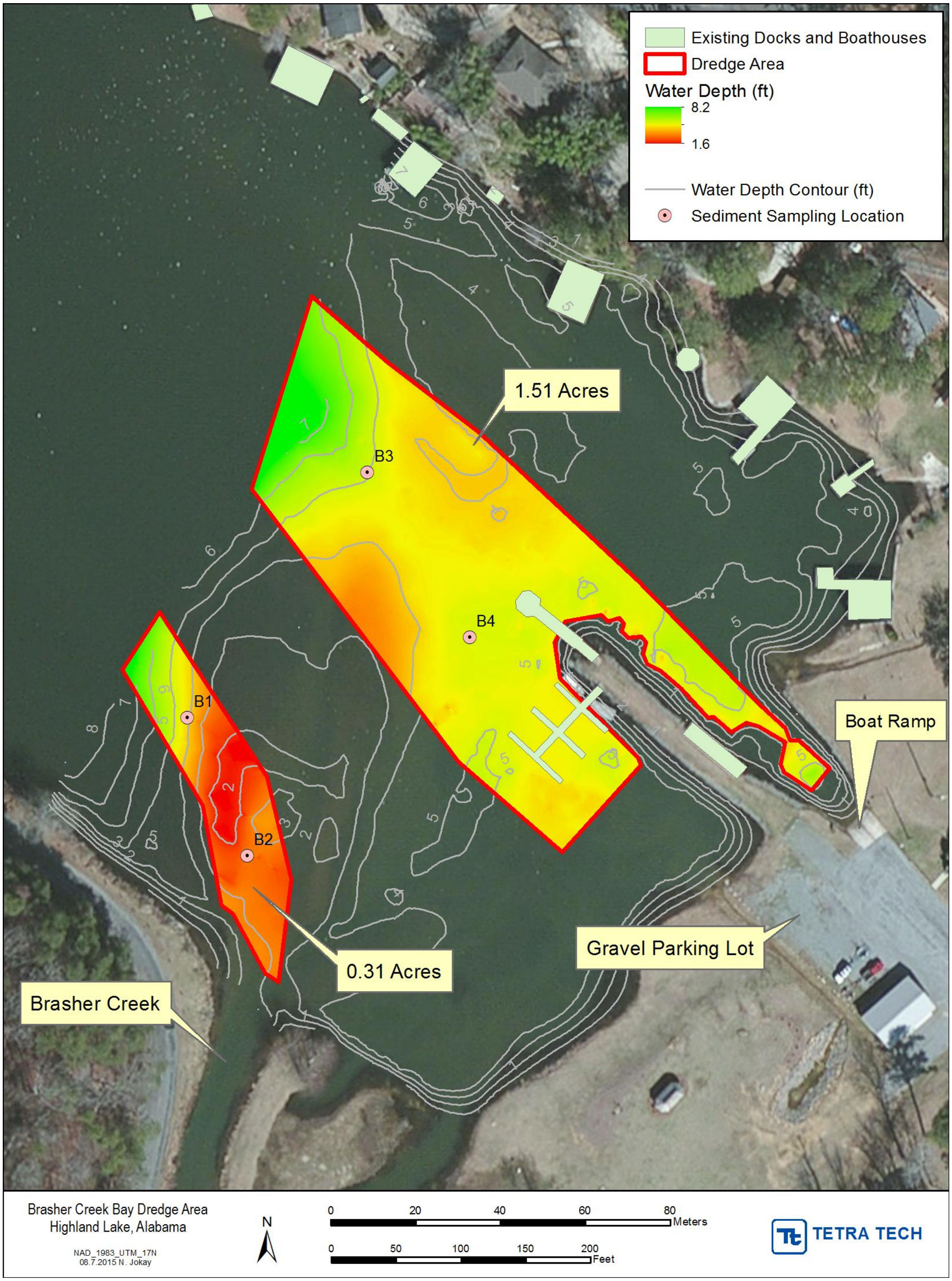

Figure 4. Proposed dredge areas in Brasher Creek Bay

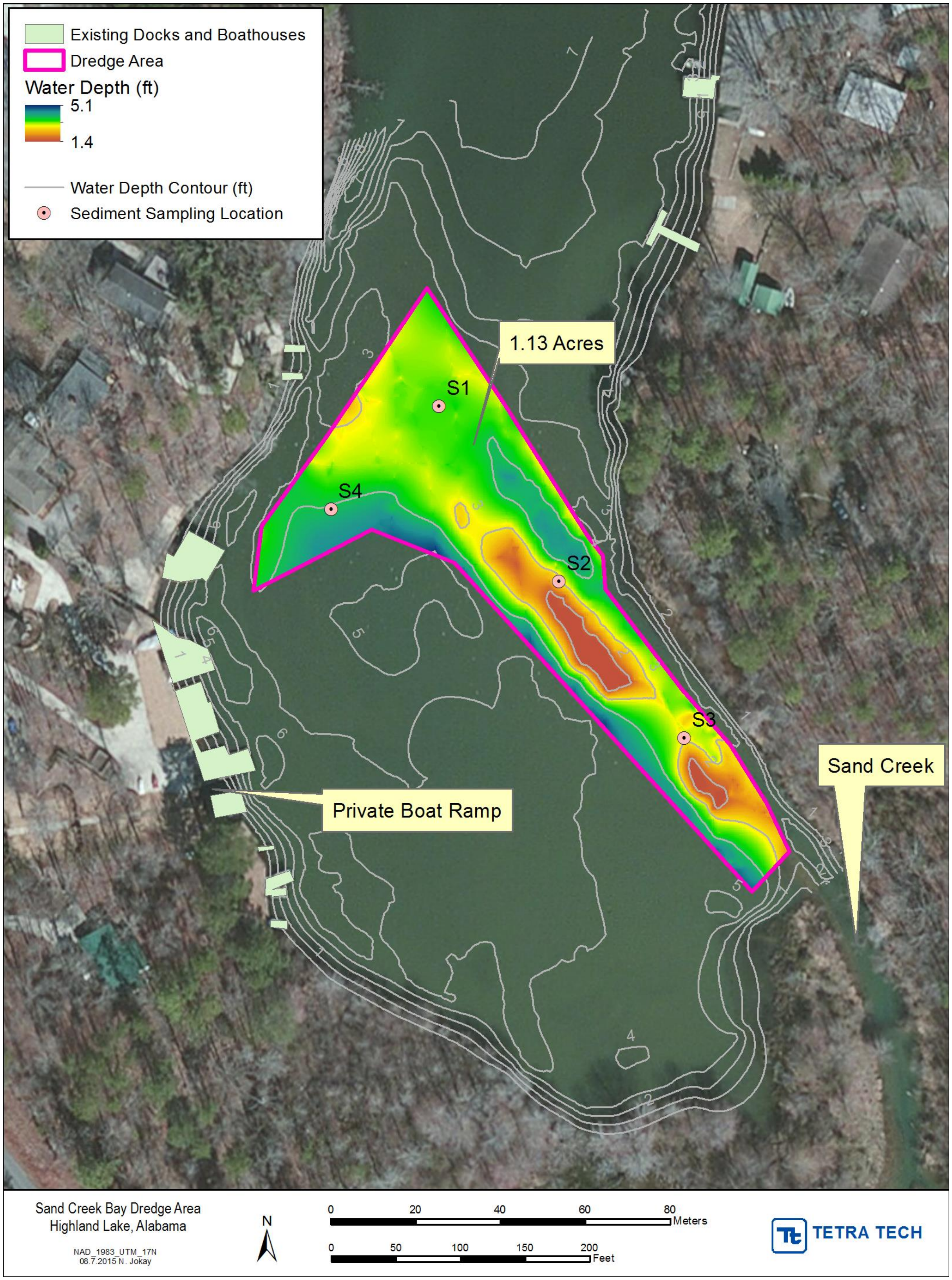

Figure 5. Proposed dredge areas in Sand Creek Bay

4 Sediment Volumes

4.1 Brasher Creek Bay Sediment Volume

The sediment thicknesses in Brasher Creek Bay range from 2.8 to 10 feet with an average of 6.6 feet. The 2014 DTM was used to calculate the volume (cubic yards [cy])of sediment above a given depth surface across the proposed Brasher Creek dredge areas outlined in red in Figure 4. This calculation was made in 1 foot depth increments from 2 to 10 feet, and is shown in Table 1.

Table 1. Sediment volumes in proposed dredge areas in Brasher Creek Bay.

Depth Plane	Sediment Volume Above Depth Plane (cy)
2 feet	10
3 feet	160
4 feet	580
5 feet	1900
6 feet	4100
7 feet	6400
8 feet	8600
9 feet	10700
10 feet	12700

4.2 Sand Creek Bay Sediment Volume

Sediment thicknesses in Sand Creek Bay range from 2.8 to 9.5 feet with an average of 6.2 feet. The 2014 DTM was used to calculate the volume of sediment above a given depth surface across the proposed Sand Creek dredge area outlined in purple in Figure 5. This calculation was made in 1 foot depth increments from 2 to 10 feet, and is shown in Table 2.

Table 2. Sediment volumes in proposed dredge areas in Sand Creek Bay.

