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MEMORANDUM

DATE: October 14, 2019

TO: Steve Morse, City of Aztec

FROM: Tandy Freel, PE
Nisa Rascon, EI
Rob Croft, PE
Todd Burt, PE

SUBJECT: **City of Aztec Reservoir No. 1 Rehabilitation Project**

I. Part I: Project Overview

i. Purpose and Introduction

The City of Aztec has contracted Bohannan Huston, Inc. (BHI) to evaluate the existing condition of Reservoir 1 in Aztec, NM, as well as assess the rehabilitation potential of the reservoir and make a recommendation on whether the reservoir should be rehabilitated or if it is more advantageous to construct a new reservoir.

BHI conducted the conditions evaluation on February 6, 2019. The evaluation includes a panel-by-panel assessment of the sloped concrete embankments to determine the degree of cracking, evidence of settlement, and panel joint condition. The joint integrity between the panels was catalogued and the concrete itself was assessed for delamination, spalling, and other types of deterioration. The bottom of the reservoir was also assessed for integrity and thickness as the impacts from previous sediment removal activity may have caused damage and may be the cause of reported leakage. A layout pattern base was created to graphically detail the conditions of the existing panels to reveal any localized, concentrated areas where subgrade issues may require complete removal and replacement of the concrete and subgrade or the built-up berm. Additionally, the bottom clay liner of the reservoir was evaluated by collecting soil samples with a hand auger. This field investigation was completed by GeoMat as a subconsultant to BHI.

Three rehabilitation options were addressed in this memo. The first option consists of methods to restore the integrity of the existing materials by repairing the concrete panels, sealing all joints, and restoring a clay liner for the bottom. The second option entails the installation of an impermeable synthetic liner to restore the integrity of the reservoir in zone 4 and the top half portion of the reservoir as these areas show the greatest signs of wear. The third option includes the installation of a liner in the entirety of reservoir. All three options include the modification of the Aztec Irrigation Ditch inlet, the installation of a ramp for entry into the reservoir, and the replacement of the tower and piping/valves to the pump station.

Two options for the new reservoir were evaluated. The first was the construction of a new larger reservoir to the east of Reservoir 3 at a higher elevation. The second option included the construction of the new reservoir in addition to a partial rehabilitation of Reservoir 1 to take advantage of the gravity feed of water from the Aztec Irrigation Ditch.

This memo consists of five parts: Part I consists of the conditions assessment; Part II focuses on the hydraulics of the existing system and the restoration of Reservoir 1 to service; Part III delineates the options and costs of the rehabilitation of Reservoir 1; Part IV delineates the options of constructing a new reservoir; and finally, Part V proposes recommendations based on the completed evaluations.

ii. Project Background

The City of Aztec has a system of three reservoirs (Reservoir 1, Reservoir 2, and Reservoir 3) where raw water is stored before being sent to the Water Treatment Plant (WTP). Reservoir 1 is the oldest and was originally constructed in the 1950s. The original construction consisted of earthen berms, concrete lined side slopes, and a clay lined reservoir bottom. There is no record of repair work done to the original concrete panels since installation. In 1981, the reservoir was expanded, and sediment was removed from the bottom of the reservoir. The expansion consisted of raising the reservoir berm and applying additional concrete lining to the side slopes above the original side slope concrete lining. The as-built drawing for this construction is available in Appendix A. In 2018, a concrete cap was added to the top of the tower due to exposed rebar, and sediment was removed from the bottom of the reservoir. Plans from this rehabilitation are included in Appendix B.

The reservoir has recently been taken offline due to leakage. Per conversations with the City, the leakage may be coming from a leaky valve, deteriorated concrete slope panels, or the compromised integrity of the reservoir's bottom clay liner due to the recent sediment removal. The water sources for Reservoir 1 are the Aztec Irrigation Ditch, the Animas Ditch, and the Animas River. The preferred source is the Aztec Irrigation Ditch as it can feed the reservoir by gravity whereas the Animas Ditch and Animas River must be pumped. Although the Aztec Irrigation Ditch is the preferred source, it cannot meet water demands without being supplemented by one of the other two sources and is only seasonally available between March and October (the Animas Ditch is also only available during this season). Since Reservoir 1 has been offline, the City has solely been pumping water from the Animas Ditch and Animas River.

The main advantage of rehabilitating Reservoir 1 is the gravity water source from the Aztec irrigation ditch. Under normal operations, water from Reservoir 1 is pumped to Reservoir 3 and then gravity fed to Reservoir 2 from where it feeds the WTP. With Reservoir 1 offline, water is pumped to Reservoir 2, then to Reservoir 3, and then to the WTP. Restoring Reservoir 1 back to service would mean a decrease in necessary pumping.

II. Part II: Reservoir Evaluation

i. Conditions Assessment

A) Panel by Panel Assessment (Top half, 3-in Gunite concrete lining built in 1981)

The field assessment included a complete visual inspection by BHI and was used to determine the degree of cracking, settlement, delamination, spalling and joint deterioration between the concrete panels. To assess the condition of the sloped concrete panels, the Reservoir was split into five different zones. A chain drag test was applied on each individual panel to determine how much of the overlay material was still attached to the underlying concrete in the panel (concrete defect known as delamination). Photographs were also captured to determine the degree of spalling as well as an aid in evaluating joint conditions between panels. Concrete spalling indicates how much material has been peeled out from the surface of the concrete and is often caused by exposure to water and freeze-thaw.

To evaluate individual panels, a rating of 1 thru 5 was given to each panel in the upper half of the embankment. As induced from Table 1, a rating of 5 represents an entirely sufficient panel and 1 represents a totally insufficient panel. To understand the rating, Figure 1, Figure 2, Figure 3, Figure 4, and Figure 5 represent the conditions generally found under each of the rating values. See findings in Figure 6.

Table 1 – Rating Guidelines for Top Concrete Panels

RATING	CONDITION
5	• GOOD CONDITION
4	• NO SIGNS OF SETTLEMENT • MINOR SPALLING OR SURFACE DELAMINATION AT ISOLATED AREAS • MINOR SURFACE DETERIORATION AT JOINTS • NOMINAL CRACKING DUE TO TEMPERATURE AND SHRINKAGE
3	• NOTICEABLE SETTLEMENT • CONCRETE SURFACE GENERALLY SPALLED OR DELAMINATED • CONCRETE DAMAGE AT JOINT IS EVIDENT • EXTENSIVE CRACKING THROUGHOUT SURFACE
2	• SIGNIFICANT SETTLEMENT • CONCRETE SURFACE SEVERELY DETERIORATED DUE TO SPALLING OR DELAMINATION • SIGNIFICANT DAMAGE OF JOINT MATERIAL • SEVERE CRACKING AND LOSS OF MATERIAL THROUGHOUT
1	• TOTAL FAILURE IN AT LEAST ONE OF THE PREVIOUSLY MENTIONED CONDITIONS

Figure 1 – Rating 5 Example

Figure 2 – Rating 4 Example

Figure 3 – Rating 3 Example

Figure 4 – Rating 2 Example

Figure 5 – Rating 1 Example

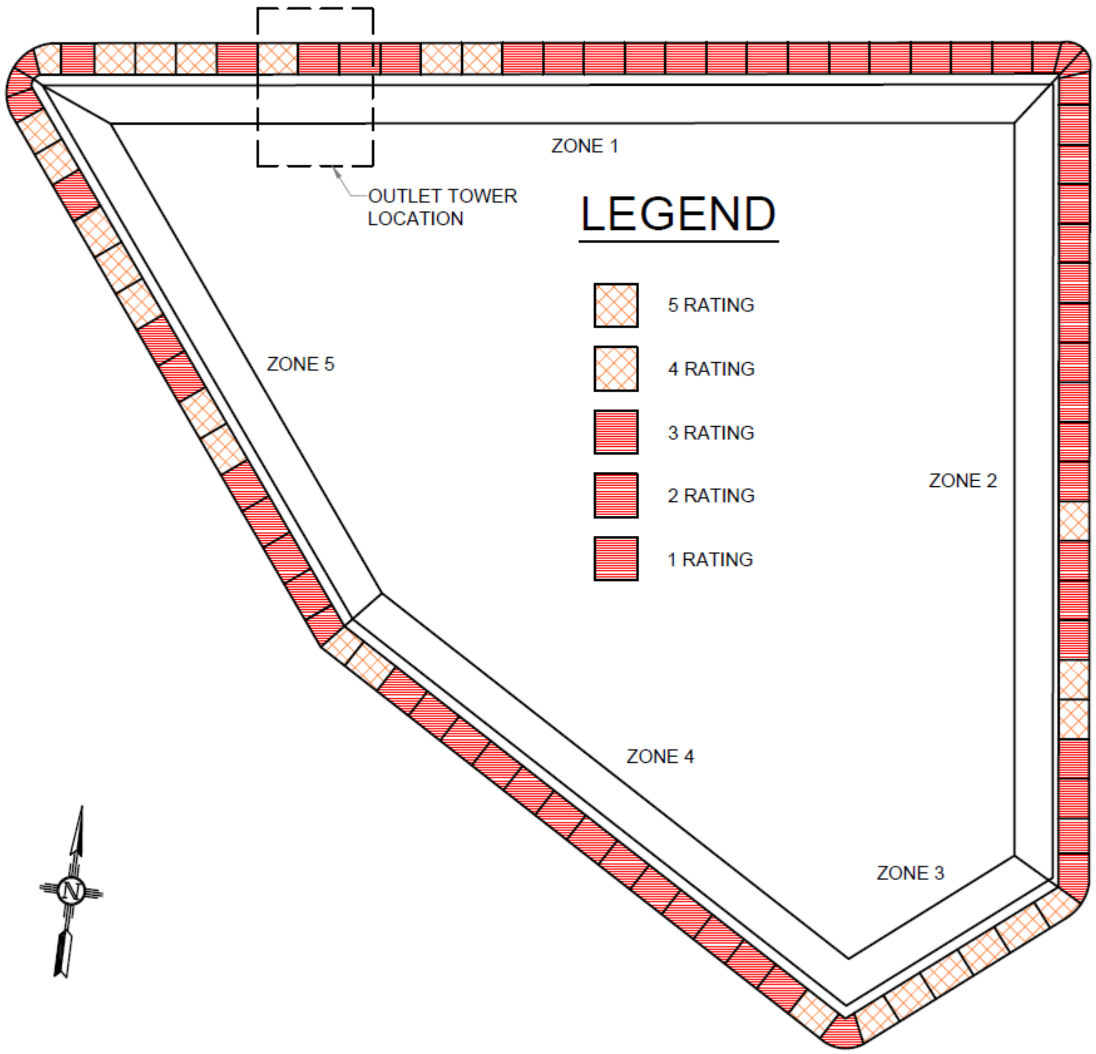


Figure 6 – Top 3" Gunite concrete lining (1981)

In general, panels receiving a rating of 3 or lower (shown in red in Figure 6) are considered to be in poor to bad condition. Chain drag test results on panels receiving a rating of 4 or 5 (see orange hatch in Figure 6) in the visual inspection showed signs of delamination but are considered to be in fair condition.

B) Zone Assessment (Bottom half, 3-in Concrete lining built in 1954)

To evaluate the bottom half of the panels outlining the reservoir, the team split up the reservoir into five different zones (See Figure 17). Areas filled with mud were removed at certain locations to evaluate and use the chain drag test as was done in the top-panel assessment process. Photographs were also captured to aid in the evaluation of the joint, spalling, and settlement conditions of the lower half concrete lining.

Using a similar approach to the top-panel rating process, the team was able to determine the existing conditions of the material in the lower half of the reservoir (See Table 1 and Figures 1 through 5). See findings in Figure 17.

Figure 7 – Signs of Spalling

Figure 8 – Longitudinal Crack

Figure 9 – Longitudinal Crack

Figure 10 – Longitudinal Crack with Delamination

Figure 11 – Signs of Spalling

Figure 12 – Signs of Spalling and Longitudinal Crack

Figure 13 - Signs of Spalling with Longitudinal Crack

Figure 14 – Longitudinal Crack

Figure 15 – Lower Lining Bulging Out (Sideview)

Figure 16 – Lower Lining Bulging Out

In general, Zone 1 presented signs of spalling covering approximately 4 ft below the horizontal ledge (See Figure 7). Zone 2 presented longitudinal cracks of 1/8 inch up to ¼ inch (see Figure 8 and Figure 9) and had significant signs of delamination and spalling (see Figure 10 and Figure 11).

Zones 3, 4, and 5 presented similar conditions throughout. Most of the upper portion of the layer is undergoing spalling surrounded with longitudinal cracks in some locations (see Figure 12, Figure 13, and Figure 14). Major embankment failure surrounding the inlet pipe that transports water from Reservoir 2 to Reservoir 1 suggests underground water seepage is causing the bottom layer on Zone 4 to bulge out (see Figure 15 and Figure 16).

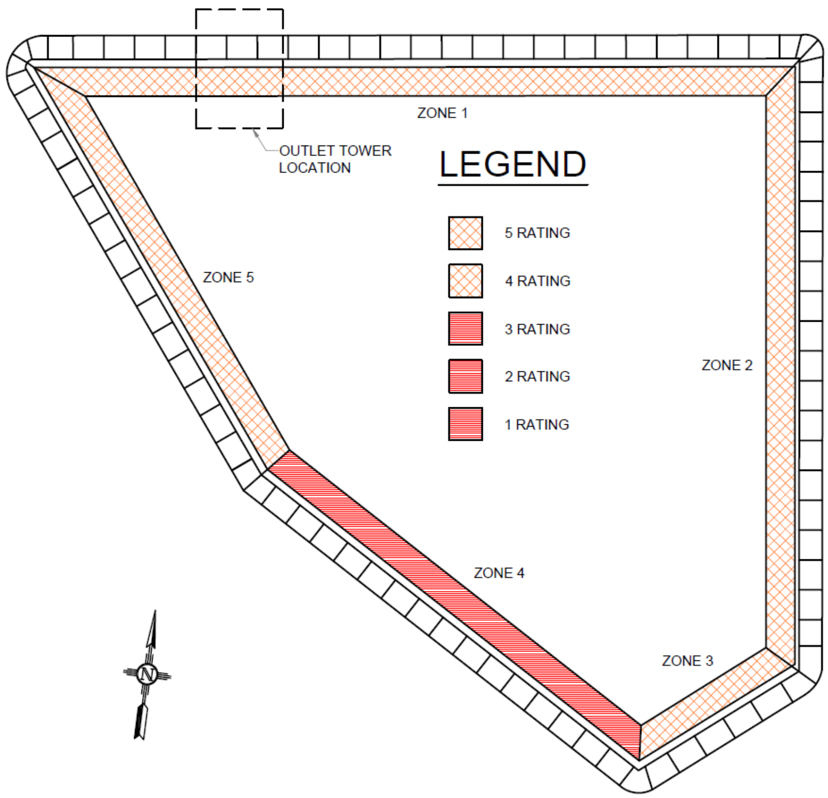


Figure 17 – Bottom 3" concrete lining (1954)

In general, zones receiving a rating of 3 or lower (shown in red in Figure 17) are considered to be in poor to bad condition. Zones 1, 2, 3, and 5 received ratings of 4 or higher (see orange hatch in Figure 17) in the visual inspection and are considered to be in fair condition.

C) Service Bridge and Outlet Tower Assessment

The outlet tower located at the northern side of Reservoir 1 was also evaluated (see Figure 18). As expected with concrete exposed to water, a leaching process starts to develop when water enters cracks in the concrete and dissolves compounds inside the mixture. In general, leaching tends to increase porosity in the concrete and degradation is enhanced. Figure 19 and Figure 20 show instances of leaching at the lower and middle layers of the tower. Above these layers, the concrete tower was rehabilitated with the 2018 project (see Figure 21) and appears to be in good condition with some minor spalling on the underside of the platform. Nominal cracking due to temperature and shrinkage forces in the concrete are present (see Figure 22). Inside the tower, the concrete showed signs of spalling, causing loss of surface material (see Figure 23).

The service bridge structure used to provide to the outlet tower is composed of a steel open-grid deck and pipe railings that appear to be in good condition. Minimal rust and deterioration of the surface coating was evident throughout (see Figure 24).

Figure 18 – Outlet Tower

Figure 19 – Leaching at lower right corner of figure

Figure 20 – Leaching in the Middle Cap of the Outlet Tower

Figure 21 – Concrete Platform

Figure 22 – Nominal Cracking

Figure 23 – Signs of Spalling

Figure 24 – Minimal Rust of Surface Coating

D) Clay Liner Assessment

A geotechnical engineer, Geomat, was contracted by BHI to perform an assessment on the integrity of the clay liner and subgrade in Reservoir 1. Fifteen soil borings were performed at depths ranging from approximately 6 inches to 30 inches. It was anticipated that the clay liner would be approximately 6 inches thick, but no distinct uniform clay liner was observed in any of the borings. Most of the soil samples from the bores were moist and a few had free water. Four of the 15 samples were analyzed in order to be classified per ASTM D2487. The full results of the assessment are located in Appendix C. The table below displays the ASTM Soil Classification of the selected bores:

Table 2 - Representative Bore Depth and Soil Classification

Boring No.	Depth (in.)	Visual Method Description of Soils, ASTM D2488	Classification for Engineering Purposes, ASTM D2487
B-1	0 to 18	Lean to Fat Clay with Sand	--
	18 to 30	Clayey Sand with Gravel	SC – Clayey Sand with Gravel
B-4	0 to 14	Clayey Sand with Gravel	SC-SM – Silty, Clayey Sand with Gravel
B-6	0 to 6	Clayey Sand with Gravel	--
	6 to 10	Sandy Lean to Fat Clay with Gravel	SC – Clayey Sand with Gravel
B-14	0 to 12	Clayey Sand with Gravel	--
	12 to 18	Lean to Fat Clay with Sand	CL – Lean Clay with Sand

ii. Summary of Assessment of Conditions Findings

Based on the field evaluation of the existing conditions of Reservoir 1, 71 percent of the upper 3-inch Gunite concrete lining (built in 1981) and 20 percent of the lower 3-inch concrete lining (built in 1954) is currently in poor to bad condition. This is due to joint failure, settlement, longitudinal cracking, delamination, and spalling conditions making Reservoir 1 not optimal for water storage. It is also necessary to understand where the current leakage is originating, the magnitude of water intrusion from Reservoir 2, and how settlement is affecting the embankment on Zone 4 to prevent future failure at this location.

Based on the information gathered in the evaluation of the outlet tower, the team concluded that the structure is in fair condition. That is, no major signs of structural failure were visually observed. However, the extent of rebar damage underneath the concrete placed in 2018 is a concern and will be considered when evaluating future repair.

III. Existing System Overview:

i. Hydraulics

A) Existing Hydraulics

Under current operations, water is pumped to Reservoir 2 from the Animas Ditch or the Animas River and is then pumped from Reservoir 2 to Reservoir 3 via the Navajo Pump Station. The pump station has two pumps rated at 2,000 GPM in a 1+1 configuration. A picture of the nameplates is shown below.

Figure 25 – Pump Nameplates

Pressure and flow readings taken during the site visit on February 2, 2019 downstream of the pump were 1,800 GPM at a pressure of 88 psi with one pump operational. This operating point is slightly lower than the 2,000 gpm that the pump is rated for, see Figure 28 for the existing pump curve. Additional readings were taken on a subsequent site visit on July 30, 2019, with similar results. The test points are shown on System Curve Figure 30. Figure 26 contains a simplified schematic of the current operations and the proposed operations with the rehabilitation of Reservoir 1. From Reservoir 3, the water gravity feeds to the WTP prior to distribution. The hydraulic profile of the current system is displayed in Figure 27.

B) Proposed Hydraulics

The proposed rehabilitation of Reservoir 1 for reinstatement into the system would reverse the sequence that water is fed into the reservoirs and would impact the hydraulic performance of the system by reducing the available suction pressure on the inlet side of the pumps. Reservoir 1 is the only reservoir in the system that can be gravity fed by the Aztec Irrigation Ditch as it is lower in elevation – 5,744 ft elevation at the Aztec ditch versus 5,739 ft elevation at the bottom of Reservoir 1, see Figure 27 for the hydraulic profile of the existing system and Figure 29 for the hydraulic profile of the system with Reservoir 1 reinstated. Restoring Reservoir 1 back to service would mean a decrease in necessary pumping of source water with the current pumps. Water from Reservoir 1 is pumped by the Navajo Pump Station to Reservoir 3. Based on the facility elevations, the projected flowrate for this operation is only 1,600 GPM with the existing pump. The water then flows by gravity to Reservoir 2 and then finally to the WTP. Pump performance is impacted by the change in the elevation difference between the suction side reservoir and the downstream reservoir. The suction side reservoir would switch from Reservoir 2 to Reservoir 1 following a rehab of Reservoir 1 which has a negative impact on the system performance.

C) System Curve

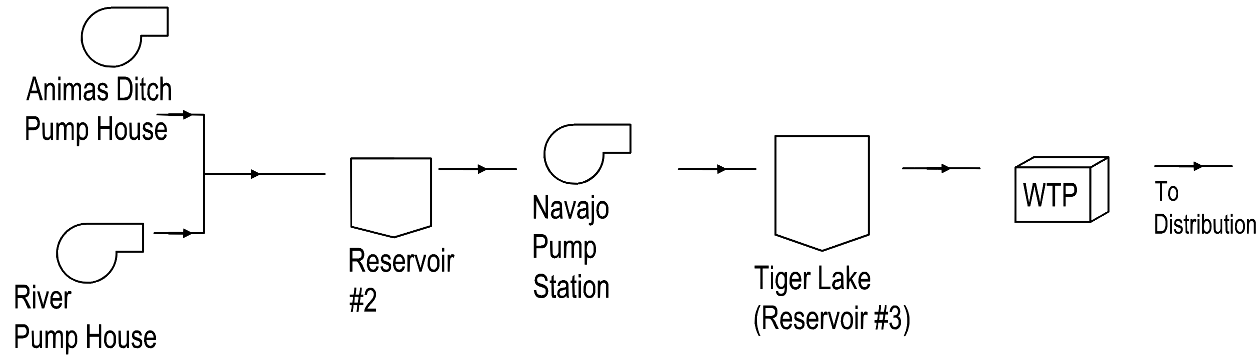
The existing pump in use is a Pentair centrifugal vertical split case pump rated for 2,000 gpm, 142 feet of head, and 1,750 rpm. Using estimated WSEs of 5,825 ft and 5,760 ft, respectively for Reservoir 3 and Reservoir 2, the Static Head was determined to be 75 ft, making the Total Dynamic Head (TDH) approximately 154 ft. The observed performance point of 1,800 gpm at 88 psi from the February 2019 site visit was used to calibrate the system curve by refining the friction coefficient for the pipe. The friction value (C factor) was determined to be 105 and was taken to be the representative friction value for the system and is used in all the system curves in this report. The reservoir water surface elevations for the suction side reservoirs are estimated at half full in order to account for more conservative low water operating conditions.

Based on the calculated system curve for current operations, see Figure 30, the existing configuration (Reservoir 2 to 3) is slightly more efficient than the proposed configuration with the rehab of Reservoir 1 (Reservoir 1 to 3) although not significantly so. The duty point flow rate decreases from an estimated 1,825 gpm for existing conditions to roughly 1,600 gpm for the system with Reservoir 1. Figure 28 depicts where the pump is performing and where it is expected to perform along the manufacturer's pump curve for the two scenarios. The reason for this decrease is the increase in static head from Reservoir 1 to Reservoir 3 as opposed to existing conditions due to the higher elevation difference between reservoirs. The WSEs used were 5,825 ft and 5,739 ft, respectively for Reservoir 3 and Reservoir 1, yielding a value of 86 ft static head vs. the 75 ft existing condition. In addition, the pipeline run is slightly longer from Reservoir 1 to Reservoir 3 than from Reservoir 2 to Reservoir 3 resulting in more projected friction-induced head loss in the pipe. It is also important to note that Reservoir 1 is lower in elevation than the pump station which does not create ideal operating conditions as it is the suction side reservoir. In order to achieve 2,000 gpm, the original rating of the pumps, the pumps would have to be replaced to accommodate for the different TDH conditions being observed in the field. A pump with a steeper curve (see Figure 31) such as the Goulds vertical turbine 125 HP Pump is recommended as it would allow a better operational range as the TDH increases. Table 3 below displays the projected performance of the system with the existing pump and with the proposed new pump. This replacement of the pumps in the booster station would require saw cutting and excavation of the existing concrete floor as well as minimal electrical replacement (from MCC to the pump motors) but would otherwise cause minimal disturbance to the operation of the station.

