OAK RIDGE CITY COUNCIL
SPECIAL MEETING

Central Services Complex Multi-Purpose Room

Tuesday, February 21, 2017

6:00 p.m.

AGENDA

I. ROLL CALL

II. RESOLUTION

a. A RESOLUTION TO ADOPT THE OAK RIDGE WATER TREATMENT PLANT EVALUATION REPORT, DATED NOVEMBER 18, 2016, PREPARED BY JACOBS ENGINEERING GROUP, INC., KNOXVILLE, TENNESSEE.

III. ADJOURNMENT

CITY CLERK MEMORANDUM
17-03

DATE: February 17, 2017

TO: Honorable Mayor and Members of City Council

FROM: Mary Beth Hickman, City Clerk

SUBJECT: SPECIAL MEETING OF CITY COUNCIL

At the request of City Manager Mark Watson, and in accordance with Article II, Section 2, of the Charter of the City of Oak Ridge, Tennessee, a special meeting of City Council is hereby called for **Tuesday, February 21, 2017 at 6:00 p.m.** in the Multipurpose Room of the Central Services Complex, 100 Woodbury Lane, for consideration of the following:

> A RESOLUTION ADOPTING THE OAK RIDGE WATER TREATEMENT PLANT EVALUATION REPORT, DATED NOVEMBER 18, 2016, PREPARED BY JACOBS ENGINEERING GROUP, INC., KNOXVILLE, TENNESSEE.

In accordance with the City Charter, matters transacted at this special meeting shall be limited to the subjects recited in the notice of the meeting.

Mary Beth Hickman

Mary Beth Hickman

cc: Mark S. Watson, City Manager
Kenneth R. Krushenski, City Attorney
Department Directors
The Oak Ridger
Oak Ridge Today
The Knoxville News Sentinel
BBB Communications

ADMINISTRATIVE MEMORANDUM
17-02

DATE: February 17, 2017

TO: Mary Beth Hickman, City Clerk

FROM: Mark S. Watson, City Manager

SUBJECT: SPECIAL CITY COUNCIL MEETING

In accordance with Article II, Section 2, of the Charter of the City of Oak Ridge, you are hereby requested to call a special meeting of the Oak Ridge City Council for Tuesday, February 21, 2017, at 6:00 p.m. in the Multipurpose Room, Central Services Complex, 100 Woodbury Lane, for consideration of the following:

- A RESOLUTION ADOPTING THE OAK RIDGE WATER TREATMENT PLANT EVALUATION REPORT, DATED NOVEMBER 18, 2016, PREPARED BY JACOBS ENGINEERING GROUP, INC., KNOXVILLE, TENNESSEE.

Mark S Watson

Mark S. Watson

CITY COUNCIL MEMORANDUM
17-07

DATE: February 17, 2017

TO: Honorable Mayor and Members of City Council

FROM: Mark S. Watson, City Manager

SUBJECT: JACOBS ENGINEERING REPORT ON THE WATER TREATMENT PLANT

Introduction

The City Council shall consider acceptance of the Final Report by Jacobs Engineering Group, Inc., Knoxville, Tennessee, assessing the Oak Ridge Water Treatment Plant and consider the selection of Option 3, which shall be a strategy of seeking the construction of a new water plant in the coming years.

Background

During the last several years, the City Manager and the Public Works Directors (2) have identified their concerns for the condition and physical stability of the 75-year-old water plant that provides potable water to the Oak Ridge community and the water services to the Department of Energy Complex. During the last year, particular focus was requested through the consulting engineering firm of Jacobs Engineering to determine any options we have as a water service provider.

The attached report identifies three options for the City to consider, with all three options, having the approximate same price tag. Options include: (1) repair and rehabilitate the existing water plant located on the top of the ridge, (2) develop a new water plant facility in the vicinity of the Booster Pump stations located easterly across the valley from the water plant, and (3) develop a new water plant at the Riverfront area. All options include significant electrical upgrades and various transmission pipe upgrades. Option 1 with the existing plant requires significant earthwork repairs to the steep slopes of the existing plant that are eroding away. Coordination of the land for Options 2 and 3 will require cooperation with the Department of Energy. All improvements will enhance energy conservation and costs of the existing operations.

The report describes the condition of the existing plant and current leakage and slope concerns. The report, in its startup, included coordination with the Department of Energy and the involved divisions of the Department. At this time, the City of Oak Ridge Council should receive and accept the findings of the report and a selection confirmed with the City staff to proceed upon. This will allow further discussions and options to be brought forward for consideration to address this major 50-year capital project.

Recommendation

Approval of the attached resolution is recommended.

Mark S Watson

Mark S. Watson

Attachment

NUMBER _____

RESOLUTION

A RESOLUTION ADOPTING THE OAK RIDGE WATER TREATMENT PLANT EVALUATION REPORT, DATED NOVEMBER 18, 2016, PREPARED BY JACOBS ENGINEERING GROUP, INC., KNOXVILLE, TENNESSEE.

WHEREAS, by Resolution 4-24-2016, City Council authorized a professional services agreement in the estimated amount of $98,250.00 with Jacobs Engineering Group, Inc. ("Jacobs"), Knoxville, Tennessee, to conduct an evaluation of Water Treatment Plant to determine the current and projected condition of the facility relative to costs associated with repairs and rehabilitation; and

WHEREAS, Jacobs has completed the evaluation and determined that while the existing plant is in good shape structurally, the process equipment is in need of replacement and/or upgrades to meet today's stricter standards; and

WHEREAS, Jacobs also identified long-term maintenance issues primarily due to the steep slope surrounding the plant and water storage tanks, and soil and rock sliding threatening the stability of the building and the tanks; and

WHEREAS, Jacobs recommends construction of a new water treatment plant as the most cost effective alternative to upgrading the equipment and stabilizing the slopes; and

WHEREAS, Jacobs recommends the new plant be constructed at the existing Raw Water Intake site which will offer increased operational flexibility and security; and

WHEREAS, the estimated project cost for a new plant at this location is $43.1 million.

NOW, THEREFORE, BE IT RESOLVED BY THE COUNCIL OF THE CITY OF OAK RIDGE, TENNESSEE:

That the Oak Ridge Water Treatment Plant Evaluation report, dated November 18, 2016, prepared by Jacobs Engineering Group, Inc., Knoxville, Tennessee, is hereby adopted.

BE IT FURTHER RESOLVED that the City Manager is directed to move forward with implementing the recommendation set forth in the report for construction of a new Water Treatment Plant at the existing Raw Water Intake site.

This the 21st day of February 2017.

APPROVED AS TO FORM AND LEGALITY:

Kenneth R. Krushenski

_____
Kenneth R. Krushenski, City Attorney

_____
Warren L. Gooch, Mayor

_____
Mary Beth Hickman, City Clerk

Oak Ridge Water Treatment Plant Evaluation

City of Oak Ridge

Water Treatment Plant Evaluation

November 18, 2016

JACOBS

JACOBS

Oak Ridge Water Treatment Plant Evaluation

Project No:	C6A01401
Document Title:	Water Treatment Plant Evaluation
Date:	November 18, 2016
Client Name:	City of Oak Ridge
Project Manager:	Bob Frear, P.E.
Author:	Ben Simerl, P.E.
File Name:	J:\C6A01401\800DELIV\810STUDY\Oak Ridge Water Treatment Plant Evaluation.docx

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BENJAMIN R. SIMERL
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 109312
STATE OF TENNESSEE
11/18/16

Contents

Executive Summary **5**
1. Introduction **7**
2. Oak Ridge Water System **8**
2.1 Existing Water System Description 8
2.2 Historical Water Demands 8
2.3 Population Projection 9
2.4 Water Demand Projections 9
2.4.1 Residential, Commercial, and Industrial Demand 9
2.4.2 Wholesale Demand 9
2.4.3 Total Service Area Water Demand Projection 10
3. Raw Water Quality **11**
3.1 Melton Hill Lake 11
3.2 General Water Quality Features 11
3.2.1 Turbidity 11
3.2.2 pH and Alkalinity 11
3.2.3 Hardness 12
4. Existing Water Treatment Plant Evaluation **13**
4.1 Raw Water Pump Station 13
4.1.1 Process Mechanical 13
4.1.2 Structural 13
4.1.3 Electrical 13
4.2 Raw Water Pipelines 14
4.3 Raw Water Storage Tank 14
4.4 Intermediate Pump Station 15
4.4.1 Process Mechanical 15
4.4.2 Structural 15
4.4.3 Electrical 15
4.5 Intermediate Water Pipelines 16
4.6 Water Treatment Plant 16
4.6.1 Process Evaluation 16
4.6.2 Structural Evaluation 23
4.6.3 Electrical 31
4.6.4 Building Mechanical and Architectural 33
4.6.5 Geotechnical 33
4.6.6 SCADA 34
4.6.7 Applicable Codes and Guidelines 35

5. Water Treatment Plant Alternatives 36
5.1 Alternative No. 1 - Upgrade Existing Water Treatment Plant 37
5.1.1 Description 37
5.1.2 Capital Cost 38
5.2 Alternative No. 2 - New Water Treatment Plant at Intermediate Pump Station 38
5.2.1 Description 38
5.2.2 Capital Cost 41
5.3 Alternative No. 3 - New Water Treatment Plant at Raw Water Intake 42
5.3.1 Description 42
5.3.2 Capital Cost 44
5.4 Operational and Maintenance Costs 44
5.5 Non-Cost Factors 44
6. Recommendations 46
6.1 Proposed Water Treatment Improvements 46
6.2 Schedule 46

Appendix A. Geotechnical Evaluation
Appendix B. Conceptual Cost Estimates

Executive Summary

The City of Oak Ridge currently operates and maintains a 1940's era water treatment plant (WTP). The existing Oak Ridge WTP has a rated capacity of 28 MGD and utilizes conventional treatment techniques consisting of coagulation, flocculation, sedimentation, filtration and disinfection to treat water from the Clinch River/Melton Hill Lake. The facility was originally constructed in the 1940's to provide water to the Manhattan Project and the City of Oak Ridge, and was subsequently expanded in the 1950's to a capacity of 28 MGD. The facility has also undergone a series of smaller improvement projects over the last 70 years. The facility was owned by the Department of Energy (DOE) until 2000, when DOE transferred ownership and operation of the plant to the City of Oak Ridge (COR). Due to reductions in water use, the current average daily demands range from 7 to 8 MGD, and maximum daily usage ranges from 11 to 12 MGD.

An evaluation of the existing WTP revealed that the overall plant is in good shape structurally, but most of the process equipment is in need of replacement/upgrades. The process equipment and basins at the WTP were designed to treat 28 MGD and meet 1940's drinking water standards, specifically a filtered water turbidity of 1.0 nephelometric turbidity unit (NTU). With today's stricter standards (filtered water turbidity of 0.3 NTU) and more stringent design guidelines; unmodified, the existing flocculation and sedimentation basins would be rated for 10 MGD.

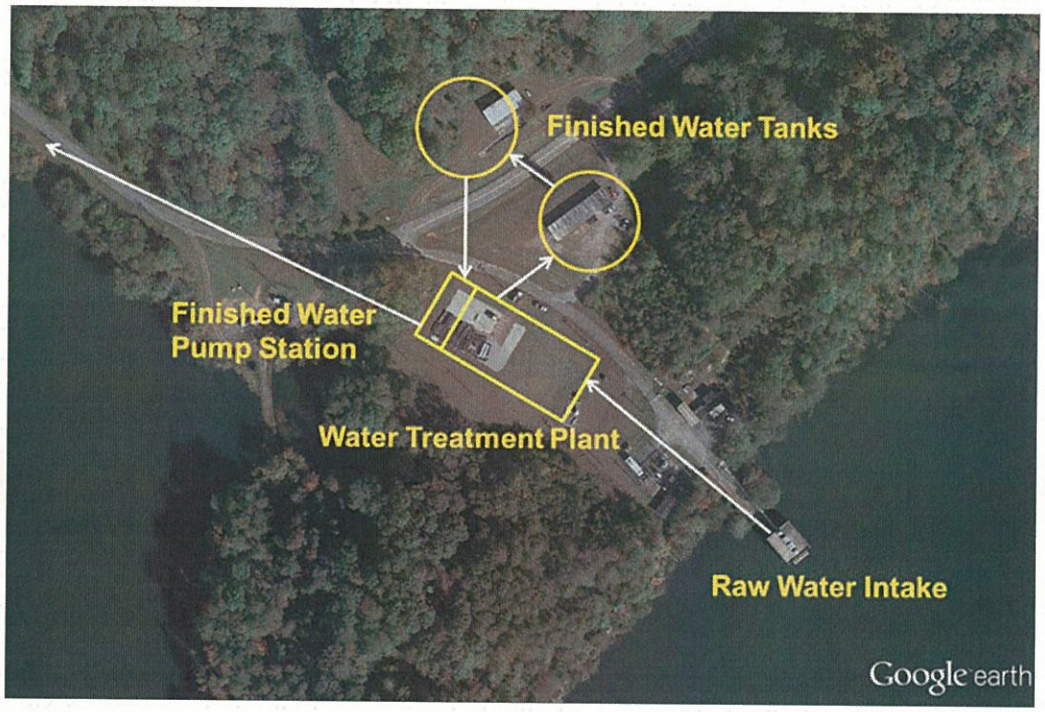
The primary long-term maintenance issues with the existing WTP are the steep slopes on the north and south side of the plant and south side of the Finished Water Reservoirs. The soil and rock on these slopes are sliding down and is threatening the stability of the treatment plant building and water storage tanks. Stabilizing and repairing these slopes will require significant effort and will likely cost over $11M.