Depth Plane	Sediment Volume Above Depth Plane (cy)
2 feet	16
3 feet	200
4 feet	1100
5 feet	2800
6 feet	4500
7 feet	6000
8 feet	7300
9 feet	8400
10 feet	9400

4.3 Total Dredge Volume

The main purpose of dredging these bays is to improve access for boats, and to provide sufficient depth such that the access is maintained for several years. Representative water depths within Brasher Creek and Sand Creek Bays are 5-6 feet. The proposed dredging plan should remove the shoal material down to a level comparable to the representative water depths in the area. Common dredging practice is to also include an “advanced maintenance” component to the dredging plan. The additional dredging in the advanced maintenance component prolongs the interval between dredging by allowing sedimentation to occur for a reasonable period of time without affecting the targeted navigational depth. If sediment is removed from the proposed dredge areas to a depth of 7 feet, the total volume of dredge material would be 12,400 CY. This total volume consists of 6,400 CY from Brasher Creek Bay and 6,000 CY from Sand Creek Bay.

5 Sediment Characterization

In this report the term “sediment” refers to the sand, silt and clay deposits as they exist at the bottom the Highland Lake. The term “dredged material” refers to the sediment and water slurry that develops when the sediment deposits are physically modified by the dredging operation. The distinction is important because the characteristics of the two materials may differ significantly.

Tetra Tech collected sediment samples from four locations in Brasher Creek Bay and four locations in Sand Creek Bay. Figures 4 and 5 show the sediment sampling locations. Tetra Tech scientists combined the individual sediment samples into one composite sample for each bay then shipped the samples to our geotechnical laboratory in Orlando, Florida. The two composite samples were analyzed to determine the sediment particle size distribution by mechanical sieve and hydrometer using standard geotechnical testing methodology[1] .

The particle size test reports showing the distribution curves for the Brasher Creek Bay and Sand Creek Bay are provided in Appendix B. The results indicate that the sediments in the two bays are generally similar; both have a median grain size (D_{50}) of about 0.15 mm. The laboratory testing classifies both sediment samples as brown silty fine sands with organics.

The silt and clay fraction of sediments is important because it directly relates to turbidity issues when the sediment is disturbed. A large silt and clay fraction may also affect the time it takes to dewater the dredged material. A final distinction is that many contaminants preferentially adhere to the soil particle surfaces < .08 millimeters (silt size particles).

The Brasher Creek Bay sediments have a higher silt/clay fraction than Sand Creek Bay sediments. About 29.0% of the Brasher Creek Bay sediment is silt/clay compared to a 25.2% silt/clay fraction for the Sand Creek Bay sediments. Table 3 provides a summary of the particle size characteristics of each bay.

Table 3. Sediment Particle Size Characteristics

Sediment Size	Brasher Creek Bay Sediments	Sand Creek Bay Sediments
Median, $D_{50,}$ (mm)	0.15	0.15
Sand (%)	71.0	74.8
Silt (%)	18.7	15.2
Clay (%)	10.3	10.0

Additional sediment characterization testing described in the following dewatering section determined that that sediments have the physical geotechnical characteristics as listed in Table 4.

[1] ASTM D422-63(2007)e2, Standard Test Method for Particle-Size Analysis of Soils, ASTM International, West Conshohocken, PA, 2007, URL: www.astm.org

Table 4. Sediment Geotechnical Characteristics

Parameter	Parameter Value
Solids Content (%)[1]	55.57
Water Content (%)[2]	78.7
Unit Weight (lb/ft^3)[2]	96.3
Dry Unit Weight (lb/ft^3)[2]	53.9
Void Ratio[2]	2.13

Notes:

1. Laboratory test result using EPA approved Standard Method 2540B[2] for total solids dried at 103-105 C^0.
2. Value derived from test result

One common technique for the management and dewatering of dredged material consists of the use of geotextile filter fabric tubes combined with polymer additives. The dredge material is placed or pumped into the tubes where the polymer additives act to aggregate the silt/clay particles into larger particles. The larger particles can then be retained by the geotextile filter fabric material while the excess water freely drains out. Many geotextile fabric manufacturers provide complementary bench scale performance testing of their fabric with a range of polymers. Tetra Tech shipped sediment and site water samples to AquaMark, Inc. in Newbury, Ohio for bench scale testing using the cone test. Appendix C provides the Cone test results.

The cone test consists of preparing a solution of 1 liter of sediment with 2 liters of water, to simulate a hydraulic dredging slurry, and a polymer additive. The solution is then poured into geotextile filter fabric cone to be filtered. Measurement of the amount of water that filters through the geotextile fabric cone in a given period of time determines the efficiency of the polymer additive. The laboratory analysis includes various combinations fabric type, and polymer dosage to determine the proper combination to produce the optimum filtration. The laboratory test reports the solids content of the residual dredged material remaining in the geotextile fabric cone. Table 5 presents the results of the cone test.

Table 5. Geotextile Fabric Cone Test Results

Polymer/Concentration	Total Solids (%)
Untreated Sediment	55.57
AQ 590 @ 70 ppm	60.75
AQ 587 @ 70 ppm	66.99
AQ 584 @ 70 ppm	63.74

[2] Standard Methods, 1997, Solids, URL: http://www.standardmethods.org/store/ProductView.cfm?ProductID=63

Table 5 shows the untreated sediment with a total solids value of 55.57%. All of the polymer additives achieved higher total solids values indicating that they were able to remove water from the simulated dredged material slurry. Polymer additive AQ 587 achieved the best results with a total solids value of 66.99%. This is equivalent to reducing the water content of the natural sediment at 78.7 % to a value of 51.2% after polymer addition and geotextile fabric filtration.

Table 6 provides a comparison of the natural sediment characteristics and the treated dredged material characteristics.

Table 6. Sediment and Treated Dredged Material Geotechnical Characteristics

Parameter	In-place Sediment Values	Dredged Material Values
Solids Content (%)	55.57	66.99
Water Content (%)	78.7	51.2
Unit Weight (lb/ft^3)	96.3	107.0
Dry Unit Weight (lb/ft^3)	53.9	70.8
Void Ratio	2.13	1.38

The polymer AQ 587 is a cationic polyacrylamide coagulation and flocculation agent that is on the National Science Foundation list of drinking water treatment chemicals[3]. It is a polymer widely used in geotextile tube dewatering applications. Appendix D provides the Material Safety Data Sheet (MSDS) that includes toxicity information for aquatic species.

[3] National Science Foundation International, 2015. NSF/ANSI 60 Drinking Water Treatment Chemicals – Health Effects, URL: http://info.nsf.org/Certified/PwsChemicals/Listings.asp?Company=C0076031

6 Dredging and Sediment Disposition

6.1 Dredging Methods

Hydraulic Dredging - The two general techniques of dredging include hydraulic and mechanical dredging. Hydraulic dredging utilizes a pumping system that draws in water and sediment through a suction head that sweeps the bottom much like a vacuum cleaner. Hydraulic dredges of the size that can perform the proposed work are truck-transportable and can mobilize to Highland Lake with relative ease.

The fine grain size sediments that occur in the project area are amenable to hydraulic dredging techniques. In typical hydraulic dredging operations, the dredged material slurry mixture of water and sediment is pumped at a level of about 13% solids.

Hydraulic dredging can transport the dredged material significant distances away from the dredging site since the slurry is a fluid material. The diameter of the discharge pipeline is the typical descriptor of the size of a hydraulic dredge. Usually a small to moderate size dredge with a discharge pipe diameter of 6 to 8 inches can pump the dredge slurry up to a mile. The addition of booster pumps along the length of the discharge pipeline can increase the total transport distance. A dredged material management area (DMMA) is required to receive the dredged material from the discharge pipeline to allow for dewatering of the material. The DMMA may be a temporary area where the excess water is allowed to drain from the dredged material until it reaches a water content that allows it to be handled and moved to a final disposition site. It may also be both the temporary dewatering and the final disposition site.

As discussed in Section 0, enhanced dewatering techniques can treat the hydraulically dredged material slurry to reduce its water content and volume thereby reducing the space requirements and costs associated with transportation and ultimate disposition of the dredged material. Dewatering techniques include polymer addition with filtration through geotextile tubes and mechanical dewatering. Mechanical dewatering involves an array of treatment steps similar to wastewater treatment including separators, clarifiers and filter press units. Enhanced dewatering techniques become increasingly more cost effective as the percent of fine particle size material in the sediment increases.

Mechanical Dredging - Mechanical dredging uses conventional excavation equipment such as clamshell and dragline buckets operated by barge mounted cranes to remove sediments. Where turbidity and contaminant re-suspension are concerns, environmental buckets can be used. Environmental buckets are variations of clamshell buckets that fully seal to minimize the loss of sediment/water when the bucket is raised.

The dredged material is typically placed into a second barge that can shuttle back and forth between the dredging site and the DMMA where the barge can be unloaded. At the DMMA the dredged material can be dewatered and subsequently transferred to trucks for transport to its ultimate beneficial reuse or disposal site.

Mechanical dredging removes the sediment at its in-place water content with some additional water being added due to the agitation of sediment particles during the dredging operation. This results in a dredged material with a significantly thicker consistency than that which results from hydraulic dredging. Depending on the actual sediment characteristics, mechanically-dredged material may be suitable for direct placement into trucks or transport containers without the additional dewatering step. The thicker consistency, the lower dredged material volume and possible reduced processing/handling may provide some economical and/or time advantages over hydraulic dredging.