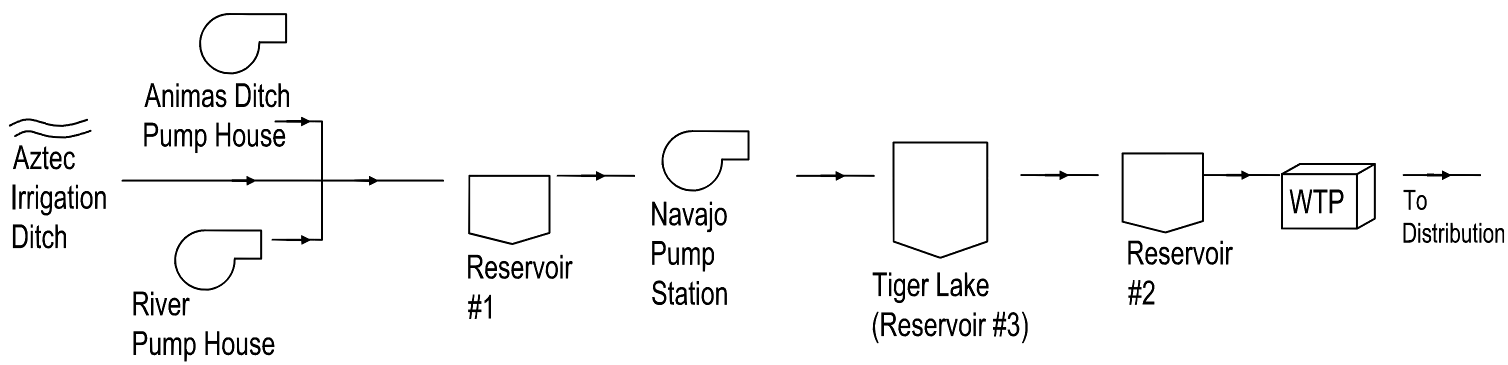
Table 3 – Option 1: Pump Option Summaries

Option	Pump	Flow (GPM)	TDH (ft)	Efficiency	Material Cost (2 pumps)
1,2,3: Reservoir 1 Rehabilitation	Existing Pentair Pump	1,700	182	~~44~~	--
	Goulds Vertical Turbine 125 HP Pump with VFDs	2,000	180	80	$83,000

Existing Operations



Options 1,2, and 3: Reservoir 1 Rehabilitation



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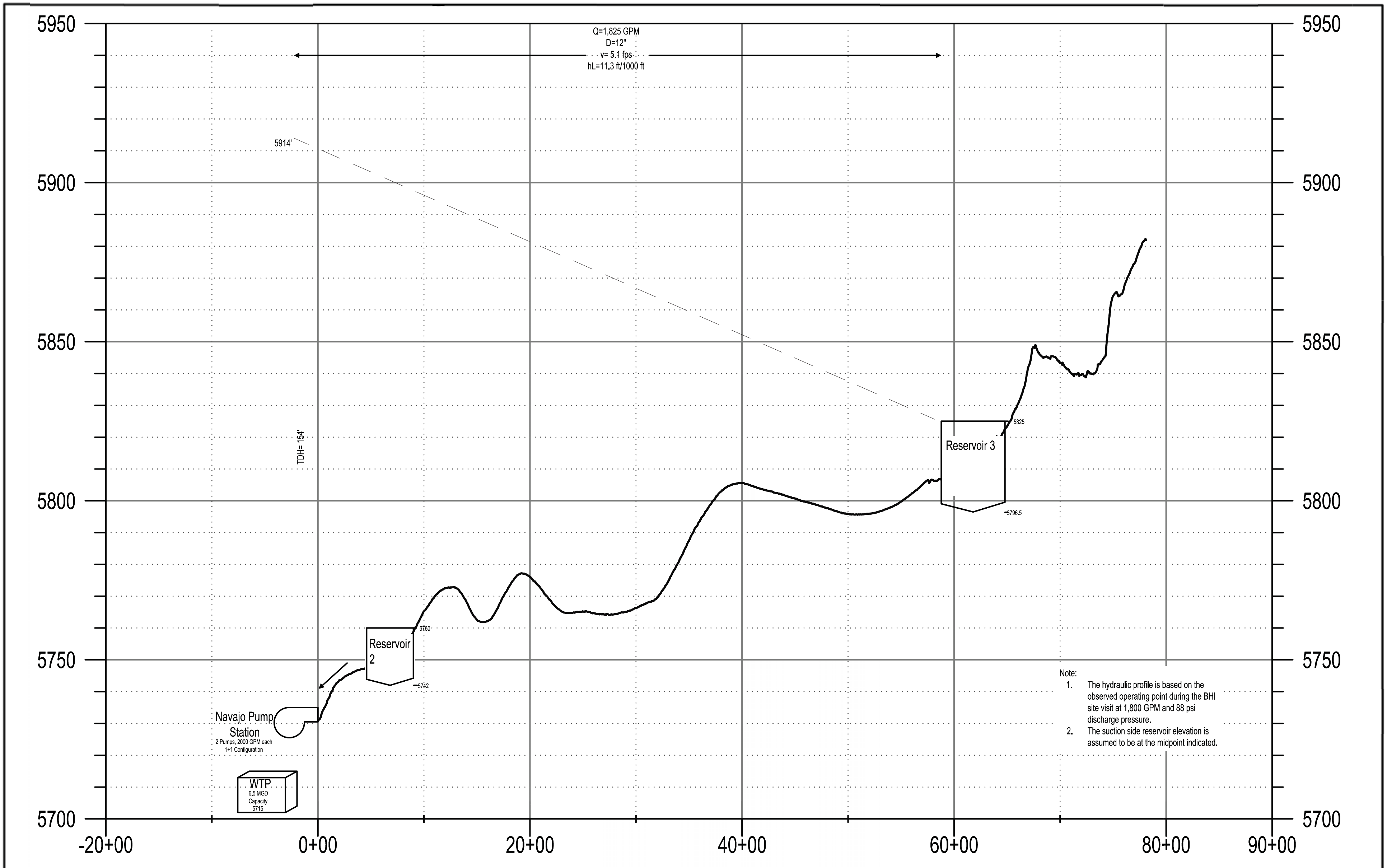
Reservoir 1 Evaluation

Figure 26
System Schematic
Existing System and Options 1,2, and 3
July 2019



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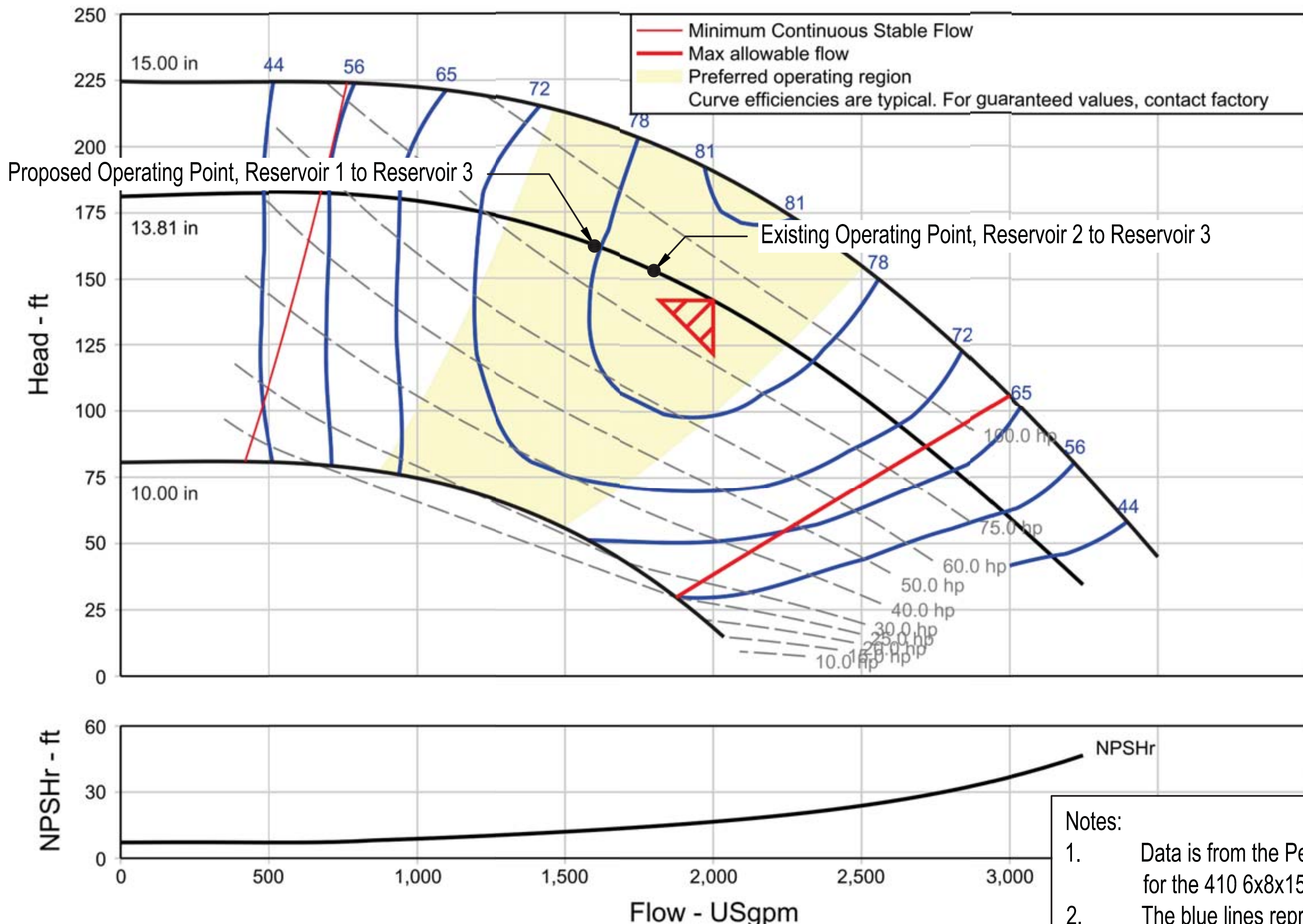
Reservoir 1 Evaluation

Figure 27
Hydraulic Profile
Existing Conditions

July 2019



Notes:

1. Data is from the Pentair Pump Curve for the 410 6x8x15 Centrifugal Split Case Pump.
2. The blue lines represent the estimated pump efficiency at these points.

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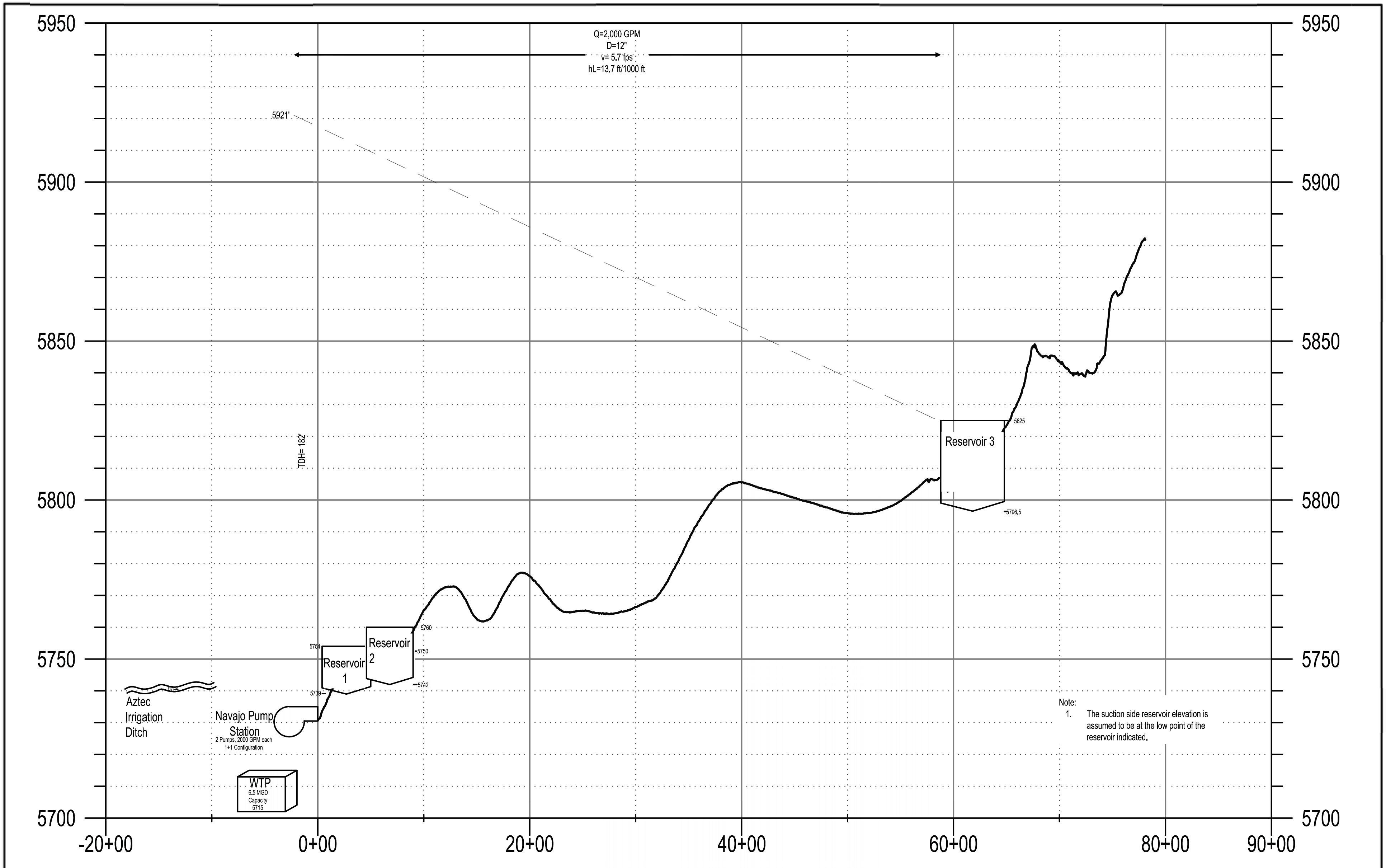
Reservoir 1 Evaluation

Figure 28
Pump Curve
Existing Pumps

July 2019



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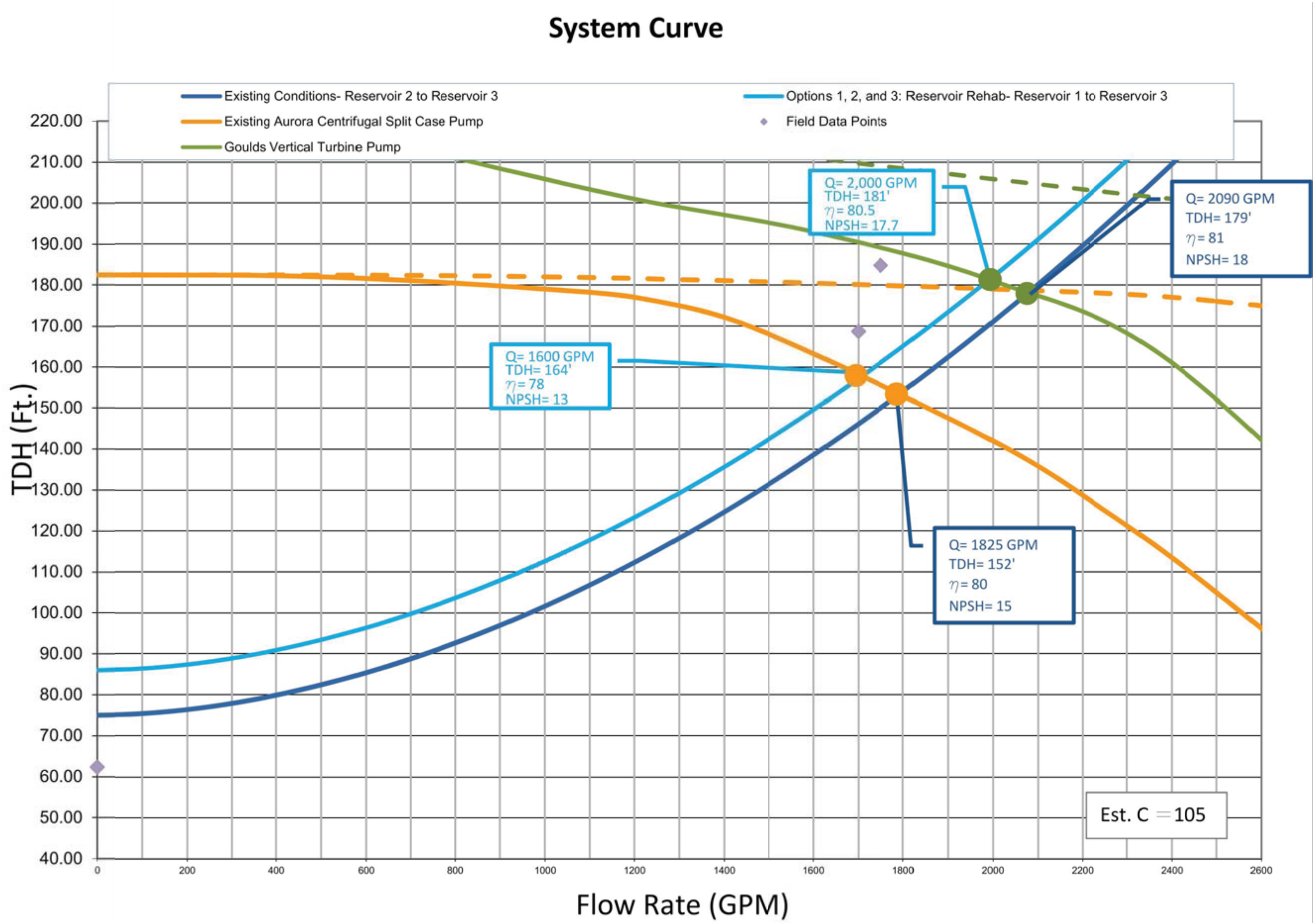
Reservoir 1 Evaluation

Figure 29
Hydraulic Profile
Reservoir 1 Rehabilitation

July 2019



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Reservoir 1 Evaluation

Figure 30
System Curve
Existing System and Reservoir 1 Rehab
July 2019

--- Duty Point ---

Flow:	2000 US gpm
Head:	181 ft
Eff:	80.5%
Power:	114 hp
NPSHr:	17.7 ft
Speed:	1770 rpm

--- Design Curve ---

Shutoff Head:	231 ft
Shutoff dP:	100 psi
Min Flow:	570 US gpm

BEP: 82.2% @ 2279 US gpm

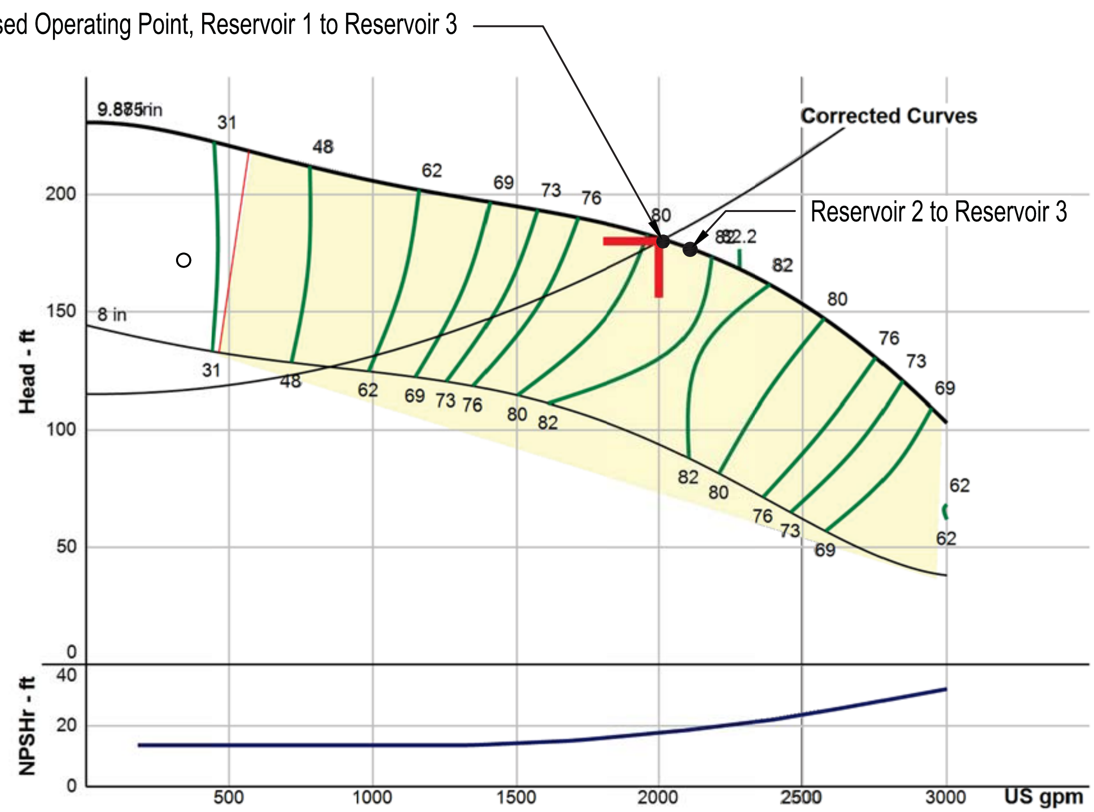
NOL Power:

120 hp @ 2638 US gpm

--- Max Curve ---

Max Power:

120 hp @ 2640 US gpm



Notes:

1. Data is from the Goulds Pump Curve for the 14RHMO Vertical Turbine Pump.
2. The green lines represent the estimated pump efficiency at these points.

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Reservoir 1 Evaluation

Figure 31
Pump Curve
Existing Pumps

July 2019

IV. Part IV: Rehab Potential

Jurisdictional Dam Determination

The Office of the State Engineer (OSE) Rules and Regulations Governing Dam Design, Construction and Dam Safety from December 7, 2009, defines a jurisdictional dam as “A dam 25 feet or greater in height, which impounds 50 acre-feet (60 MG) or more of water and is 6 feet or greater in height”. Dam height is determined as the difference in elevation between the crest and the downstream toe. As the elevation of the downstream toe is unknown at this time, the constructed ground surface elevation was used for this evaluation which provides a more conservative estimate of the height. The height was determined using 5,735 ft for the crest elevation and 5,717 ft for the constructed ground surface yielding a height of 18 ft, see Appendix A for the As-built drawing of Reservoir 1. The maximum capacity of the reservoir was determined to be roughly 31.25 Acre-Feet (10.184 MG) as seen in the As-built drawing. The OSE provides a simplified chart for the evaluation of a jurisdictional dam, the characteristics of Reservoir 1 are plotted on the chart below in Figure 32. See Appendix D for the full relevant section from the Dam Safety Bureau rules. Based on the OSE criteria, Reservoir 1 does not qualify as a jurisdictional dam which makes the potential rehab process easier, especially in the case of the modification of the irrigation ditch inlet structure which was a point of concern, as the state engineer does not regulate the design unless it is determined to be unsafe. Non-jurisdictional dams still need to comply with 19.326.2.15 of the NMAC unless otherwise exempt. Projects can be submitted to the OSE Dam Safety Bureau for official review of the jurisdictional status of a dam.