Discussions were held with both Anderson County Water Authority and West Knox Utility District about supplying water to COR and DOE; neither system had excess capacity and would have to construct the required filter and pumping capacity to supply COR and DOE. In addition, a large amount of water transmission piping would be needed to transfer the water into the COR and DOE distribution systems.

The most cost effective alternative, given the significant geotechnical work needed to stabilize the existing plant site, is the construction of a new WTP at the existing Raw Water Pump Station site. A new WTP constructed adjacent to the existing raw water intake would put all of COR's water treatment infrastructure in the same location, offering increased operational flexibility and security. Co-locating treatment processes and pumping also allows for potential savings through the sharing of electrical services and backup power systems.

Water from the existing intake and Raw Water Pump Station would be pumped directly to the new WTP on the same site. The new facility is proposed to utilize a membrane ultrafiltration system. Membrane filtration systems offer high levels of treatment in a small footprint and are cost effective compared to new conventional treatment plants.

The new WTP would pump drinking water into two new 3.5 MG finished water storage tanks adjacent to the WTP. A new high service pump station would pump water into COR's (and Y-12/ORNL) distribution systems. The new WTP will also include a backup power generation system or dual service feeds. To accommodate future expansion and changing conditions, space will be allocated on the site and in the membrane building for future structures, hydraulic capacities will be large enough to accommodate ultimate planned flows, and pipe stub-outs will be provided where appropriate for diverting future flows to new process units.



The proposed WTP alternative does not utilize the existing Finished Water Storage Tanks at the existing WTP site. Finished water storage capacity is instead provided at the new WTP site due to the high cost of the slope stabilization needed to protect the existing Finished Water Storage Tanks.

The proposed WTP has a conceptual cost of $43.1M. The conceptual cost estimate includes the design, bidding, permitting, and construction costs and also includes a 20 percent contingency for unknown factors at this stage of project planning. The construction cost includes the infrastructure (pipe, concrete, building, and site work) for up to 20 MGD of treatment capacity, and the process equipment (membrane cartridges and pumps) for 16 MGD of capacity. Additional floor space would be provided in the water plant building to allow for future addition of up to 4 MGD of membrane filter modules for a simple expansion to 20 MGD.

Conceptual Cost Estimate
New WTP at Raw Water Intake

Item	Cost	
Raw Water Pump Station	$	2,637,000
16 MGD Membrane Filtration Plant	$	32,253,000
High Service Pump Station	$	2,032,000
24-inch Finished Water Pipeline	$	6,229,000
WTP Project Cost	**$**	**43,151,000**

1. Introduction

The City of Oak Ridge (COR) currently operates and maintains a 1940's era water treatment plant (WTP) that was originally constructed and operated by the Department of Energy (DOE), shown below in Figure 1-1. The original maximum capacity of the plant was 28 million gallons per day (MGD). However, due to reductions in water use, the current average daily demands ranges from 7 to 8 MGD, and maximum daily usage ranges from 11 to 12 MGD. The City has become concerned about operating the existing WTP for the next 20 years. This report is intended to define the needs of the existing WTP and includes a comparison to the costs associated with the construction of a new WTP to assist COR in determining the future path of COR's WTP operations.

2. Oak Ridge Water System

2.1 Existing Water System Description

The Oak Ridge water system currently serves approximately 13,000 residential customers, 414 commercial customers, and 25 industrial customers. In addition to serving customers within its service area, Oak Ridge also sells water to the U.S. Department of Energy's Y-12 National Security Complex and Oak Ridge National Lab (ORNL). The COR's water distribution provides water to over 14,000 customers, has approximately 265 miles of 2 to 30-inch water distribution line, 12 storage tanks holding 15.8 MG of water and 6 booster pump stations.

The existing Oak Ridge WTP has a rated capacity of 28 MGD and utilizes conventional treatment techniques consisting of coagulation, flocculation, sedimentation, filtration and disinfection to treat water from the Clinch River/Melton Hill Lake.

2.2 Historical Water Demands

Water demands from the Oak Ridge system have decreased steadily from 2005 to 2016. Table 2-1 presents historical average day water production from January 2005 through April 2016. As Table 2-1 shows, the average day production has decreased from 10.88 MGD in 2005 to 7.80 MGD in 2015. The monthly peak water usage also shows a similar trend, decreasing from 12.36 MGD in 2005 to 8.64 MGD in 2015.

Y-12 Raw Water was water utilized to supplement streamflow in the Upper East Fork of Poplar Creek as part of a mercury environmental mitigation project. This water was pumped using the WTP raw water intake, pump station and pipeline and diverted to the Upper East Fork of Poplar Creek after the Intermediate Pump Station. This water volume is not counted in the water plant production quantities listed in Table 2-1. Y-12 Raw Water usage was discontinued in May 2014.

Table 2-1 - Historical Water Demand (MGD)

Year	Oak Ridge WTP Average Production	City of Oak Ridge	ORNL	Y-12	Y-12 Raw Water
2005	10.88	3.74	2.58	4.55	4.75
2006	10.04	4.39	2.30	3.35	4.61
2007	9.83	4.89	2.46	2.48	4.21
2008	10.22	4.54	2.39	3.29	4.08
2009	10.36	4.51	2.75	3.10	3.03
2010	9.81	4.22	2.83	2.77	3.25
2011	9.42	4.46	2.26	2.70	2.76
2012	7.73	3.69	1.55	2.48	2.58
2013	7.72	3.38	0.68	3.66	2.36
2014	8.05	3.82	0.79	3.45	--
2015	7.80	4.10	2.19	1.51	--
2016[1]	7.84	4.02	2.22	1.60	--

[1] Data through October 2016

2.3 Population Projection

A water demand projection through 2035 was calculated to determine the water treatment capacity needed for the system. The first step in this demand projection was to project population growth within the service area. The population of the City of Oak Ridge and surrounding Anderson County has grown at approximately a 0.5 percent annual rate since 2000. This modest growth is projected to continue over the next 20 years. Table 2-2 presents the population projections for the City of Oak Ridge.

Table 2-2 - Oak Ridge Population Projection

Year	Oak Ridge	Anderson County
2015	29,302	77,285
2020	30,035	79,061
2025	30,785	80,713
2030	31,555	82,202
2035	32,334	83,444

1. US Census, www.census.gov
2. Tennessee State Data Center, 2012, http://cber.bus.utk.edu/
3. Center for Business and Economic Research, University of Tennessee, Knoxville

2.4 Water Demand Projections

The COR provided an average of 7.8 MG of water per day in 2015 to a total of approximately 13,000 customers (11,291 residential and 1,653 commercial and industrial). Peak demands at the WTP have averaged 156% of the average flow over the last several years.

2.4.1 Residential, Commercial, and Industrial Demand

To generate the City's residential, commercial and industrial water demand projections for the 20-year planning period, the population projections were used as a starting point, but other trends observed within the service area that contribute to residential demand growth also were incorporated into the projection. Renovation development of older properties is expected to be a continuing trend inside the City. Renovation of older plumbing systems with tighter plumbing systems and more water efficient fixtures generally reduces water demand independent of changes in population. Because commercial and industrial water use is not differentiated in the WTP production data, future commercial and industrial demands are assumed to follow the growth rate of the COR for the purposes of this report and are included in the residential demand projections. Future commercial and industrial demands are typically tied to specific development projects and are difficult to accurately project.

2.4.2 Wholesale Demand

Oak Ridge currently has two wholesale customers, Y-12 and ORNL. Y-12's annual water usage has averaged 3.0 MGD over the past 10 years, but their average usage has dropped to 1.5 MGD in 2015 and 1.60 thru October 2016. This usage is considerably less than Y-12's historical water usage and their water usage has steadily decreased as it has downsized and modernized some of its facilities. Y-12 representatives have indicated that they do not anticipate significant changes from recent water usage over the next 20 years. ORNL's annual water usage has averaged 2.1 MGD over the past 10 years. Average projected demand for Y-12 and ORNL combined is anticipated to be approximately 3.7 MGD over the next 20 years.

2.4.3 Total Service Area Water Demand Projection

Table 2-3 presents the average and peak day water demand projection for the Oak Ridge WTP. These projections include both COR and Y-12/ORNL projected water demands. Future peak demands are assumed to be the same as the historical peak/average ratio of 1.55.

Table 2-3 - Current and Future Demands Projected for Oak Ridge

Year	WTP Average Demand	WTP Peak Day Demand
2015	7.8	12.2
2020	7.9	12.3
2025	8.0	12.5
2030	8.1	12.7
2035	8.2	12.8

3. Raw Water Quality

3.1 Melton Hill Lake

Raw water for the WTP is obtained from Melton Hill Reservoir, a 5,470 acre Tennessee Valley Authority (TVA) reservoir on the Clinch River. Melton Hill Reservoir is located within the Lower Clinch River Watershed. The lower Clinch's watershed is approximately 55 percent forested, 18 percent developed and residential, and 16 percent pasture/hay.

Raw water quality data was obtained and analyzed for Melton Hill Lake for a 2-year period from January 2014 to December 2015. A summary of selected raw water characteristics is presented in Table 3-1.

Table 3-1 - Water Quality at Melton Hill Intake

Parameters	Concentration (mg/L)*		
	Minimum	Maximum	Median
Turbidity (NTU)	0.9	31.2	4.5
pH (units)	7.4	8.3	7.7
Total Alkalinity (CaCO3)	90	138	116
Total Hardness	100	156	136
Nitrate as N			0.3

* mg/L unless otherwise stated

The reservoir is subject to some variability in key water quality parameters that include turbidity, pH, manganese, and algal content. Changes in turbidity largely occur in response to short term weather phenomena that result from runoff within the tributary watershed. Conversely, manganese, pH and algal content can be affected by internal reservoir cycles that can vary from year-to-year depending on annual conditions and reservoir outflow. The color/organic content is largely derived from natural decay processes within the watershed.

3.2 General Water Quality Features

3.2.1 Turbidity

Melton Hill Reservoir experiences little seasonal variation in raw water turbidity, with the higher levels related to storms and runoff in the tributary watershed. Turbidity is a surrogate measure of the solid particulate content (cloudiness) of water. In a statistical compilation of data from January 2014 through December 2015, median turbidity of the raw water was 4.5 nephelometric turbidity unit (NTU), with a maximum of 31.2 NTU. These data exhibit some general seasonal tendencies towards higher levels in the winter, but peaks also can occur at other times of the year in response to rainfall events.

3.2.2 pH and Alkalinity

A compilation of the raw water pH data from January 2014 through December 2015 yields a median value of 7.7 and a range of 7.4 to 8.3. Factors that can influence raw water pH include the consumption of carbon dioxide by algae, seasonal variations in the quality of water entering the reservoir, and mixing of lower pH bottom waters during the turnover of a reservoir in the late summer/early fall period. Therefore, raw water pH is often an indicator of other phenomena that can also affect treatment.

A compilation of the data for alkalinity from January 2014 through December 2015 yields a median of 116 mg/L as calcium carbonate CaCO3 and a maximum of 138 mg/l as CaCO3. These alkalinity levels represent moderate to high levels of alkalinity that are adequate to offset the acidity of the coagulant doses used at the Oak Ridge WTP. As a consequence, pH adjustment is not needed to offset the effects of the coagulant addition. In general, moderate to high alkalinity water, like Melton Hill Lake, is less likely than low alkalinity water to suffer from deteriorated performance (flocculation) in cold weather.

3.2.3 Hardness

Hardness can be a parameter of concern due to scaling and staining, if it occurs at excess levels in finished water. Hardness in the raw water at the treatment shows some variability over a range from 100 mg/L as CaCO3 up to 156 mg/L as CaCO3, with a median of 136 mg/L as CaCO3. These are moderate levels that do not require consideration for removal by treatment. The variations may, however, have some effect on the response to coagulants and are one of several possible seasonal factors in that regard.

4. Existing Water Treatment Plant Evaluation

The existing Oak Ridge WTP has a rated capacity of 28 MGD and utilizes conventional treatment techniques consisting of coagulation, flocculation, sedimentation, filtration and disinfection to treat water from the Clinch River/Melton Hill Lake. The facility was originally constructed in the 1940's to provide water to the Manhattan Project and the COR, and was subsequently expanded in the 1950's to a capacity of 28 MGD. The facility has also undergone a series of smaller improvement projects over the last 70 years. The facility was owned by DOE until 2000, when DOE transferred ownership and operation of the plant to COR. The water plant processes and structures are described and evaluated in the following sections.

4.1 Raw Water Pump Station

4.1.1 Process Mechanical

The original Raw Water Pump Station (RWPS), constructed in 1943, pumped water from the Clinch River directly to the WTP. The pump station consisted of four 2,750 gpm/370 hp pumps. All four pumps were together capable of pumping up to 8,800 gpm directly to the WTP through dual 24-inch cast-iron mains.

The current RWPS was constructed and put into service concurrent with the construction of Melton Hill Dam in 1963. The RWPS currently consists of 2 traveling screens and 6 vertical turbine pumps, each rated at 4,200 gpm at 325 feet of head. These pumps are equipped with constant speed 450 hp motors. These pumps draw water from the wetwell beneath the pump station and convey it via combination of 42-inch, 36-inch, and 24-inch diameter steel, cast-iron, ductile-iron, and concrete pipelines to the WTP.