Mechanical dredging systems require that transfer facilities be relatively close to the dredge site to minimize the time and expense of transferring the dredged material from the dredging site to the handling/truck loading site. The shoreline transfer site also needs to have direct access to water that is deep enough water to accommodate a fully loaded barge (approximately five feet in depth).

Access to the site may be a problem for mechanical dredging equipment. Barge units large enough to support a crane or to receive dredged material are generally too large to be transported by truck. Sectional barges are modules on the order of 8 ft by 8 ft by 4 ft deep that are truck transportable. They can be joined together to create larger units if any desired size. Sectional barge units can overcome the access problem but they are mostly used by specialty contractors and their use can add a significant increment to the project cost.

Comparative Dredged Material Volumes – Each of the dredging techniques results in different dredged material characteristics. This is principally due to the amount of water that is added to the sediment by its agitation of the dredging techniques. Table 7 compares the sediment/dredged material characteristics for the proposed total Brasher Creek Bay and Sand Creek Bay dredging case scenarios.

Table 7. Sediment and Treated Dredged Material Geotechnical Characteristics

Parameter	In-place Sediment	Mechanically Dredged Material[1]	Hydraulically Dredged Material	Dewatered Dredged Material[3]
Solids Content (%)[1]	55.57	51.8	13.0	66.99
Water Content (%)[2]	78.7	93.0	668.1	49.1
Unit Weight (lb/ft^3)[2]	96.3	94.3	69.6	108.0
Dry Unit Weight (lb/ft^3)[2]	53.9	48.9	9.1	72.5
Void Ratio[2]	2.13	2.44	17.59	1.32
Volume (cy)	12,400	13,670	73,450	9,220

Notes:

1) Mechanical dredging adds an assumed 10% water by volume
2) Hydraulic dredging adds an assumed 2 parts of water to 1 part of sediment by volume
3) Dewatering of hydraulically dredged material involves polymer addition and filtration in geotextile tubes.

6.2 Dredged Material Management

Some of the principal physical constraints on dredging in Highland Lake are the limitations associated with upland and in-water disposal/reuse options. Disposal option areas include:

1. Upland disposal sites
    a. 1.2 acres at the disposal site used in 2000 (Sand Creek Bay)
    b. 0.8 acres at Pat Bellew Park (Brasher Creek Bay)
2. Open water disposal sites
    a. 4.7 acres approximately 1,000 feet from the Brasher Creek Bay dredging area
    b. 4.4 acres approximately 1,500 feet from the sand Creek Bay dredging area
3. In water land creation
    a. Extension of right bank of Brasher Creek to create a peninsula

The following paragraphs discuss the features and limitations of these options.

6.2.1 Upland Disposal Sites

Sand Creek Bay Upland Disposal Area

The 2000 disposal site at Sand Creek includes two potential areas of 0.61 acres each. A small, potential wetland area of about 0.14 acres lies between these two areas. Figure 10 shows the potential Sand Creek disposal area. The regulatory status of the isolated wetland is unclear at this time, and would need to be confirmed through a site visit by the USACE. If the wetland is not under the USACOE jurisdiction, or if the portion that would need to be impacted (filled) is under 0.1 acres, then consolidation of the individual areas may be possible to yield an overall site area of about 1.4 acres.

The ground elevation on the west side of the 2000 disposal site at Sand Creek Bay increases in elevation towards Lake Shore Drive. It may be possible to take advantage of the topography and design the confinement facility to tie into the site grade such that only three sides of the facility would need to have dikes.

U.S. Army Corps of Engineers[4] guidance for the design and operation of diked disposal facilities for hydraulically dredged materials provides procedures to calculate the minimum settling pond surface area. The minimum settling pond surface area is about 0.6 acres, assuming a small dredge with a 6 inch discharge pipe and a flow rate of 2.9 cubic feet/second (cfs) as well as a representative zone settling velocity. Larger dredges (discharge pipe diameters of 8 inches or more) would require an area that is larger than the Sand Creek Bay site.

[4] US Army Corps of Engineers, 1987. Confined Disposal of Dredged Material, Engineer Manual EM 1110-2-5027, 30 September 1987

The small size of the available upland disposal site makes conventional earthen dike containment very inefficient. A large portion of the available area would be taken up by the dike footprint. There are various bin type products available that allow dikes to be safely built with vertical walls that minimize the dike footprint. One such product consists of a multicellular structure with side walls comprised of twisted wire mesh and internally lined with geotextile fabric (see Figure 6 – Maccaferri FlexMac© DT). The structure is open on the top and bottom to allow easy filling with earth to create the containment dike. The open bottom of the units allow them to be dismantled by lifting and allowing the bin fill material to simply spill out of the bottom. A bin type wall on the containment area is recommend as a means to optimize storage capacity if hydraulic dredging and diked containment are selected as a dredging methodology. Figure 7 is a sketch of the proposed bin wall dike section.

Figure 6. Representative fillable bin type product

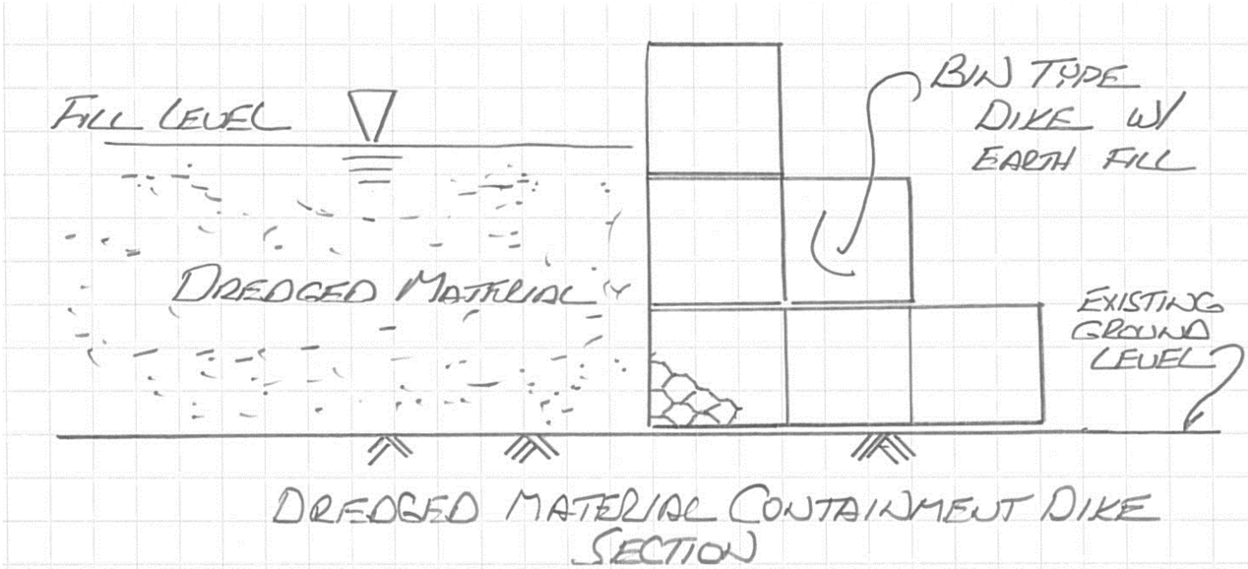

Figure 7. Dredged material containment dike section

The sediments proposed for dredging contain a relatively high silt/clay fraction. Additional testing in the form of a column settling test and a slurry consolidation test would be required for the design of a diked dredged material management area. Table 7 includes the expected initial dredged material volumes that would be produced by the various dredging and treatment options. Without the benefit of the additional testing, it appears that the high volume of dredged material slurry resulting from a hydraulic dredging operation of both bays would make a diked disposal area at Sand Creek unfeasible.

Geotextile tubes provide an additional means to contain dredged materials on upland disposal sites. Complementary testing at AquaMark, Inc. and recommendations by Maccaferri, USA, indicate that polymer additives and filtration/containment of the dredged material can quickly drain the dredged material to the smallest residual volume (see Table 7) of the various dredging techniques. The dredged material discharged from the hydraulic dredge would be pumped into large diameter geotextile tubes that are up to 200 ft in length. Table 8 provides the sizes and capacities of geotextile tubes that could be used.

Table 8. Geotextile Tube Sizes and Capacities

Tube Circumference (ft)	Tube Filled Height (ft)	Tube Filled Base Width (ft)	Tube Filled Volume (cy/lin ft)	Required Tube Length[1] (ft)
30	4	13.1	1.67	7500
45	6	19.6	3.73	3500
60	8	26.2	6.65	2000

Notes:

1) Based upon a total Brasher Creek Bay-Sand Creek Bay sediment volume of 12,400 CY.

The area required for geotextile tube containment of the proposed total dredged material volume using the 60 ft circumference tubes is about 1.37 acres assuming one layer of tubing filled to a height of 8 ft. If the consolidation of the sites at Sand Creek Bay is possible, then this site could accommodate all of the dredged material volume from both bays in a single layer of 60 ft circumference geotextile tubes filled to a height of 8 ft.

The use of different dredging techniques at the two dredging areas would add considerable costs to the overall dredging program, so the most practical and cost effective option for the project as a whole should be selected for the dredging methodology in both bays.

