Rehabilitation of Raw Water Reservoir for Franklin WTP

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ABSTRACT
The city of Franklin, Tennessee, a suburb of Nashville, initiated a rehabilitation project for their existing 35-acre raw water reservoir to fix leaks caused by several deep fissures in the earthen basin. Because of the leaks, the reservoir ran complete dry during an extended drought season. When the Tennessee government released economic stimulus dollars, this site was among the top 10 projects earmarked to receive funding. After a failed attempt at using a natural clay liner, the city selected a potable water grade geomembrane to solve its water containment issues. This paper will go over the reservoir history, sizing options, liner material options, construction overview and lessons learned during the project.

1. INTRODUCTION

During the summer of 2007, the city of Franklin, Tennessee and its surroundings were experiencing a severe drought. Due to the high heat and low flows in the Harpeth River, Franklin struggled to meet water supply demands in the area. The city's raw water reservoir, which can hold 85 million gallons, was completely dry for several months. As a result, the 2.0 MGD Franklin water treatment plant was inoperable for periods of time. Water is normally pumped from the Harpeth River into the raw water reservoir, where it is later treated before consumption.

Over the next 2 years, the drought officially ended and upgrades were put in the city's water distribution system. This helped to ease worries about Franklin's water system, except for the reservoir. It was estimated that 1 million gallons of untreated water per day leaked from the reservoir, even after temporary installations of clay along the cracks in the bottom.

Figure 1: Reservoir in 2008 after the major drought of 2007

2. RESERVOIR HISTORY

The Franklin reservoir was originally built in the 1950's and during that time the water treatment plant was designed for 1 million GPD. The reservoir served as a source of water during the warm summer months where water was pumped from the Harpeth River. The reservoir was 30 acres in size and designed to hold up to 100 million gallons of water. During the 1960's, the water treatment plant was upgraded to handle 2 million GPD. Over the years, volume within the reservoir was lost due to accumulated filter backwash solids reducing the capacity to only 80 million gallons. Also, the original clay liner was no longer working and there were continuous leaks in the bottom.

The reservoir's problems had been common knowledge for years among past and current city officials, who had planned for the city to pay $3.9 million on a rehabilitation project. However, in late 2009 Franklin received $2.5 million from the Recovery Act/State Revolving Fund – a $1.5 million loan to be paid over 20 years and $1 million that will never have to be repaid. As a result, the city of Franklin only had to come up with $1.4 million for the rehabilitation project.

3. SCOPE OF PROJECT

AECOM Engineers was hired to investigate and design alternatives, optimize sizing of the reservoir and recommend life cycle synthetic liner materials for an improved and enlarged reservoir for water conservation at the treatment source.

3.1 Liner System Alternatives

Eight different types of liner systems were evaluated and based on a design life of at least 20 years. They are as follows:

- Geosynthetic clay liner (GCL) with 12" of soil cover
- HDPE liner left uncovered
- HDPE liner with 12" of soil cover
- LLDPE liner with 12" of soil cover
- Reinforced Chlorosulfonated Polyethylene (CSPE) left uncovered
- Reinforced Ethylene Propylene Diene Monomer (EPDM) left uncovered
- Reinforced Polypropylene (fPP-R) left uncovered
- Reinforced Ethylene Interpolymer Alloy (EIA-R) left uncovered

These eight alternatives were narrowed down to two, based on evaluations of long-term liner systems that had been in service for 20 years or more. In addition, it was decided that 12" of soil cover on top of the geomembrane or GCL was too costly over a 35-acre site. The two options chosen were CSPE (Hypalon) and EIA-R (XR-3 PW/XR-5 PW). In addition, AECOM decided to specify a 36-mil thickness in the reservoir bottom and 45-mil thickness on the side slopes. A thicker geomembrane was recommended on the sides for higher abrasion resistance from potential wave action.

3.2 Resizing of the Reservoir

Alt.	Scope	Water Volume (MG)	Excavation C.Y.	Off-Site Spoil C.Y.	Avg MG/Yr WTP Production	Years @ 0.0 MGD WTP of past 31	Average Days per yr @ 0.0MGD WTP	Estimated Grading & Modifications Cost - No Liner	5yr savings (loss) including sludge/liner**
A.	Existing - Minimun Rehab	85.5	-	-	1,201	8	28.6	$100,000	$1,459,370
B.	Raise Spillway 1.0 ft	95	-	-	1,206	7	25.9	$175,000	$1,465,539
C.	Raise Spillway 1.5 ft	100	-	-	1,208	6	26.5	$200,000	$1,474,840
D.	Raise Spillway 2.0 ft, raise berm 8"	105	1500	-	1,211	5	27.8	$250,000	$1,474,613
E.	Raise Spillway 2.0 ft, raise berm 12" & cut for balanced cut/max spoil ~654	109	20,800	-	1,212	5	25.4	$475,000	$1,404,466
F.	Raise Spillway 2.0 ft & cut to "level" Bottom ~ 652.2 ft	113	40,600	20,000	1,214	5	22.8	$700,000	$1,334,418
G.	Raise Spillway 3.0 ft, add cut to berm, cut 4' below 652.2 "leveled bottom", & low	155	204,000	154,000	1,229	0	0	$2,850,000	$647,475

Figure 2: Seven alternatives to increase the water volume of the reservoir

AECOM looked at seven alternatives to increase the overall capacity of the reservoir from 80 million gallons to a potential 155 million gallons (see Figure 2). With a combination of raising the spillway 2 feet, raising the berm 8 inches and excavating soil in the bottom, the optimum design volume came to be 105 million gallons (Alternate D). This was based on the estimated grading and modifications cost at $250,000 and only 1,500 yards of excavation required.