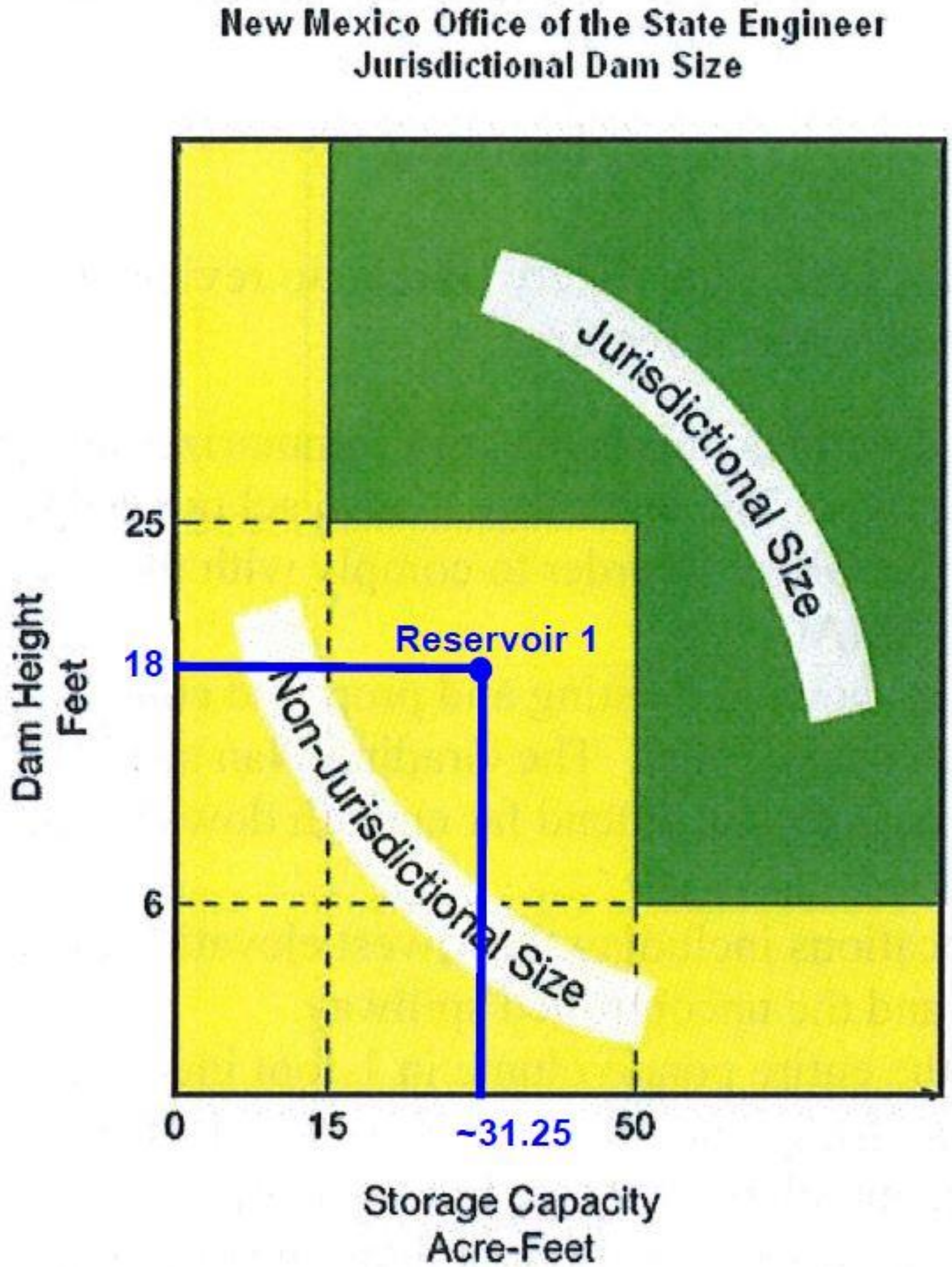


Figure 32 – Jurisdictional Dam Determination Chart

Overall Necessary Rehabilitation Items

The following three options deal primarily with the rehabilitation of the lining of the reservoir for water resistance. Other miscellaneous items listed below are also necessary in order to restore the reservoir to good working order and are included as standard items in the cost estimates of the three options. Although many small items are included, a majority of the necessary items are concerned with the inlet/outlet structures for the reservoir, so Figure 33 was created to clarify which items are being referenced.

Aztec Irrigation Ditch Inlet - The Aztec Irrigation Ditch inlet has a history of clogging due to the small diameter of the existing pipe and the high silt content of the influent. An open channel configuration can be used for this inlet which would decrease the likelihood of clogging. The basic design envisioned for this modification is a rectangular channel from the existing irrigation ditch to the existing inlet at the reservoir where a headwall would be constructed. To allow trucks to be able to drive around the perimeter of the reservoir, a traffic rated steel top grate would be installed above the rectangular channel. The existing flow meter would be recalibrated for the rectangular channel to decrease costs. Although design would be necessary for this modification, it is feasible as the reservoir does not qualify as a jurisdictional dam.

30-inch Piping from Reservoir 2 - The piping from Reservoir 2 to Reservoir 1 is in Zone 4 of the reservoir which contains a significant amount of damage to the structural integrity of the concrete due to this outfall. The approximately 350 LF of piping should be replaced as part of the project.

24-inch Overflow to Animas Ditch - The overflow line to the Aztec ditch is silted in and needs replacement; this includes approximately 450 LF of 24-inch pipe.

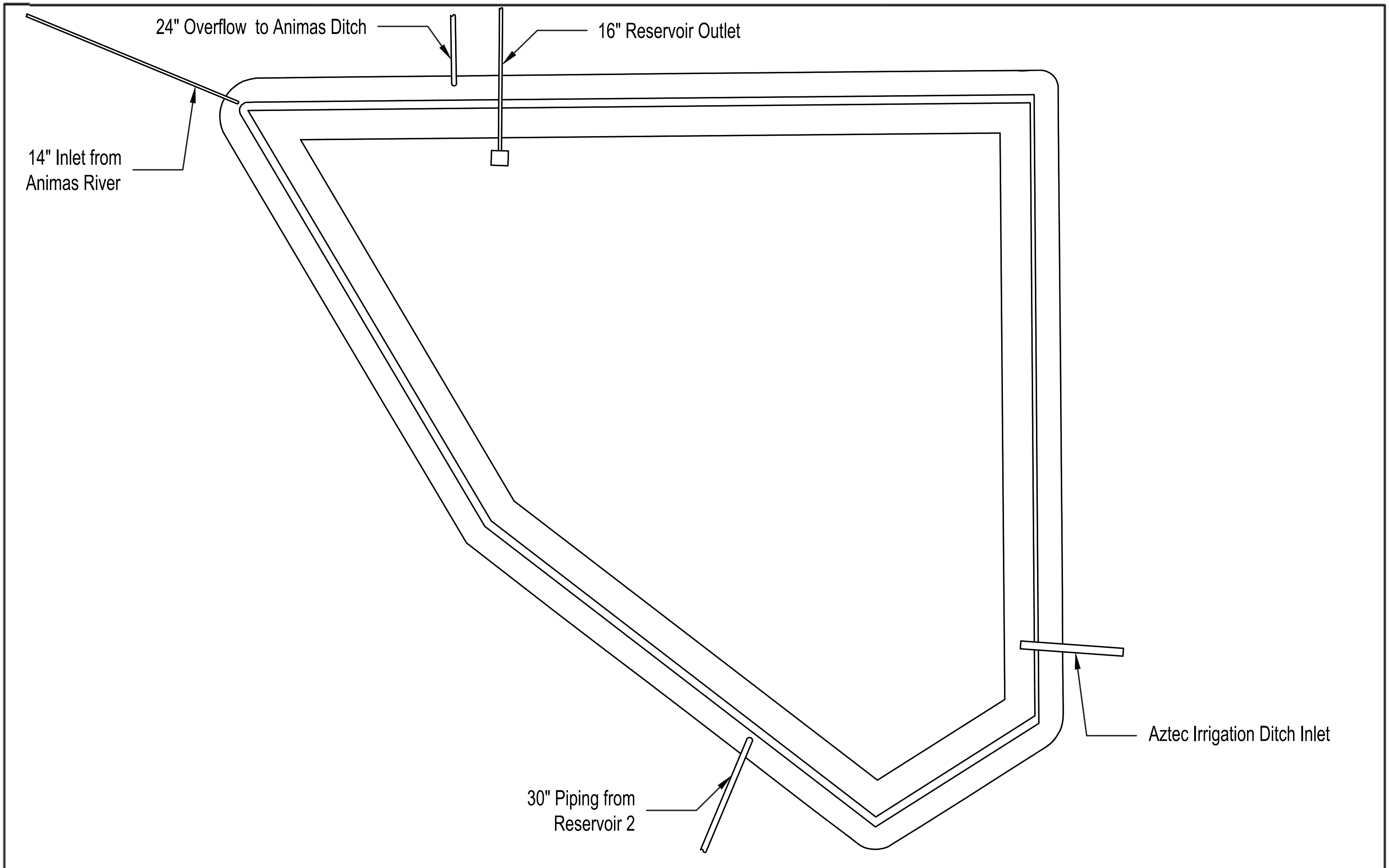
16-inch Drainage Line and Valve - The tower is in poor condition and needs replacement, the piping and valve to the pump station should also be replaced as part of this effort as the piping appears corroded and the valve is leaking.

Prefabricated Baffles- Reservoir 1 previously had baffles and which were considered to be a good addition with the water appearing clearer in subsequent cells. New replacement baffles are included in the cost estimates.

Ramp - A concrete ramp into the reservoir is included in order to increase accessibility for cleaning. In the first two rehabilitation options, the ramp would be solely concrete but in Option 3, a product such as polylock would be added during the installation of the concrete which would allow the HDPE liner to be welded easily and attached to the concrete. See Appendix E for further details on how polylock is commonly installed reservoirs to ensure the water tightness of the liner.

Rope Ladders – The installation of rope ladders in the reservoir is recommended as a safety improvement for emergency situations.

Outlet Structure Tower- During the site evaluation, it was noted that there are underlying problems beneath the most recent layer of concrete. There is concern that the exposure to water and freeze-thaw over time has compromised the structural integrity of the tower. Regardless of which option is chosen, we recommend that a new outlet structure be built at the location of the existing structure. Although the steel bridge used to access the structure was found to be in decent condition and could be reused after rehab and recoating of the steel members, it is also recommended that the catwalk be replaced with the tower.



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Reservoir 1 Evaluation

Figure 33
Reservoir 1
Inlet and Outlet Locations

July 2019

Options Overview

Three options were considered for the rehab of Reservoir 1 including:

- Option1: Rehab of the existing concrete panels to restore structural integrity and also the restoration of the bottom of the reservoir to minimize possible seepage.
- Option 2: Partial rehab of the concrete panels in the reservoir and installation of a liner along the top row of panels which have faced more wear and tear from the elements, in Zone 4, and along the floor of the reservoir.
- Option 3: Full relining of the reservoir with a liner.

i. Option 1: Rehab of Concrete Panels

A) Option 1 Overview

Using the information gathered from the site visit evaluation of the concrete panels, joint conditions and intake tower structure, the team evaluated different methods to restore the integrity of Reservoir 1. One such method looked at keeping as much of the existing structure in place. This implies that both top and bottom concrete panels would stay in place but be repaired by patching areas where delamination and spalling have caused the shotcrete to deteriorate over time. To perform the repair, panels that received a rating of 3 or less in our site visit evaluation would need to be completely removed and replaced with 6-inch concrete lining. As shown in Figure 6 and Figure 17, 64 out of the 90 panels located in the upper half of the reservoir would need to be replaced. For the lower panels, a complete removal and replacement of Zone 4 is required. Based on calculations performed by the team, 20,382 sq. ft of shotcrete would need to be removed and replaced.

Once the shotcrete has been completely replaced with 6-inch concrete lining, removal and replacement of all the existing joints located around the concrete panels is necessary. During the site evaluation, the team found the existing joint material to be insufficient for holding water. Based on the existing conditions, expansion joints are recommended to provide these panels the ability to expand and contract while preventing water intrusion through the joints. To outline the existing panels in the reservoir, an estimated 5,258 ft of joint material would be required.

Rehabilitation would also include restoration of the clay layer at the bottom of the reservoir as the Geotech report noted that the original clay liner layer was non-existent. Replacement of the clay liner would be necessary in addition to the concrete panel improvements to increase the impermeability of the reservoir, although complete impermeability may be impossible with these construction materials. It is recommended that a geosynthetic clay liner (GCL) is installed rather than a clay layer originally installed in the reservoir. A GCL has two general configurations, the first consists of a layer of bentonite clay installed between two geotextiles and the second consists of a layer of bentonite glued to a geomembrane base. The first option would likely be the most beneficial in this application as it would be less susceptible to disturbance. GCL's have the advantage of self-healing minor holes in the GCL if the liner is disturbed and also having low hydraulic conductivity (depending on type of bentonite, additives, and geosynthetic material).

Option 1 involves preserving as much of the existing structure in place as possible while correcting all deficiencies in the concrete panels and joints, previous experience has proven that it may not be the best option long term. Sealing leaking joints before addressing issues with settlement of the earth beneath the panels will only fix the problem temporarily. Within a short amount of time, movement in the soils will cause adjacent panels to separate once more, leading to continued leakage. Another concern that the team has with this option is that the existing shotcrete will continue to degrade due to exposure to the weather conditions in this area.

The addition of the ramp mentioned in the additional necessary items would make the maintenance of Reservoir 1 easier as it would increase accessibility. However, it would still require manual cleaning of the bottom of the reservoir as cleaning with heavy equipment may damage the integrity of the bottom GCL liner.

B) Cost Estimate

Table 4 below details the cost of rehabilitation of the concrete panels. The estimate includes the concrete panel rehab, clay liner replacement, and the overall necessary items included in the previous section.

Table 4 – Option 1: Rehab of Concrete Panels Cost Estimate

No	Item	Quantity	Unit	Unit Price	Total Price
	Base Bid				
1	Mobilization and Demobilization	1	LS	$51,000	$51,000
2	Construction Staking, Survey and Record Drawings	1	LS	$22,000	$22,000
3	Materials Testing	1	LS	$39,000	$39,000
4	Site Clearing and Grubbing	1.0	AC	$2,000	$2,000
5	Demo of Concrete	20,382	SF	$6	$122,292
6	Concrete Lining - 6"	20,382	SF	$20	$407,640
7	Joint Material	5,258	LF	$30	$157,740
8	General Concrete, Tower Structure	36	CY	$700	$25,200
9	General Concrete, Ramp (Includes Wall and Footing)	62	CY	$700	$43,400
10	Tower Steel (includes catwalk)	1	LS	$23,000	$23,000
11	Reline bottom with GCL	79,000	SF	$1.5	$118,500
12	Irrigation Ditch Inlet Structure	1	LS	$10,000	$10,000
13	Prefabricated Baffle with Anchoring System	850	LF	$90	$76,500
14	Replace Inlet Piping, 30" WL, Reservoir 2 to Reservoir 1	350	LF	$175	$61,250
15	Replace Drainage Line, 24" WL	450	LF	$110	$49,500
16	Replace Drainage Line and Valve, 16"	1	LS	$25,400	$25,400

No	Item	Quantity	Unit	Unit Price	Total Price
17	New Pumps with VFDs and Installation (Vertical Turbine)	1	LS	$210,000	$210,000
	Subtotal Base Bid				**$1,444,500**
	Construction Contingency			**30%**	**$433,400**
	Design and Construction Admin			**15%**	**$281,700**
	NM Gross Receipts Tax on Construction			**8.2500%**	**$178,200**
	TOTAL PROJECT COST				**$2,337,800**
This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from this opinion.					

ii. Option 2: Half Concrete Rehab, Half Liner

A) Option Overview

Another method evaluated to restore the integrity of the reservoir, is adding an impermeable synthetic liner in addition to repairing some of the existing panels. Figure 34 displays the areas where the liner would be installed and the areas that would consist solely of concrete rehabilitation. From our site visit evaluation, it was determined that in order to maintain the integrity of the reservoir, all concrete panels in the upper half of the reservoir would need to be cleared of faulty material and replaced by a layer of impermeable liner. To achieve a successful installation of the liner in the upper half, the shotcrete panels would need to be ground down to a flattened surface in order to avoid ripping the liner. The step between the upper and lower sections of the shotcrete panels would need to be completely removed and replaced so that the liner can be properly attached to the upper portion of the reservoir. The liner would also be attached into a newly dug trench of concrete surrounding the top boundary of the reservoir. Based on calculations performed by the team, roughly 116,000 sq. ft of impermeable synthetic liner would be required and 20,382 sq. ft. of concrete would need to be removed.

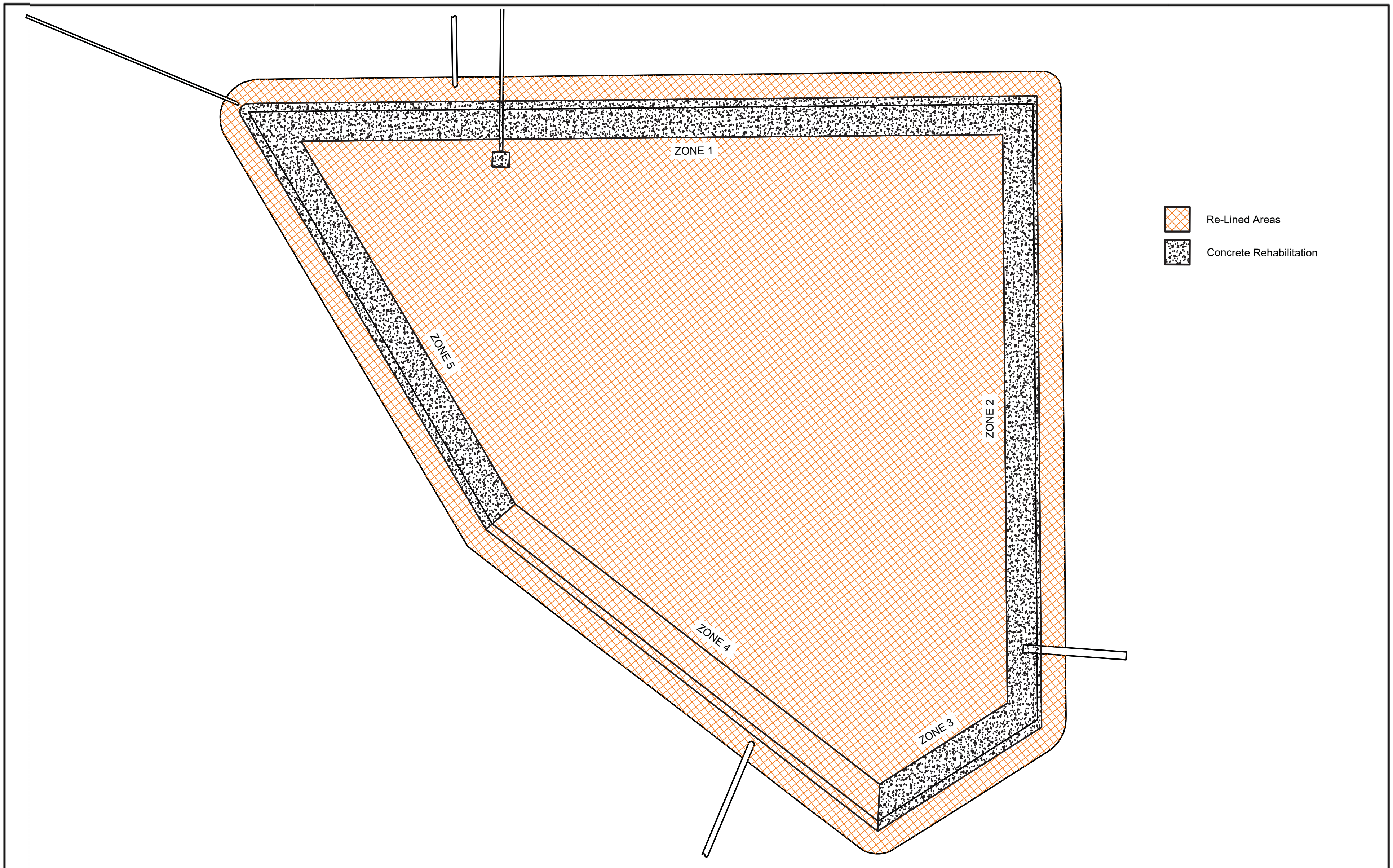
In regard to the lower portion of the reservoir, panels found to have extensive cracking and/or spalling would require specific maintenance procedures including but not limited to the removal and replacement of all joints and delaminated and spalled concrete. In our evaluation, we determined that Zone 4 (including both top and bottom panels) would need to be completely removed and replaced by the impermeable liner. The team noticed extensive damage to the slopes surrounding the inlet pipe from Reservoir 2 and the placement of the liner would prevent further damage to the earthen slopes. For this option, an estimated 3,541 ft of joint material would be required for the lower portion.

This alternative will use a 60 mil HDPE liner backed by a 200 mil geonet to provide additional support and cushioning for the liner against the remaining concrete. The area around the inlet/outlet pipes and the ramp would be double lined so that the topmost liner acts as the sacrificial liner in the event of damage, maintaining the watertight integrity of the liner. Although this method of partial concrete rehab/partial liner installation will improve the reservoir integrity, it will not be completely watertight.

During our site evaluation, it was determined the outlet structure's most recent layer of concrete may present design obstacles. The team is concerned that the exposure to water and freeze-thaw over time has compromised the tower's structural integrity. Regardless of which option is chosen, we recommend that a new outlet structure is built at the location of the existing structure. However, the steel bridge used to access the structure was found to be in good condition and could be reused after minor maintenance procedures are completed.

While the purpose of this option is to replace the most deteriorated portions of the reservoir with a synthetic liner and keep the existing panels that are in good condition in place, previous experience has proven it may not be the best option long term. As mentioned previously in option 1, repairs to the existing shotcrete panels will not address issues with settlement and continued exposure to the weather elements on concrete in the lower area.

The addition of a ramp to the reservoir would make the maintenance easier as it would increase accessibility. A 24-inch sacrificial layer of sand will cover the liner to provide protection during cleaning operations. This will allow trucks to enter the reservoir and will greatly increase the efficiency of cleaning. The specific methods for protecting the liner shall be refined during the design phase to more effectively protect the liner.



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Reservoir 1 Evaluation

Figure 34
Reservoir 1
Option 2 Re-Lined Areas

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B) Option Cost

Table 5 details the cost of rehabilitation. The estimate includes the concrete panel rehab, liner/geonet installation, and the overall necessary items included in the previous section.

Table 5 – Option 2: Rehab of Concrete Panels and Liner Installation Cost Estimate

No	Item	Quantity	Unit	Unit Price	Total Price
	Base Bid				
1	Mobilization and Demobilization	1	LS	$54,000	$54,000
2	Construction Staking, Survey and Record Drawings	1	LS	$20,000	$20,000
3	Materials Testing	1	LS	$35,000	$35,000
4	Site Clearing and Grubbing	1.0	AC	$2,000	$2,000
5	Demo of Concrete	20,382	SF	$6	$122,292
6	Concrete Lining - 6"	2,633	SF	$20	$52,660
7	Joint Material	3,541	LF	$30	$106,230
8	General Concrete, Tower Structure	36	CY	$700	$25,200
9	General Concrete, Ramp (includes wall and footing)	62	CY	$700	$43,400
10	Tower steel - rehab steel and new steel (includes catwalk)	1	LS	$23,000	$23,000
11	Liner, materials and installation, liner and Geonet	1	LS	$225,000	$225,000
12	Anchor Trenches and earthwork for liner installation	1	LS	$25,000	$25,000
13	Concrete work for liner installation	1	LS	$45,000	$45,000
14	24" Layer Sand	5,830	CY	$20	$116,600
15	Irrigation Ditch Inlet Structure	1	LS	$10,000	$10,000
16	Prefabricated Baffle with Anchoring System	850	LF	$90	$76,500
17	Replace Inlet Piping, 30" WL, Reservoir 2 to Reservoir 1	350	LF	$175	$61,250
18	Replace Drainage Line, 24" WL	450	LF	$110	$49,500
19	Replace Drainage Line and Valve, 16"	1	LS	$25,400	$25,400
20	New Pumps with VFDs and Installation (Vertical Turbine)	1	LS	$210,000	$210,000
	Subtotal Base Bid				**$1,328,100**
	Construction Contingency			**30%**	**$398,500**
	Design and Construction Admin			**15%**	**$259,000**
	NM Gross Receipts Tax on Construction			**8.2500%**	**$163,900**
	TOTAL PROJECT COST				**$2,149,500**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from this opinion.

iii. Option 3: Completely New Liner

A) Option Overview

The last rehabilitation option for Reservoir 1 is the complete relining of the reservoir with the 60 mil HDPE liner and the 200 mil geonet. For this option, all the concrete in the reservoir will need removal to prevent concrete separation from the slopes and damage to the liner. This option also includes all the basic rehabilitation items included in the previous options such as the replacement of the tower and irrigation ditch inlet structures as well as the addition of baffles and a concrete ramp.

This option also includes the 24-inch sacrificial layer of sand included above the liner for protection to allow trucks to enter the reservoir for cleaning. The specific methods for protection of the liner would be refined during the design phase to more effectively protect the liner.

B) Option Cost

The projected costs of this option are provided in Table 6. This option includes all the miscellaneous rehabilitation items of the previous items but swaps out any restoration of the concrete panels with complete reservoir relining.

Table 6 –Option 3: New Liner Installation Cost Estimate

No	Item	Quantity	Unit	Unit Price	Total Price
	Base Bid				
1	Mobilization and Demobilization	1	LS	$49,000	$49,000
2	Construction Staking, Survey and Record Drawings	1	LS	$18,000	$18,000
3	Materials Testing	1	LS	$32,000	$32,000
4	Site Clearing and Grubbing	1.0	AC	$2,000	$2,000
5	Demo of Concrete	47,500	SF	$6	$285,000
6	General Concrete, Tower Structure	36	CY	$700	$25,200
7	General Concrete, Ramp (includes wall and footing)	62	CY	$700	$43,400
8	Tower steel - rehab steel and new steel (includes catwalk)	1	LS	$23,000	$23,000
9	Liner, materials and installation, liner and Geonet	1	LS	$235,000	$235,000
10	Anchor Trenches and earthwork for liner installation	1	LS	$25,000	$25,000
	24" Layer Sand	5,830	CY	$20	$116,600
11	Irrigation Ditch Inlet Structure	1	LS	$10,000	$10,000
12	Prefabricated Baffle with Anchoring System	850	LF	$90	$76,500
13	Replace Inlet Piping, 30" WL, Reservoir 2 to Reservoir 1	350	LF	$175	$61,250
14	Replace Drainage Line, 24" WL	450	LF	$110	$49,500
15	Replace Drainage Line and Valve, 16"	1	LS	$25,400	$25,400
16	New Pumps with VFDs and Installation (Vertical Turbine)	1	LS	$210,000	$210,000
	Subtotal Base Bid				**$1,286,900**
	Construction Contingency			**30%**	**$386,100**
	Design and Construction Admin			**15%**	**$251,000**
	NM Gross Receipts Tax on Construction			**8.2500%**	**$158,800**
	TOTAL PROJECT COST				**$2,082,800**
This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from this opinion.					