Pat Bellew Park

Pat Bellew Park has the potential to serve as an upland disposal site for the dredged material from Brasher Creek Bay. The park site has the advantage of being town property, being close to the dredging area, and having a previous use for dredged material storage. However, the site is limited in available space. In addition, the site is developed as a park and there may be public opposition to the temporary loss of that amenity during the execution of the dredging program.

Using a 0.8 acre footprint, the area outlined in Figure 11 can hold about 1,300 cubic yards of dredged material for each foot of dredged material thickness. Hydraulic dredging would allow the use of geotextile tubes for dewatering and disposal. Stacking two layers of geotextile tubes (described in the Sank Creek upland disposal section) would allow the containment of all of the estimated volume within the limits of the 0.8 acre site at Pat Bellew Park. However, the large volume of dredged material slurry that results with hydraulic dredging is well beyond what could be accommodated at Pat Bellew Park. Therefore hydraulic dredging with disposal at the park site is unfeasible.

A mechanical dredging technique is not a preferred method if the Pat Bellew site is the dredged material disposal site. The site lacks adjacent deep water access necessary to support barge operations. Excavation of a barge access area would be required, using equipment operating on land at the park site. This option is not cost effective, and would impact public use activities in and around the park.

6.2.2 Open Water Disposal Sites

Portions of Highland Lake that are greater than 20 feet deep are potential open water disposal sites. Figure 11 and Figure 12 show potential disposal areas that are within 1,500 feet of the Sand Creek Bay and Brasher Creek Bay dredging areas. The relatively large footprints of these areas together with their depth provide more than enough capacity to handle the proposed dredging volumes. The capacity of the Brasher Creek Bay site is 8,000 cy of dredged material per foot deposit thickness. The capacity of the Sand Creek Bay site is 7,000 cy of dredged material per foot of deposit thickness. These disposal areas were selected for their proximity to the dredge areas. The size, shape, and exact location of these disposal areas can be adjusted in the final dredging and disposal plan.

The percentage of fine material in the sediments presents a potential turbidity concern for the open water disposal options. Brasher Creek Bay sediments contain 29% of silt and clay. While Sand Creek Bay sediments contain 25.2%. Pumping of hydraulically dredged material directly to these offshore disposal sites has the potential to create turbidity plumes at and in the vicinity of the sites.

Direct placement of mechanically dredged material would also have turbidity issues. However, the smaller volumes of mechanically dredged material as well as its denser condition than the hydraulic dredging slurries would create less turbidity than hydraulic dredging. It is also possible to use an environmental bucket that completely seals once it is closed. This prevents the movement of suspended dredged materials off of the bucket as it moves through the water column. The environmental bucket could place the dredged material close to the bottom to reduce turbidity during placement.

Use of the polymer-geotextile tube treatment technique could potentially reduce turbidity conditions to acceptable levels if applied at open water disposal sites. Quiet lake conditions and relatively shallow water depths make diver-assisted placement and filling of the geotextile tubes feasible. The polymer additives and the geotextile filtration of the effluent may also reduce turbidity to acceptable levels (50 NTUs above background levels).

Placing dredged material form the bays into deeper water is not expected to have any notable negative environmental consequences. The sediment is believed to be clean and uncontaminated. The disposal area footprint is small compared to the total surface area of the lake, and the sediment from the bays is likely similar in nature to that of deeper water areas, and is therefore not expected to change the quality of aquatic habitat. Also, the total volume of dredge material is only 0.16% of the total lake volume, so placing this material in deep water, rather than removing it from the lake will have a negligible effect on lake volume.

6.2.3 In Water Land Creation

The in water land creation dredged material use option presents similar turbidity related issues as does the open water disposal option. The percentage of fine sands, silts, and clay particle size material will result in turbidity plumes during placement in the water. The shallow water placement will also contribute to high visibility of the turbidity plumes. Silt screens floating at the surface can help to limit the extent of the plumes in the upper water column.

Over the long-term, the high percentage of fines will also contribute to the erosion of the created land features under wave and current action. The design of the created land features will therefore require stabilization along the perimeter of any created land. This can be in the form of riprap or bulkheads.

Geotextile tubes may also serve to contain the dredged material and stabilize the resulting land feature against long term erosion. However, it will be necessary to cover exposed segments of the tubes to prevent UV radiation damage. This would likely involve covering the tubes with riprap or a similar stabilization treatment.

The in-water disposal option in Brasher Creek Bay includes extending the right bank of Brasher Creek into a peninsula where Brasher Creek discharges into the Bay. Figure 11 shows the plan view of the proposed land creation. It extends out into the bay in a northerly direction and then curves to the northwest to run parallel to and be offset by about 90 feet from the western shore of the bay. The proposed peninsula is 100 feet wide and has a centerline length of 480 feet. At its offshore end the existing water depth is about 20 feet. It has a surface area of about 1.1 acres. Using multiple layers of filled geotextile tubes at the offshore end and reducing the stacking to a single layer at the nearshore end would provide a system that contains all of the dredged material from Brasher Creek and Sand Creek Bay dredging areas.

The peninsula extension would serve two separate purposes. First, it would address the question of where to put the dredged material. Second, it would assist in maintaining the discharge velocity from Brasher Creek and help to direct the flow and its sediment load away from the current shoaling location, and toward deeper water where it will have a reduced impact in recreational navigation.

The upper portions of the geotextile tubes would need to be protected from UV radiation impact damage. A riprap shoreline treatment or a marine mattress alternative treatment with aquatic vegetation plantings would provide the required protection. A cover layer of soil and grass would provide protection for the top surfaces of the geotextile tubes. A portion of the peninsula might include a run of about 100 feet of sheet pile bulkhead. This would provide an area for boat access/docking on the peninsula. Figure 7 shows a cross section of the proposed peninsula with the upper surface protection elements. Figure 8 shows an example of the placement of marine mattress units on filled geotextile tubes.