The bottom of the wetwell is at 748 feet mean sea level (MSL) and the pump station operating floor elevation (EL) is 804. The 1961 pump station drawings list the low Melton Hill Lake EL at 756 and the max probable high water EL as 804. From TVA operating data, the water level of the reservoir typically fluctuates between 793 and 795 feet. TVA lists the full pool EL (top of dam gate) of Melton Hill Lake at 796.

The COR currently feeds hydrogen peroxide (50 percent solution) at the RWPS as a pre-oxidant to oxidize seasonal iron/manganese. The hydrogen peroxide dosage at the RWPS ranges from 0.4 to 2.0 mg/L and averages 1.2 mg/L.

The raw water magnetic flow meter at the RWPS is not functional.

4.1.2 Structural

The existing pump station structure was reviewed and the concrete is in good structural condition.

4.1.3 Electrical

1. Service:

The RWPS electrical system operates at 2,400V, which is difficult for COR to work on. Additionally, there are very few local electrical contractors with experience working with 2,400V systems. The substation located at the pump station consists of three transformers, two of which are 13.2kV-2,400V and one that is 13.2kV-480V. The two 2,400V secondary transformers serve the "east" and "west" side

of the station through a 2,400V switchgear lineup located in a dedicated electrical building. The power feed from the switchgear to the pump station is routed in a covered cable tray supported on a rack system. The 480V secondary transformer feeds various smaller pumps plus lighting and receptacle power by way of a 480V-120/208V transformer.

Converting the power system to 480V, new 13.2kV to 480V transformers will be required. Also, the 2,400V switchgear in the electrical building will need to be replaced with 480V switchgear. Since the current requirements for the 480V equipment will be greater than that of 2,400V new conductors will be required from the switchgear to the equipment. A new cable tray or conduit will be required as the existing cable tray will not hold the larger conductors.

2. Generator:

A 1,250kW diesel engine generator provides backup power for the RWPS. The generator is also 2,400V rated. The generator feeds a transfer switch that is connected only to the "east" side of the switchgear. The 2,400V transfer switch is also connected to a 2,400V-480V transformer which is connected to a 480V transfer switch to feed the 480V equipment.

Converting the generator to 480V would require a new 480V generator. This generator should be rated at least 1,500kW depending upon the number of pumps that would be required to run on emergency power. A new 480V transfer switch will be required but since everything will be at 480V, a second transfer switch will not be required.

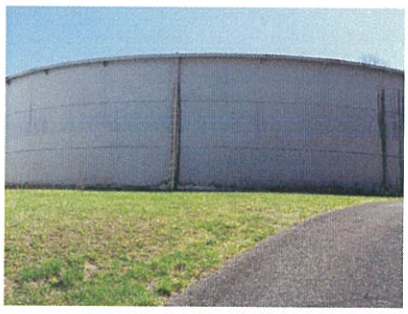
4.2 Raw Water Pipelines

The raw water pipe from the RWPS to the Raw Water Storage Tank is made up of approximately 2,900 feet of dual 42-inch and 36-inch pipelines installed along Pump House Road. The 42-inch main was constructed in 1963 and the 36-inch line was constructed in 1983. These two pipelines connect to the dual 24-inch cast iron raw water pipelines approximately 1,000 feet south of Bethel Church Road. The dual 24-inch lines then convey water approximately 5,800 feet to the Raw Water Storage Tank.

The 24-inch parallel pipelines are located on the west side of Scarboro Road and were constructed in 1943 and 1963. The pressure class of the 24-inch raw water pipeline varies from Class 250 near the RWPS to Class 200 and 150 near the Intermediate Pump Station. Several piping interconnection between the dual transmission mains allow diversions from sections of each main for maintenance and repairs. Over the last 16 years, COR has repaired 18 separate leaks or breaks on the 24-inch pipelines.

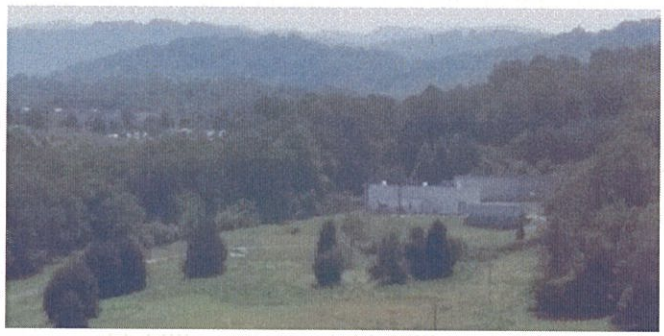
4.3 Raw Water Storage Tank

The Raw Water Storage Tank is a 1.5 MG steel open-topped tank at the Intermediate Pump Station site. The tank is approximately 115 feet in diameter and has bottom EL of 1,019 and a sidewall depth of 20 feet. The overflow EL of the Raw Water Storage Tank is 1,038 feet MSL. The tank provides storage of raw water for the Intermediate Pump Station and was constructed with the pump station in 1954. The tank has accumulated several feet of sediment over the years and is in need of cleaning and painting both internally and externally.



4.4 Intermediate Pump Station

4.4.1 Process Mechanical



The Intermediate Pump Station consists of 5 horizontal, split-case centrifugal pumps that transfer water from the Raw Water Storage Tank to the WTP. The pumps are 1,800 rpm, Allis-Chalmers pumps, rated for 5,000 gpm at 175 feet total dynamic head (TDH), and powered by 250hp motors. Four of the pumps are powered by constant speed 2,400V, 3-phase motors and one of the pumps is powered by a 480V, 3-phase motor equipped with a variable frequency drive (VFD). The variable speed pump is used in conjunction with the other constant speed pumps match the raw water flow to the plant demand. The existing pumps are at the end of their useful life, with limited spare parts available. One of the existing pumps is out of service, and its parts are being used to keep the other pumps operational. The operating floor EL of the pump station is approximately 1,010 feet MSL. The flowmeter at the Intermediate Pump Station is not functioning.

4.4.2 Structural

The existing pump station structure was reviewed and the concrete is in good structural condition.

4.4.3 Electrical

1. Service:

The Intermediate Pump Station also operates at 2,400V. There are two separate 13.2kV feeders serving the station. One feeder feeds the "east" side of the station through a 13.2kV-2400V transformer and the other feeder feeds the "west" side of the station through a second 13.2kV-480V transformer. Both "east" and "west" feeds continue to a 2,400V switchgear lineup in a switchgear building similar to the RWPS. As stated above, there are five 250hp pumps at the pump station, four of which are 2,400V rated and one that is 480V rated. It is fed through a 2,400V-480V transformer and is controlled with a VFD. This is the only one of the pumps to be connected to a VFD. Miscellaneous 480V smaller pumps, plus the lighting and receptacle power are fed by pole mounted transformers in the substation area through panel boards located inside the pump house.

For the same reasons as stated in Section 3.1.3, the station should be converted to 480V power. Converting the power system to 480V, new 13.2kV to 480V transformers will be required. Also, the 2,400V switchgear in the electrical building will need to be replaced with 480V switchgear. Since the current requirements for the 480V equipment will be greater than that of 2,400V new conductors will be required from the switchgear to the equipment. Since the feeds from the switchgear building to the pump house are underground and probably not large enough to carry the larger conductor, a new location must be found to locate the 480V switchgear with separate feeds to the motors. One possible location is at the site where the original switchgear was located inside the pump house.

2. Engine Generator:

There is no generator currently at the station. However, there have been times when both feeders were out, so a standby generator should be installed. This generator should be rated at least 1500kW depending upon the number of pumps that would be required to run on emergency power. A new 480V transfer switch will also be required.

4.5 Intermediate Water Pipelines

Dual 24-inch cast-iron pipelines convey water approximately 4,200 feet from the Intermediate Pump Station to the WTP. The 24-inch parallel pipelines are located on the west side of Scarboro Road and east side of the Intermediate Pump Station and were constructed in 1943 and 1963. The pressure class of the 24-inch raw water pipeline varies from Class 200 near the Intermediate Pump Station to Class 150 to the WTP. These two pipelines pass to the west of the Y-12 New Hope Center, cross Bear Creek Road, and go up the steep slope to the water plant. These two critical water lines cross through the area needing significant slope stabilization south of the existing WTP.

4.6 Water Treatment Plant

4.6.1 Process Evaluation

Evaluations of each treatment unit were performed to determine the limiting process and to identify any bottlenecks. Operational and electrical improvements have also been identified. Basic hydraulic data for the existing facilities are shown in Table 4-1.

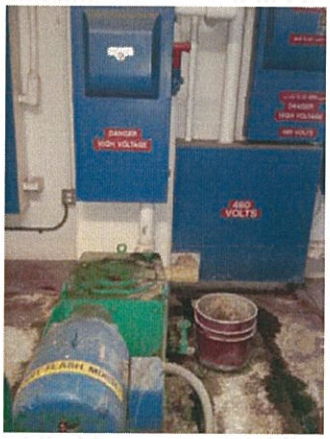
Table 4-1 - Hydraulic Data for the Oak Ridge WTP

Unit Processes	Flow = 28 MGD	Flow = 10 MGD	Current State Design Standards[1]
Surge Tanks			
Number	2		
West Tank Volume, gal	88,569		
East Tank Volume, gal	194,325		
Rapid Mix			
Number	1		
Volume, gal	3,800		
Detention Time, sec	11.7	32.7	(<30)
Flocculation Basins			
Trains	2		
Number	3 (in series)		
Dimensions (length x width) , ft	125.5 x 15.25		
Side Water Depth, ft	14		
Volume, gal, each train	172,500 (each train)		
Detention Time, min	20.8	58.3	>30 (>45 rec.)
Effluent Flume Velocity, ft/s	1.1	0.8	<0.5
Sedimentation Basin No. 1			
Trains	2 (parallel)		
Number	1		
Dimensions (length x width) , ft	125.5 x 50		
Side Water Depth, ft	16		
Volume, gal, each train	834,000		
Detention Time, hr	1.43	4.00	> 4.0[1]
Surface Overflow Rate, gpm/sf	1.01	0.36	0.25-0.38

Effluent Weir Length Effluent Weir Rate, gpm/ft Sludge Removal	740 13.1 bi-annual	4.7	< 8-10 Continuous
Solids Contact (Upflow) Clarifiers Trains Number Rating, MGD, ea	2 1 6.0 Currently Not Utilized		
Sedimentation Basin No. 2 Trains Number Dimensions (length x width) , ft Side Water Depth, ft Volume, gal, each train	2 1 65.75 X 50 16 386,000 Currently Not Utilized		
Filters Number Length, ft Width, ft Filtration Rate, gpm/sf	14 29 14 3.42	1.22	2.0 (4.0 high rate)
Clearwells Number Total Volume, gallons Side Water Depth, ft Total Detention Time, hr	2 125,000 5 0.26	0.75	
Finished Water Storage Number Total Volume, MG Side Water Depth, ft Total Detention Time, hr	2 7.0 24.5 6	16.8	15.3[2]

[1] TDEC Public Water System Design Criteria
[2] Volume of Distribution System Elevated Storage = 1 Day Average System Demand

1. Surge Tanks:



Water from the twin raw water pipelines flows from the Intermediate Pump Station to the WTP and into two surge tanks, located east and west of the WTP. The west surge tank has a volume of 75,000 gallons and an overflow EL of 1,164.9 and the east tank has a volume of 150,000 gallons and an overflow EL of 1,166.9. Flow from the two tanks is controlled via actuated valves to the rapid mix basin.

2. Rapid Mix:

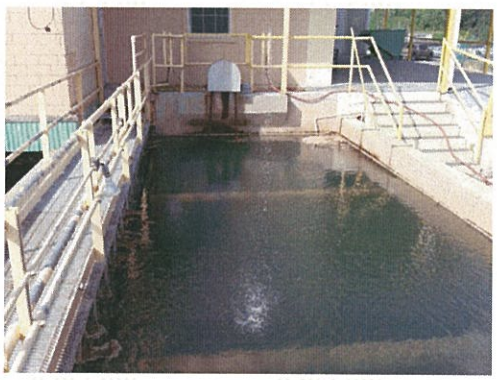
The existing rapid (flash) mix basin is located at the north end in the center of the main treatment plant building. The basin has a theoretical hydraulic detention time of 11.7 seconds at 28 MGD. Theoretical hydraulic detention time assumes that no short circuiting is occurring in the basin. Typical design standards dictate a detention time of less than 30 seconds to provide sufficient mixing while preventing the settling of floc in the rapid mix basin. Mixing in the basin is provided by a

single 25hp, brand vertical mixer. Flow is split between the two flocculation-sedimentation trains after the rapid mix by dual weirs.

The primary coagulant (Delta Floc 812 - polyaluminum hydroxychlorosulfate) is added in a rapid mix basin at an average dosage of 23 milligrams per liter (mg/L). Chlorine is added for pre-oxidation and disinfection at an average dosage of 1.6 mg/L at the rapid mix basin immediately after the coagulant is added.

3. Flocculation Basins:

In each train, coagulation and flocculation are provided by three horizontal paddle wheel flocculators arranged in series. The flocculation chambers are 15 feet and 3 inches wide by 125 feet and 6 inches long and divided into three cells. The flocculation basins provide a detention time of 20.8 minutes at 28 MGD plant flow and 58.3 minutes at 10 MGD. During cold water conditions, it is desirable to have a detention time between 30 and 45 minutes. The three flocculators were originally designed to operate at sequentially decreasing speeds to allow for the growth of the floc as the water passes through the flocculators and to prevent turbulence from destroying the larger floc in the most downstream flocculator chamber.