II. Part V: New Reservoir Options

The construction of a new reservoir, Reservoir 4, may be the most advantageous option in the long run as the all new construction can be more easily quality controlled and all new materials will have a longer lifespan. Although several options were considered initially for the location of Reservoir 4, the vacant site to the east of Reservoir 3 was chosen as the preferred site due to several considerations including the preference expressed by the City during the BHI site visit in February. The main advantages of this location are that it is on city land and not BLM, so the land will not require a lease in addition to the close proximity to Reservoir 3 which allows for the possibility of interconnected trails between the reservoirs for public use. Figure 35 displays the proposed site/ configuration.

Two options, Options 4 and 5, were evaluated with respect to construction of a new reservoir. Option 4 consists of the construction of a new reservoir to the east of Reservoir 3 while Option 5 also includes the construction of this new reservoir but also includes the partial rehabilitation of Reservoir 1 to take advantage of the gravity feed of water from the Aztec Irrigation Ditch. Figure 36 displays the simplified system schematics for these two options.

Hydraulics and System Curve with Reservoir 4

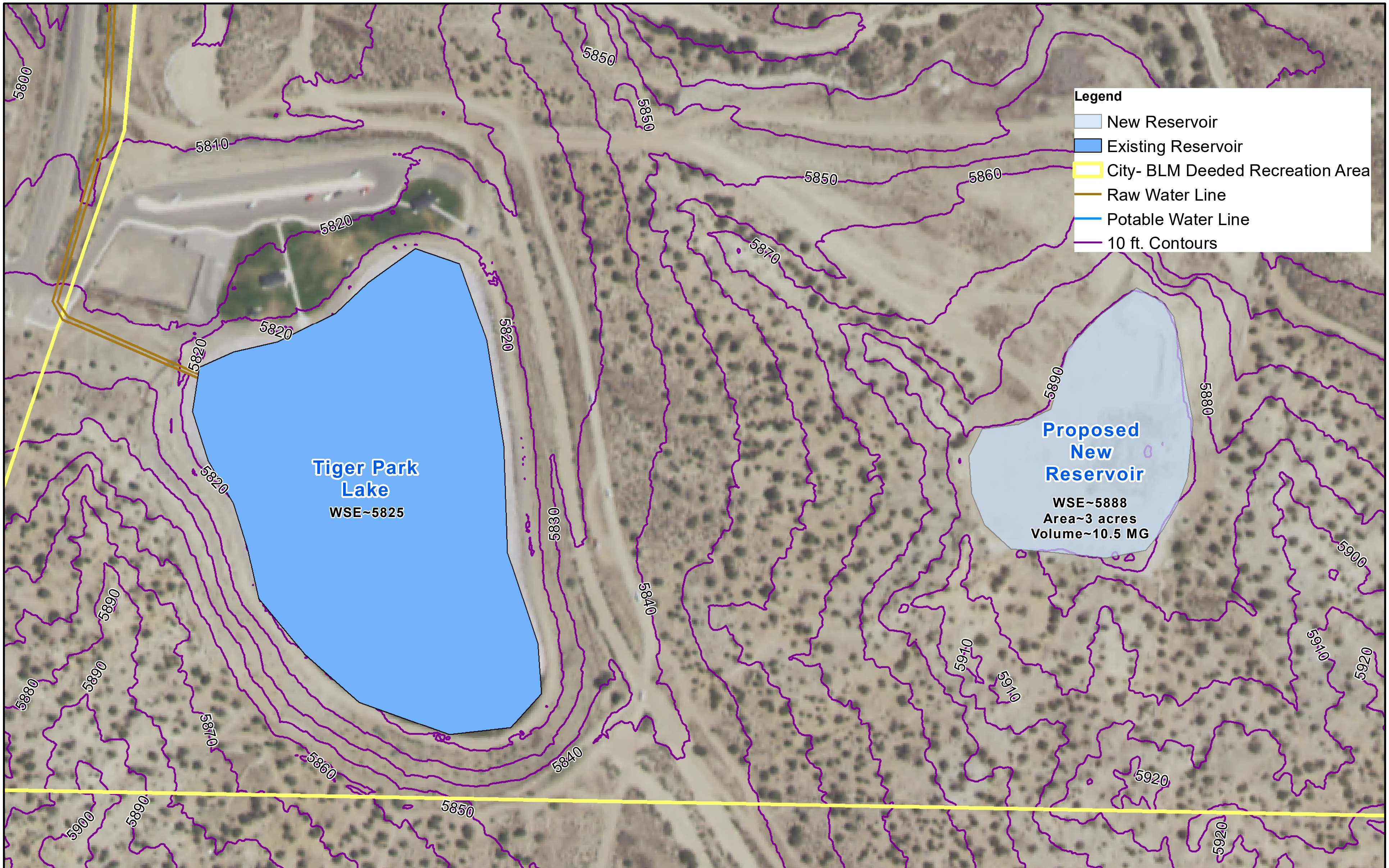
Using an estimated WSE of 5,888 ft for the new reservoir based on the site topography and 5,750 ft for Reservoir 2, the static head is 138 ft. The same calculated friction factor for the pipe was used as before, C=105. Based on these parameters, the flow would only be 1,200 gpm with the existing pump, see Figure 37 for the system curve. This flow is only 60 percent of the desired 2,000 gpm of the pump and the efficiency would be at 71 percent. In addition, the operating head is estimated to be at 178 ft which is very close to the max head of the existing pump (max rated head is 182.5 ft) and nearing pump run-out condition. This operating condition is very close to the left flat part of the curve meaning that very small head changes cause large flow rate and efficiency changes. It is possible that the existing pump may not be able to pump at these head conditions if the assumed elevations used for the analysis are slightly different than the actual elevations once the reservoir is constructed. Modifications to the pump station are necessary for this new reservoir.

Option 5 has the same limitations as those detailed above for Option 4 but to a slightly greater degree. Because the suction side reservoir would be Reservoir 1 or Reservoir 2, the maximum possible static head for this scenario will be larger (because Reservoir 1 is at a lower elevation than Reservoir 2) which will mean the existing pump will pump a lower flow rate and efficiency – 1,125 gpm at 70 percent efficiency. This rate is unacceptably low and would not function with the system.

The System Curve in Figure 37 includes the existing condition system curve as well as the system curves for Options 4 and 5 for the new reservoir. In addition, two pump curves were added to the existing pump curve to display possible replacement pumps for the system.

Table 7 is a summary of the differences between the pumps displayed in the system curve. The exact pumps shown were chosen as they are in the same line of pumps as the existing, so they would be familiar to the operators and would ensure consistency in the system; other pumps with the same operating specifications would also be appropriate for these conditions. The largest pump is the most expensive, but is also the most efficient and the one able to provide the 2,000

GPM that the existing pump is rated for in the new system configuration. If a 1,200 gpm operating flow is sufficient, a smaller pump can be chosen that is capable of producing at the estimated TDH and flow could be considered. Alternate pump types, such as a vertical turbine, can also be considered with this Option.



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City of Aztec
Figure 35
Reservoir 4 Siting

P:\20190476\WR\Calculations\Programs\ArcGIS\Maps\AztecReservoir2Site.mxd
Author: nrascon

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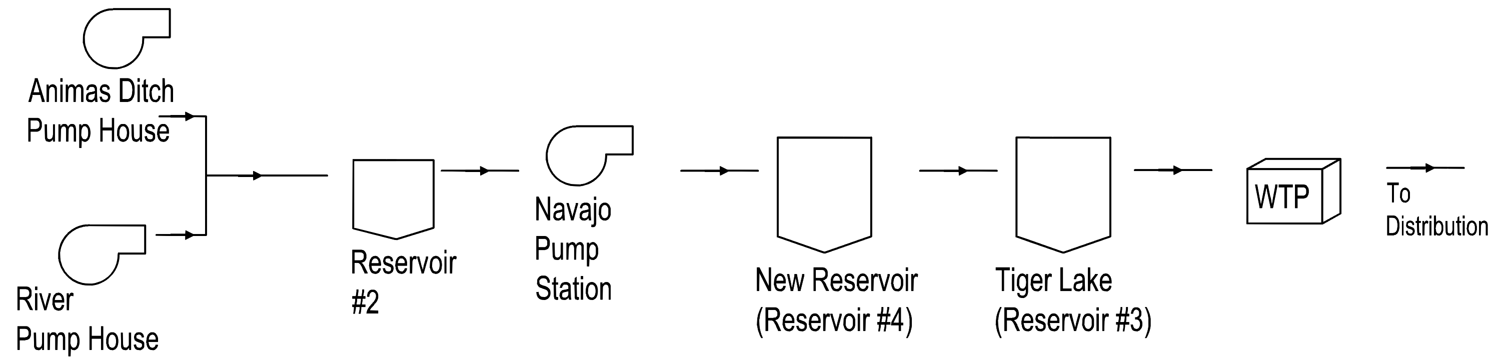
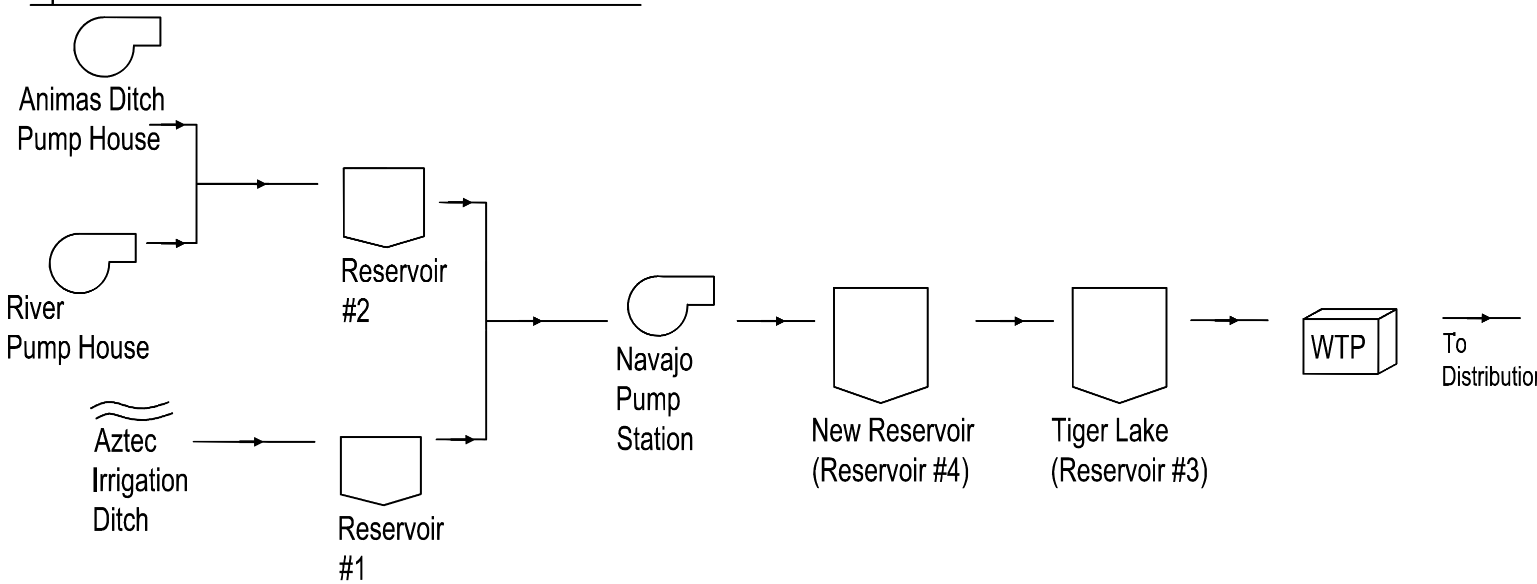
Option 4: New Reservoir



Option 5: New Reservoir and Reservoir 1 Rehabilitation



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Reservoir 1 Evaluation

Figure 36
System Schematic
Options 4 and 5

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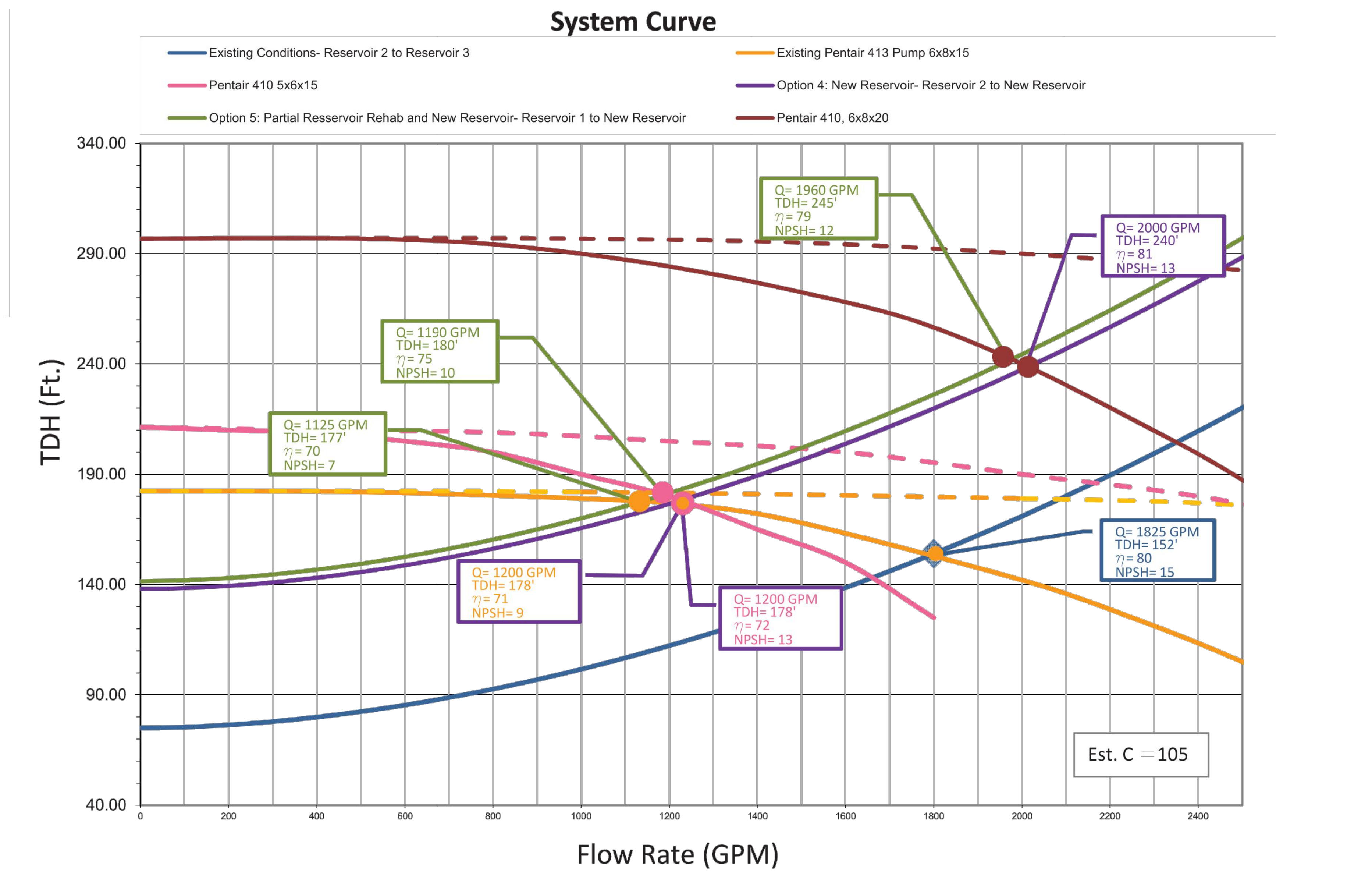

Reservoir 1 Evaluation

Figure 37
System Curve
Existing System and All Options

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Table 7 – Option 1: Pump Option Summaries

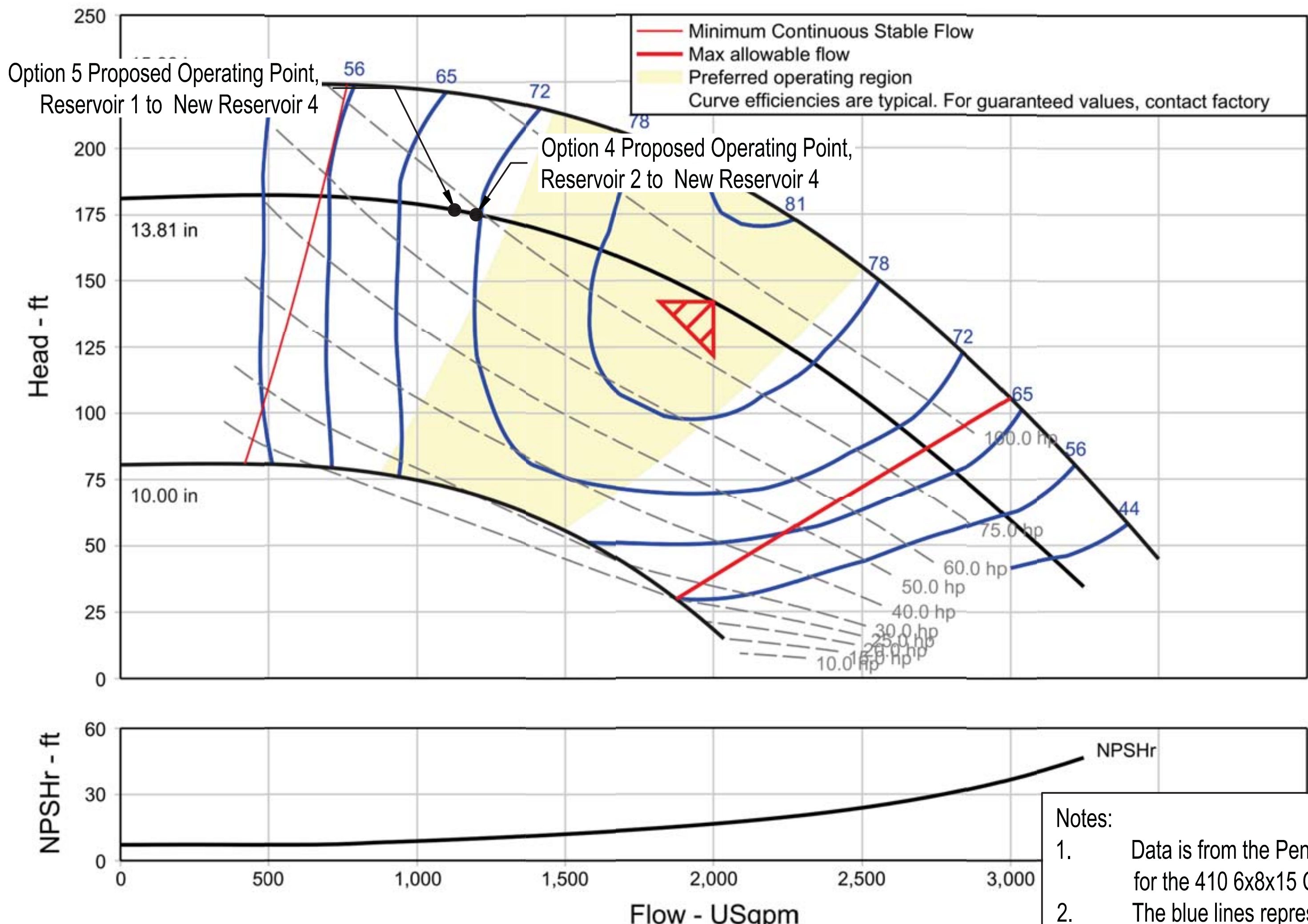
Option	Pump	Flow (GPM)	TDH (ft)	Efficiency	Material Cost (per pump)
4: New Reservoir 4 Above Tiger Lake	Existing Pentair Pump	1,200	178	71	--
	Standard Pentair 413 5x6x15, 100 HP	1,200	178	72	$60,000
	Standard Pentair 413 6x8 20, 200 HP	2,000	240	81	$90,000
5: Partial reservoir 1 Rehab and New Reservoir 4	Existing Pentair Pump	1125	177	70	--
	Standard Pentair 413 5x6x15, 100 HP	1190	180	75	$60,000
	Standard Pentair 413 6x8 20, 200 HP	1,960	245	79	$90,000

Based on the table above and assuming that a flow rate of 1,200 is too low for the system, the preferred pump is the largest pump. The larger pump can provide 2,000 gpm at 81 percent efficiency for Option 4 and 1,960 gpm at 79 percent for Option 5, which is what the observed operating point was for the system. Figures 38 and 39 illustrate the above operating points for the existing pump and proposed larger pump respectively.

The hydraulic profiles are based on the preferred pump option and display the 2,000 gpm and 1,960 gpm flows for Options 4 and 5, respectively, as well as the corresponding head conditions for these scenarios. These profiles are shown in Figure 40 and Figure 41.

Jurisdictional Dam Determination

The proposed reservoir size and location was evaluated to ensure a non-jurisdictional dam. The topography at the proposed reservoir location allows for it to be excavated out rather than bermed up. Although dam height is usually measured from the downstream toe of the slope to the crest, since the construction method would minimize this, the full proposed depth of the reservoir was used as the height of the dam, which would be a huge safety factor, to ensure that we are safely away from the jurisdictional dam size limits. See Figure 42 for classification chart.



Notes:

1. Data is from the Pentair Pump Curve for the 410 6x8x15 Centrifugal Split Case Pump.
2. The blue lines represent the estimated pump efficiency at these points.

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Reservoir 1 Evaluation

Figure 38
Pump Curve
Existing Pumps

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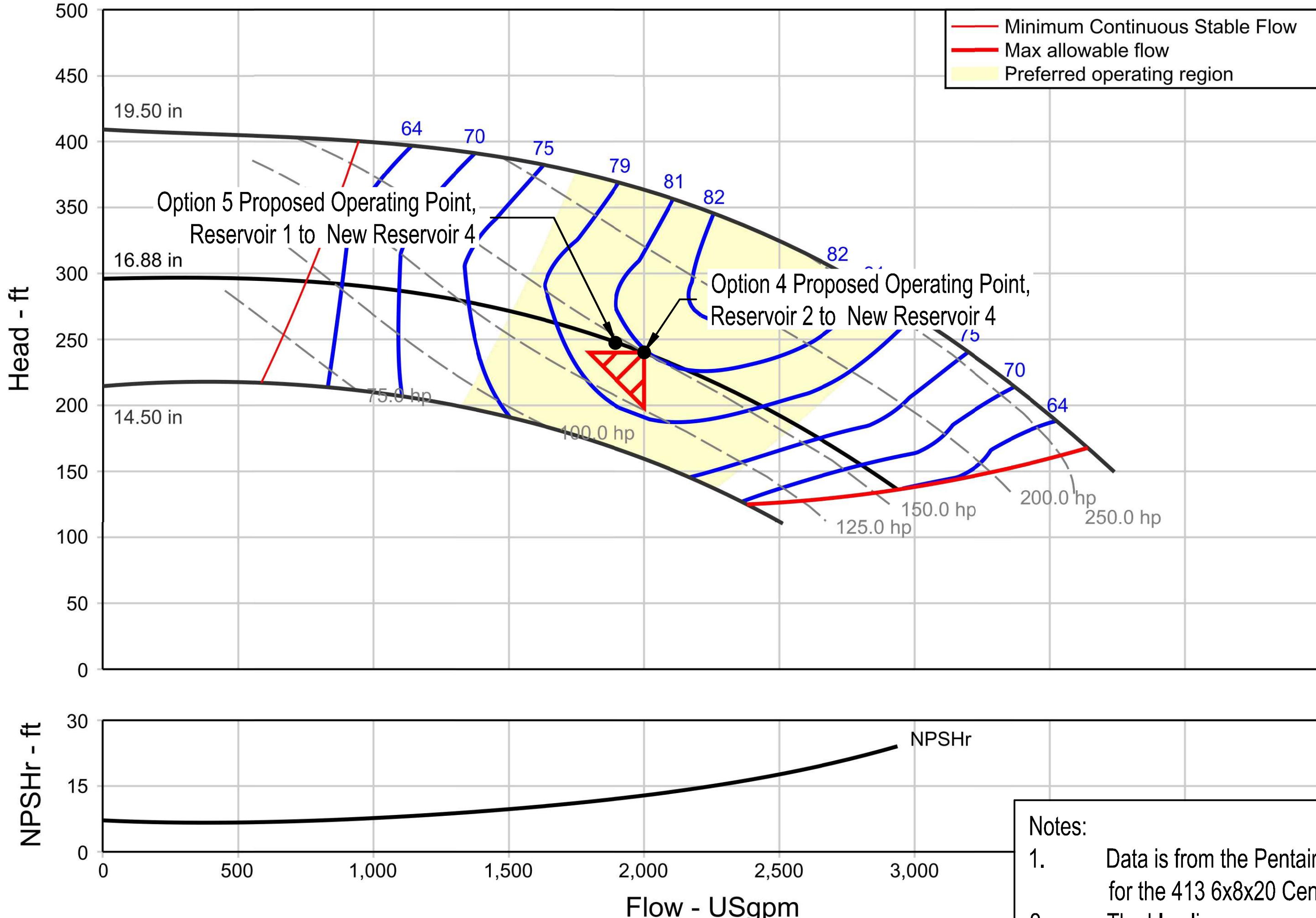

Notes:
1. Data is from the Pentair Pump Curve for the 413 6x8x20 Centrifugal Split Case Pump.
2. The blue lines represent the estimated pump efficiency at these points.