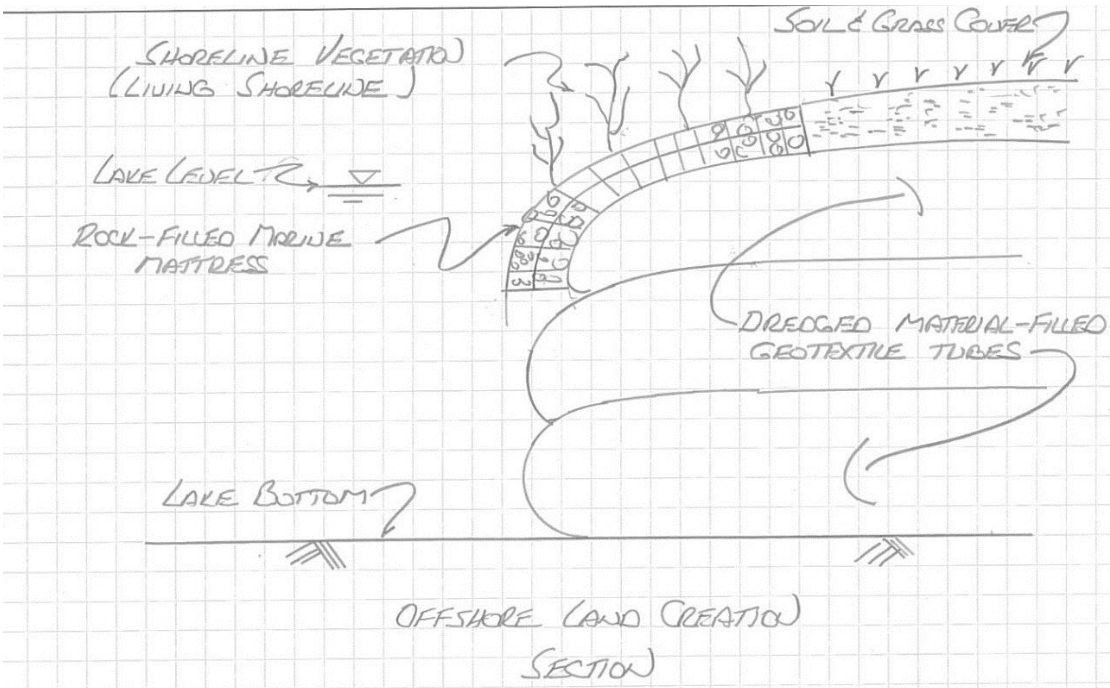

Figure 8. Offshore land creation option typical shoreline section

Figure 9. Marine mattress on filled geotextile tubes

Figure 10. Sand Creek upland sediment disposal option for Sand Creek Bay

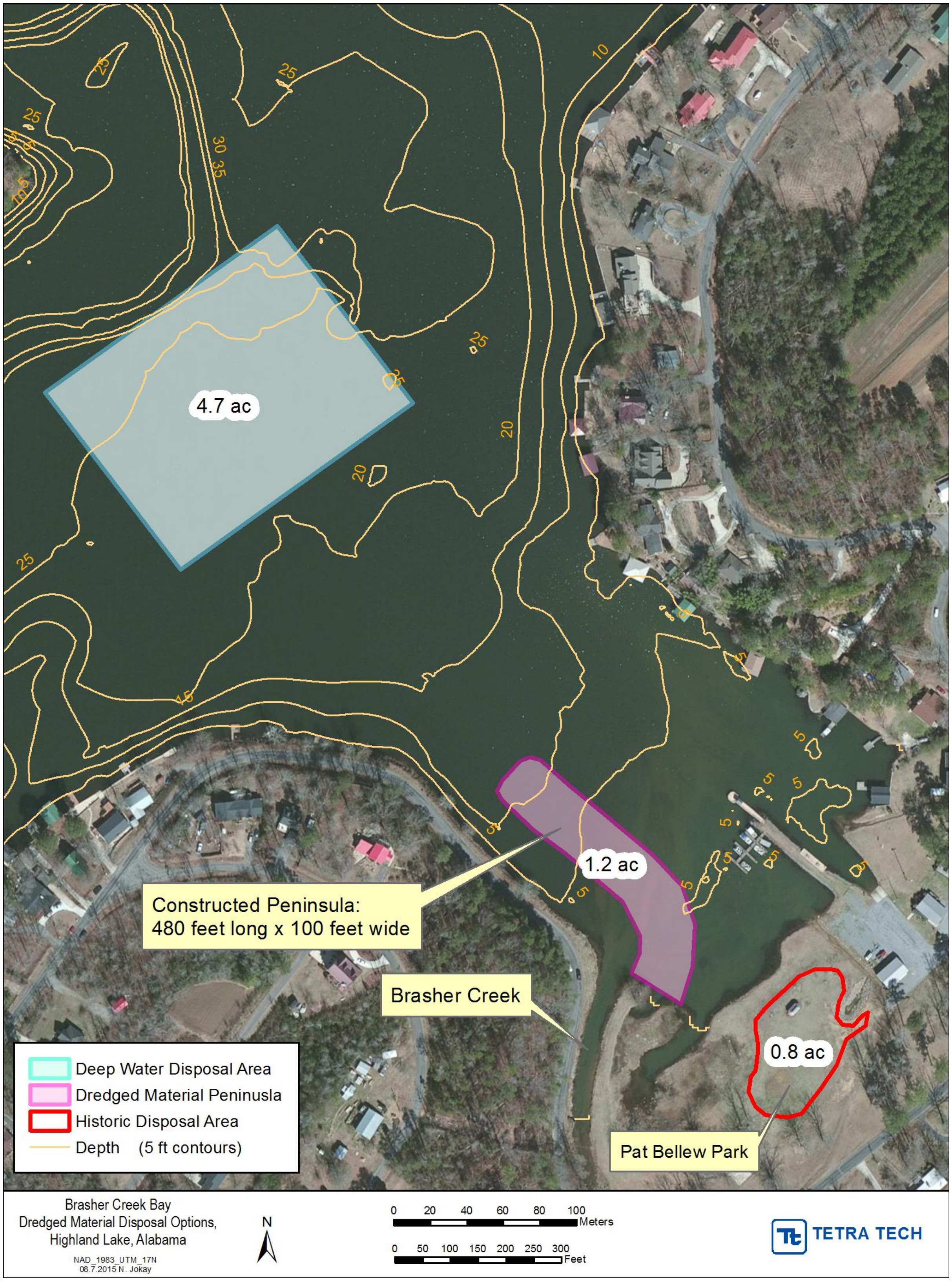

Figure 11. Dredged sediment disposal options for Brasher Creek Bay

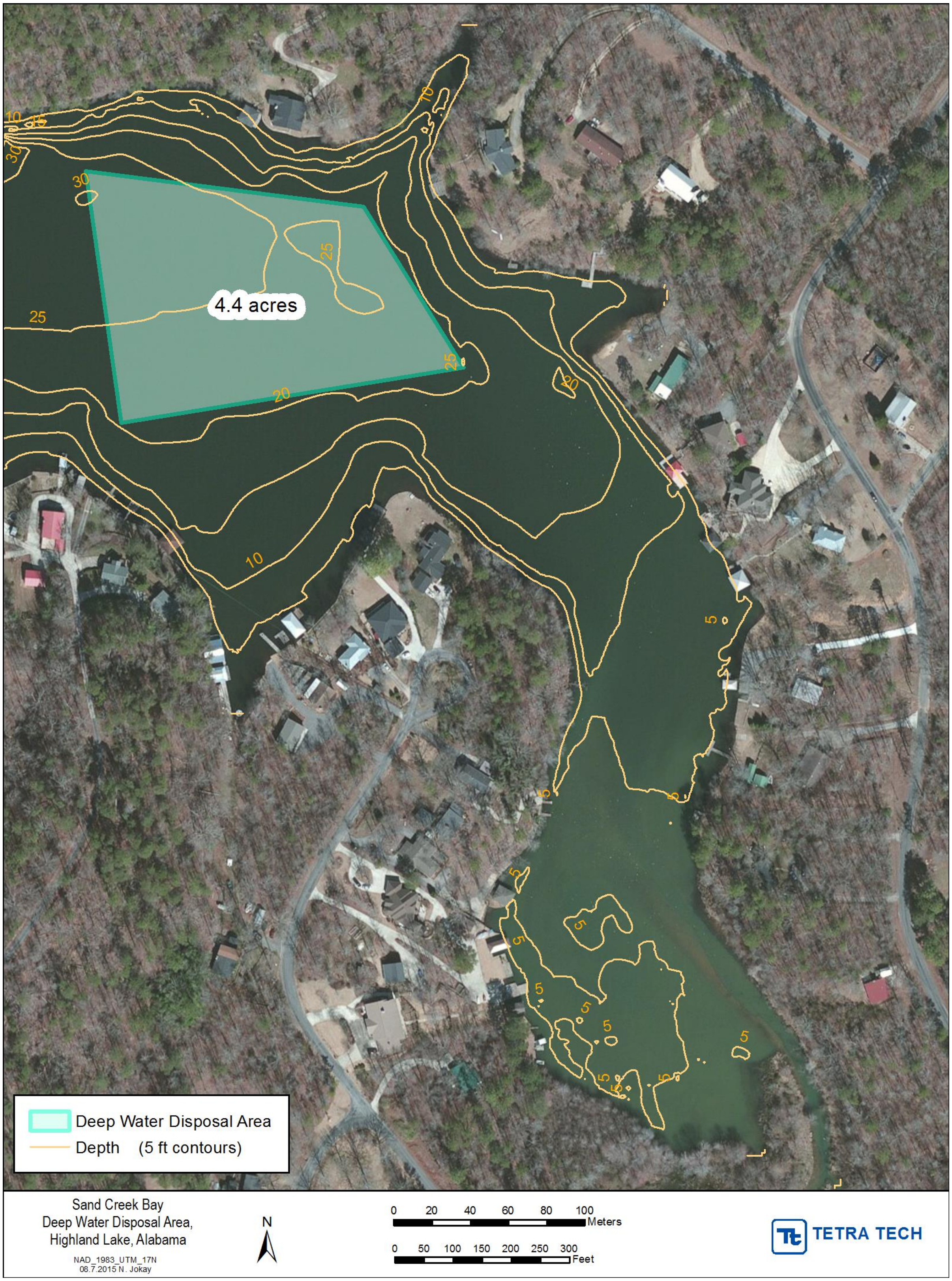

Figure 12. Dredged sediment deep water disposal option for Sand Creek Bay.

6.3 Dredging and Disposal Options

Sections 7.1 and 7.2 outline the general range of options for dredging and disposal of the 12,400 cubic yards of sediment targeted for removal from Brasher Creek Bay and Sand Creek Bay. This section further develops ten dredging and disposal options that pair a dredging methodology with a disposal plan. A brief description is provided for each, including four mechanical dredging options (M-1 through M-4) and six hydraulic dredging options (H-1 through H-6). The options are summarized in Table 9.

6.3.1 Mechanical Dredging Options

Option M-1 – This option consists of mechanically dredging the targeted sediment deposits in the two bays. The dredged material would be placed on a barge for transport to deep water disposal sites near each of the dredging areas. The barge would be moved into an area enclosed by a floating turbidity barrier and a crane with a sealable environmental bucket would lower the dredged material to the bottom where it would be carefully released to minimize the transport of the dredged material away from the immediate vicinity of the disposal area.

Option M-2 – This option is essentially the same as Option M-1 except that the work is divided into two phases to spread out the cost of the work over time. The option illustrates the cost penalties associated with multiple mobilizations.

Option M-3 – This option is similar to Option M-1 except that it involves dredging and open water disposal of sediment from Brasher Creek Bay only.

Option M-4 – This option consists of mechanically dredging the targeted sediment deposits in the two bays with the placement of the dredged material at the previously used Sand Creek Bay site. Site improvements would cover the full 1.35 acres of the site including a potential wetland. Bin-type units filled with material excavated from the site would form the perimeter containment dike.

Option M-5 – This option is similar to Option M-4 except that it involves dredging and upland placement of dredged material from Sand Creek Bay only.

Option M-6 - This option consists of mechanically dredging the targeted sediment deposits in the two bays with the placement of the dredged material at the Pat Bellew Park site on Brasher Creek Bay. Bin-type units like those used in Option M-3 would provide the perimeter containment dike. This site is smaller than the Sand Creek Bay site and would require a higher perimeter dike. The existing park site would be at least temporarily lost to the community and its redevelopment might be difficult due to the large volume of material that would be placed there. This option is believed to be unfeasible due to its limited size and the anticipated public reaction to the loss of the park site.