The flocculation equipment is over 70 years old and routine maintenance on the units is very difficult, due to the lack of available spare parts and technical support.

4. Settling Basins:

Each of the two trains at the WTP has a single sedimentation basin equipped with influent and effluent flumes. Flow is distributed into the first settling basin through a 3 feet wide trough from the flocculators. The water level in the settling basins is controlled at the downstream of the basins by v-notch effluent launders in the last section of the sedimentation basin.

The most significant deficiency of the existing sedimentation basins is their size. Their small size results in higher than desirable surface overflow rates. The sedimentation basins appear to be significantly undersized for the WTP design capacity. The sedimentation basins have a surface loading rate greater than 1,460 gallons per day per square foot (gpd/sf) of surface area at the design flow of 28 MGD. Current design of sedimentation basins utilizes a surface overflow rate of 500 to 700 gpd/sf. The basins also have a detention time of 1.4 hours at 28 MGD. Current Tennessee Department of Environment and Conservation (TDEC) Public Water Supply Design Criteria require water treatment plants to provide 4 hours of detention time in the sedimentation basin.

Several items have been identified that will enhance the performance of the sedimentation basins. Possible improvements include modifications to the influent and effluent flumes, installation of plate or tube settlers and effluent launders, and the use of alternative coagulants. Because the size of the basins cannot be increased easily, plate or tube settlers can be installed in the existing basins to increase the effective surface area available for settling.

The lack of a mechanized solids removal process in the sedimentation basins is also a significant deficiency. Current solids removal practices in the sedimentation basin are labor intensive. Typically, the basins are drained every 6 months and hosed clean to washout solids. Not only is this very labor intensive, it also limits the potable water production of the WTP during basin cleaning.

Solids removal at the WTP can be improved by leveling the floor of the basins with concrete, replacing the existing mud valves at the new floor level, and installing a continuous sludge removal system in the basin. Vacuum, chain-and-flight, or other sludge removal system can be installed to provide continuous and uniform sludge removal to prevent excessive sludge build-up from the bottom of the basins. Excessive sludge build-up on the basin bottom can impair settling efficiency and impact water quality. If anaerobic conditions develop in the sludge layer at the bottom of the basins, iron and manganese can be re-solubilized and carried through the filters, causing water quality problems in the distribution system. Automatic sludge removal equipment will prevent operators from periodically having to shut the plant down to clean out the existing basins.

5. Upflow Clarifiers and 2nd Sedimentation Basin:

Each treatment train at the WTP is also equipped with a 6 MGD solids-contact upflow clarifier, also known by the brand name of Superpulsator. The upflow clarifiers were originally installed in 1955 and connected to the 2nd sedimentation basin to boost the ability of the plant to treat higher flows and solids loadings. Prior to the Melton Hill Reservoir construction in 1963, the raw water for the plant came directly from the Clinch River and was likely subject to large turbidity variations during and after rainfall events. This fluctuation would have been somewhat alleviated once the Reservoir was constructed.

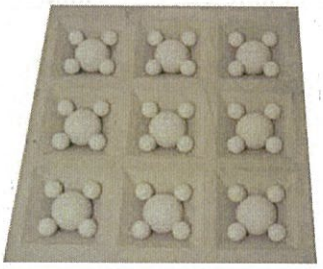
Up to 12 MGD of the plant raw water flow was routed directly from the Surge Tanks into these two trains, one each on the east and west end of the plant. The upflow clarifiers and the 2nd sedimentation basin operated in parallel to the main treatment train of rapid mix, flocculation, and sedimentation basins and discharged their settled water into the filter influent trough. When COR took over the plant, these basins had fallen into disrepair, were sending high sediment loads to the filters, and were subsequently removed from service. Due to the lower water demands over the last 10 years, these basins haven't been needed.

6. Filters:

The plant has a total of 14 dual-media gravity filters, each with a surface area of 406 square feet and a design hydraulic loading of 3.42 gpm/sf at a total plant flow of 28 MGD. Hydraulic calculations indicate that a maximum of 12 feet of head loss is available across each filter.

The hydraulic loading of 3.42 gpm/sf on the filters is reasonable and operation at higher loading rates could be considered under some circumstances. However, with the high loadings on the upstream flocculation and sedimentation basins, additional loading on the filters is not recommended.

The media configuration used within the plant is as follows:



Anthracite
Effective Size: 0.9-0.99 mm
Depth: 24 inches
Sand
Effective Size: 0.45-0.55 mm
Depth: 18 inches
Gravel
Depth: 12 inches

The filter media is supported by layers of gravel on an underdrain that consists of ceramic balls set in 7–inch deep conical depressions in the concrete base, commonly known as a Wheeler Bottom. The conical depressions are located approximately 12 inches on center across the filter bottom. The ceramic balls prevent the migration of filter support gravel into the filter support channel and clearwell below. Water is collected beneath the underdrain in a chamber below the filter floor. Flow is conveyed through piping to the clearwell beneath the filters. Each filter is equipped with an effluent rate of flow controller that regulates the filtration rate.

Current backwash practice is for operators to connect a laptop computer to the filter console. Plant operators report that the backwashing sequence for each filter typically requires about an hour to complete. Treated water from the clearwell is used to clean the media. Water plant filters are typically backwashed based on a rise in headloss, a rise in turbidity, or time-in-service. Due to the low loading rate on the filters, the Oak Ridge Water Plant operators backwash a filter based on its time in service or turbidity (typically every 6 to 7 days). With 14 filters in service, the Oak Ridge Water Plant backwashes 2 to 3 filters per day.

Each filter console provides automated open-close control of the influent valve, backwash water supply valve, surface wash valve, drain valve, and filter-to-waste valve. In addition, each filter console provides automatic control of the filter rate of flow controller to maintain filter flow rate during normal filter operations. The filter effluent valves are controlled by local level controllers located in the filter control panels.

The flow from the backwash pump can only be regulated by an actuated 24-inch butterfly valve on the pump discharge pipe. Control of the backwash water rate during the backwash cycle is important to prevent washout of the filter media during backwash and to insure that the backwash rate is sufficient to thoroughly expand and wash the media.

A filter-to-waste system is provided to allow for curing of the media as a filter run is initiated following backwash. The existing filter-to-waste valves at the plant are aging cone valves.

The plant uses a surface wash system that places the sweep arms at the top of the media when in normal operation. This type of arrangement is capable of obtaining good cleaning of the media during backwash, but is susceptible to plugging as the sweep nozzles age.

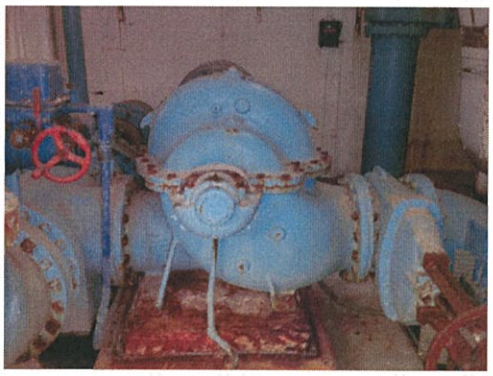
Potential improvements to the filters that could be implemented include installation of new underdrains, an air wash/air scour system, modulating filter-to-waste valves, and new drain valves. These improvements should help to improve filter run times, shorten backwash run times, and ultimately decrease filtered water turbidities.

Several underdrain alternatives are available with physical configurations that would allow the replacement of the existing underdrain with minimum modifications to the filter box. The new underdrains could allow for the elimination or minimization of the gravel layer, thus allowing a greater depth of filter media or more headspace for media expansion during backwash. This would provide greater flexibility for future installation of alternative media configurations.

Installation of an air wash system would provide an opportunity for improvement of the backwash cycle and would also allow some flexibility for utilizing deeper media alternatives in the future. An air wash system will help to improve cleaning of the media during backwash and shorten backwash run times, both of which will improve the plant ability to produce potable water. Several types of air scour systems are available to retrofit these filters and can be used with the existing underdrain or potential new underdrain.

Most of the filter piping valve actuators have been recently replaced, but the filter drain valves are cone valves connected to the filters with a rectangular flanged section of pipe. Replacement of the cone valve will require replacement of this section of pipe. The pipe will need to be specially fabricated for this installation.

7. Backwash Pumps:



The water plant is equipped with two 8,000 gpm at 40 feet TDH, horizontal split-case centrifugal pumps. The pumps are located in the basement of the main operations building, draw water from the plant clearwell, and are controlled by the filter backwash consoles. A third backwash pump is located on the balcony above the main backwash pumps as a backup unit. This pump requires priming prior to use due to its elevation above the clearwell.

The filter backwash pumps are over 70 years old and the pump bases are showing signs of severe corrosion. It is recommended that these pumps be replaced with new VFD operated pumps that will improve reliability and efficiency, and allow for more precise automation of the backwash flow rate to the filters. A variable

frequency drives and flowmeter will help properly regulate and modulate the amount of water used during backwash to prevent the washout of media during the backwash sequence.

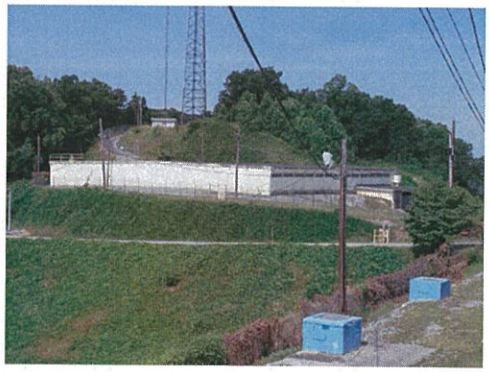
8. Clearwell:

Two 125,000 gallon clearwells beneath the east and west filters collect water from the filters and serves as the location for post-filtration chemical feed. The west clearwell is beneath Filter Nos. 3-7 and the east clearwell is beneath Filter Nos. 8-12. The bottom of the clearwell is at EL 1,129.0 and ceiling is at EL 1,135.67. The clearwell water level floats on the elevation of the finished water storage tanks. Water is conveyed from the clearwell to the two finished water storage tanks via dual 24-inch cast-iron water lines. The 24-inch outlets leave the clearwell at EL 1,121.0.

Post-treatment chemical addition occurs in a mixing chamber between Filter Nos. 7 and 8 and includes the addition of corrosion control chemical at an average dosage of 0.7 mg/L, fluoride at an average dosage of 0.8 mg/L and chlorine for disinfection at 3.6 mg/L.

The clearwell was inspected with a robotic camera in April 2016, as there is no way for the clearwell to be removed from service for inspection or repairs without removing the water plant from service and draining the finished water storage tanks. The inspection revealed several leaking cracks that require epoxy grout crack injection repairs, but no major structural problems were found.

9. Finished Water Storage Tanks:



The plant has two in-ground concrete finished water storage tanks. The western tank has a capacity of 3 MG. The eastern tank has a capacity of 4 MG. Both tanks have concrete roofs. The eastern tank roof also has a membrane liner over the concrete to prevent rainwater from leaking into the tank. These tanks, combined with 8.3 MG of elevated storage in the Oak Ridge Water Distribution System, provide the TDEC mandated amount of water storage.

The overflow elevation of the finished water tanks is 1,140 feet MSL. The floor EL of the 4 MG tank is 1,115.50 and the floor EL of the 3 MG tank is 1,118.00. Water level indication for the tanks is provided in the plant control room. An interior overflow standpipe provides primary protection against overflow. Secondary protection is provided by screened built-in openings at the junction between the wall and the roof.

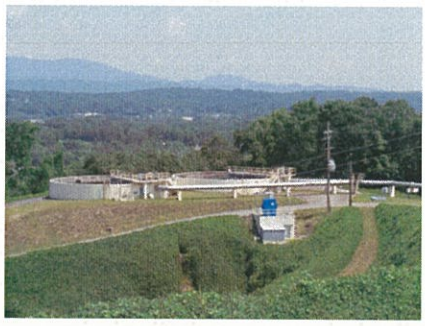
The finished water storage tanks were inspected with a robotic camera in April 2016. The inspection revealed no major structural concerns and only minor concrete stress cracking.

10. Post-Filtration Chemical Feed Systems:

The plant currently utilizes chlorine gas for disinfection, fluoride for cavity protection and zinc phosphate for corrosion control. Plans are currently in the works for chemical feed improvements which will convert the plant from chlorine gas to sodium hypochlorite. The project will construct a new chemical storage

building behind the plant maintenance building to provide bulk storage of sodium hypochlorite and fluoride.

11. Residuals Management:



Residual solids captured in the sedimentation basins and the filters are washed into two circular clarifier tanks located on the north side of the WTP. These concrete tanks provide hydraulic storage for waste filter backwash water, which is clarified and the supernatant is recycled back to the surge tanks. Sedimentation basin drainage is drained to one of three sediment ponds carved into the north slope of the ridge for settling.

Automated sludge removal in the sedimentation basins will eliminate the need to frequently drain and wash down the basins, but the tanks will still need to be able to accommodate this volume of water and sludge. Connecting these tanks to COR's sewer system will allow for more operational flexibility.

4.6.2 Structural Evaluation

A preliminary evaluation of the structure was conducted in order to provide preliminary findings and estimated costs related to any recommended repairs and/or modifications.