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Reservoir 1 Evaluation

Figure 39
Pump Curve
New Pumps

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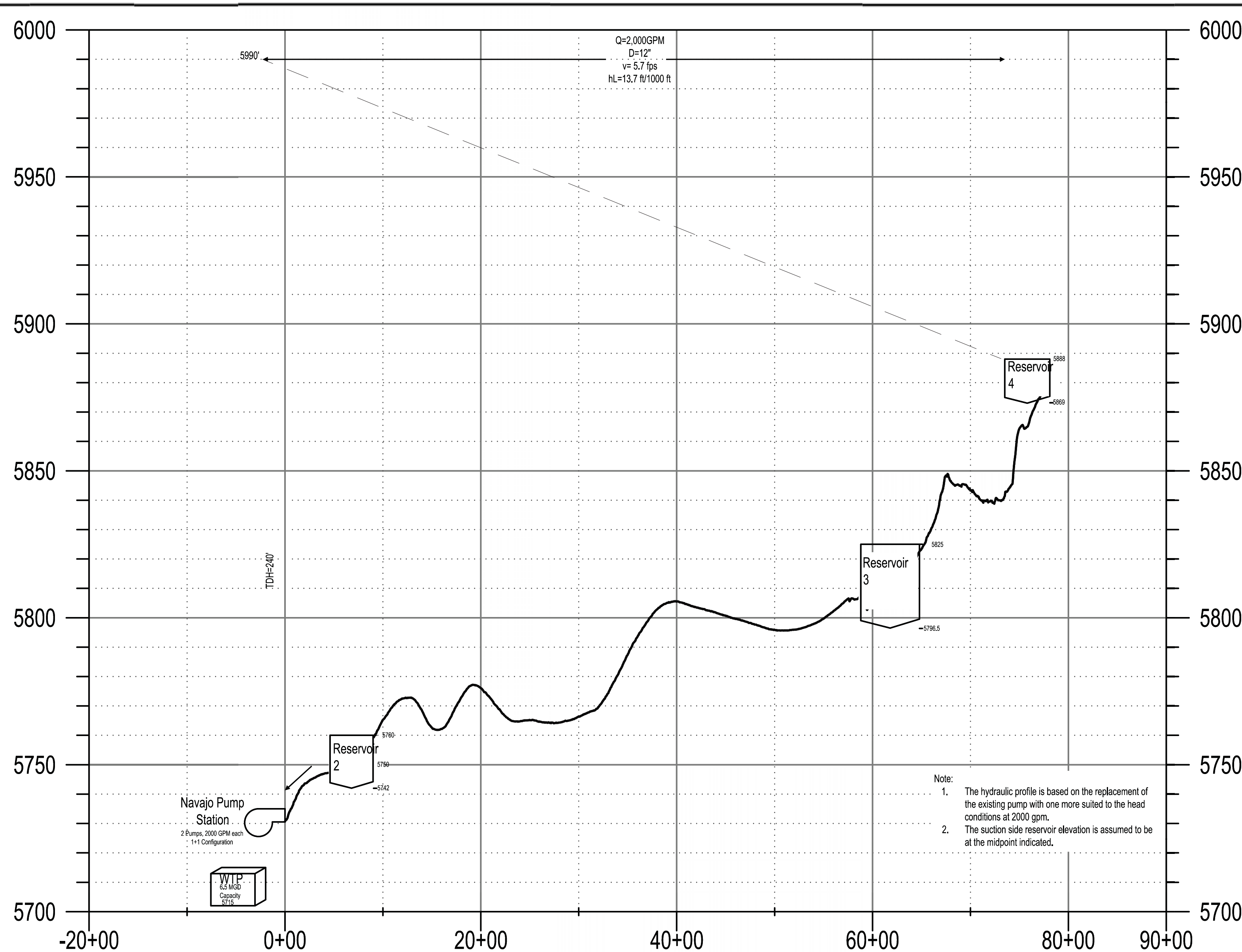

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Reservoir 1 Evaluation

Figure 40
Hydraulic Profile
Option 4: Reservoir 4

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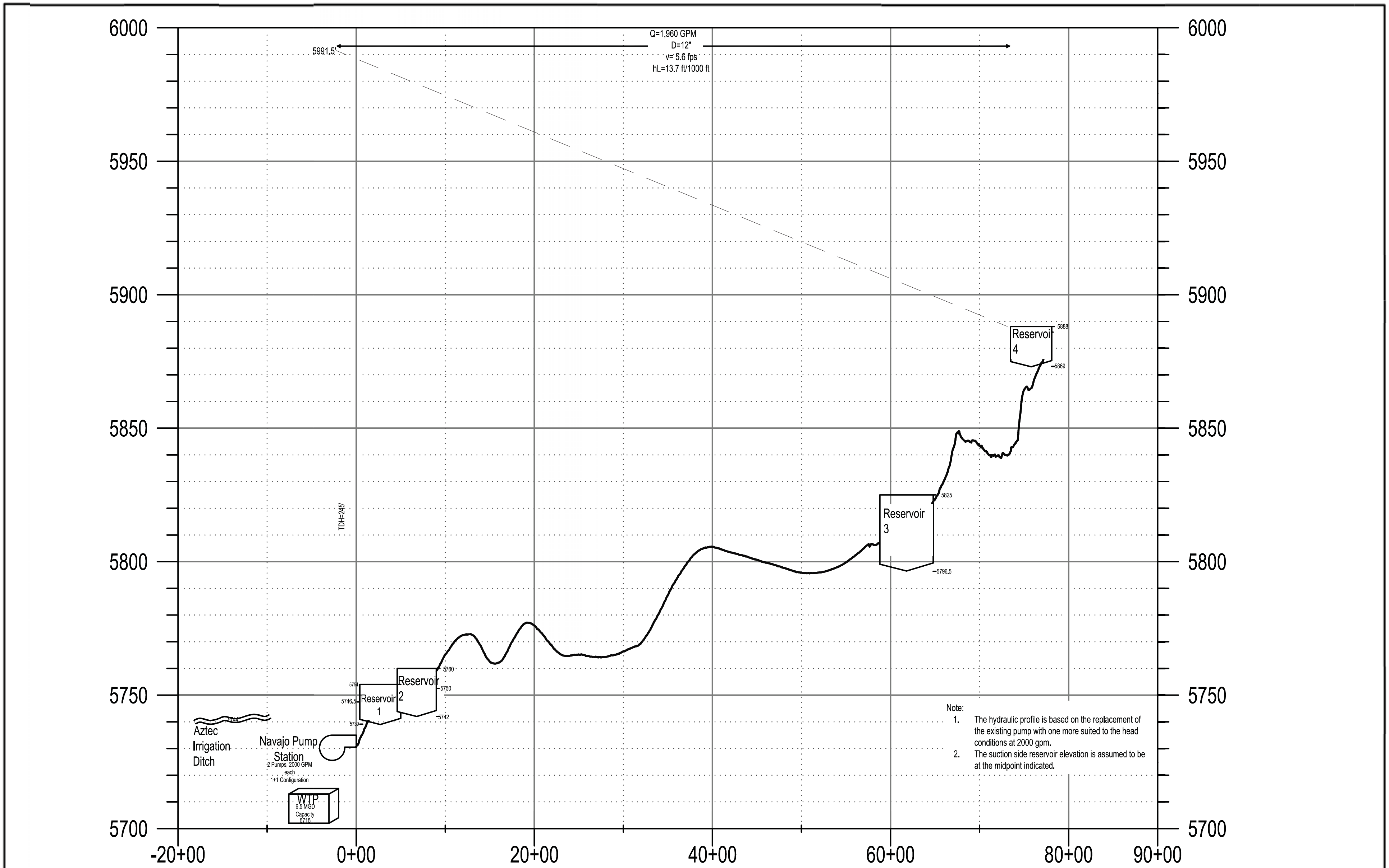

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Reservoir 1 Evaluation

Figure 41
Hydraulic Profile
Option 5: Reservoir 4

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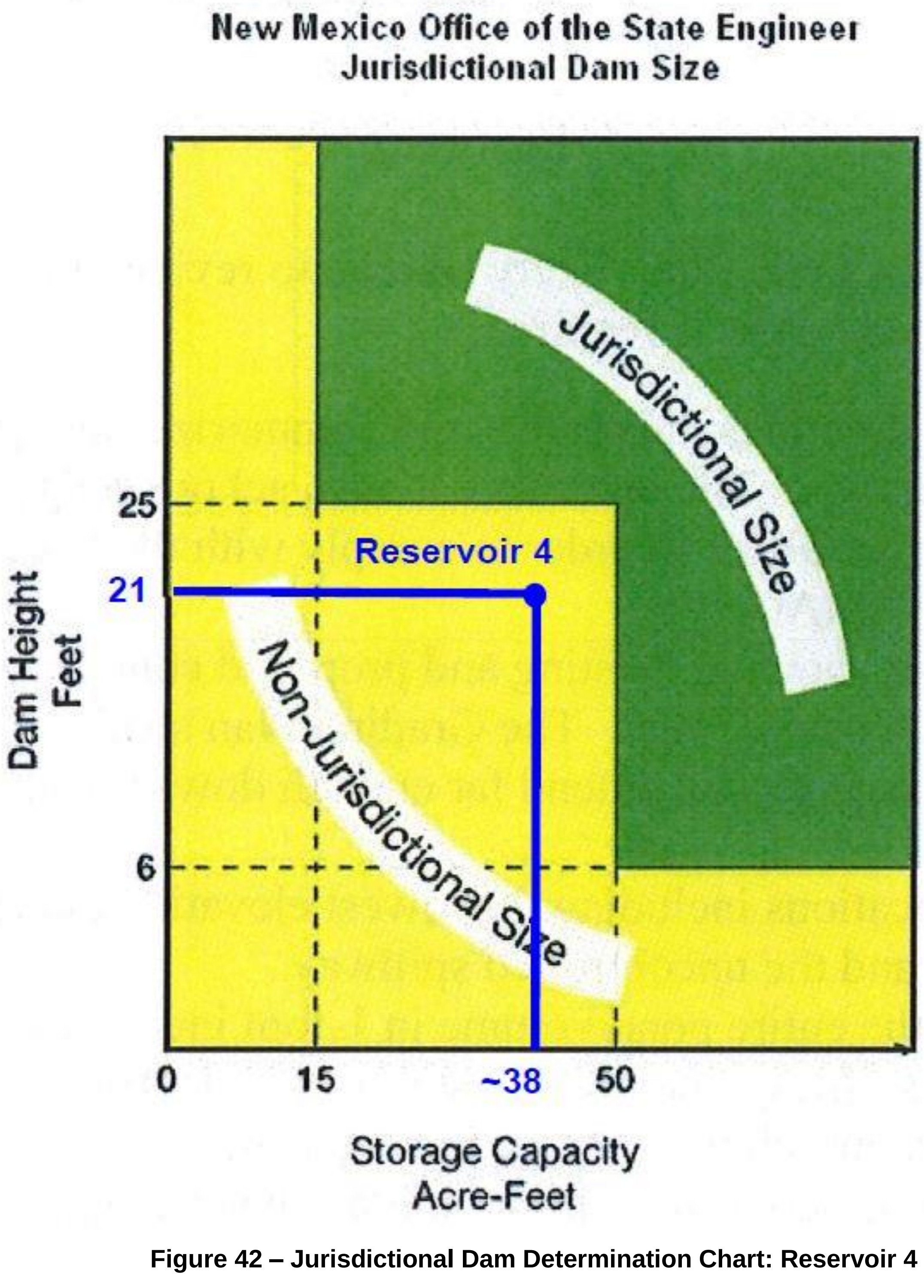


Figure 42 – Jurisdictional Dam Determination Chart: Reservoir 4

i. Option 4: Reservoir East of Reservoir 3

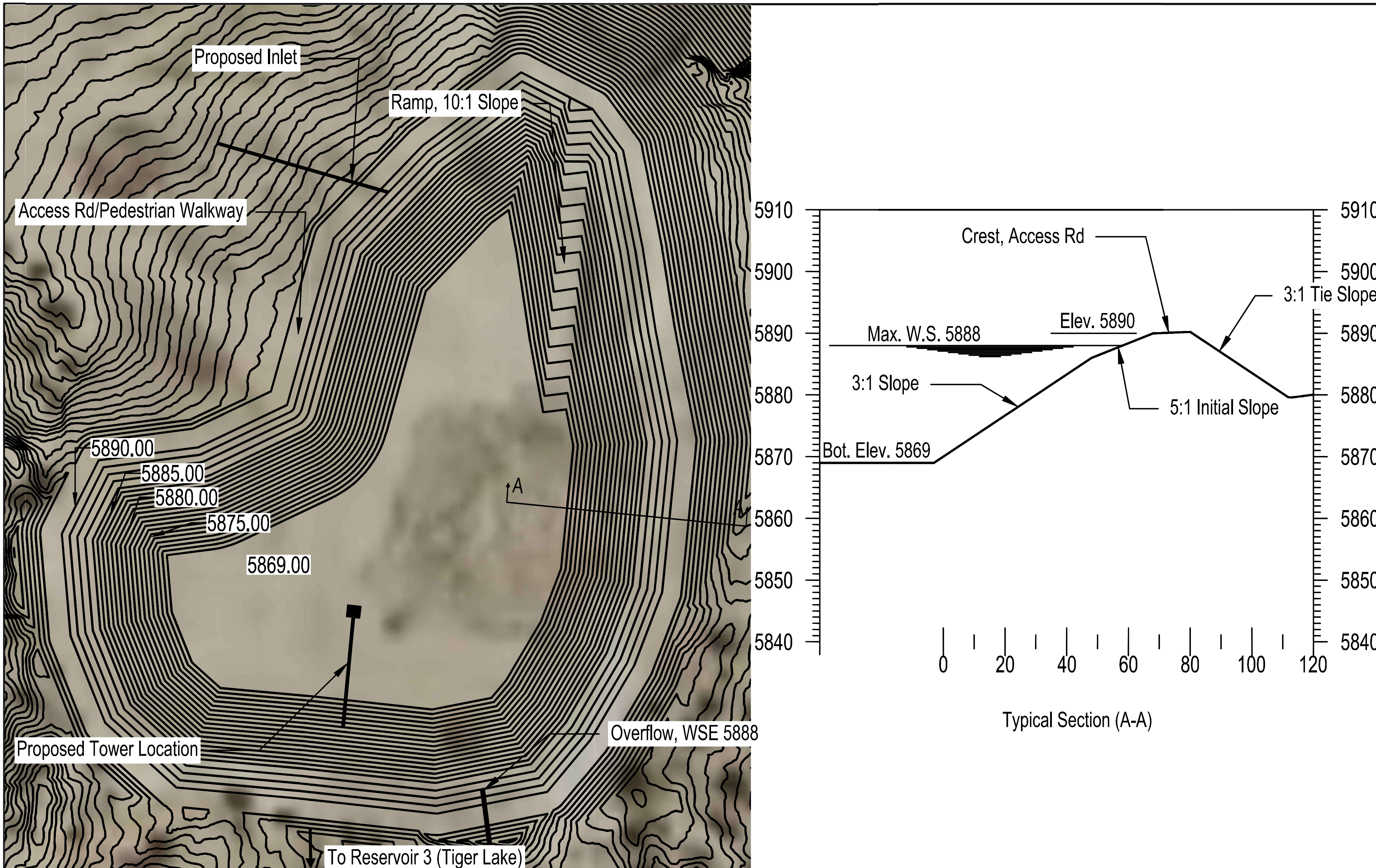
A) Option Overview

The new Reservoir 4 location is shown in Figure 35. The reservoir area is roughly 3 acres and has a capacity of 10.5 million gallons of water, a modest increase from the approximate 10.184 of the existing Reservoir 1. The new reservoir WSE is 5,888 ft which allows for two feet of freeboard from the top of the structure. The WSE is 63 feet above the WSE of Reservoir 3 and the floor of Reservoir 4 is 44 feet above, meaning that the reservoir would have enough elevation to drain fully into Reservoir 3. Minimal freeboard is preferred as the City expressed a desire to convert this reservoir into a park that ties into the existing Reservoir 3 (Tiger Lake Park). In addition, the initial slope was kept shallow and then increased 20 feet from the edge in case of an accidental fall into the reservoir. The remaining slope into the reservoir is 3:1. The liner for this reservoir would not need the geonet backing as there is no existing rough material like concrete behind it, which makes this a more favorable cost for the liner than in the Reservoir 1 relining options. A tower structure will be necessary for the discharge into Reservoir 3 as well as an altitude valve to prevent overflowing of Reservoir 3. Baffles are included in the cost as they were a beneficial part of the earlier Reservoir 1 but would be installed in Reservoir 2 as this new reservoir would not be the primary settling reservoir. Area landscaping for trails and picnic areas and aesthetic elements can be included in order to convert this into a park for public enjoyment like the existing Tiger Lake Park but is not currently part of the option. An outflow/waterfall into Reservoir 3 is not included in the cost estimate below but can be included as an add-on. Preliminary grading for the proposed reservoir and structure locations is provided in Figure 43.

This option also includes the 24-inch sacrificial layer of sand included above the liner for protection to allow trucks to enter the reservoir for cleaning. The amount of sand needed for this reservoir would be lower than for Reservoir 1 as there is a smaller floor area. The specific methods for protection of the liner would be refined during the design phase to more effectively protect the liner.

B) Option Cost

The cost estimate in Table 8 includes site excavation, new pumps, the liner, tower structure, and piping for the reservoir. It does not include any of the aesthetic elements to make this facility into a park.



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Reservoir 1 Evaluation

Figure 43
Reservoir 4
Preliminary Grading

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Table 8 –Option 4: Reservoir 4 Cost Estimate

No	Item	Quantity	Unit	Unit Price	Total Price
	Base Bid				
1	Mobilization and Demobilization	1	LS	$77,000	$77,000
2	Construction Staking, Survey and Record Drawings	1	LS	$29,000	$29,000
3	Materials Testing	1	LS	$50,000	$50,000
4	Site Clearing and Grubbing	4.0	AC	$2,000	$8,000
5	New Pumps and Installation	1	LS	$180,000	$180,000
6	Liner, materials and installation, liner only	1	LS	$138,000	$138,000
7	Anchor Trenches and earthwork for liner installation	1	LS	$25,000	$25,000
8	Excavation and Disposal of Excess Material	80,114	CY	$10	$801,141
9	General Concrete, Ramp (includes wall and footing)	65	CY	$700	$45,500
10	24" Layer Sand	3285	CY	$20	$65,700
11	New Piping to Reservoir/Inlet Piping (12" WL) including valves	1	LS	$110,000	$110,000
12	Outlet Structure and Outlet Piping	1	LS	$60,000	$60,000
13	Reservoir 2: Prefabricated Baffle with Anchor System	500	LF	$90	$45,000
	Subtotal Base Bid				**$1,634,400**
	Construction Contingency			**30%**	**$490,400**
	Design and Construction Admin			**15%**	**$318,800**
	NM Gross Receipts Tax on Construction			**8.2500%**	**$201,600**
	TOTAL PROJECT COST				**$2,645,200**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual construction costs will not vary from this opinion.

ii. Option 5: Partial Reservoir 1 Rehab and New Reservoir 4

A) Option Overview

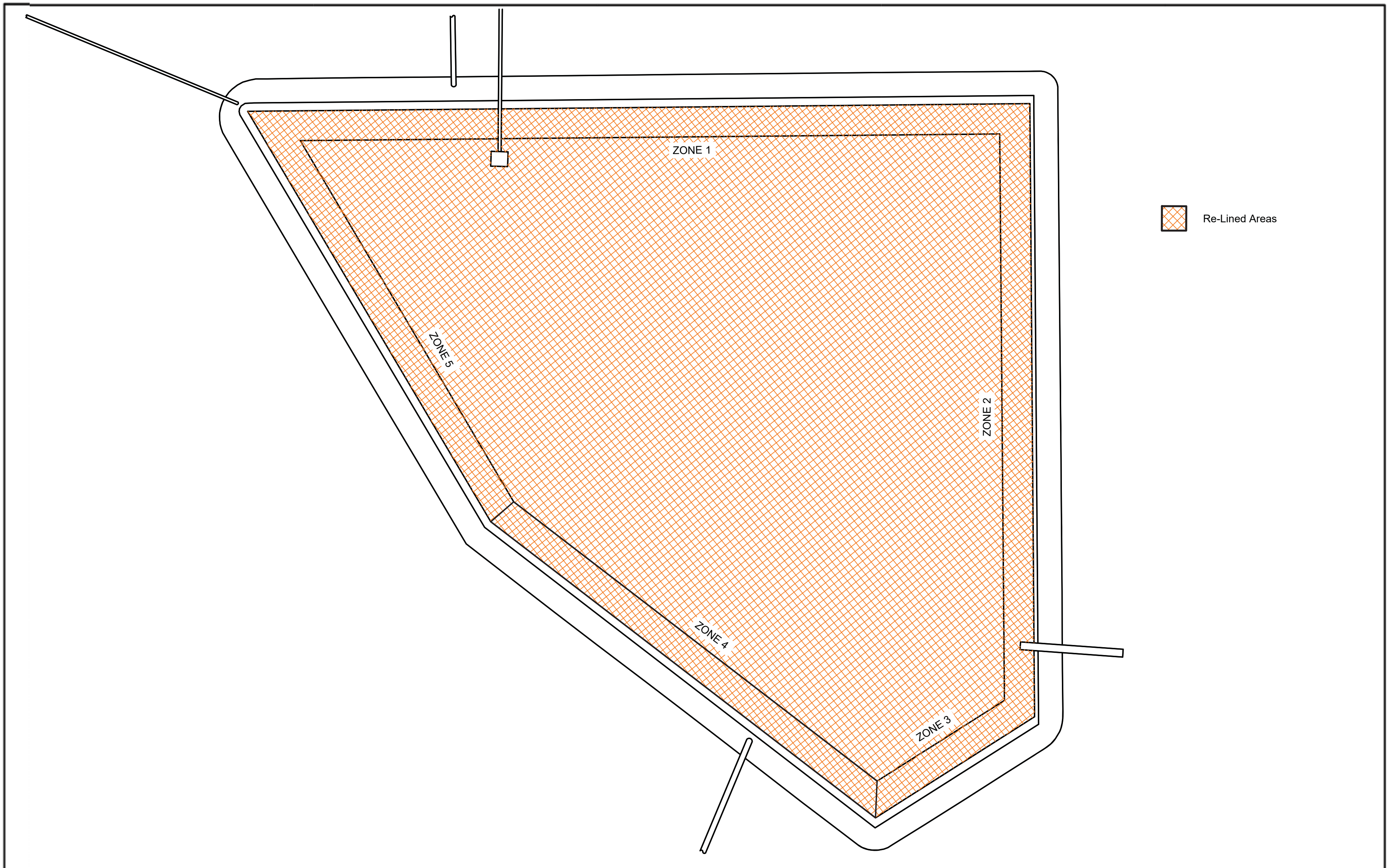
This option involves the partial rehabilitation of Reservoir 1 as well as the construction of the new Reservoir 4. The purpose of the rehabilitation would solely be to take advantage of the gravity flow from the Aztec Irrigation Ditch. Rehabilitation of Reservoir 1 includes only the bottom half of the reservoir and results in a reduced capacity of roughly 5 MG with a new overflow elevation of 5,725 ft. This option would also require the basic rehabilitation items included in Options 1 through 3 with a few minor adjustments: the replacement of the 24-in overflow line to the Animas Irrigation Ditch would include the relocation of the overflow to a lower elevation for the reduced capacity, the 14-in Inlet from the Animas River may be abandoned, it is recommended that the outflow from Reservoir 2 be renovated in case there is a need to drain that reservoir in the future. The area for rehabilitation is displayed in Figure 44.

This option, like Option 4, would also require new pumps due to the head differential. Rehabilitation of Reservoir 1 would entail the removal of concrete in areas where it may be damaging to a liner installation and then the relining of the bottom and bottom side slopes with 60 mil HDP liner and 200 mil Geonet.