6.3.2 Hydraulic Dredging Options

Option H-1 – This option consists of hydraulically dredging the targeted sediment deposits in the two bays and depositing the dredged material in geotextile tubes at the previously used Sand Creek Bay site.

A dredge discharge pipe that can be floating or submerged would deliver the dredged material from the dredge to the disposal site. An adequately sized dredge can pump material from either dredging site directly to the disposal site either on its own power or with the assistance of a booster pump located at some intermediate location along the dredge discharge pipe route. A polymer admixture would be injected into the dredged material stream before it enters the tubes to induce flocculation of the fine grain components in the dredged material slurry. The increased size of the flocculated particles results in their being trapped within the geotextile filter tubes. The tubes allow the excess water to escape with relatively low suspended sediment concentration levels. After a relatively short time, the dredged material dries enough where it can be removed from the tubes and exported to an ultimate disposal site. It can also be left in the tubes that can be covered with earth and be planted to restore the site to a natural appearance.

Option H-2 - This option consists of hydraulically dredging the targeted sediment deposits in the two bays and depositing the dredged material in a diked containment area at the previously used Sand Creek Bay site. Conventional earth dikes or earth filled bin-type units may be used. The bin-type units minimize the dike footprint and have been considered in this option due to the limited area of the site. The dredged material slurry would be pumped into the containment area. It would settle out leaving a layer of clarified water that would drain out of the containment area through a weir structure. The dredged material would eventually dry sufficiently to be either exported to an ultimate disposal site or graded and planted as part of the site restoration. The Sand Creek Bay site does not have sufficient capacity to contain the hydraulically dredged material. Therefore, this option is unfeasible.

Option H-3 - This option consists of hydraulically dredging the targeted sediment deposits in the two bays and depositing it in geotextile tubes at an in-water location in Brasher Creek Bay. The filled geotextile tubes would provide the foundation for a peninsula shaped landmass. This peninsula would extent the eastern shore of Brasher Creek and would serve to direct future sediment-laden discharges out to deeper water where deposition could occur without impacting recreational navigation in the marina area. The filled tubes would have to be covered to protect them from UV radiation degradation and abrasion/impact damage by boats.

Option H-4 – This option is similar to Option H-3 except that it involves dredging sediments from Brasher Creek Bay and depositing them in geotextile tubes at an in-water location in Brasher Creek Bay.

Option H-5 - This option consists of hydraulically dredging the targeted sediment deposits in the two bays and depositing the dredged material directly into deep water areas of the lake that are nearby to the dredging areas. The direct discharge of the dredged material slurry has a higher potential for high turbidity impacts to the lake waters than does Option M-1 where the dredged material placement is controlled to minimize turbidity. This option is believed to be unfeasible from a regulatory perspective.

Option H-6 - This option consists of hydraulically dredging the targeted sediment deposits in the two bays and depositing the dredged material in a diked containment area at the Pat Bellew Park site on Brasher Creek Bay. The option is similar to Option H-2 except for the site location. There is insufficient space at the site to contain the dredged material. In addition there would likely be substantial public opposition to the loss of the park site. Therefore, this option is considered to be unfeasible.

Option H-7 - This option consists of hydraulically dredging the targeted sediment deposits in the two bays and depositing the dredged material in geotextile tubes at the Pat Bellew Park site on Brasher Creek Bay. Even though the final volume of the dried dredged material is less in this option than in Option H-6, there is still insufficient space to accommodate it at the Park site. For this reason as well as for the anticipated public opposition, this option is considered to be unfeasible.

7 Opinion of the Probable Cost

7.1 Preliminary Opinion of Construction Costs

Preliminary cost estimates were developed for the most feasible dredging and disposal options outlined in Section 14. This is a feasibility study where details of the various options are sketched out in a limited amount of detail so that the features, impacts and costs of the options can be relatively compared. A feasibility study generally only carries out the design development to about 30% of the level necessary to produce full construction documents. Relatively large contingency allowances are typically included at feasibility level cost estimating to compensate for the uncertainties associated with a low level of design development. A 25% contingency allowance is included in the cost estimates provided here.

Table 9 provides a comparative summary of the issues and features associated with each option. Evaluation shows some of these options may be either environmentally or politically unfeasible. The table provides preliminary construction cost estimates for the five options that appear to be feasible. Appendix E provides the details of the preliminary cost estimates for the feasible options.

Table 9. Summary of dredging and disposal options

Option	Description	Cost	Issues	Features	Comments
Mechanical Dredging Options					
M-1	Dredging of both bays and open water disposal in deep water lake areas	$344,000 ($27.74/CY)	• Public concerns • Turbidity control	• Abundant capacity • Minimal site improvements	Feasible- **Recommended option**
M-2	Dredging of both bays and open water disposal in deep water lake areas in two phases	$384,000 ($30.97/CY)	• Public concerns • Turbidity control	• Abundant capacity • Minimal site improvements	Feasible
M-3	Dredging of Brasher Creek Bay and open water disposal in deep water lake areas	$234,000 ($36.56/CY)	• Public concerns • Turbidity control	• Abundant capacity • Minimal site improvements	Feasible
M-4	Dredging of both bays and upland disposal at Sand Creek site with diked containment	$485,000 ($39.11/CY)	• Possible wetland • Limited space	• Previously used site • Close to lake	Feasible
M-5	Dredging of Sand Creek Bay and upland disposal at Sand Creek site with diked containment	$367,000 ($61.17/CY)	• Possible wetland • Limited space	• Previously used site • Close to lake	Feasible
M-6	Dredging of both bays and upland disposal at Pat Bellew Park with diked containment	NA	• Limited space • Conflict with park usage	• Close to lake	Unfeasible
Hydraulic Dredging Options					
H-1	Dredging of both bays and upland disposal at Sand Creek site with geotextile tubes	$639,000 ($51.53/CY)	• Possible wetland • Limited space	• Previously used site • Close to lake	Feasible
H-2	Dredging of both bays and upland disposal at Sand Creek site with diked containment	NA	• Possible wetland • Insufficient space	• Previously used site • Close to lake	Unfeasible

Option	Description	Cost	Issues	Features	Comments
H-3	Dredging of both bays and In lake land creation	$982,000 ($79.19/CY)	• Additional regulatory requirements	• Directs creek flow to deep water for reduced future maintenance • Creation of new recreational land	Feasible
H-4	Dredging of Brasher Creek Bay and in lake land creation	$581,000 ($90.78/CY)	• Additional regulatory requirements	• Directs creek flow to deep water for reduced future maintenance • Creation of new recreational land	Feasible
H-5	Dredging of both bays and open water disposal in deep water lake areas	NA	• Public concerns • Turbidity control	• Abundant capacity • Minimal site improvements	Unfeasible due to direct discharge
H-6	Dredging of both bays and upland disposal at Pat Bellew Park with dikes	NA	• insufficient space • Conflict with park	• Close to lake	Unfeasible
H-7	Dredging of both bays and upland disposal at Pat Bellew Park with geotextile tubes	NA	• Limited space • Conflict with park usage	• Close to lake	Unfeasible

7.2 Assumptions

This section outlines the assumptions that were required to develop the cost estimates. The principal assumptions are summarized in Table 10, which influence several aspects of the project. The assumptions that are associated with the individual cost categories are summarized in Table 11.

Table 10. Principal Assumptions

Assumption	Discussion
Dredging footprint and volume	2.95-acre total dredging area and 12,400 cubic yards of sediment in place based upon our 2015 bathymetric survey, a maximum depth of -7 ft. and setbacks from structures and property limits. A new bathymetric survey will be required prior to construction.
Sediment quality	Sediment is considered to be clean and no chemical testing is required
Dredging and disposal	Options M-1, M-2, and M-3 - Mechanical dredging with dredged material placed on barges and transported to the open water disposal sites Option M-4 and M-5 - Mechanical dredging and disposal in a diked containment area at Sand Creek Bay site Option H-1 – Hydraulic dredging with disposal in geotextile tubes with polymer additive at Sand Creek Bay site Option H-3 and H-4 – Hydraulic dredging with disposal in geotextile tubes with polymer additive at an in-water location in Brasher Creek Bay
Contingency	25% allowance as is typical for a 30% stage of design development cost estimate.

Table 11. Cost Category Assumptions

Assumption	Discussion
Field Data Collection	
Surveys	Recent surveys will be required to support design and permit applications.
Regulatory Permits	
Applications	Completing and submitting applications with US Army Corps of Engineers and Alabama Department of Environmental Protection. This includes a pre-application meeting, application preparation, two rounds of responses to requests for additional information, public noticing, NOI preparation, and the Construction General permit fee. It does not include a wetland delineation, which may be required if the Sand Creek upland disposal site is used.
Engineering Design	
Feasibility study	The feasibility study that is the subject of this report. The cost of this study is not included in the cost estimate.
Final design	Development of the construction documents (plans and specifications for the project) based upon the accepted 30% design.
Construction support	Limited support for the contract bidding process, assistance with bid selection, construction observations and final certification to regulatory agencies.
Construction	
Project organization and control	Contractor costs including required surveys and implementation of best management practices to control spills and stormwater drainage on the site.
Handling and transfer area	Site preparation – development of a staging area to provide access to the dredging areas and logistical support to the offshore dredging operations.
	Site restoration – site cleanup, light grading and re-vegetation of the staging area. Site security – temporary fencing to limit access to construction area.
Dredged Material Testing	
	No dredged material chemical quality testing is included. No elutriate testing is included.
Environmental Monitoring	
	Periodic sampling of water to verify that the dredging operations are not exceeding permitted turbidity levels.