Typical Exterior Wall Crack

1. Structure Description:

As noted previously within this report, the original WTP structure was constructed circa late 1940's with additional east and west filter bays added to each end of the original structure in the 1950's era. The main WTP structure consists of an elongated rectangular structure running east to west, and is designed as a symmetrical structure about a north/south centerline. Refer to Figures 4-1 and 4-2. The clearwell portion of the structure, pipe galleries, and flumes provide for plant water service and serve as the building's overall foundation. This portion of the structure (i.e. below EL 1140 +/-) consists of reinforced cast-in-place concrete walls and slabs and bears on and is embedded within a zone of rock (refer to the Geotechnical Discussion). Note that the extent of the clearwell foundation is limited to the area beneath Filter Nos. 3-12, and does not extend into rock below Filter Nos. 1, 2, 13, or 14 (i.e., filter bays that were added during the 1950's era construction).

Typical Surface Deterioration

Filter bay, pump, and piping gallery construction (below EL 1147) consist of reinforced cast-in-place concrete walls and slabs. Building construction above EL 1147 consists of reinforced concrete frames (column and beam system) with infilled concrete roof panels and masonry walls.

2. Site Inspection Findings:

During the initial site visit, the east and west ends of the structure were noted to have some areas of concern, with other areas where cracking and/or surface deterioration is the result of settlement or age. In addition to the noted surficial wall cracks, a few areas associated with interior foundation or support walls revealed water leakage coming from the clearwell. Most of the observed wall cracking could be repaired; however, some notable cracking at the most eastern and western ends to the structure revealed settlement issues associated with the sloughing of the steep embankment slope.

As noted previously, the end filter bays (Filter Nos. 1, 2, 13, and 14) do not rest on rock, but rather bear on earthen material. Because of the very close proximity to the steep southern slope at the corners of these east and west areas and loss of support from the bearing stratum due to either soil particle movement and/or settlement, the end bays show signs of cracking (tensile stresses within the concrete walls) and undermining of their foundation slabs. Within the existing structure, only a few areas of concern were noted related to masonry infill wall cracking and minor deterioration of some of the gallery pedestal columns, slabs, and walls.It was noted that some building modifications had been implemented within the filter level, and are described in detail later.

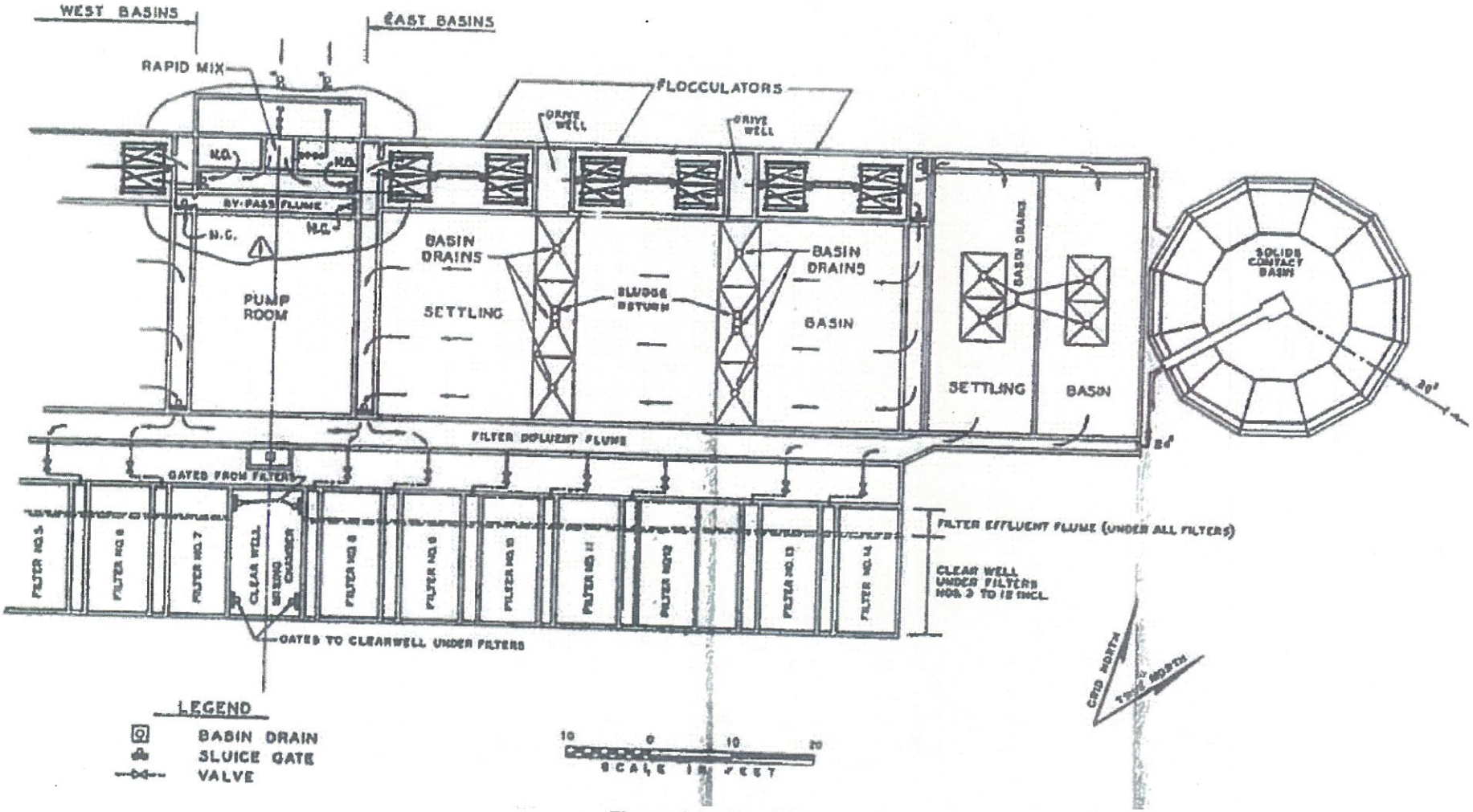


Figure 4-1 – Partial Plan

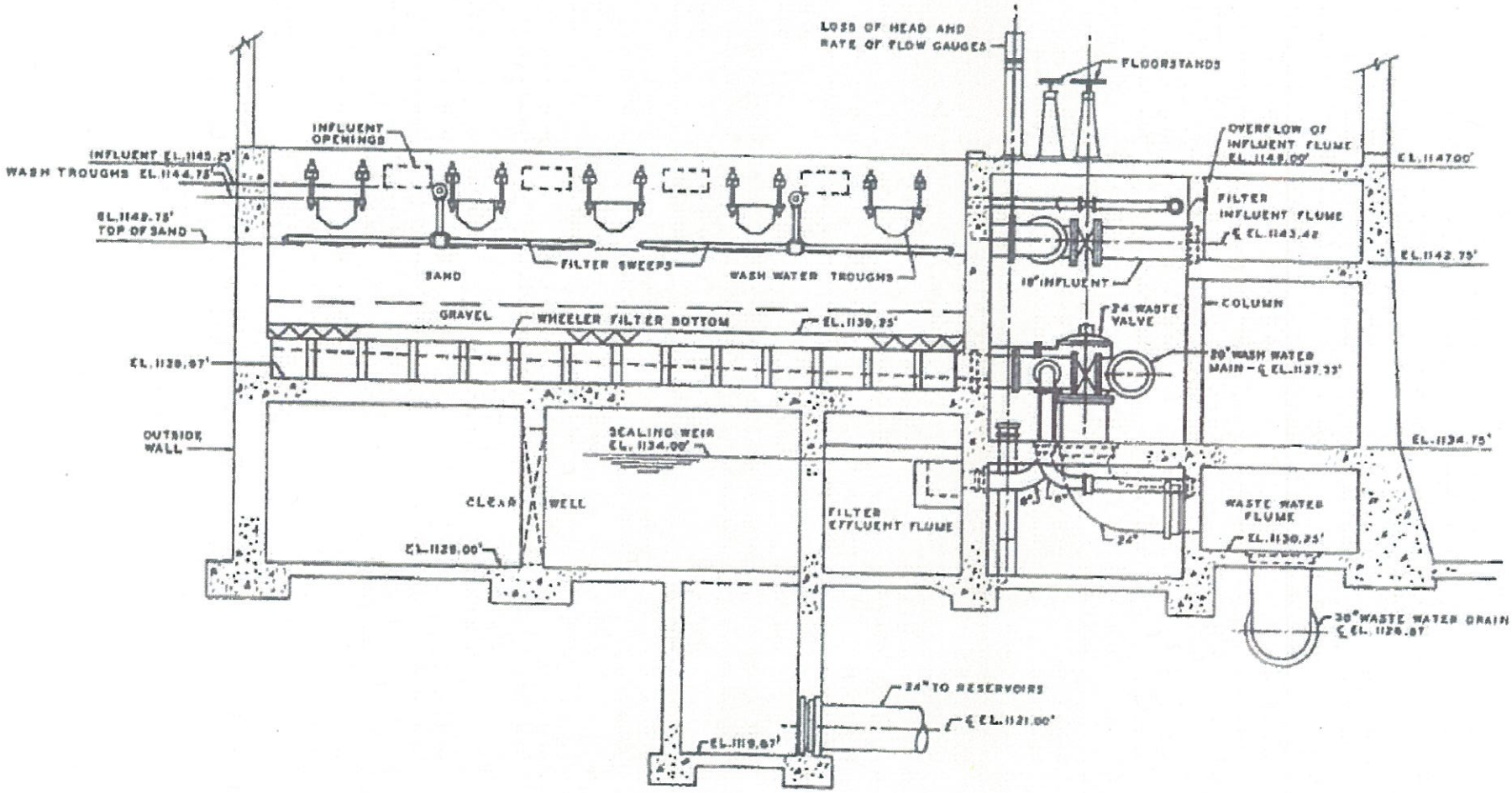


Figure 4-2 – Cross Section

3. Structure Design Evaluation:

Except for the cracking, settlement concerns of the end filter bays, and general surface deterioration, the current structure does not present any immediate safety concerns related to the overall structural integrity. However, an existing structure evaluation related to the potential affects that may result due to natural phenomena needs to be assessed in accordance with the adopted City of Oak Ridge Codes. In particular, concern of how the structure would be impacted if a seismic event was to occur was preliminarily investigated. It is understood that current Codes for new buildings would contain requirements that govern building configuration, strength, stiffness, detailing, and special inspection and testing. While the strength and stiffness Code requirements may be transferred to existing buildings; the other provisions are not. Older buildings typically do not contain seismic-force-resisting elements having details of construction to satisfy current ductility practices.

Using International Building Code 2012 (IBC), as adopted by the City of Oak Ridge, and noting that IBC, Chapter 34 (which addresses the alteration, repair, addition, and change of occupancy of existing buildings and structures), Section 3404.5, Voluntary Seismic Improvements, may be implemented if the following can be demonstrated:

a. The altered structure and the altered nonstructural elements are no less conforming with the provisions of this code with respect to earthquake design than they were prior to the alteration.
b. New structural elements are detailed as required for new construction.
c. New or relocated nonstructural elements are detailed and connected to existing or new structural elements as required for new construction.
d. The alterations do not create a structural irregularity as defined in American Society of Civil Engineers (ASCE) 7 or make an existing structural irregularity more severe.

Also, IBC Chapter 34 references the International Existing Building Code (IEBC) which provides procedures for evaluation and design of seismic-force-resisting systems of existing buildings where consideration of seismic forces is required. IEBC, Section 301.1.4 discusses evaluation and design procedures per ASCE 41.

Using ASCE 41-13 (which is basically a compilation of previous versions of ASCE 31 and 41 prior to the 2013 edition), the following evaluation has been preliminarily investigated in order to determine the magnitude of recommended seismic improvements that may be necessary if the structure is to remain in service for an extended period of time.

4. ASCE 41-13 Approach:

Potential seismic deficiencies in existing buildings may be identified using ASCE 41. If the evaluation is voluntary, the owner may choose to accept the risk of damage from future earthquakes rather than upgrade, or demolish the building. Seismic evaluation conducted in accordance with ASCE 41-13 is outlined in Sections 1.4.1 to 1.4.5. ASCE41-13 describes the evaluation process consisting of three tiers (also shown in Figure 3): Tier 1 screening procedure, Tier 2 deficiency-based evaluation procedure, and Tier 3 systematic evaluation procedure. This report implements the Tier 1 process in order to identify other deficiency-based alternatives for retrofitting the building.

Figure 4-3 provides the steps that may be involved in assessing various existing buildings. The following parameters were selected for the existing WTP building.