This option also includes the 6-in sacrificial layer of sand included above the liner for both the rehabilitated Reservoir 1 and the new Reservoir 4. The specific methods for protection of the liner would be refined during the design phase to more effectively protect the liner.

B) Option Cost

The cost estimate for this option includes both the new Reservoir 4 costs as well as rehabilitation costs for Reservoir 1.



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800.877.5332

Reservoir 1 Evaluation

Figure 44
Reservoir 1
Option 5 Re-Lined Areas

July 2019

Table 8 – Option 5: Partial Reservoir 1 Rehab and New Reservoir 4

No	Item	Quantity	Unit	Unit Price	Total Price
	Base Bid				
1	Mobilization and Demobilization	1	LS	$71,000	$71,000
2	Construction Staking, Survey and Record Drawings	1	LS	$26,000	$26,000
3	Materials Testing	1	LS	$46,000	$46,000
4	Site Clearing and Grubbing	4.0	AC	$2,000	$8,000
	Reservoir 4				
5	New Pumps and Installation	1	LS	$180,000	$180,000
6	Liner, materials and installation, liner only	1	LS	$152,000	$138,000
7	Anchor Trenches and earthwork for liner in-stallation	1	LS	$25,000	$25,000
8	Excavation and Disposal of Excess Material	80114	CY	$10	$801,141
9	General Concrete, Ramp (includes wall and footing)	65	CY	$700	$45,500
10	New Piping to Reservoir/Inlet Piping (12" WL) including valves	1	LS	$110,000	$110,000
11	Outlet Structure and Outlet Piping	1	LS	$60,000	$60,000
12	24" Layer Sand	3285	CY	$20	$65,700
	Reservoir 1				
13	Demo of Concrete	4,795	SF	$6	$28,770
14	Liner, materials and installation, 60 mil HDPE and Geonet	1	LS	$207,000	$207,000
15	Anchor Trenches and earthwork for liner in-stallation	1	LS	$22,500	$22,500
16	General Concrete, Tower Structure	36	CY	$700	$25,200
17	General Concrete, Ramp (Includes Wall and Footing)	62	CY	$700	$43,400
18	Tower Steel (includes catwalk)	1	LS	$23,000	$23,000
19	24" Layer Sand	5830	CY	$20	$116,600
20	Irrigation Ditch Inlet Structure	1	LS	$10,000	$10,000
21	Prefabricated Baffle with Anchoring System	800	LF	$90	$72,000
22	Replace Inlet Piping, 30" WL, Reservoir 2 to Reservoir 1	350	LF	$175	$61,250
23	Replace Drainage Line, 24" WL	450	LF	$110	$49,500
24	Replace Drainage Line and Valve, 16"	1	LS	$25,400	$25,400
	Subtotal Base Bid				**$2,261,000**
	Construction Contingency			**30%**	**$678,300**
	Design and Construction Admin			**15%**	**$440,900**
	NM Gross Receipts Tax on Construction			**8.2500%**	**$278,900**
	TOTAL PROJECT COST				**$3,659,100**

This estimate of construction cost is only an opinion. BHI cannot and does not guarantee that proposals, bids, or actual Construction Costs will not vary from this opinion.

III. Evaluation of Options

i. Summary Table, option & cost

Below is a summary of the proposed options for the system of reservoirs. Options 1 through 3 propose different methods of rehabilitation to the existing Reservoir 1 while options 4 and 5 incorporate a new reservoir. Cost is only one of the important considerations for the determination of the best option. The new reservoir options have the convenience of all new materials and construction methods for longevity but the inconvenience of requiring new pumps in the system.

As seen in the table below, the cheapest option overall is Option 3, the complete relining of Reservoir 1 with an HDPE liner and geonet. The cost of the concrete rehabilitation adds up quickly and ends up being more expensive in the long run. The impermeability offered by Option 3 remains superior to Option 2, however, and is the better option.

The last two options, Options 4 and 5, have a higher price than the previous three, which is understandable as Options 4 and 5 provide a completely new reservoir. The highest cost in these two options stems from the excavation and disposal of excess material which has already been done in Reservoir 1 as it is existing. All five options require the replacement of the pumps in the existing booster station for better operations. Although Option 5 is the highest initial investment, the addition of a new reservoir while rehabilitating a portion of Reservoir 1 will increase storage capacity for the City while allowing for the use of the Aztec Irrigation Ditch water. Option 5 also gives flexibility to the City to phase work as the new reservoir and the rehabilitation of Reservoir 1 do not have to be done concurrently.

Table 9 – Summary Table

Option	Description	Cost
1	Rehab of Concrete Panels	$2,337,800
2	Mix of Concrete and liner rehab	$2,149,500
3	Completely new liner	$2,082,800
4	Reservoir 4	$2,645,200
5	Partial Reservoir 1 Rehab and New Reservoir 4	$3,659,100

Recommendation

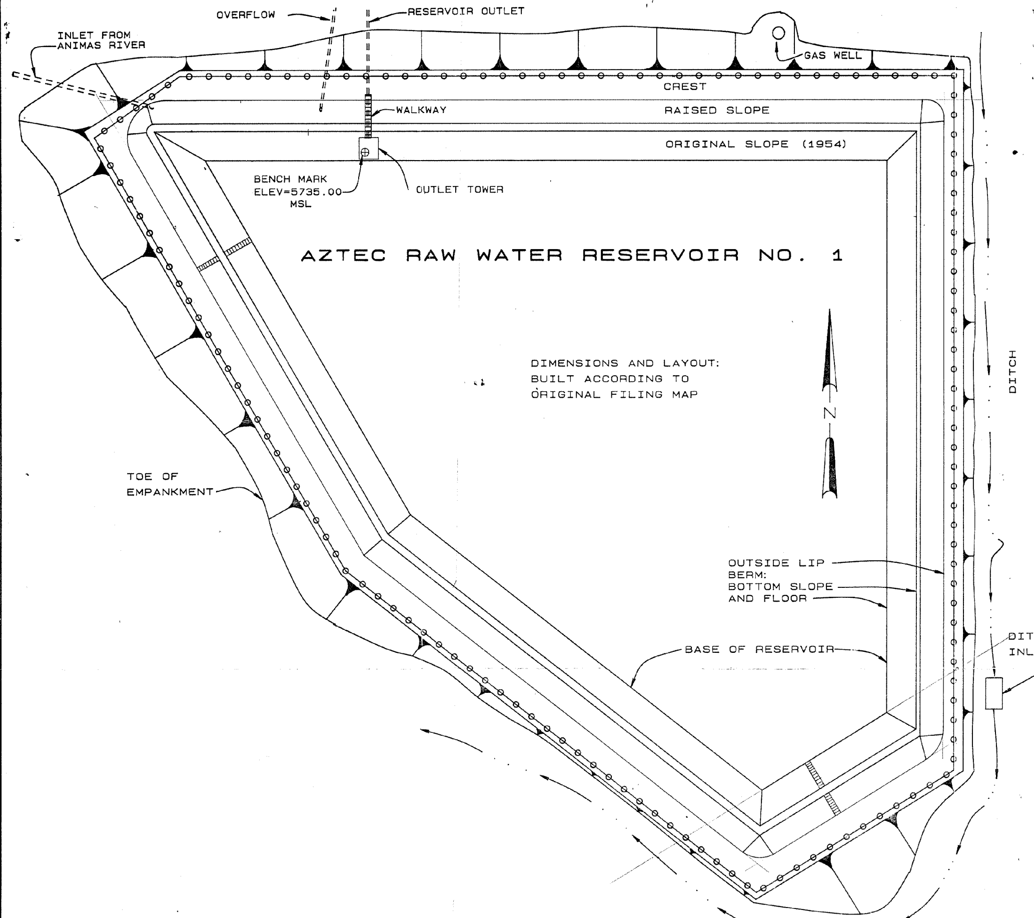
Based on the fact that Option 1 and Option 2 leave a portion of the existing concrete panels and joints in place and will not prevent seepage, these options are not considered viable. Based on cost alone, the full re-lining of Reservoir 1 is the most advantageous option. Construction of a new Reservoir is a higher capital cost, but it would also provide community benefits in the form of an additional recreational area. In addition, the construction would be completely new so there would be no pre-existing concerns or prior leakage as is present in Reservoir 1. All options include a ramp for easy maintenance and new inlet/outlet structures so these would not be differentiating factors in the recommendation. The main difference between the rehabilitation and new reservoir options is the location, how desirable it is for the City to add the new public use area that would be possible with Option 4, and the desire to continue use of the Aztec Irrigation Ditch. Further analysis of the leakages in Reservoir 1 would also be necessary to establish the full scope of the rehabilitation work.

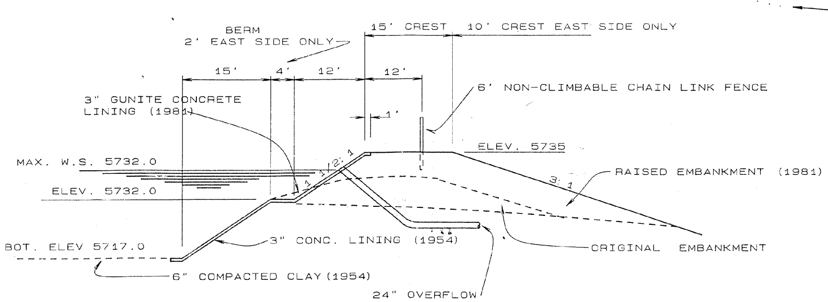
It is BHI’s opinion that Option 3 is the best option based on perceived benefit and cost as it has the lowest cost and allows for the continued use of the Aztec Irrigation Ditch. This option would include the following to complete this project:

- The existing concrete liner would be removed and disposed of. Reservoir 1 would be re-graded and excess material would be removed during construction.
- An HDPE Liner would be installed to replace the existing concrete liner.
- Flow from the irrigation ditch would continue into Reservoir 1 via gravity and a new inlet diversion for this area.
- A concrete ramp would allow for heavy machinery to be driven down into the reservoir for cleaning and the sand layer at the bottom of the reservoir would protect the liner at the bottom from damage during cleaning; it should be noted that very heavy machinery is not recommended on these liners.
- A 24-inch sand layer at the bottom would be installed on top of the new liner.
- Baffles would be installed with this option. The main consideration in this option is the ease of removal of baffles for cleaning; the desired order/method of cleaning would need to be established in the design phase in order to select an appropriate baffle design for the conditions. It is important to note that more complex baffle designs increase greatly in cost, and most baffle systems are not designed for easy removal for cleaning; the basic baffle design commonly used can be seen in Appendix F.
- The mechanisms by which the baffles are raised and lowered to prevent sediment accumulation on the bottom of the baffles would also need to be addressed in the design phase; in the basic design the tension of the baffle is adjusted for the desired location and level.
- The pumps within the existing pump station shall be replaced with vertical turbine pump assemblies to obtain a flow of 2,000 gpm. The replacement pumps may require additional HP than the existing pump which will require modifications to the existing electrical components within the station.

TF/crh

APPENDIX A: RESERVOIR AS-BUILT





TYPICAL SECTION

SCALE: 1" = 10'

MAP OF THE CITY OF AZTEC RAW WATER RESERVOIR NO. 1.

LOCATED IN SAN JUAN COUNTY, STATE OF NEW MEXICO.

ALL COURSES TRUE SCALE OF MAP, 1 IN. = 30 FEET.

THE UNDERSIGNED, CITY OF AZTEC, CLAIMANT, WHOSE POST OFFICE ADDRESS IS AZTEC, 87410, COUNTY OF SAN JUAN, STATE OF NEW MEXICO, HAS CAUSED TO BE LOCATED, BY A QUALIFIED REGISTERED PROFESSIONAL ENGINEER AND LAND SURVEYOR THE CITY OF AZTEC RAW WATER RESERVOIR AS HEREINAFTER DESCRIBED AND INDICATED, HEREBY MAKES THESE SEVERAL STATEMENTS RELATIVE THERETO AND OFFERS THIS MAP AND STATEMENTS FOR ACCEPTANCE AND FILING IN COMPLIANCE WITH THE LAWS OF THE STATE OF NEW MEXICO.

THE RAW WATER RESERVOIR SHOWN HEREON HAS THE FOLLOWING CHARACTERISTICS:

RESERVOIR AS BUILT

CREST WIDTH	15 FEET
INSIDE SLOPES	1 1/2 TO 1
OUTSIDE SLOPES	3 TO 1
OUTISDE SLOPE SURFACE	EARTH
MAXIMUM HEIGHT ABOVE FOUNDATION	18 FEET
LENGTH	1475 FEET
MAXIMUM WIDTH AT BASE	125 FEET
FREEBOARD	3 FEET
FINAL CONSTRUCTION COST	$ 64,404
CONTRACTOR	KENT NOWLIN CONSTRUCTION
DATE OF ACCEPTANCE	OCTOBER, 1975

RESERVOIR SURFACE AREAS AND CAPACITIES

W.S. ELEV.	DEPTH	W.S. AREA	CAPACITY	
FT.	FT.	AC.	M.G.	AC. FT.
17	0	1.72	0.000	0.000
18	1	1.76	0.570	1.749
19	2	1.81	1.155	3.545
29	3	1.86	1.755	5.386
21	4	1.90	2,370	7.274
22	5	1.95	3.000	9.207
23	6	2.00	3.645	11.187
24	7	2.04	4.305	13.212
25	8	2.09	4.980	15.284
26	9	2.14	5.670	17.402
27	10	2.18	6.375	19.565
28	11	2.27	7.107	21.812
29	12	2.31	7.854	24.105
30	13	2.34	8.616	26.442
31	14	2.38	9.393	28.826
32	15	2.42	10.184	31.256

INLET WORKS

(1) AZTEC DITCH IRRIGATION OUTLET - 18" ROUND SLIDE IN A COMBINATION CHECK AND HEADWALL STRUCTURE. MAX. FLOW RATE - 950 GPM. DITCH OUTLET WITH SPARLING METER MODEL 1-245, SERIAL NO. 101706, 12 INCH. CAPACITY 200 MIN. TO 2000 MAX. GALLONS PER MINUTE, AND AN INDICATOR - TOTALIZER DIAL INDICATING GALLONS PER MINUTE AND TOTALIZING IN THOUSANDS OF GALLONS.

(2) LOWER ANIMAS DITCH OUTLET - 12" ROUND SLIDE HEADGATE MOUNTED INTO CONCRETE IRRIGATION DITCH OUTLET INTO WET WELL. MAXIMUM RATE OF DIVERSION 450 GPM. WET WELL EQUIPPED WITH JOHNSTON VERTICAL TURBINE PUMP - 250 GPM, 133 FT. HEAD, 20-HP, 220 VOLT, 3-PHASE, INSTALLED 1955. METER ON OUTLET IS SIX INCH SPARLING MODEL CF 115, SERIAL NO. CAPACITY OF 90 MIN. TO 900 MAX GALLONS PER MINUTE, AND INDICATOR - TOTALIZER DIAL INDICATING GALLONS PER MINUTE AND TOTALIZING IN THOUSANDS OF GALLONS

(3) ANIMAS RIVER INTAKE - 30" ROUND SLIDE HEADGATE INTO CONCRETE WET-WELL. SETTLING POND AHEAD OF INLET 180-FT. LONG, 40-FT. WIDE, AND 12-FT. DEEP. MAXIMUM RATE OF DIVERSION - 2500 GPM. WET WELL EQUIPPED WITH ALLIS CHALMERS WET PIT TYPE CWV PUMP - 2000 GPM, 180-FT. HEAD, 200-HP, 480 VOLT, 3-PHASE, 60-CYCLE, 1750 RPM, INSTALLED 1979. METER ON MAIN TRANSMISSION LINE FROM ANIMAS RIVER, INCLUDING LOWER ANIMAS DITCH, LOCATED AT WATER TREATMENT PLANT. METER IS SPARLING MODEL K487, 14-INCH PROPELLER METER, SERIAL NO. 114030, CAPACITY OF 250 MIN. TO 3000 MAX. GPM, AND AN INDICATOR-TOTALIZER DIAL INDICATING GALLONS PER MINUTE AND TOTALIZING IN THOUSANDS OF GALLONS. METER INSTALLED 1979

OVERFLOW

24 INCH CORRUGATED METAL OVERFLOW PIPE WITH INVERT ELEV. AT 5732 AND HAS A MAXIMUM DISCHARGE OF 18.5 CUBIC FEET PER SECOND OR 8200 GPM.

THE THREE POINTS OF DIVERSION ARE DESCRIBED AS FOLLOWS:

(1) FROM THE ANIMAS RIVER AT A POINT LOCATED IN THE SW1/4 SE1/4 OF SEC. 4, T.30N., R.11W, WHENCE THE SE CORNER OF SAID SEC. 4 BEARS S.48 DEG. 30 MIN. E., 1950.3 FEET DISTANT.

(2) FROM THE LOWER ANIMAS DITCH AT A POINT IN THE SE1/4 SW1/4 OF SEC. 3 T.30N, R.11W., WHENCE THE SE CORNER OF THE SE1/4SW1/4 OF SAID SEC. 3 BEARS S.18 DEG. 30 MIN. E., 1379.8 FEET DISTANT.

(3) FROM THE AZTEC DITCH AT A POINT IN THE SW 1/4 SE1/4 OF SEC. 3, T.30N R.11W, WHENCE THE S. QUARTER CORNER OF SAID SEC. 3 BEARS S. 70 DEG. 30 MIN. W., 941.7 FEET DISTANT.

THE OULTET GATE FROM THE RESERVOIR NO. ONE IS LOCATED AT A POINT IN THE SW1/4 SE1/4 SEC. 3, T.30 N., R.11W., WHENCE THE S1/4 CORNER OF SAID SEC. 3 BEARS S.48 DEG. 30 MIN. W., 832.2 FEET DISTANT.

ALL BEARINGS AND DESCRIPTIONS ARE NEW MEXICO PRINCIPAL MERIDIAN.

STATE OF NEW MEXICO)
) SS.
COUNTY OF SAN JUAN)

I, CONN BROWN, BEING FIRST DULY SWORN, UPON MY OATH, STATE I AM THE CITY MANAGER OF THE CITY OF AZTEC, AN INCORPORATED MUNICIPALITY UNDER THE LAWS OF THE STATE OF NEW MEXICO. THAT THE ACCOMPANYING MAP AND STATEMENTS WERE MADE UNDER THE AUTHORITY OF THE CITY COMMISION OF SAID CITY OF AZTEC, AND THAT, IN THEIR BEHALF, I HAVE READ AND EXAMINED THE STATEMENTS AND REPRESENTATIONS THEREON AND STATE THAT THE SAME ARE TRUE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

CITY OF AZTEC, NEW MEXICO
BY *Conn Brown*
CITY MANAGER

SUBSCRIBED AND SWORN TO BEFORE ME THIS *21st* DAY OF *January* 1986.

NOTARY PUBLIC
MY COMMIISION EXPIRES *11-26-88*.

STATE OF NEW MEXICO)
) SS.
COUNTY OF SANTA FE)

I, WILLIAM F TURNEY, BEING FIRST DULY SWORN, UPON MY OATH STATE THAT I AM THE REGISTERED PROFESSIONAL ENGINEER AND LAND SURVEYOR WHO MADE THE MAP OF THE CITY OF AZTEC RAW WATER RESERVOIR NO. ONE, THAT SUCH MAP WAS PREPARED FROM FIELD NOTES OF ACTUAL SURVEYS MADE BY ME OR UNDER MY DIRECTION AND THAT THE SAME ARE TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF.

REGISTERED PROFESSIONAL ENGINEER AND LAND SURVEYOR NO. 553 NEW MEXICO WILLIAM F. TURNEY

William F. Turney
REGISTERED PROFESSIONAL ENGINEER
AND LAND SURVEYOR
LICENSE NO. 553

SUBSCRIBED AND SWORN BEFORE TO ME THIS *20th* DAY OF *January* 19*86*

NOTARY PUBLIC
MY COMMISION EXPIRES *21 May 1988*.

STATE OF NEW MEXICO)
) SS.
COUNTY OF SANTA FE)

I HEREBY CERTIFY THAT THE ACCOMAPNYING PLANS HAVE BEEN DULY EXAMINED BY ME AND APPROVED AS TO FORM AND CONTENT, AND WERE DULY ACCEPTED FOR FILING ON THE ______ DAY OF ______________ 19____.

S. E. REYNOLDS
STATE ENGINEER

W.F TURNEY AND ASSOCIATES
CONSULTING ENGINEERS
SANTA FE NEW MEXICO

CITY OF AZTEC, NEW MEXICO

AS BUILT OF RAW WATER RESERVOIR NO. 1

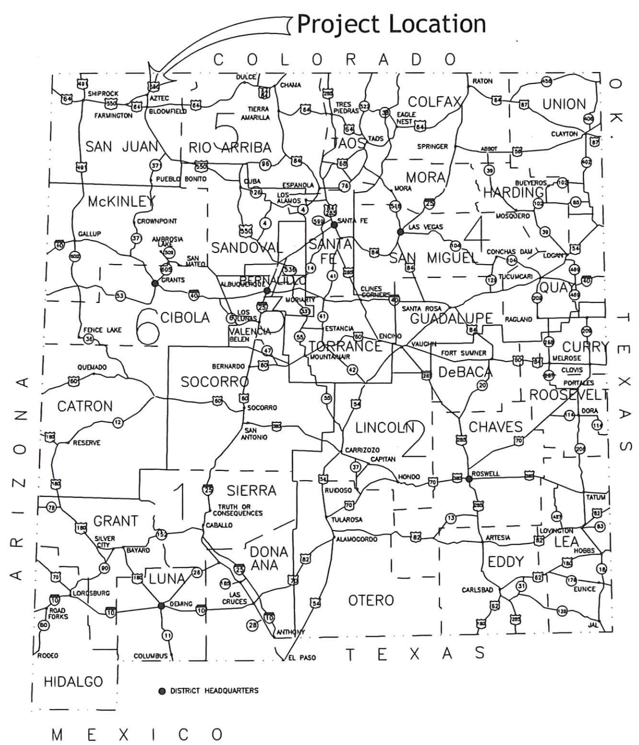
DRAWN	CHECKED	PROJECT NO.	SCALE	DATE	SHEET
BT	WFT	74-10	1" = 30'	JAN. 1986	1 OF 1

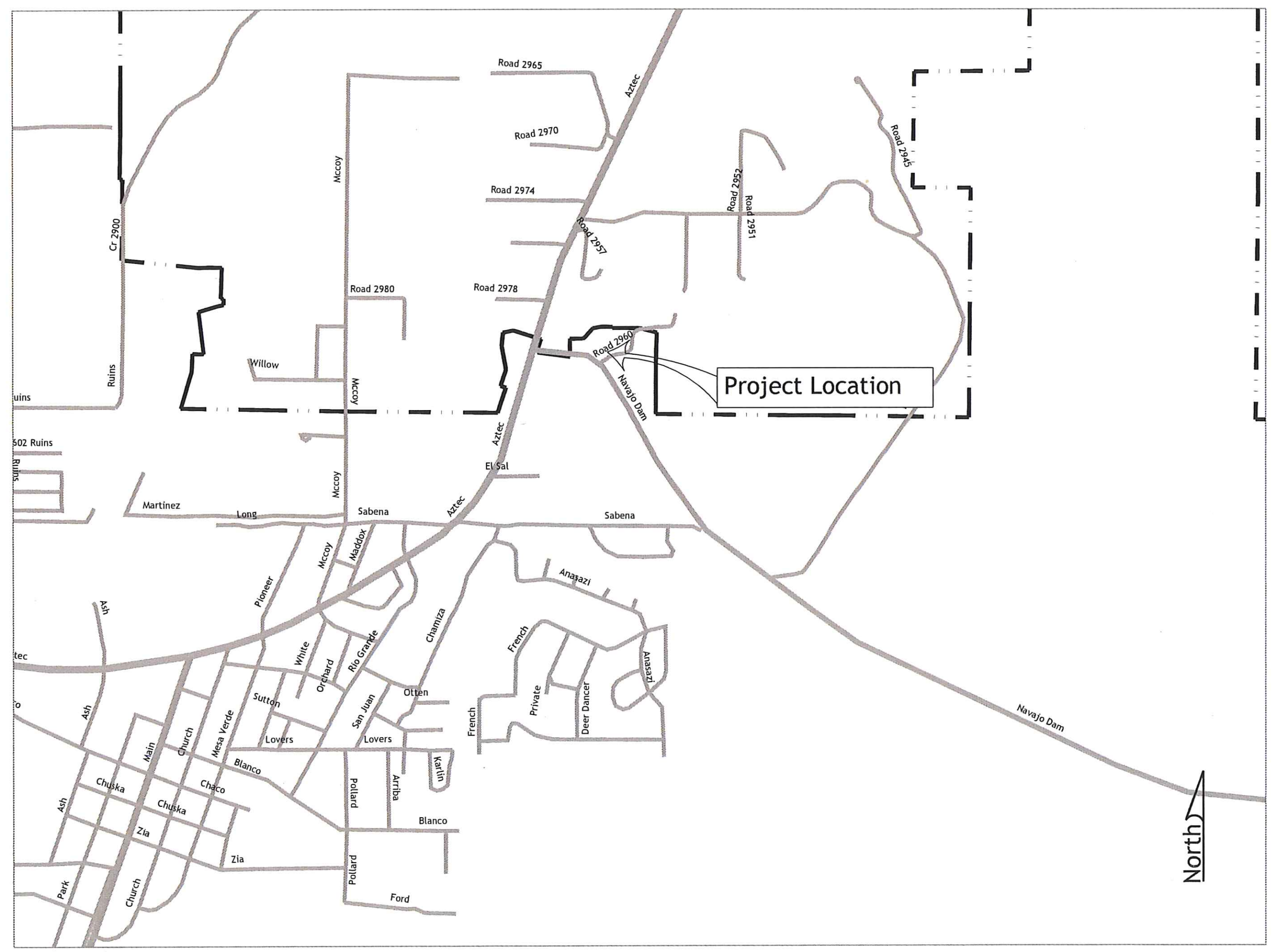
APPENDIX B: RESERVOIR 2018 REHABILITATION