8 Recommended Dredging and Disposal Plan

Primary recommendation- (M-1 in Table 9)

Tetra Tech recommends dredging of 12,400 CY of sediments from Brasher Creek Bay and Sand Creek Bay using mechanical dredging equipment and transporting the dredged material with a barge to deep water disposal sites near each of the dredging areas. An overview of the preliminary dredging and disposal plan is depicted in Figure 13. Details of Brasher Creek Bay and Sand Creek Bay are shown in Figures 14 and 15, respectively. The equipment would consist of a crane barge with an environmental clamshell bucket-equipped crane to excavate the sediment and place the dredged material at disposal sites, a dredged material barge to receive and transport the dredged material, tug to maneuver the equipment and a workboat for logistics and survey support. As discussed previously, it will probably be necessary to utilize sectional barges to address site access issues.

The equipment would excavate the sediments using the environmental bucket-equipped crane from each of the two proposed dredging areas, transport it to the adjacent deepwater disposal site (approximately 20 feet in depth) and then place the dredged material on the bottom using the environmental bucket-equipped crane. The near-bottom placement with the sealed bucket together with a turbidity barrier suspended in the upper portion of the water column will help to control turbidity to acceptable levels.

The recommended approach eliminates the problems associated with the use of upland disposal sites that include:

- Limited available space
- Disruption of the use and replacement of facilities at Pat Bellew Park
- Potential wetland impact at Sand Creek upland disposal site
- Disposal site preparation, management and restoration costs
- Dredged material treatment costs including geotextile tubes and polymer
- Possible need for the ultimate disposition of the dredged material at some other site

Secondary recommendation- (H-3 in Table 9)

The in-water land creation option, described in Section 6.2.3, is a secondary recommendation. Significant benefits of this option include:

- Diversion of the sediment laden flow of Brasher Creek out to deeper water where the deposition of the sediment would not have a significant impact on recreational navigation in Brasher Creek Bay
- Creation of additional public waterfront land with high potential for recreational usage

The in-water land creation option would be the most expensive dredging and disposal option. It could not be done in combination with the primary option because of the different dredge methods