Building Performance Levels

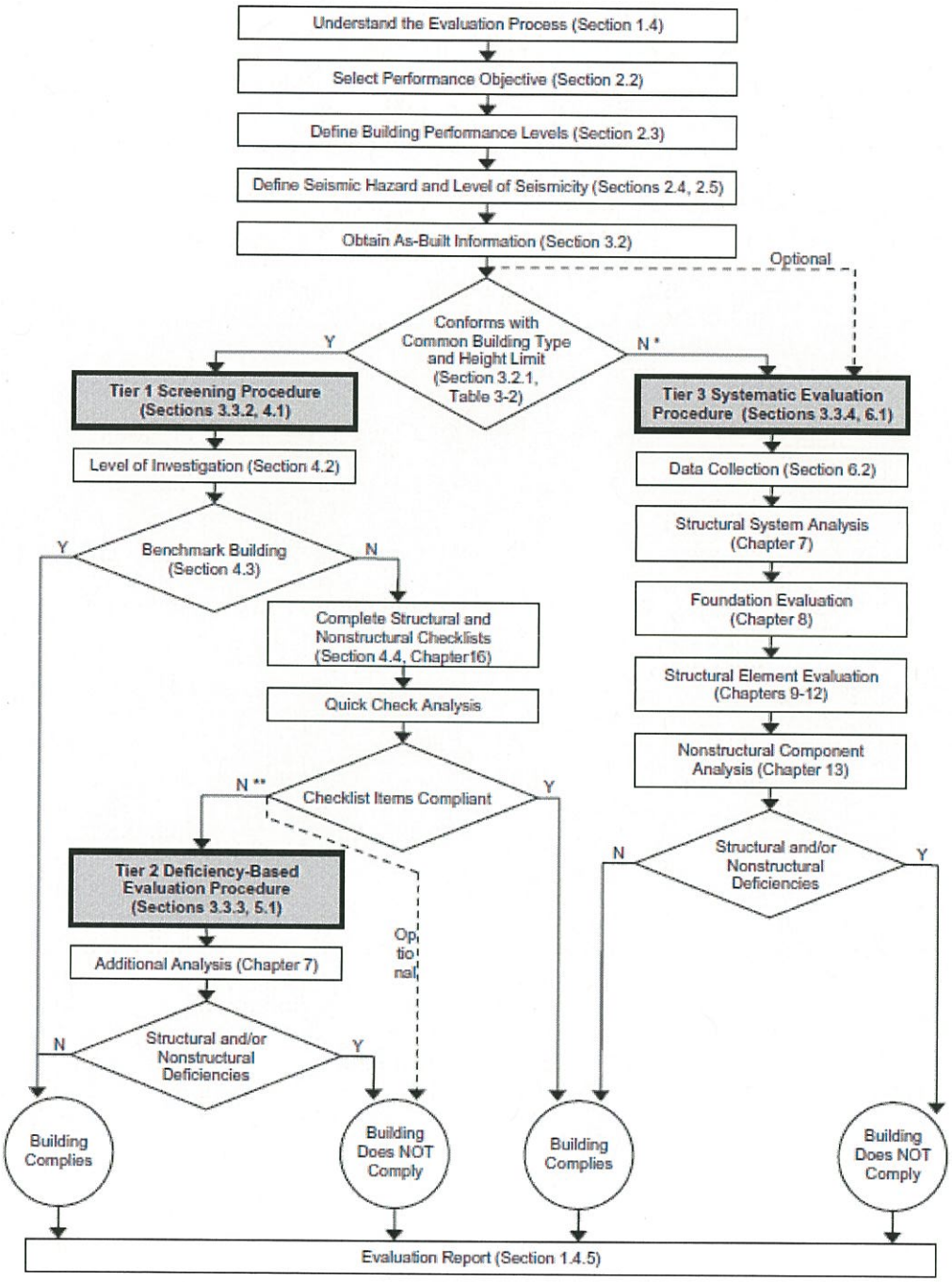
Structural Performance Level, Immediate Occupancy, (S-1) per Section 2.3.1. This indicates that the building would remain safe to occupy and essentially retains its pre-earthquake strength and stiffness.

Nonstructural Performance Level, Position Retention, (N-B) per Section 2.3.2. This indicates that the occupants of a building performing work are able to occupy the building safely, though normal use might be impaired, some cleanup might be needed, and some inspections might be warranted. However, building equipment is secured in place and might be able to function.

Basic Performance Objective for Existing Buildings – BSE-1E per Table 2-1.

Seismic Hazard Level – Probability of Exceedance 20 percent/50 years, i.e. mean return period of 225 years. Per 2.4.1.4, from USGS web site, Sxs = 0.082 and Sx1 = 0.031 for Site Class B (rock).

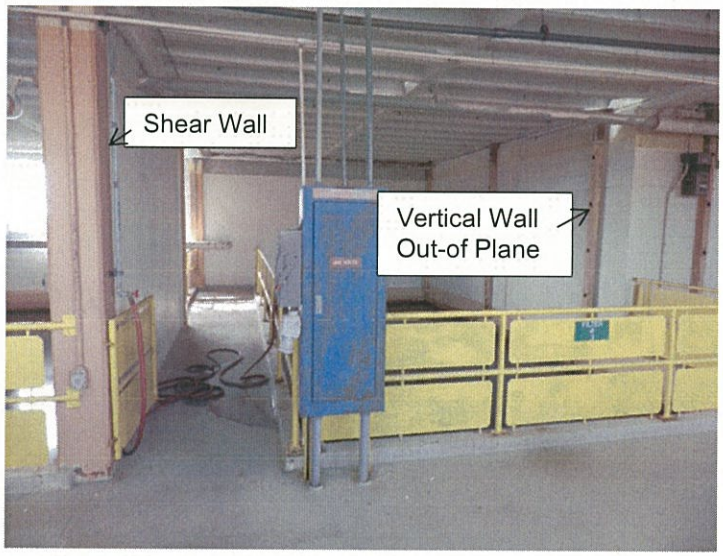
Level of Seismicity – Moderate, per Section 2.5.



* It may be beneficial for the engineer to perform a Tier 1 Screening Evaluation prior to a Tier 3 Systematic Evaluation even though it is not required.
** The evaluation process may proceed directly to the Tier 3 Systematic Evaluation as an option.

Figure 4-3 – Evaluation Process

As-Built Information – Per Section 3.2, obtain sufficient general information about the building to determine the permitted evaluation procedure, i.e. building type classification in accordance with Table 3-1. The building type for this structure is controlled by the upper story consisting of concrete moment frames (C1). Existing building design drawings were investigated, original design drawings were found, but no as-built drawings were discovered. In addition, design drawings showing various seismic alterations made in 1994 were reviewed and the drawings compared with those improvements that could be visually verified. In addition, calculations for the seismic alterations were attempted to be found as similar calculations were found to be conducted in August 1994 for the Intake Building. But, no structural calculations were found specifically for the WTP building and its proposed modifications. The photo below depicts some of the types of seismic improvements that were made to the structure.



Seismic Improvements

Per Figure 4-3, the Tier 1 and 2 evaluation procedures are applicable to this particular structure and are not restricted and meet the restricted number of stories noted within Table 3-2, i.e. Building Type = C1 and Moderate/S-1 Level of Seismicity restricts number of stories to eight stories. Therefore, Tier 1 procedures will be used to provide for a preliminary evaluation of the existing building.

5. Tier 1 Screening Procedures:

Chapter 4 provides procedures to be used for Tier 1 evaluations, which include several sets of checklists. The purpose of the screening phase is to be able to quickly identify buildings that may comply with the provisions of ASCE 41. As part of this procedure, if a building can be Benchmarked, it would not require any additional structural evaluations. Since drawing documentation of previously designed seismic retrofits and the visual evidence that the building was indeed upgraded to include these designed retrofits, the most recent Code for the design would be allowed to be used for Benchmarking purposes.

The seismic retrofits previously noted were designed using the 1991 Uniform Building Code. Section 4.3 provides guidance for those buildings that may be able to be noted as a Benchmarked Building (i.e. a building that would not need to be structurally evaluated per Tier 1 procedures). Using Table 4-6, it is noted that for structures with a building type designation as reinforced concrete moment-resisting frames (C1), a Uniform Building Code of 1994 or later would be allowed for those structures designated as Life Safety only.

Thus, the seismically retrofitted WTP building does not meet the quick evaluation technique for determining if the building could be Benchmarked. As such, additional evaluations will be required in accordance with the remaining Tier 1 or Tier 2 procedures.

The other adjoining structures (3 MG and 4.5 MG drinking water tanks and the Sludge Tank) were visually inspected for structural deficiencies and no observations were noted. However, similar to the evaluation for the WTP building, these structures would also need to be further examined for seismic loads.

6. Summary:

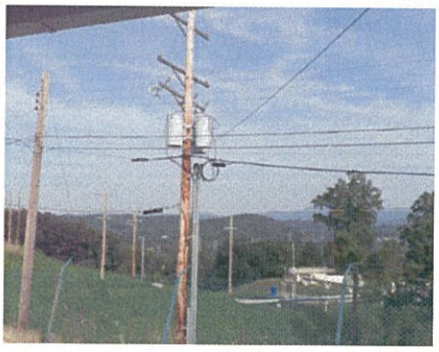
Since the building does not meet the requirements for a Benchmarked building, and since no as-built drawings and/or calculations can be reviewed it is recommended that additional investigations would need to be performed to ensure that the building could provide the assurance that the structural and non-structural elements could safely resist a designed seismic event in order to allow for the WTP to essentially remain or at least be placed-back into immediate service after a seismic event.

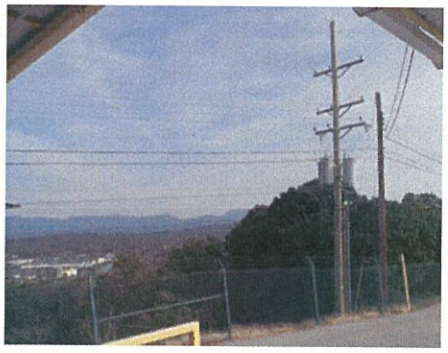
The additional design evaluation may require some core sampling, additional field investigations, analyses, design analyses, and recommendations for any retrofitting (if required).

4.6.3 Electrical

1. Incoming Service:

The water plant has two incoming 13.2 kV overhead power lines from the COR Electric Department. Each feed has a 300 kVA pole-mounted, 13.2kV-480V transformer bank which in turn feed the east and west ends of the plant, through an underground service into an east and west load center cabinet. Both of these load centers feed an east and west disconnect inside the main building located in the "Flash Mixer Room". From there circuit extend to the rest of the main building.

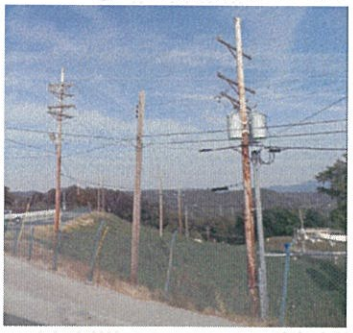




2. Engine Generator:

An alternate source of power, to the dual feeders, is a newly installed 400 kW generator located near the maintenance building. This generator replaces an older 300 kW Waukesha Diesel engine that was originally installed in the 1940's. The 300kW unit did not provide sufficient power to operate the plant and power the filter backwash pump simultaneously. This unit was disconnected from the plant in late May 2016.

3. The existing electrical system appears to be adequate to handle the existing loads, but there are a number of deficiencies in the current system arrangement:

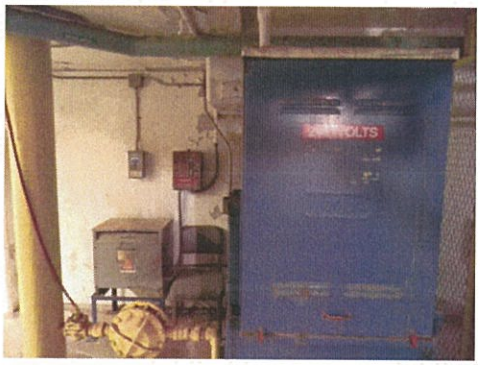


a. The two incoming 13.2 kV feeds are mounted on the same pole line. This satisfies the code requirement of having two electrical feeds but if a pole were to fall or be knocked over, both feeds would be lost.

b. Both of the electrical feeds appear to be routed into the "Flash Mixer Room". There are many electrical panels and disconnects located in this room, some of which do not have adequate "working space" due to the installation of the Flash Mixer and associated motor. The National Electric Code (NEC) requires a 3 foot working space in front of electrical panels rated up to 240V and 4 foot working space for a 480V panel. As shown by the picture, this working space does not exist.

c. Due to the age of the panels and disconnects in the Flash Mixer Room, and in other locations in the plant, the Arc Flash rating for the panels may be at a dangerous level since many of these may be original equipment.

d. Some of the electrical equipment, due to exposure to moisture and chemicals, have become rusty or corroded, which may become difficult to access.



4. If the decision is made to refurbish the existing building, a second pole line should be constructed to supply the second feeder and a dedicated area should be constructed to house a motor control center that does not have any obstructions.

4.6.4 Building Mechanical and Architectural

The WTP building mechanical systems (HVAC and plumbing) and architectural features were reviewed for code compliance and to identify any specific improvements. The site and building accessibility were reviewed to determine their compliance with the Americans With Disabilities Act (ADA) and the Tennessee Building Code.