3.3 Removal of the Filter Backwash Solids

Another means of increasing the capacity of the reservoir was removal of the existing filter backwash solids. There was a significant volume of material due to over four decades of use, with the solids now being diverted to the sanitary system. The filter backwash solids had high levels of aluminum and copper and was considered a “special waste” if taken outside the reservoir, since it was processed. The options were as follows:

- No action – poor bearing/volume soil
- Beneficial reuse for up to 6,000 acres of cropland
- Take to a Class 1 landfill
- Take to a Construction and Demolition (C+D) landfill as a day cover

The option chosen was to haul the filter backwash solids to a C+D landfill, which required 1,900 dump truck loads or a total of 33,000 cubic yards.

Figure 3: Disposal of filter backwash solids

During the solids removal, numerous areas of soft spots were found. To fix this, large rip rap from the side slopes was used in these areas for stabilization of the soil. This was a great use for the rip rap, since it had to be removed from the sides of the reservoir anyway before installation of the geomembrane liner and geoweb system. The haul off and rough grading of the reservoir bottom took approximately 3 months to complete.

3.4. Geomembrane Liner and Geoweb Installation

Even though the reservoir will be holding “raw water” from the Harpeth River, the facility owner wanted the liner system to be NSF 61 certified for potable water. After one month of fine grading the reservoir bottom, installation of the geomembrane liner started. Since the geomembrane was a heavily reinforced coated fabric with excellent physical properties such as puncture resistance, a geotextile below the liner was not needed.

Figure 4: Geomembrane liner installation

The EIA-R was prefabricated into panels 90 feet wide by 180 feet long (16,200 SF each). Fabrication of the geomembrane was performed by Colorado Lining International’s New Caney, TX facility and installation of liner and geoweb was by Geosynthetics, Inc. (GSI). A total of 95 prefabricated geomembrane panels were delivered to the job site. This allowed for only 2 field seams per acre required, which dramatically reduced the amount of CQA testing in the field.

A thicker 45-mil reinforced EIA-R was installed on the side slopes since they will experience greater exposure to the elements and a 36-mil reinforced EIA-R was installed on the reservoir bottom. Liner installation was completed in approximately 2 months and required over 1.5 million square feet (35 acres). Sand tubes made out of the EIA-R were also placed along the bottom to prevent wind uplift when the reservoir is empty.

Due to concerns from potential wave action when the reservoir is full of water, AECOM recommended a geoweb with stone be installed along the top of the side slopes and on top of the geomembrane liner. After the geoweb was in place, a concrete anchor trench was installed. The geoweb with stone was also placed below the 24” influent pipe to prevent scouring and as a ramp down to the toe of slope for vehicle access when needed.

Figure 5: Installation of geoweb along the side slopes

To control any solids and sediment coming from the 24” influent pipe, a 200 foot long floating baffle system was installed. The baffle was also made out of an EIA-R potable grade geomembrane. A bench was installed inside the area of the baffle to help confine the sediment and also provide a specific area for clean out when needed.

4. CONSTRUCTION COMPLETION AND LESSONS LEARNED

The Franklin reservoir rehabilitation project went out for bid in December of 2009 and the notice to proceed was given on April 1, 2010. The reservoir was operationally complete in October of 2010, with the final construction cost being over budget by only 1% ($3,946,762). The general contractor was Summit Construction based out of Nashville, TN. Once completed, the reservoir achieved a total of 113 million gallons of storage which was 8% over the original design of 105 million gallons.

Some issues and lesson learned that came up during construction included:

- Subsurface conditions can vary greatly and were worse than expected in some areas
- Unit grading quantities can vary from design estimates
- Constructability of the geoweb “keyway” was more difficult than expected
- Geoweb needs concrete at the toe for more stable installation
- Baffle curtain should be anchored in some way at the bottom due to high flows

This rehabilitation project was able to improve and enlarge the raw water reservoir for water conservation at the treatment source by using a high performance geomembrane liner for leakage abatement. There was sustainable reuse of the filter backwash solids that were disposed of as a regulated solid waste and used as a daily cover at a C+D landfill. The project also had sustainable reuse of the interior rock rip rap, which was used as structural fill material to improve low bearing soft spots in the reservoir bottom. The city of Franklin has potential plans to expand this water treatment facility and the impoundment for a future growth effort.

Figure 6: Completed reservoir rehabilitation shown now full of water

REFERENCES

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