Aztec Reservoir #1 Rehabilitation

City of Aztec, New Mexico

San Juan County





Vicinity Map
Scale: 1"= 1000'

811
Know what's below. Call before you dig.
It's the Law!
New Mexico One Call, Inc.
NMOC
Professional Resources for Damage Prevention

UTILITY OWNERS

CITY OF AZTEC DEPARTMENT OF PUBLIC WORKS
(505) 334-7660

CITY OF AZTEC ELECTRIC DEVELOPMENT
(505) 334-7660

QWEST (TELEPHONE)
(505) 325-2311

COMCAST CABLE
VICTOR APPLEGATE 505-402-0055

PNM (GAS)
505-324-3783

Sheet List Table	
Sheet	Sheet Title
1-1	Cover Sheet
2-1	Excavation Plan
2-2	Disposal Site and General Notes

Revision Log
1
2
3
4
5
6
Plot Date: 03/20/2018 - 2:40pm

Project: AZTEC RESERVOIR #1 REHABILITATION

Sheet Description: COVER SHEET

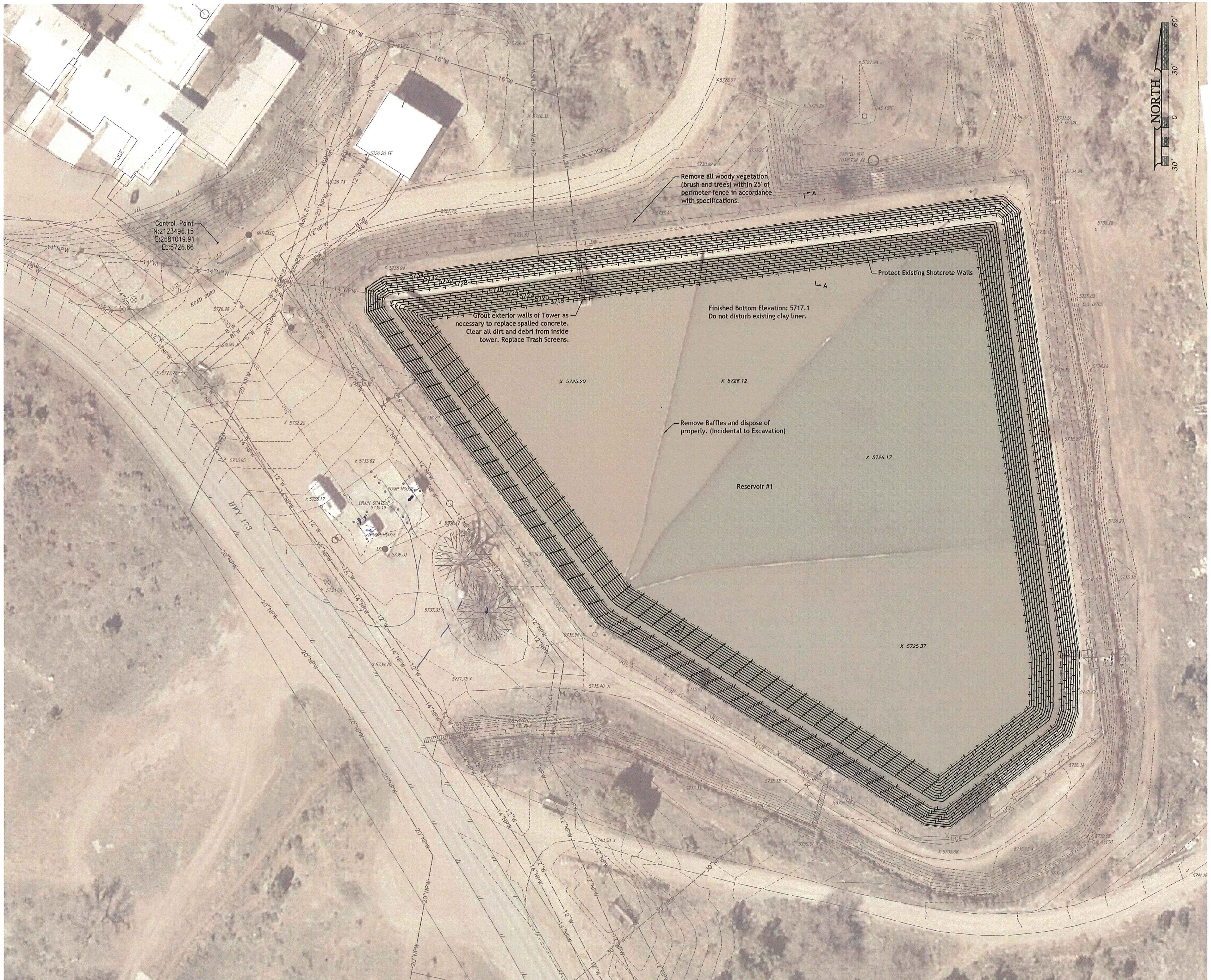
R. CLAYTON HARRISON
NEW MEXICO
REGISTERED PROFESSIONAL ENGINEER
3/20/18

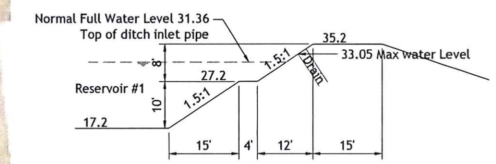
CHC Engineers, LLC
50 Valley Court
Durango, CO
970-387-8765

Project Date: 3/20/18

Proj: 18004

1-1





1 Section A-A
Scale: NTS

Revision Log

1	.
2	.
3	.
4	.
5	.
6	.

Plot Date: 03/20/2018 – 2:40pm

Owner: City of Aztec

Project: AZTEC RESERVOIR #1 REHABILITATION

Sheet Description: EXCAVATION PLAN

R. CLAYTON HARRISON NEW MEXICO 14238 3/20/18 REGISTERED PROFESSIONAL ENGINEER

CHC Engineers, LLC
50 Valley Court
Durango, CO
970-387-8765

Project Date: 3/20/18

Proj: 18004

2-1

GENERAL NOTES

1. A disposal site for excavation material is provided.
2. No additional payment will be made for any hauling of materials. The transportation of materials shall be considered incidental to the item to which the work pertains.
3. Existing utilities are shown based on information at hand. The contractor shall verify utility locations and elevations to avoid potential conflicts.
4. The contractor shall coordinate and cooperate with all utility companies and City of Aztec with regard to relocating, adjusting, replacing, and/or repairing utilities during construction.
5. The contractor is responsible for maintaining the area and streets free and clear of any debris that is tracked from the site.
6. All roads shall be serviceable and maintained for fire protection and emergency vehicles during construction unless otherwise approved by the City Engineer.
7. The contractor shall provide reasonable access to property owners affected by the construction. All affected residents shall be informed of any driveway or road closures at least 48 hours prior to closure. Access to residencies shall not be denied for more than 48 hours without the approval of the City Engineer.
8. Overnight parking of the contractor's equipment or material stockpiles shall not obstruct driveway openings or designated traffic lanes.
9. The contractor shall replace all destroyed or damaged facilities with equal or superior improvements as provided by the City Engineer.
10. The contractor shall be responsible for reporting and clean up of spills associated with project construction and shall report and respond to spills of hazardous material such as gasoline, diesel, motor oils, solvents, sewer chemicals, toxic and corrosive substances, and other materials which may be a threat to public health or the environment. The contractor shall be responsible for reporting past spills encountered during construction and of current spills not associated with construction. Reports shall be made immediately to the NM Environment Department at (505) 827-9329, (866) 428-6535.
11. Contractor shall keep work site in an orderly condition. During construction, at completion of daily work, contractor shall remove all debris and leave work site in a condition acceptable to the City Engineer.
12. The contractor is responsible for reporting any discrepancies discovered in the plans and/or specifications and of all conflicts during construction immediately to the City Engineer both verbally and in writing.
13. Traffic control shall comply with the Manual on Uniform Traffic Control Devices (MUTCD). Traffic control plans shall be submitted to the City Engineer for approval one week prior to installation.
14. This project does require an SWPPP. Contractor shall aply for and recieve SWPPP prior to excavatation.
15. All requirements outlined in the Federal Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) and the New Mexico Clean Water Act shall be strictly adhered to during the course of constructing this project. Exposed areas of disturbance shall be kept to a minimum to perform project construction.

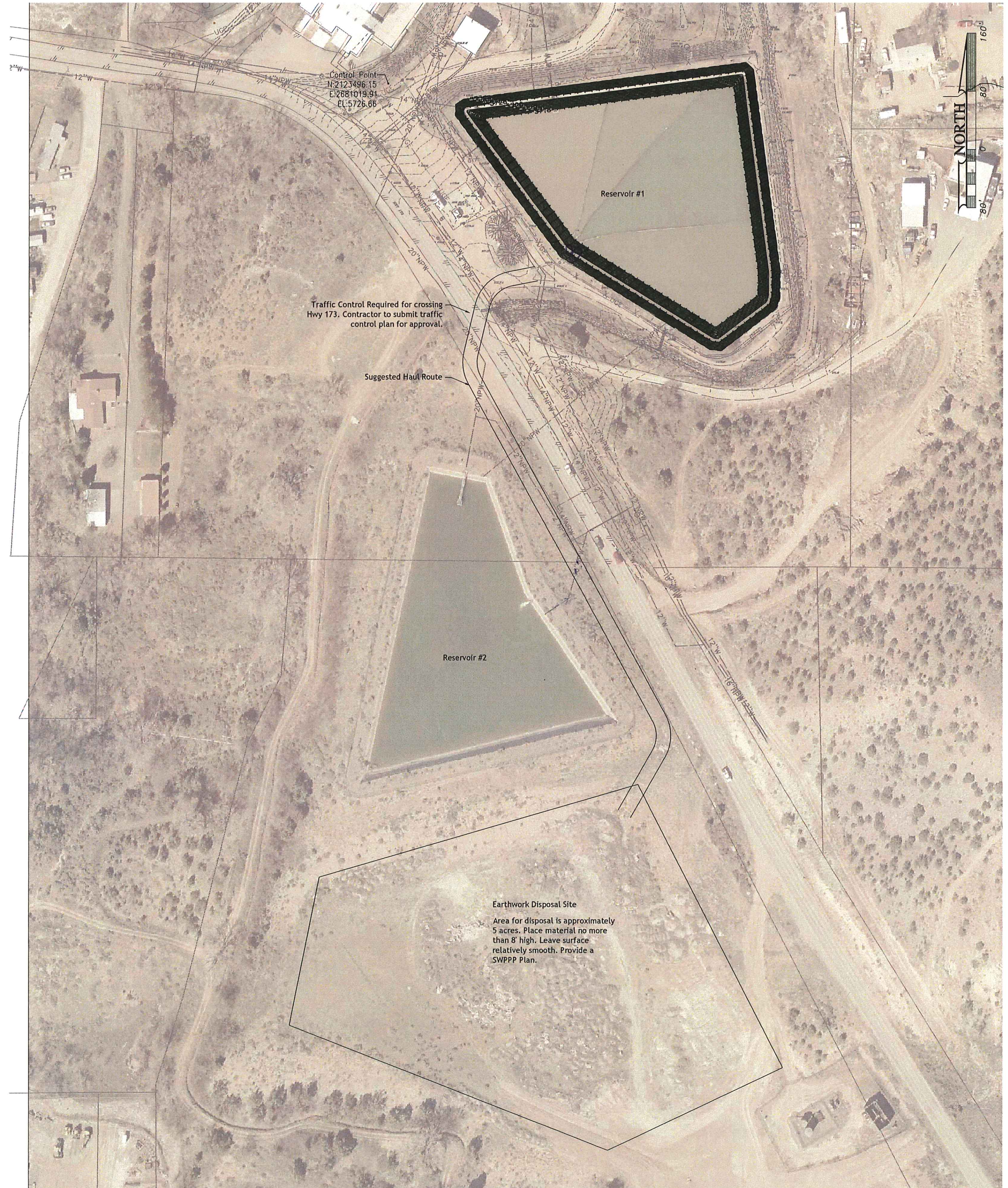
CONSTRUCTION TESTING

1. The project will have verification, and density tests completed by a geotechnical engineering company to verify compaction.
2. The City will use GEOMAT to provide Quality Assurance (QA) testing to ensure the work has been accomplished in accordance with the specification. The contractor shall coordinate with GEOMAT for required QA testing to comply with NMDOT specifications. Contract shall coordinate all testing.
3. Necessary retesting by GEOMAT will be charged back to the contractor. GEOMAT contact phone ~ (505)327-7928.
4. Gradation of proposed imported material shall be submitted to GEOMAT and to the Aztec public works director for approval prior to import.
5. No material pits have been designated for this project. The contractor may obtain specification borrow from any acceptable source.

REVEGETATION NOTES

If the contractor damages areas outside of the construction limits, revegetation is required in those areas.

1. Seedbed preparation shall be conducted by scarifying soil in order to remove large rocks or debris and break down clumps of soil to obtain consistent soil texture. Noxious and competitive species shall be removed from seedbed.
2. All revegetated areas shall be mulched after seeding by applying weed free straw at a rate of one ton per acre. Hydro-mulching is also an acceptable application method.
3. The seed mix shall be high plains/foothills erosion control grass mixture or BLM seed mix #2 at a rate to achieve 50 seeds per square foot for drilled seed. Application rates shall be doubled if broadcast method is used.
4. Coordinate seeding dates as follows: a. Period 1 = October 15th through April 15th b. Period 2 = July 1st through August 15th
5. Revegetation shall be considered incidental to the project and no measurement or payment shall be made therefore.



Revision Log: 1 2 3 4 5 6

Plot Date: 03/20/2018 - 2:40pm

Owner: City of Aztec

Project: AZTEC RESERVOIR #1 REHABILITATION

Sheet Description: DISPOSAL SITE AND GENERAL NOTES

R. CLAYTON HARRISON
NEW MEXICO
14238
3/20/18
REGISTERED PROFESSIONAL ENGINEER

CHC Engineers, LLC
50 Valley Court
Durango, CO
970-387-8765

Project Date: 3/20/18

Proj: 18004

2-2

APPENDIX C: GEOMAT RESERVOIR NO.1 CLAY LINER AND SUBGRADE EXPLORATION

February 22, 2019

Todd Burt, P.E.
Bohannan Huston, Inc.
7500 Jefferson Street NE
Albuquerque, New Mexico 87109

RE: Reservoir No. 1 Clay Liner and Subgrade Exploration
City of Aztec, New Mexico
GEOMAT Project No. 191-3229

As requested, on February 18, 2019 GEOMAT performed fifteen soil borings in the bottom of the City of Aztec's Raw Water Reservoir No. 1 Sediment Pond. The soil borings were advanced by hand methods to depths between approximately 6 inches to 30 inches where auger refusal was encountered on gravels and cobbles. Standing water was present at the west side of the pond around the intake tower and in the central portion of the pond. We understand it was anticipated there would be an approximately 6 inch thick clay liner layer in the pond. No distinct, uniform clay liner layer was observed in our borings. The moisture condition of the soils in each of the borings was moist except for B-4, B-7, B-13, and B-14, where free water was encountered in the four borings. Table 1 presents the boring depths and visual descriptions of the soil conditions encountered in each of the fifteen borings.

Table 1 – Soil boring approximate locations, depths, visual soil descriptions, and unified soil classifications.

Boring No.	Approximate Latitude	Approximate Longitude	Depth Explored (in.)*	Visual Method Description of Soils, ASTM D2488	Classification for Engineering Purposes, ASTM D2487
B-1	36.834661	-107.975554	0 to 18	Lean to Fat Clay with Sand	--
			18 to 30	Clayey Sand with Gravel	SC – Clayey Sand with Gravel
B-2	36.834841	-107.975418	0 to 18	Sandy Lean to Fat Clay	--
			18 to 24	Clayey Sand	--
B-3	36.835066	-107.975460	0 to 18	Sandy Lean to Fat Clay with Gravel	--
B-4	36.835284	-107.975497	0 to 14	Clayey Sand with Gravel	SC-SM – Silty, Clayey Sand with Gravel
B-5	36.835510	-107.975527	0 to 10	Clayey Sand with Gravel	--
			10 to 16	Lean to Fat Clay with Sand	--
B-6	36.835405	-107.975796	0 to 6	Clayey Sand with Gravel	--
			6 to 10	Sandy Lean to Fat Clay with Gravel	SC – Clayey Sand with Gravel
B-7	36.835449	-107.976088	0 to 6	Clayey Sand with Gravel	--
B-8	36.835341	-107.976353	0 to 18	Clayey Sand with Gravel	--
B-9	36.835381	-107.976609	0 to 18	Clayey Sand with Gravel	--
B-10	36.835126	-107.976308	0 to 20	Clayey Sand	--
B-11	36.835091	-107.976059	0 to 8	Clayey Sand	--
B-12	36.834887	-107.976035	0 to 12	Clayey Sand	--
B-13	36.835133	-107.975649	0 to 10	Lean to Fat Clay with Sand	--
B-14	36.834920	-107.975631	0 to 12	Clayey Sand with Gravel	--
			12 to 18	Lean to Fat Clay with Sand	CL – Lean Clay with Sand
B-15	36.834768	-107.975790	0 to 12	Sandy Lean to Fat Clay with Gravel	--

*Auger refusal was encountered on gravels and cobbles at the total depth explored in each of the borings.

Soil samples were collected from select boring locations and depths. Particle size analysis and Atterberg limits tests were performed on four of these samples in order to classify them per ASTM D2487. The unified soil classifications of these four samples are presented in Table 1. The test results for these four samples are included in the attached Laboratory Reports.

Thank you for the opportunity to be of service to you on this project. If you have any questions or need additional information, please let us know.

Sincerely yours,
GEOMAT, Inc.

Nathaniel J. Compton, P.E.
Construction Services Manager

Attachments: Laboratory Report (4)

Distribution: Addressee (1), Tandy Freel, P.E. (1)

GEOMAT INC.
915 Malta Avenue ◆ Farmington, NM 87401 ◆ Tel (505) 327-7928 ◆ Fax (505) 326-5721

LABORATORY REPORT

Client: Bohannan Huston, Inc.
7500 Jefferson Street NE
Albuquerque, NM 87109

Attn: **Todd Burt, P.E.**

Report Date: February 22, 2019
GEOMAT Project No: 191-3229
Page No: 1 of 1
Lab No: 7760

Project: City of Aztec Reservoir No. 1 Clay Liner and Subgrade Exploration

Location: Aztec, New Mexico

Sampled By: J. Kelly & D. Holiday/GEOMAT
Sampled Date: February 18, 2019
Requested By: T. Burt/BHI

Sample Location: Boring B-1 at 18" to 30" Depth
Source: Boring Cuttings
Material Description (Color, Symbol, Group): ASTM Classification: SC – Clayey Sand with Gravel

Sieve Analysis, ASTM C117, C136		
Sieve Size	% Passing	Specifications
6"		
5"		
4"		
3"		
2 ½"		
2"	**100**	
1 ½"	**74**	
1"	**74**	
¾"	**72**	
½"	**69**	
3/8"	**68**	
No. 4	**64**	
No. 8	**62**	
No. 10	**61**	
No. 16	**58**	
No. 30	**48**	
No. 40	**43**	
No. 50	**38**	
No. 100	**32**	
No. 200	**26**	

Plasticity Index, ASTM D4318		
	Results	Specifications
Liquid Limit (LL)	**29**	
Plastic Limit (PL)	**17**	
Plasticity Index (PI)	**12**	

Reviewed By: Nathan Compton

Distribution: BHI – Todd Burt, P.E. (1), Tandy Freel, P.E. (1)

Note: This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at client's request.

GEOMAT INC.
915 Malta Avenue ◆ Farmington, NM 87401 ◆ Tel (505) 327-7928 ◆ Fax (505) 326-5721

LABORATORY REPORT

Client: Bohannan Huston, Inc.
7500 Jefferson Street NE
Albuquerque, NM 87109

Report Date: February 22, 2019
GEOMAT Project No: 191-3229
Page No: 1 of 1
Lab No: 7761

Attn: **Todd Burt, P.E.**

Project: City of Aztec Reservoir No. 1 Clay Liner and Subgrade Exploration

Sampled By: J. Kelly & D. Holiday/GEOMAT
Sampled Date: February 18, 2019
Requested By: T. Burt/BHI

Location: Aztec, New Mexico

Sample Location: Boring B-4 at 0" to 14" Depth
Source: Boring Cuttings
Material Description (Color, Symbol, Group): ASTM Classification: SC-SM – Silty, Clayey Sand with Gravel

---

Sieve Analysis, ASTM C117, C136		
Sieve Size	% Passing	Specifications
6"		
5"		
4"		
3"		
2 ½"		
2"	**100**	
1 ½"	**85**	
1"	**82**	
¾"	**81**	
½"	**79**	
3/8"	**78**	
No. 4	**74**	
No. 8	**72**	
No. 10	**71**	
No. 16	**66**	
No. 30	**48**	
No. 40	**38**	
No. 50	**30**	
No. 100	**23**	
No. 200	**19**	

Plasticity Index, ASTM D4318		
	Results	Specifications
Liquid Limit (LL)	**24**	
Plastic Limit (PL)	**18**	
Plasticity Index (PI)	**6**	

Reviewed By: Nathan Compton

Distribution: BHI – Todd Burt, P.E. (1), Tandy Freel, P.E. (1)

Note: This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at client's request.

GEOMAT INC.
915 Malta Avenue ◆ Farmington, NM 87401 ◆ Tel (505) 327-7928 ◆ Fax (505) 326-5721

LABORATORY REPORT

Client: Bohannan Huston, Inc.
7500 Jefferson Street NE
Albuquerque, NM 87109

Report Date: February 22, 2019
GEOMAT Project No: 191-3229
Page No: 1 of 1
Lab No: 7762

Attn: **Todd Burt, P.E.**

Project: City of Aztec Reservoir No. 1 Clay Liner and Subgrade Exploration

Sampled By: J. Kelly & D. Holiday/GEOMAT
Sampled Date: February 18, 2019

Location: Aztec, New Mexico

Requested By: T. Burt/BHI

Sample Location: Boring B-6 at 6” to 10” Depth
Source: Boring Cuttings
Material Description (Color, Symbol, Group): ASTM Classification: SC – Clayey Sand with Gravel

---

Sieve Analysis, ASTM C117, C136		
Sieve Size	% Passing	Specifications
6”		
5”		
4”		
3”		
2 ½”		
2”	**100**	
1 ½”	**88**	
1”	**85**	
¾”	**85**	
½”	**85**	
3/8”	**84**	
No. 4	**83**	
No. 8	**83**	
No. 10	**82**	
No. 16	**81**	
No. 30	**80**	
No. 40	**56**	
No. 50	**48**	
No. 100	**40**	
No. 200	**33**	

Plasticity Index, ASTM D4318		
	Results	Specifications
Liquid Limit (LL)	**33**	
Plastic Limit (PL)	**19**	
Plasticity Index (PI)	**14**	

Reviewed By: Nathan Compton

Distribution: BHI – Todd Burt, P.E. (1), Tandy Freel, P.E. (1)

Note: This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at client’s request.