1. Accessibility:

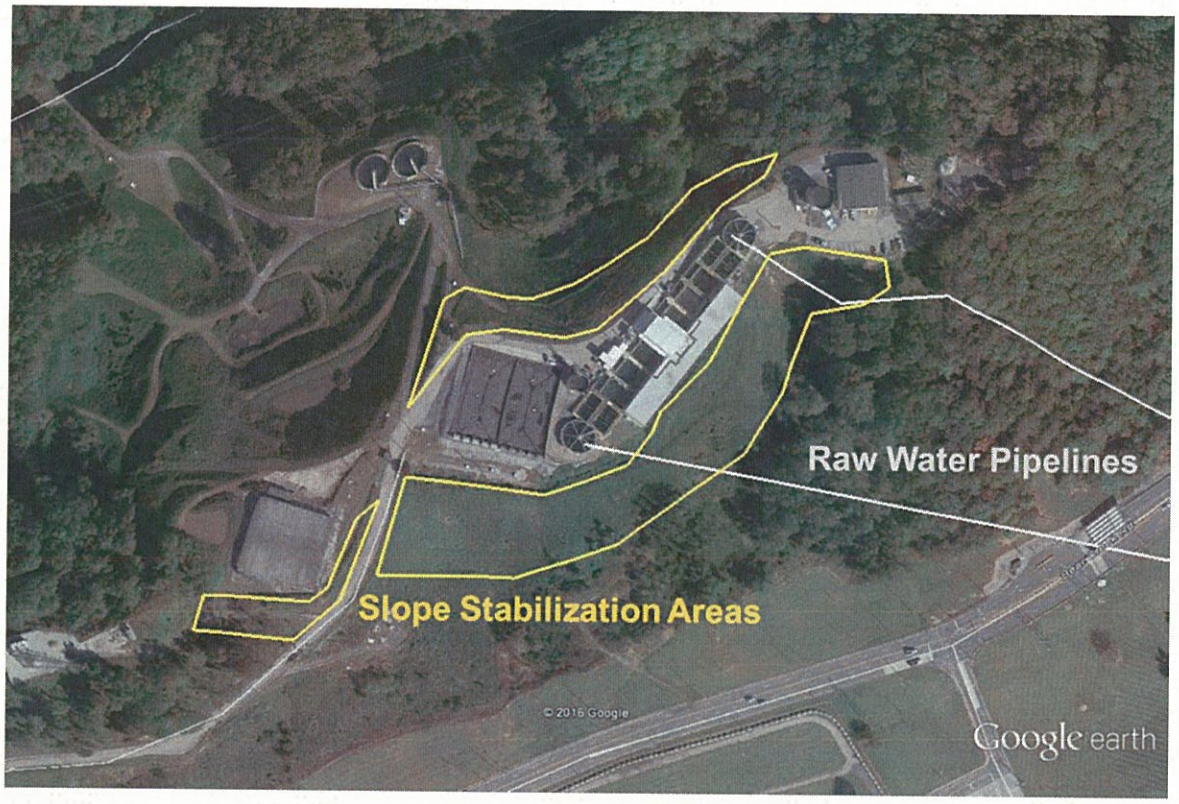
   The bathroom facilities for the water plant are located a floor below the laboratory and control room and the filter gallery is located 1/2 floor below the laboratory and control room. The plant is equipped with a freight elevator that reaches the basement level, lower level (bathroom/pipe gallery floor), control room/laboratory floor, and upper floor. The plant also has a ramp on the north side of the main water plant building from the parking lot to the loading dock, which then provides access into the plant office/lab/control room.

2. Building Mechanical:

   The filter building windows, roof, and HVAC system have been recently replaced and were all in good condition.

4.6.5 Geotechnical

A geotechnical evaluation was made of the site surrounding the WTP to evaluate the slopes that are showing signs of distress (movement). The evaluation revealed that significant work will be needed to stabilize the north and south facing slopes adjacent to the WTP and the two finished water storage reservoirs shown below. The slope stabilization would consist of remediation and stabilization of the existing slopes and would include the construction of either a large concrete/soil/rip-rap buttress or a slope anchor system or a combination of both systems. Due to the large areas of unstable slopes on both the north and south sides of the plant site and south of both finished water reservoirs, the work to correct this issue will be significant. The complete report detailing the geotechnical exploration is provided in Appendix A.



4.6.6 SCADA

The plant's control system (PLC's, HMI/operator work stations, and cabinets) is working well and is in good condition. Some necessary plant software is being run on Windows XP operating systems due to the lack of compatible software capable of running on current operating systems. This will need to be addressed as legacy hardware becomes more difficult to procure. The plant's filter control elements (instrumentation and valving) are also in good shape with replacements having been made when necessary.

1. Monitoring:

   Opportunities exist for further integration/consolidation of the plant's control systems and for continued build out of centralized monitoring of pump stations.

2. Record Keeping:

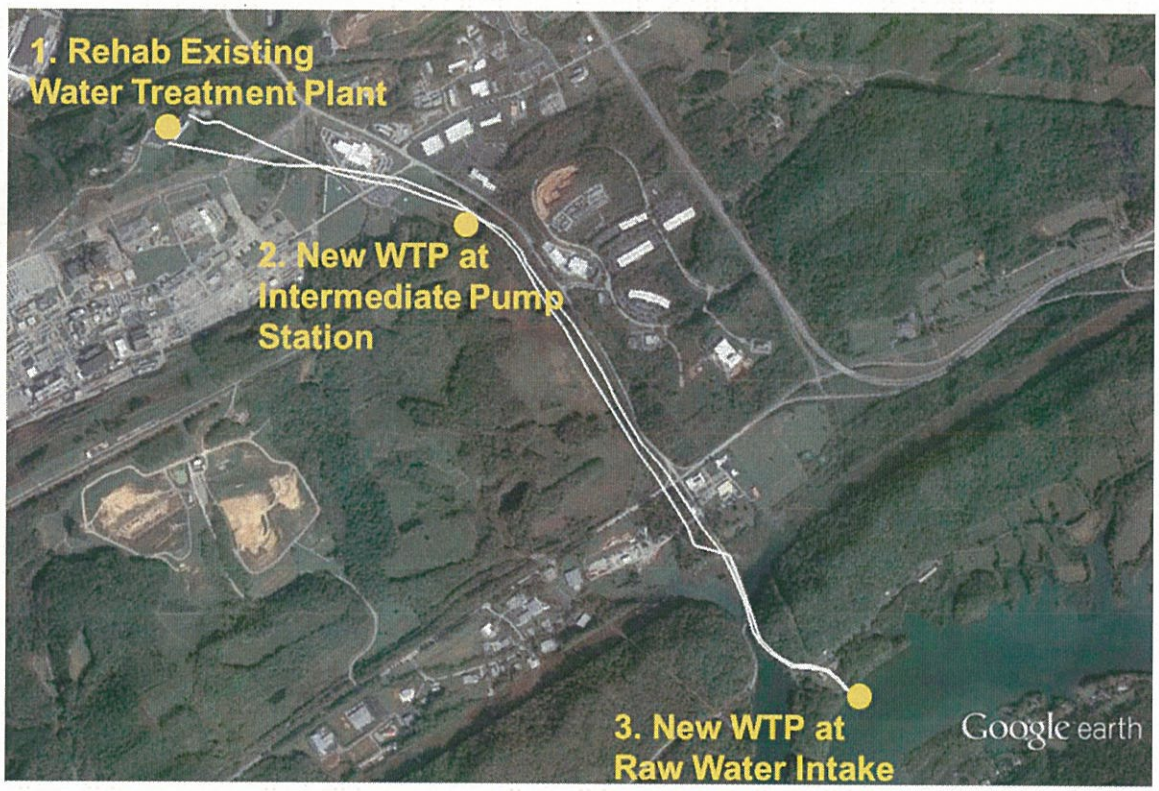
   Filter Chlorine Residual Data is stored on an old (10+ years) desktop computer that is also connected to the Filter Particle Counters. No backup or redundancy exists for these records.

4.6.7 Applicable Codes and Guidelines

- International Building Code, 2015 Edition
- National Standard Plumbing Code, 2015 Edition
- National Electric Code, 2014 Edition
- International Mechanical Code, 2015 Edition
- National Fire Protection Association (NFPA), 2012 Edition
- 10 States Recommended Standards for Water Works
- TDEC Division of Water Resources, Chapter 0400-45-01 Public Water Systems
- TDEC Division of Water Resources, Community Public Water Systems Design Criteria, 2008

5. Water Treatment Plant Alternatives

Three alternatives were considered to provide COR and its primary bulk customers (Y-12 and ORNL) an effective, reliable water treatment facility. These alternatives include rehabilitation and upgrade of the existing WTP and two new WTP options, one located at the existing Intermediate Pump Station and the other located at the existing Raw Water Intake.



The new WTP alternatives both would have an initial rated peak capacity of 16 MGD, with provisions for expansion to a capacity of 20 MGD. Space is reserved on each new plant site plan for additional structures to allow ultimate expansion to 28 MGD. The design criteria for buried piping, flowmeters, chemical storage and feed equipment, is based on a maximum WTP filtered water flow of 20 MGD. The existing raw water intake and pump station and proposed high service pumps stations would be sized for a peak flow of 16 MGD with space allocated for future expansion to a minimum of 20 MGD. The major difference between the two new plant alternatives is the site location and the utilization of the existing finished water reservoirs. Detailed conceptual cost estimates are provided in Appendix B.

Discussions were also held with Anderson County Water Authority and West Knox Utility District about supplying water to the COR and DOE. Neither system had excess treatment plant capacity and would have to construct the required capacity. In addition, to supply the water to COR and DOE several miles of large transmission pipeline would need to be constructed to connect to the large pipe distribution systems.

The cost to obtain water from either of these alternate sources is estimated to be significantly more expensive than the alternatives discussed in Section 5.

5.1 Alternative No. 1 - Upgrade Existing Water Treatment Plant

5.1.1 Description

Alternative No. 1 considers the work necessary to rehabilitate and upgrade the existing WTP. The existing plant is capable, with equipment improvements, of treating a maximum capacity of 16 MGD. The scope of work is based on the plant evaluation in Section 3. This alternative includes the following items:

Raw Water Intake and Pump Station

Replace Existing Traveling Screens
Replace Existing Vertical Turbine Pumps
New Variable Frequency Drives
Replace Pump Station Valves and Piping
New Engine Generator
New Transformer and 460V Motor Control Center
New Instrumentation, Flowmeter, and Control System

Raw Water Pipeline

New 24-inch Water Line between the Raw Water and Intermediate Pump Stations
Maintain one of the two existing 24-inch Water Lines for Redundancy

Intermediate Pump Station

Replace Existing Centrifugal Pumps
New Variable Frequency Drives
Replace Pump Station Valves and Piping
New Engine Generator
New Transformer and 460V Motor Control Center
New Instrumentation, Flowmeter, and Control System

Intermediate Water Pipeline

New 24-inch Water Line between the Intermediate Pump Station and the WTP
Maintain one of the two existing 24-inch Water Lines for Redundancy

Water Treatment Plant

Replace Existing Process Equipment
- Rapid Mixer
- Flocculators
- Filter Media
- Filter to Waste Valves
- Backwash Pumps
- Chemical Feed and Storage – Coagulant/Corrosion Inhibitor

New Process Equipment
- Sedimentation Basin Tube Settlers
- Sedimentation Basin Sludge Collectors
- Filter Air Scour System

Structural
- Concrete Surface Repairs

- Concrete Crack Repair
- Demolition of Obsolete Structures
- Geotechnical
  - Underpinning Existing Filters
  - Slope Stabilization
    - North Slope
    - South Slope
    - 4 MG Finished Water Reservoir
    - 3 MG Finished Water Reservoir
- Electrical, Instrumentation, and Controls
  - Replace Building Power Distribution System
  - New Engine Generator
  - New Transformer and 460V Motor Control Center
  - New Instrumentation and Control System
- Building Mechanical Improvements
- Building Improvements
  - Office Renovations
  - Ceiling Repairs
  - Door Replacement
  - Painting

5.1.2 Capital Cost

A conceptual cost estimate is presented in Table 5-1 for the improvements listed in Section 5.1.1. The conceptual cost estimate includes the design, bidding, permitting, and construction costs and also includes a 20 percent contingency for unknown factors at this stage of project planning.

Table 5-1 - Conceptual Cost Estimate
Alternative No. 1 - WTP Rehabilitation and Upgrade

Item	Cost
Raw Water Pump Station	$ 5,929,000
24-inch Raw Water Pipeline	$ 3,494,000
Intermediate Pump Station	$ 3,726,000
24-inch Intermediate Water Pipeline	$ 3,055,000
Existing Water Treatment Plant	$ 30,295,000
WTP Project Cost	**$ 46,499,000**

5.2 Alternative No. 2 - New Water Treatment Plant at Intermediate Pump Station

5.2.1 Description

Alternative No. 2 proposes to construct a new WTP along the existing raw water transmission pipeline at the existing Intermediate Pump Station. The new WTP will be constructed on undeveloped property to the south of the existing Intermediate Pump Station and storage tank and have access from Scarboro Road. A preliminary site plan for the new WTP at the Intermediate Pump Station site is presented in Figure 5-1.

Water from the existing intake and RWPS would be pumped to the new WTP using an existing and a new raw water pipeline. The new WTP would pump drinking water into a new finished water storage tank near the existing Intermediate Pump Station. Once the new plant is operational, the existing open top 1.5 MG raw water storage tank would either be demolished and replaced or retrofitted with a roof to provide additional storage and redundancy at the Intermediate Pump Station. In this alternative, the existing Intermediate Pump Station would be converted to a high service pump station and would pump water into the existing 4 MG and 3 MG finished water tanks at the existing WTP site and COR's water distribution system using the existing and a new intermediate water lines. The new WTP will also include a backup power generation system or dual service feeds. The newly installed 400KW generator will be utilized at this site, if it can meet the demands.

Alternative No. 2 utilizes the existing finished water storage tanks at the existing WTP site. Geotechnical work, discussed in Section 4, to stabilize the slopes on the south side of these tanks will be necessary for the long-term utilization of these tanks. The existing WTP will be physically disconnected from the system and left in place in accordance with TDEC requirements.