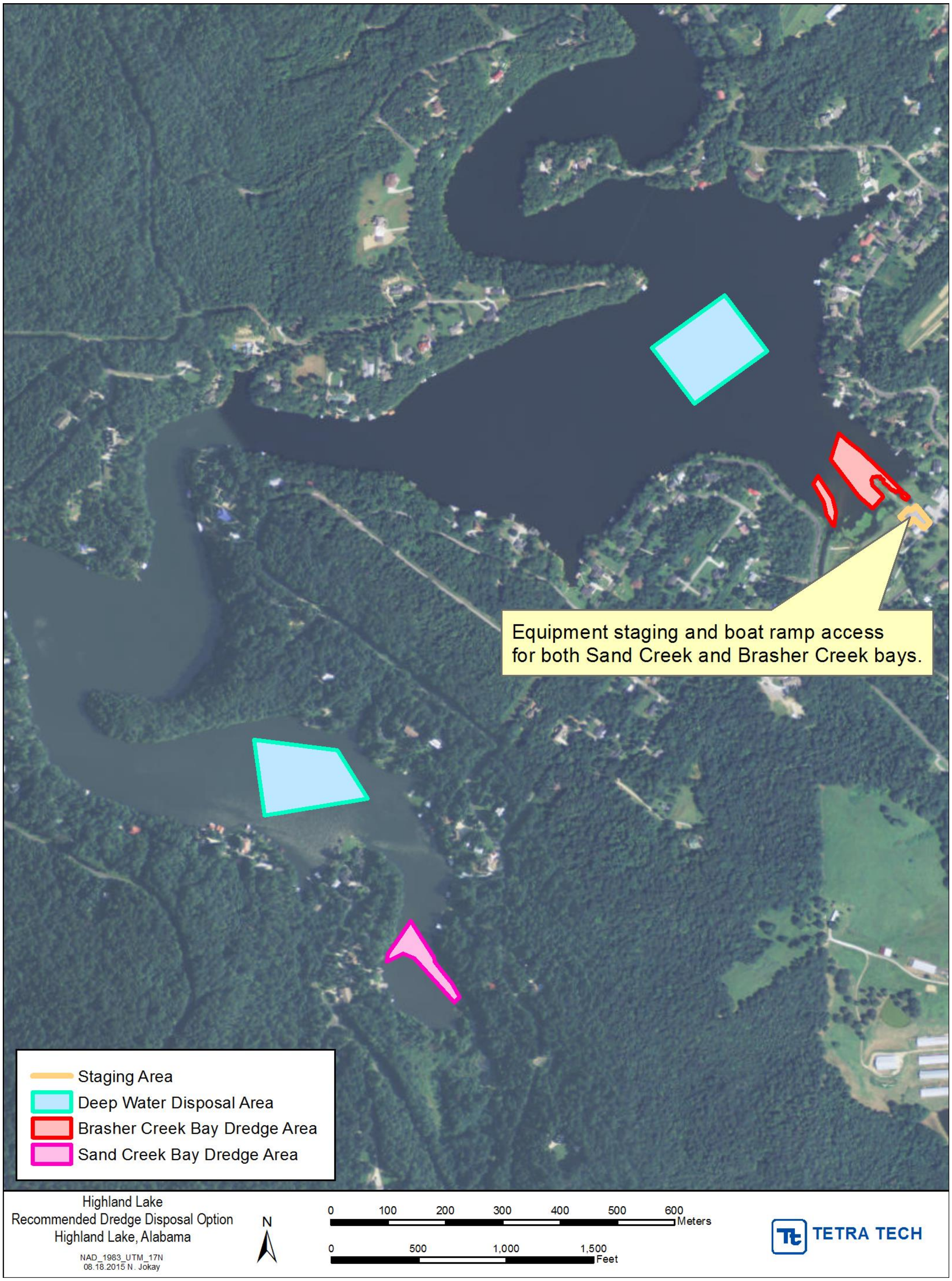

Figure 13. Recommended dredging and disposal plan overview

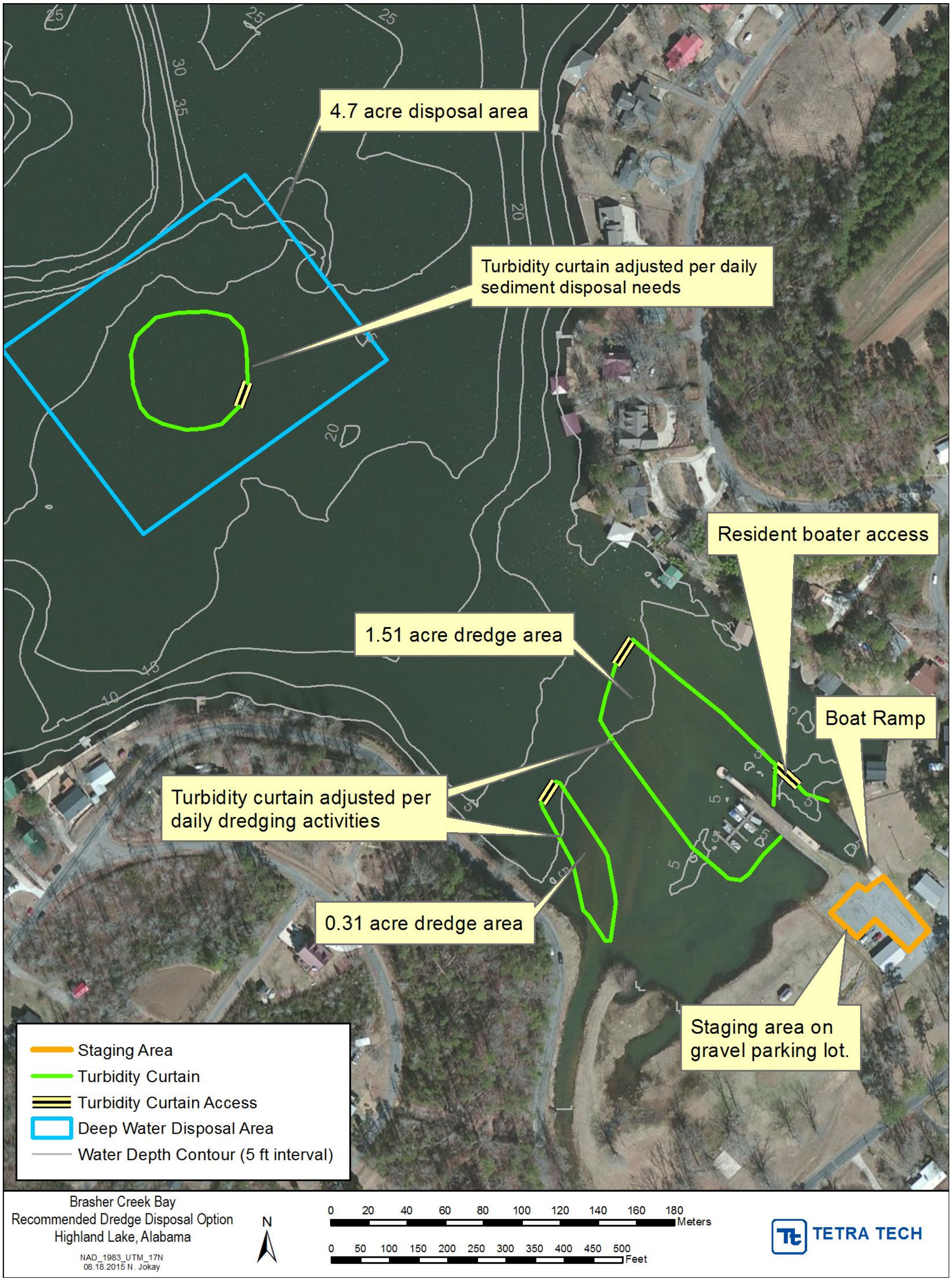

Figure 14. Recommended dredging and disposal plan- Brasher Creek Bay detail

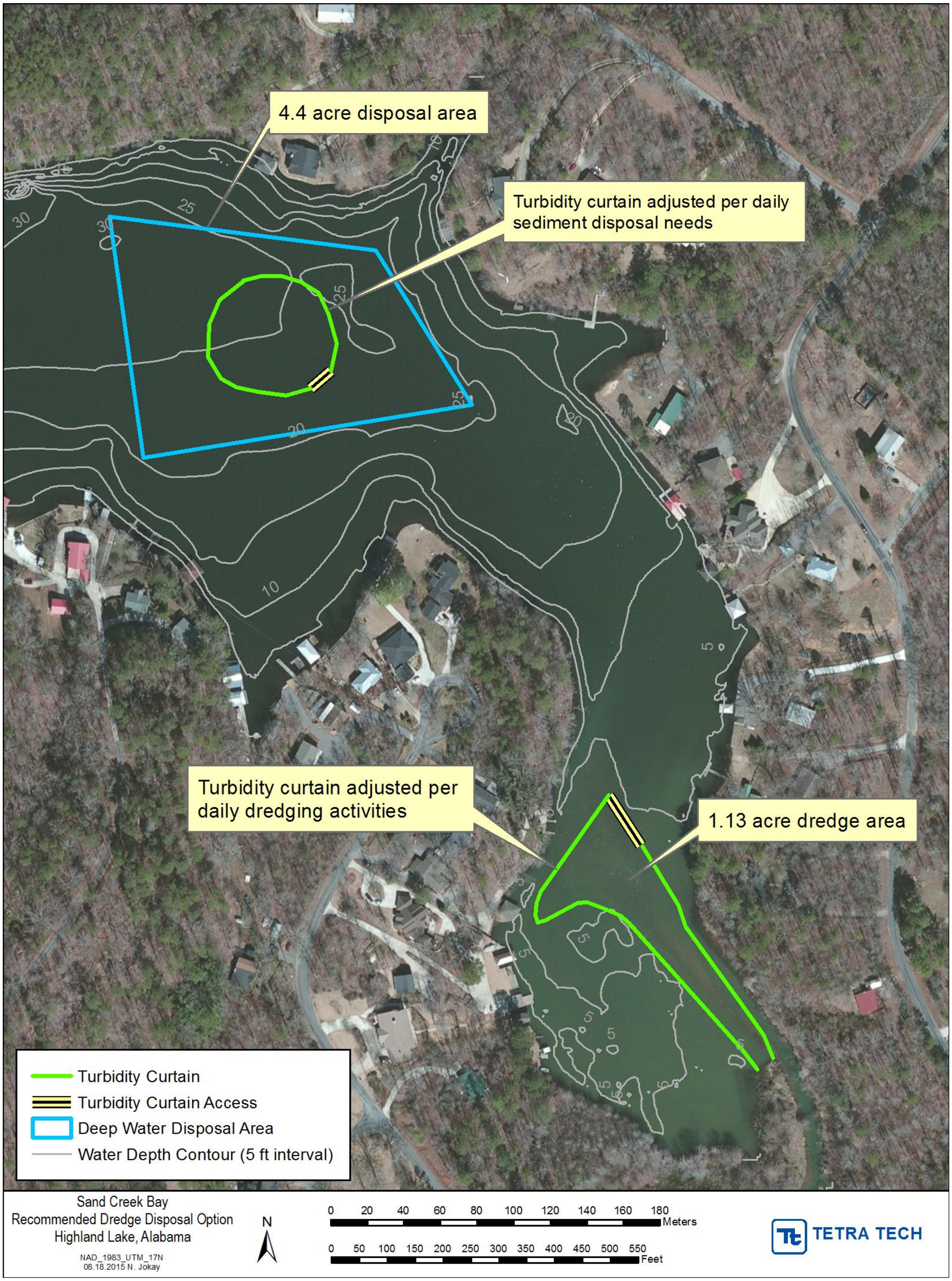

Figure 15. Recommended dredging and disposal plan- Sand Creek Bay detail

9 Permitting

Tetra Tech coordinated with the U. S. Army Corps of Engineers (USACE) Mobile District and the Alabama Department of Environmental Management (ADEM) to discuss permitting requirements associated with dredging.

9.1 USACE Permitting

Section 404 of the Clean Water Act (CWA) establishes a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States. Permit requirements will depend on the location and size of the disposal area:

- The project will not need a Section 404 permit if all dredge material is disposed of in uplands.
- The project could be permitted under a **Nationwide** 18 permit if the in-water disposal footprint is under 0.10 acre.
- The project will require an **Individual** 404 permit if it involves the disposal of material in-lake over a footprint greater than 0.10 acres, or if it involves the disposal of >25 cu. yds. of loose material in open water.

If there is a wetland impact <0.10 acres, no mitigation is required. If it is an isolated wetland, the USACE would not have jurisdiction over it. The USACE could make a determination that it is isolated. That determination would have to go through EPA and USACE headquarters, but that's a relatively easy process.

The USACE verified that Highland Lake is not regulated under Section 10 of the Rivers and Harbors Act (33 U.S.C. 403) (pers. comm. Amiee Smith, USACE Mobile District, May 12, 2015). This is notable because Section 10 requires that the construction of any structure in or over any navigable water of the United States, or the accomplishment of any other work affecting the course, location, condition, or physical capacity of such waters is unlawful unless the work has been recommended by the Chief of Engineers.

The USACE does not foresee any specific permitting difficulties with the recommended open water disposal option from the USACE perspective, although an alternatives analysis would need to be conducted as part of the individual permitting process to demonstrate that other options are not feasible or cost effective (pers. comm. Courtney Shea, USACE Mobile District, August 19, 2015). The evaluation conducted for this feasibility study can serve as the alternatives analysis.

Other agencies such as U.S. Fish and Wildlife Service and ADEM will have an opportunity to comment on the project during the permitting process. These agencies may require additional biological surveys or water quality and sediment testing to ensure that wildlife is protected and water quality is maintained.

The USACE recommends a pre-application meeting and site visit to allow for a formal decision on jurisdiction and permitting requirements. Tetra Tech recommends requesting a pre-application upon determining the preferred dredge and disposal options.

9.2 ADEM Permitting

Construction General Permit

The project will require coverage under General NPDES Permit No. ALR100000 for discharges associated with regulated construction activity if proposed activities will result in land disturbance equal to or greater than one acre. To obtain coverage under this general permit, the Town of Highland Lake (or the general contractor) must submit a Notice of Intent (NOI) to ADEM in accordance with the permit requirements.

This permit requires that the operator/owner of the construction site implement and maintain effective erosion and sediment controls in accordance a Construction Best Management Practices Plan (CBMPP) prepared and certified by a Qualified Credentialed Professional (QCP). The project is not in a Priority Construction Site Watershed; therefore the CBMPP is not required to be submitted to ADEM along with the NOI.

A QCP or Qualified Credentialed Inspector (QCI) must conduct regular inspections of regulated construction activities to ensure effective erosion and sediment controls are being maintained. In certain circumstances, the QCI or QCP must also monitor construction site discharges for turbidity. To obtain coverage under the construction general permit, the Town of Highland Lake will need to pay a permit fee in the amount of $1,155.

Water Quality Review

Tetra Tech spoke with ADEM about the project and the alternatives that were evaluated, and ADEM did not foresee any permitting difficulties with the recommended open water disposal option, though the reviewer did not know of any precedents in the state for open water disposal (pers. comm. Falon Hooks, ADEM, August 19, 2015). ADEM's Department of Environmental Management will review the project in conjunction with the USACE Section 404 permitting process, and will issue state Water Quality Certification (WQC) when there is reasonable assurance that discharges resulting from the proposed activities will not violate applicable water quality standards established under Section 303 of the Clean Water Act (CWA), and state water quality regulations. ADEM will require that during construction there is not an increase in turbidity of greater than 50 NTUs outside of the turbidity curtain. The Town of Highland Lake will need to pay a water quality permit fee that will depend on the project acreage, but will not exceed $3,530.