GEOMAT INC.
915 Malta Avenue ◆ Farmington, NM 87401 ◆ Tel (505) 327-7928 ◆ Fax (505) 326-5721

LABORATORY REPORT

Client: Bohannan Huston, Inc.
7500 Jefferson Street NE
Albuquerque, NM 87109

Report Date: February 22, 2019
GEOMAT Project No: 191-3229
Page No: 1 of 1
Lab No: 7763

Attn: **Todd Burt, P.E.**

Project: City of Aztec Reservoir No. 1 Clay Liner and Subgrade Exploration

Sampled By: J. Kelly & D. Holiday/GEOMAT
Sampled Date: February 18, 2019

Location: Aztec, New Mexico

Requested By: T. Burt/BHI

Sample Location: Boring B-14 at 12” to 18” Depth
Source: Borings Cuttings
Material Description (Color, Symbol, Group): ASTM Classification: CL – Lean Clay with Sand

---

Sieve Analysis, ASTM C117, C136		
Sieve Size	% Passing	Specifications
6”		
5”		
4”		
3”		
2 ½”		
2”		
1 ½”		
1”		
¾”		
½”		
3/8”	**100**	
No. 4	**99**	
No. 8	**99**	
No. 10	**99**	
No. 16	**98**	
No. 30	**95**	
No. 40	**93**	
No. 50	**92**	
No. 100	**88**	
No. 200	**82**	

Plasticity Index, ASTM D4318		
	Results	Specifications
Liquid Limit (LL)	**47**	
Plastic Limit (PL)	**25**	
Plasticity Index (PI)	**22**	

Reviewed By: Nathan Compton

Distribution: BHI – Todd Burt, P.E. (1), Tandy Freel, P.E. (1)

Note: This is a summarized report of the referenced procedures and does not include all reporting requirements. Additional data can be provided at client’s request.

APPENDIX D: DAM SAFETY BUREAU EVALUATION OF NON-JURISDICTIONAL DAMS

OFFICE OF THE STATE ENGINEER
Dam Safety Bureau
Evaluation of Non-Jurisdiction Dams
December 7, 2009

The Office of the State Engineer (OSE) Dam Safety Bureau receives requests to evaluate whether a proposed impoundment is a jurisdictional dam. Section 72-5-32 NMSA defines a jurisdictional dam as 25 feet or greater in height and storing more than 15 acre-feet or a dam that stores 50 acre-feet or greater and is 6 feet or more in height. Figure 1 graphically shows the size requirements for a jurisdictional dam. The OSE provides design requirements for jurisdictional dams that are described in Title 19, Chapter 25, Part 12 of the New Mexico Administrative Code (19.25.12 NMAC). The OSE recommends that 19.25.12 NMAC be followed for non-jurisdictional dams that are not subject to review and permitting by the OSE to ensure that non-jurisdictional dams are designed and constructed in a safe manner.

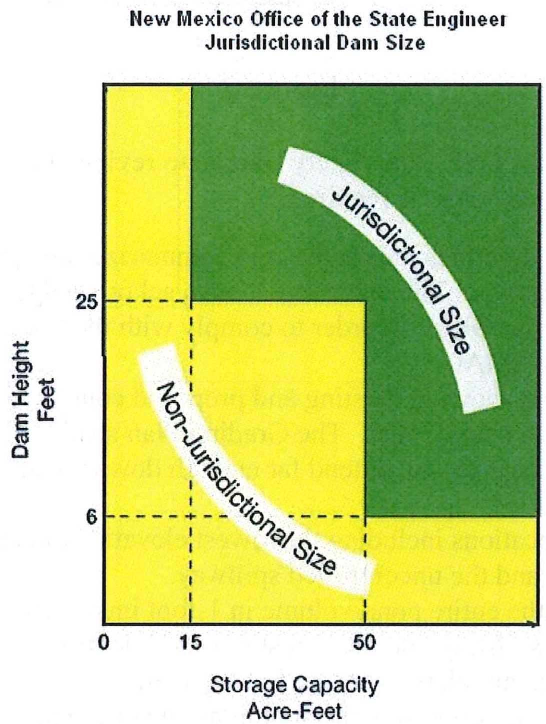


Figure 1

Section 7 of 19.25.12 NMAC contains definitions for height and storage to determine the jurisdictional status. Subsection K of 19.25.12.7 NMAC defines dam height as the vertical distance from the lowest point on the downstream toe to the dam crest. Where construction drawings identify cosmetic fill to be placed on the downstream slope of a dam, the OSE will measure properties of the dam and reservoir based on the engineered fill dimensions. The engineered fill shall be stable without relying on the buttressing benefits of the cosmetic fill. Engineered fill consisting of upstream slopes no steeper than 3 horizontal to 1 vertical, downstream slopes no steeper than 2 horizontal to 1 vertical and the dam crest width no less than dam height in feet divided by 5 plus 8 feet ($H/5 + 8$) is generally considered stable for typical conditions. Seepage shall not exit on the downstream face of the engineered fill.

Subsection DD of 19.25.12.7 NMAC defines jurisdictional storage as the volume of water in the reservoir from the lowest elevation of the downstream toe to the elevation of the spillway crest. Storage is measured to the dam crest if no uncontrolled spillway is provided. Subsection AA of 19.25.12.7 NMAC notes an uncontrolled or ungated outlet conduit used to drain the reservoir is not considered a spillway. Figure 2 shows the storage behind a dam. The gray area depicts the volume of storage for determining jurisdictional status of a dam with no spillway.

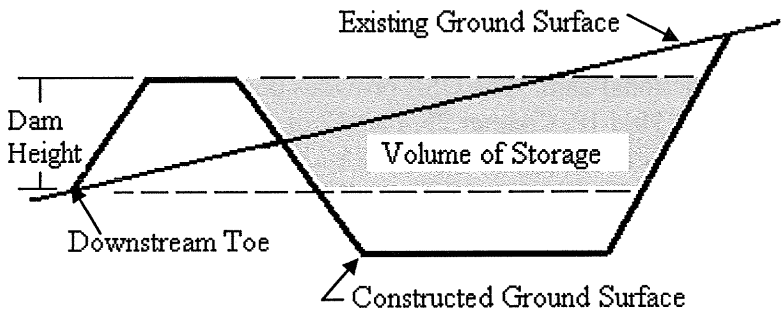


Figure 2

If a project is submitted to the OSE Dam Safety Bureau to review the jurisdictional status of a dam, the documentation listed below is required.

1. A transmittal letter that describes the project and summarizes key properties, elevations and any other critical information. The letter should also acknowledge the intent to contact the local Water Rights District Office in order to comply with the State Engineer Pond regulation contained in 19.26.2.15 NMAC.
2. Grading Plan of the pond showing existing and proposed contours in 1-foot increments. Contours shall be labeled every 5 feet. The Grading Plan shall also show the spillway location, cross-section location and extend far enough downstream to allow for an evaluation of failure potential.
3. Cross-sections at key locations including the lowest elevation along the downstream toe, the outlet works alignment and the uncontrolled spillway.
4. Stage-storage table for the entire pond volume in 1-foot increments. Storage at the elevation of the downstream toe, spillway and dam crest must be identified in the table. The table must provide incremental and cumulative storage in acre-feet.
5. Drawings and calculations supporting the submittal must be signed and stamped by the NM registered professional engineer that supervised the preparation of the documents.

APPENDIX E: POLYLOCK DETAILS

GSE

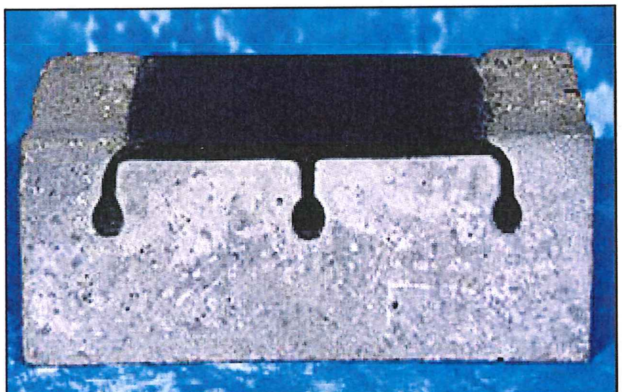
The Pioneer Of Geosynthetics

SINCE 1972

Application Sheet

Concrete Embedment Strip

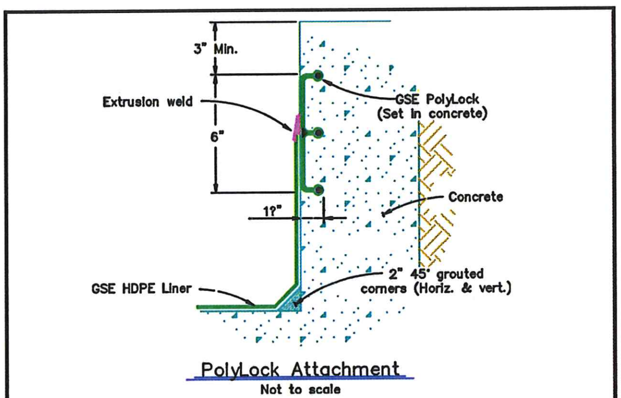
GSE was the first company to develop an extruded HDPE concrete embedment strip for geomembrane attachment. GSE PolyLock is a rugged, durable HDPE profile that can be cast-in-place or inserted into wet concrete, leaving the welding surface exposed upon completion of concrete preparation. The embedment of anchor fingers provides a high strength mechanical anchor to the concrete. When properly installed and utilized with a geomembrane, GSE PolyLock provides an outstanding barrier to leakage. GSE PolyLock is the most effective and economical cast-in-place mechanical anchor system for HDPE.



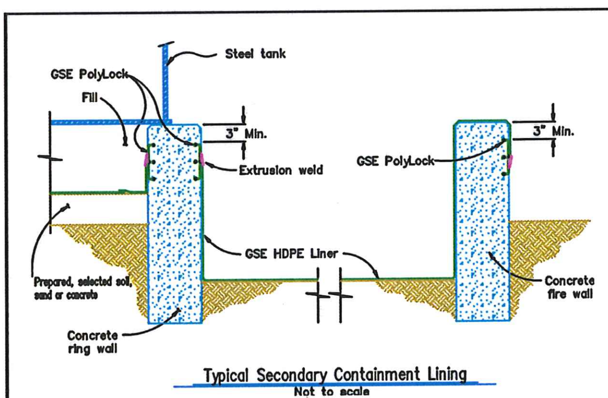
GSE PolyLock provides a wide welding surface to attach polyethylene geomembranes.

GSE PolyLock Specifications

Dimensions	
Standard length, ft (m)	10 (3)
Width, in (cm)	6 (15)
Anchor Finger Length, in (cm)	1 (2.5)
Chemical Resistance	Excellent
Tensile Strength, lb/in2 (MPa)	>4,000 (28)
Low Temperature Brittleness,°F (°C)	<-120 (<-84)



Typical GSE PolyLock attachment into concrete with geomembrane attached.

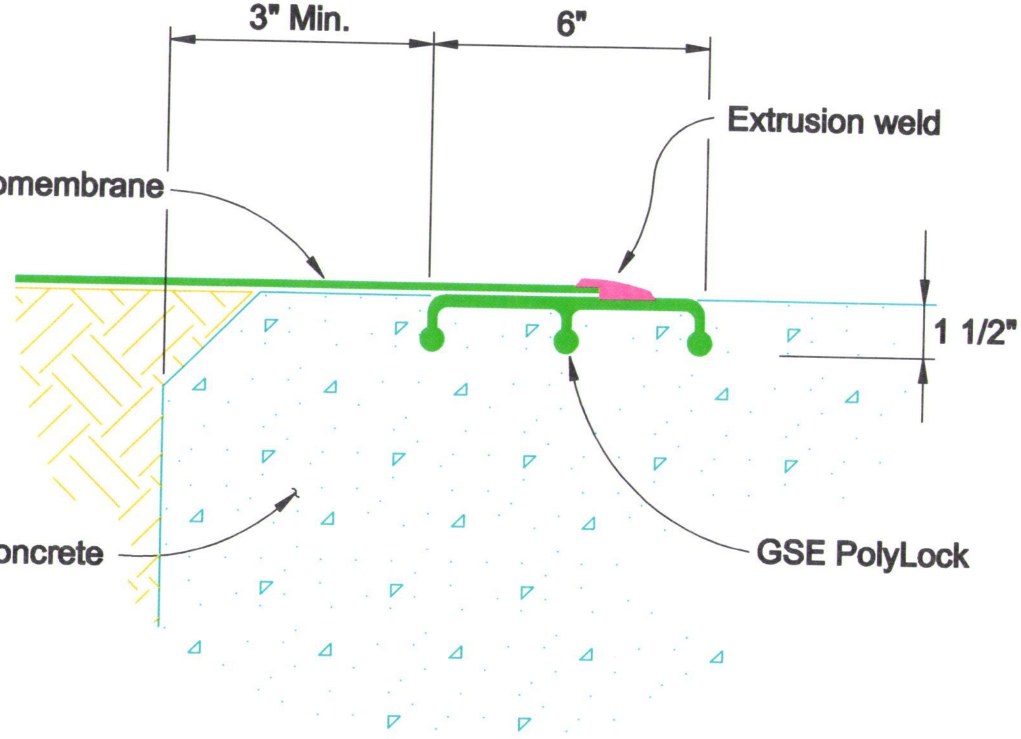


Typical secondary containment lining showing geomembrane attached to GSE PolyLock.

AP10 Polylock R07/01/09

Note

EARTH ADJACENT TO CONCRETE COLLAR TO BE WELL COMPACTED TO PREVENT FUTURE DIFFERENTIAL SETTLEMENT.
ALL CONCRETE COLLARS TO BE CHAMFERED A MINIMUM OF 1" (TYP.) @ ALL CORNERS IN CONTACT WITH LINER.



PolyLock Attachment

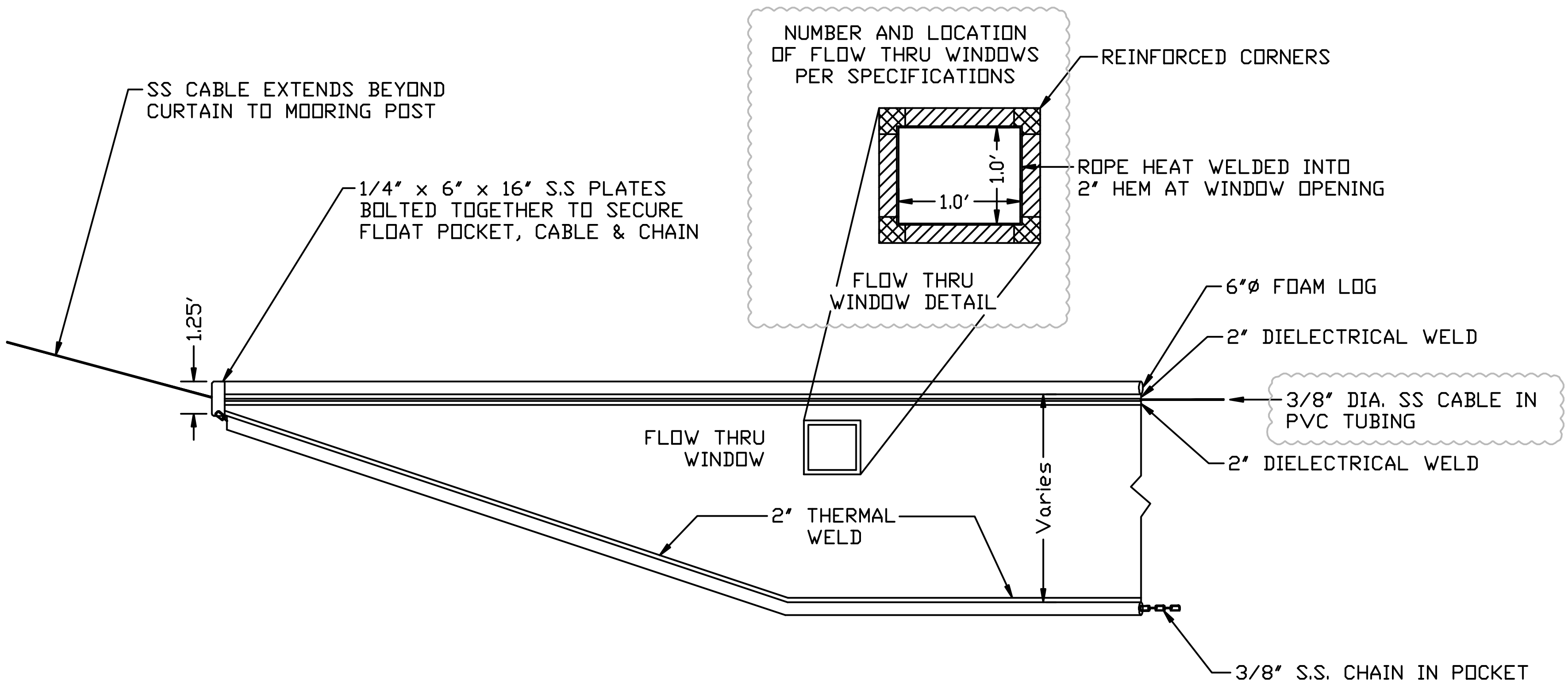
Not to scale

GSE Environmental, LLC
19103 Gundle Road
Houston, Texas 77073-3598
800-435-2008 / 281-443-8564

DRAWN	MG	DATE	01/10/2010	REVISION	0	DWG. NO.	GSE–025

APPENDIX F: BAFFLE DETAILS

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



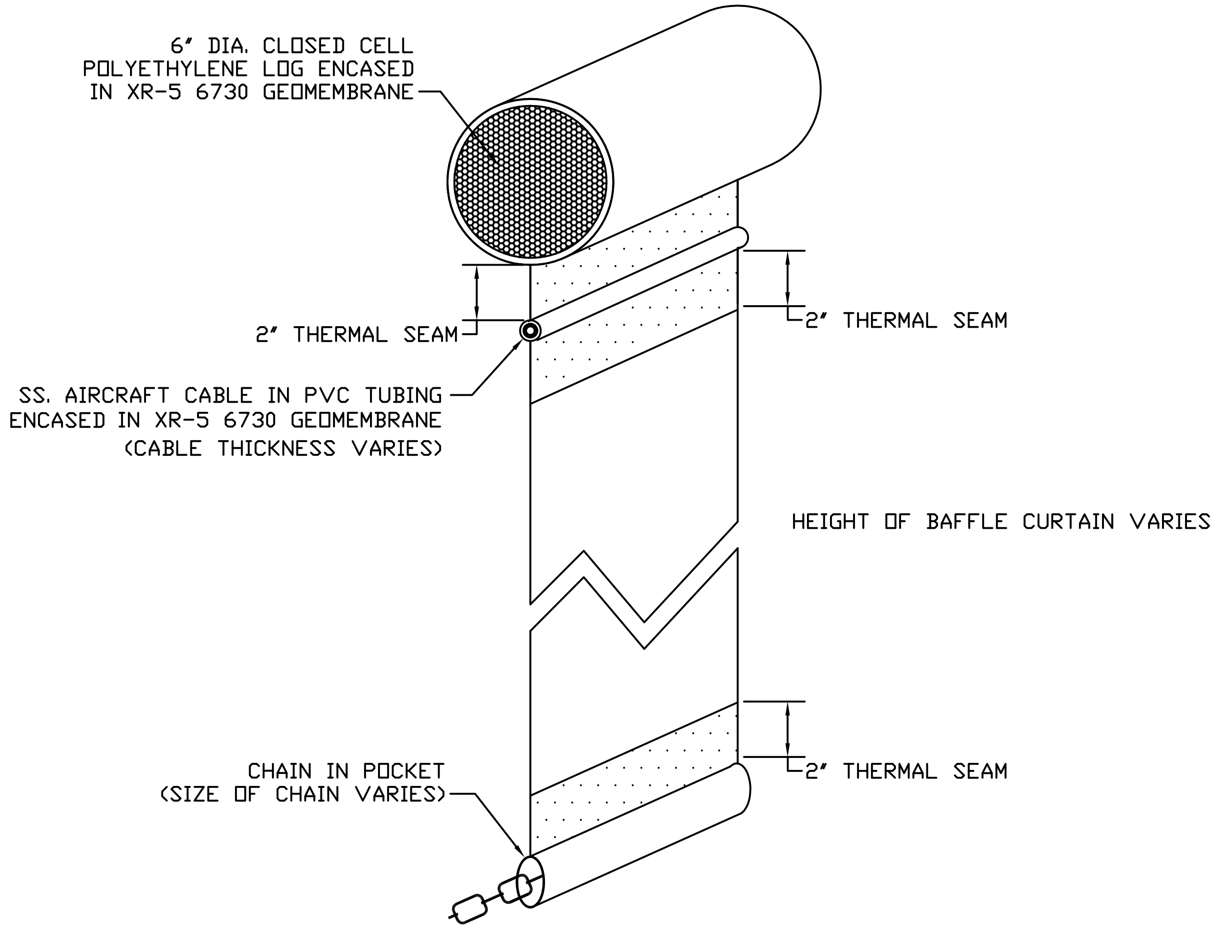
LANGE CONTAINMENT SYSTEMS, INC.
5150 RACE COURT
DENVER, CO 80216
(303) 446-8644 FAX (303) 446-8798

Floating Baffle Curtain

Typical Design Detail

SIZE: A	DRAWN BY: C. Thomas	APPROVED BY: ________	REV: 10/1/15
SCALE: NTS	DWG NO: 115-0085B_WindsorWWTP-TypBaf		DATE: 8/15/15

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



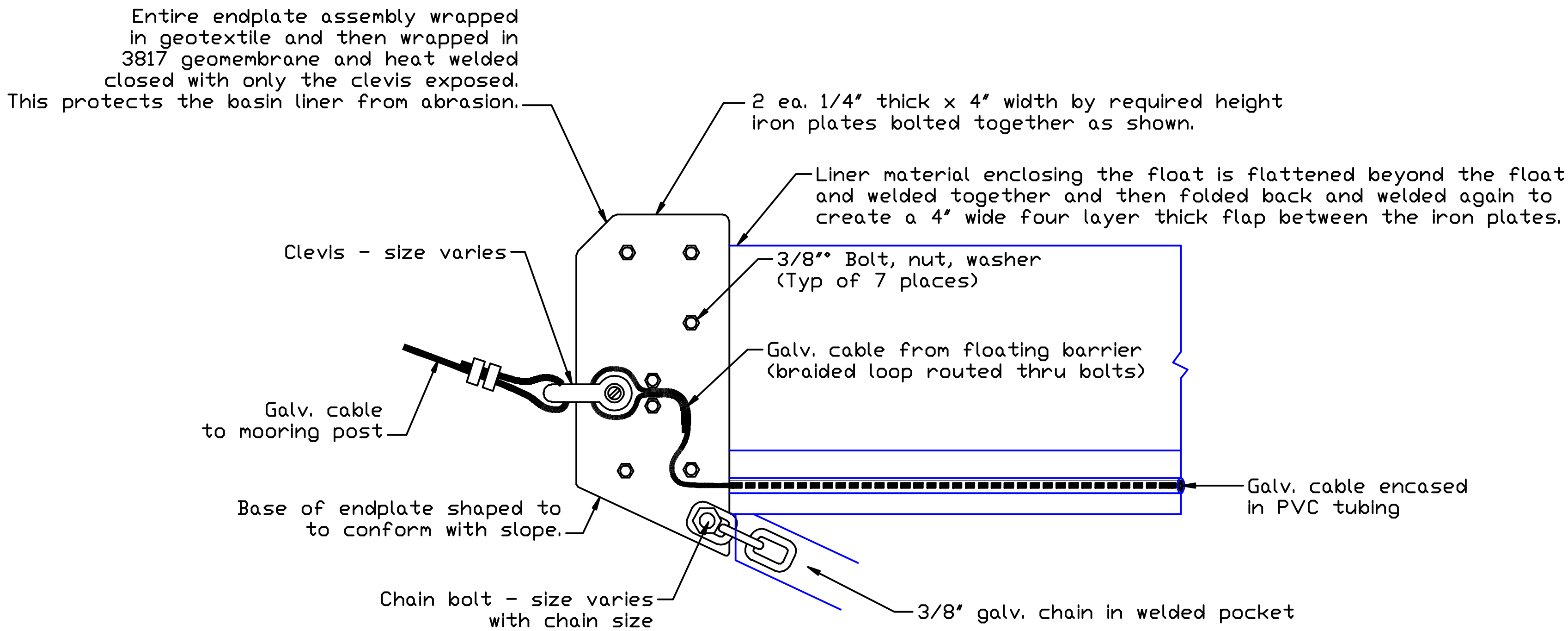
LANGE CONTAINMENT SYSTEMS, INC.
5150 RACE COURT
DENVER, CO 80216
(303) 446-8644 FAX (303) 446-8798

Floating Baffle Curtain

Typical Design Detail

SIZE: A	DRAWN BY: C. Thomas	APPROVED BY: ________	REV: ______
SCALE: NTS	DWG NO: 109-0000		DATE: 8/4/09

REVISIONS			
REV	DESCRIPTION	DATE	APPROVED



LANGE CONTAINMENT SYSTEMS, INC.
5150 RACE COURT
DENVER, CO 80216
(303) 446-8644 FAX (303) 446-8798

Floating Baffle Curtain

Typical End Plate for Floating Baffle Curtain

SIZE: A	DRAWN BY: C. Thomas	APPROVED BY: ________	REV: 3/23/16
SCALE: NTS	DWG NO: 115-0085C_WindsorWWTP-EndPlate		DATE: 8/15/15