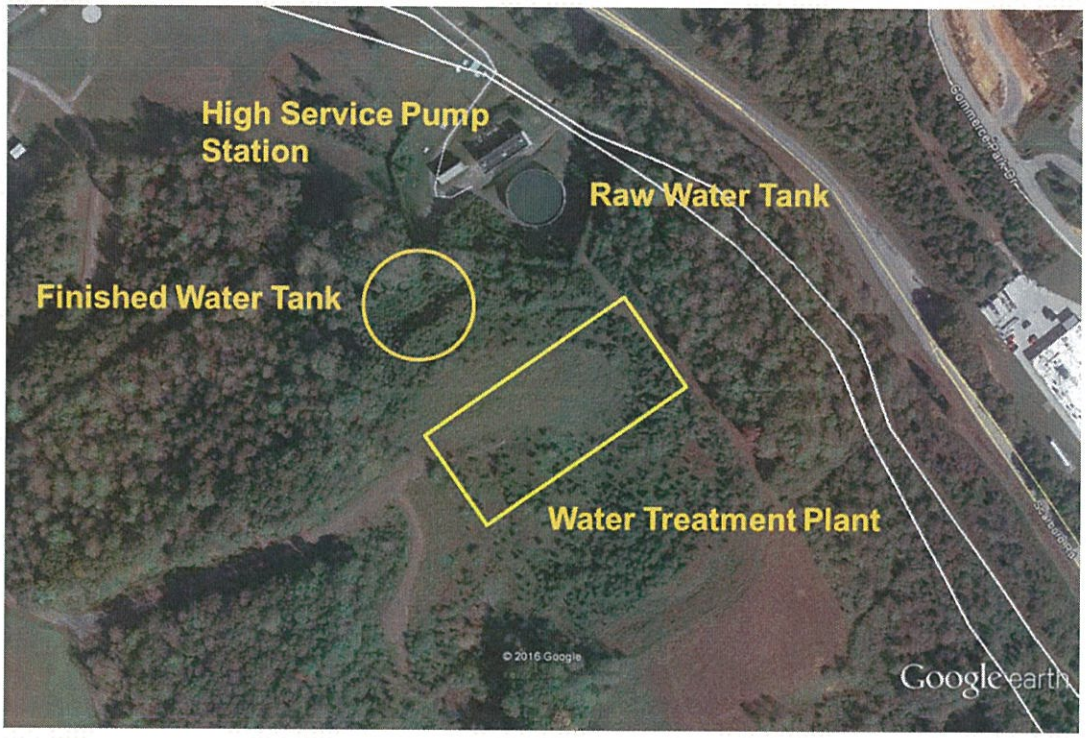


Figure 5-1 – New WTP at the Intermediate Pump Station site

To accommodate future expansion and changing conditions, space will be allocated on the site and in the membrane building for future structures, hydraulic capacities will be large enough to accommodate ultimate planned flows, and pipe stub-outs will be provided where appropriate for diverting future flows to new process units. A typical membrane filtration plant configuration is shown below in Figure 5-2.

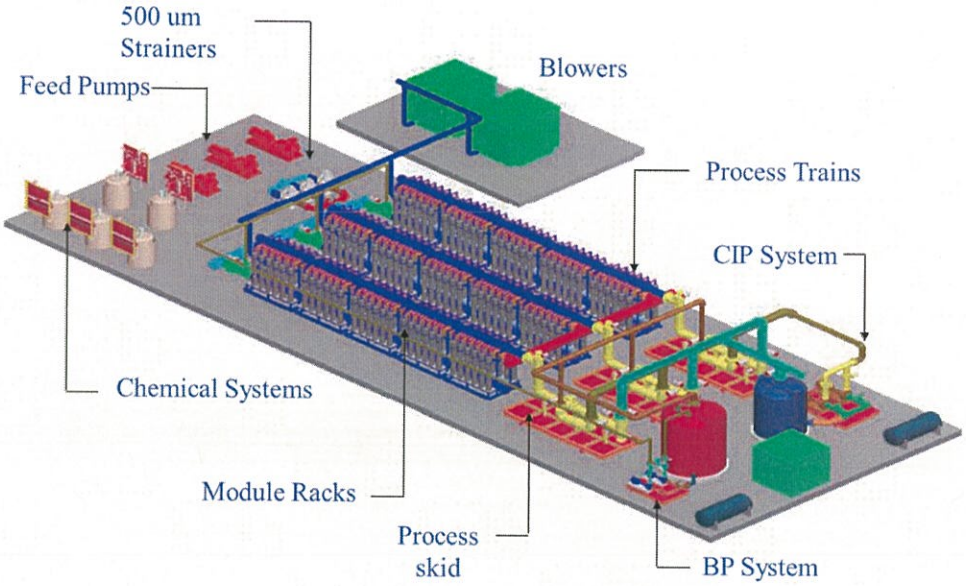


Figure 5-2 – Typical Membrane Filtration Plant

This alternative includes the following items:

Raw Water Intake and Pump Station

Replace Existing Traveling Screens
Replace Existing Vertical Turbine Pumps
New Variable Frequency Drives
Replace Pump Station Valves and Piping

Raw Water Pipeline

New 24-inch Water Line between the Raw Water and Intermediate Pump Stations
Maintain one of the two existing 24-inch Water Lines for Redundancy

Membrane Filtration Plant

Coagulant Addition and Mixing
Single-stage Flocculation
Ultrafiltration Membrane Filtration
Chemical Storage and Feeds System (disinfection, fluoridation, and corrosion control)
Clearwell Storage Tank
Membrane Backwash Handling, Dewatering, Disposal, Discharge
Engine Generator
Transformer and 460V Motor Control Center
Instrumentation and Control System
Laboratory and Control Rooms
Operator and Superintendent Offices

Finished Water Pump Station (Existing Intermediate Pump Station)

Replace Existing Centrifugal Pumps
New Variable Frequency Drives
Replace Pump Station Valves and Piping

Finished Water Pipeline

New 24-inch Water Line between the proposed WTP and the existing WTP
Maintain one of the two existing 24-inch Water Lines for Redundancy

Finished Water Storage Reservoirs

Geotechnical
Slope Stabilization
4 MG Finished Water Reservoir
3 MG Finished Water Reservoir

The proposed site is inside the Y-12 secured perimeter and is owned by DOE. At this time there are no known environmental issues with the proposed site, but given the long history of work at Y-12 an environmental study to confirm the suitability of the proposed site should be completed as soon as practical during the preliminary engineering phase of design should Alternative No. 2 be selected. This site was proposed to be the location of ground storage raw water lagoons for a 1980 project that was not constructed. Geotechnical investigations performed for that project did not note any environmental issues with the site.

5.2.2 Capital Cost

A conceptual cost estimate is presented in Table 5-2 for the improvements listed in Section 5.2.1. The conceptual cost estimate includes the design, bidding, permitting, and construction costs and also includes a 20 percent contingency for unknown factors at this stage of project planning. The construction cost includes the infrastructure (pipe, concrete, building, and site work) for up to 20 MGD of treatment capacity, and the process equipment (membrane cartridges and pumps) for 16 MGD of capacity.

Table 5-2 - Conceptual Cost Estimate
Alternative No. 2 - New WTP at Intermediate Pump Station

Item	Cost	
Raw Water Pump Station	$	5,929,000
24-inch Raw Water Pipeline	$	3,494,000
16 MGD Membrane Filtration Plant	$	30,674,000
High Service Pump Station	$	3,726,000
24-inch Finished Water Pipeline	$	3,055,000
WTP Project Cost	**$**	**46,878,000**

5.3 Alternative No. 3 - New Water Treatment Plant at Raw Water Intake

5.3.1 Description

Alternative No. 3 proposes to construct a new WTP at the existing RWPS site; a preliminary site plan is presented in Figure 5-3 below. A new WTP constructed adjacent to the existing raw water intake would put all of COR's water treatment infrastructure in the same location, offering increased operational flexibility and security. Co-locating treatment processes and pumping also allows for potential savings through the sharing of electrical services and backup power systems. The newly installed 400KW generator would be utilized at this location, if it can meet the requirements. The existing plant will be physically disconnected from the water system as per TDEC requirements.

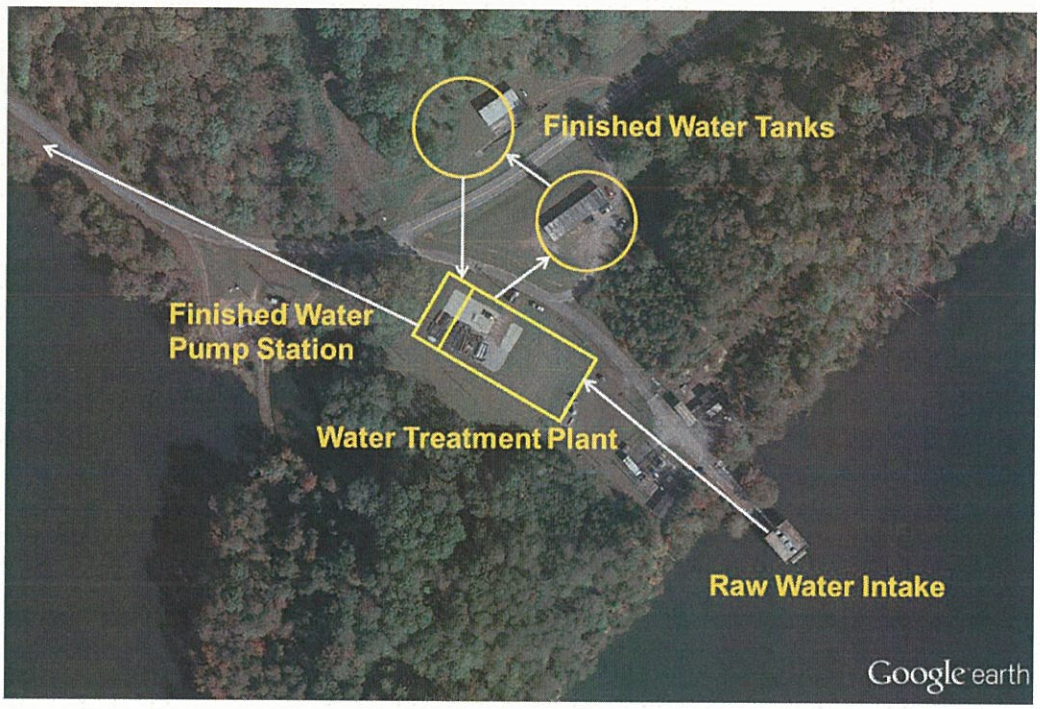


Figure 5-3 – New WTP at existing RWPS site

Water from the existing intake and RWPS would be pumped directly to the new WTP on the same site. The new facility is proposed to utilize a membrane ultrafiltration system. Membrane filtration systems offer high levels of treatment in a small footprint and are cost effective compared to new conventional treatment plants.

The new WTP would pump drinking water into two new 3.5 MG finished water storage tanks adjacent to the WTP. A new high service pump station would pump water into COR's (and Y-12/ORNL) distribution systems. The new WTP will also include a backup power generation system or dual service feeds. To accommodate future expansion and changing conditions, space will be allocated on the site and in the membrane building for future structures, hydraulic capacities will be large enough to accommodate ultimate

planned flows, and pipe stub-outs will be provided where appropriate for diverting future flows to new process units.

Alternative No. 3 does not utilize the existing finished water storage tanks at the existing WTP site. Finished water storage capacity is instead provided at the RWPS site due to the high cost of the slope stabilization needed to protect the existing finished water storage tanks. This alternative includes evaluation of the Oak Ridge Water System to ensure that gravity service from the City's elevated storage tanks can supply the required water to the Y-12 storage tanks. The operating conditions for the Y-12 water storage tanks will not be changed by this alternative.

This alternative includes the following items:

Raw Water Intake and Pump Station

Replace Existing Traveling Screens
Replace Existing Vertical Turbine Pumps
New Variable Frequency Drives
Replace Pump Station Valves and Piping

Membrane Filtration Plant

Coagulant Addition and Mixing
Single-stage Flocculation
Ultrafiltration Membrane Filtration
Chemical Storage and Feeds System (disinfection, fluoridation, and corrosion control)
Membrane Backwash Handling, Dewatering, Disposal, Discharge
Engine Generator
Transformer and 460V Motor Control Center
Instrumentation and Control System
Laboratory and Control Rooms
Operator and Superintendent Offices

Finished Water Storage Reservoirs

2 – 3.5 MG Concrete Ground Storage Tanks

Finished Water Pump Station

Centrifugal Pumps with Variable Frequency Drives
Pump Station Valves and Piping
Flowmeter, Instrumentation, and Controls

Finished Water Pipeline

New 24-inch Water Line to Scarboro Road and S. Illinois Avenue
New 24-inch Water Line along Bear Creek Road to connect to existing Y-12 Water Tanks
Maintain one of the two existing 24-inch Water Lines for Redundancy

The proposed site has been owned by COR, since DOE transferred ownership to the City in 2000. At this time there are no known environmental issues with the proposed site, but an environmental/geotechnical study to confirm the suitability of the proposed site should be completed as soon as practical during the preliminary engineering phase of design should Alternative No. 3 be selected.

5.3.2 Capital Cost

A conceptual cost estimate is presented in Table 5-3 for the improvements listed in Section 5.3.1. The conceptual cost estimate includes the design, bidding, permitting, and construction costs and also includes a 20 percent contingency for unknown factors at this stage of project planning. The construction cost includes the infrastructure (pipe, concrete, building, and site work) for up to 20 MGD of treatment capacity, and the process equipment (membrane cartridges and pumps) for 16 MGD of capacity.

Table 5-3 - Conceptual Cost Estimate
Alternative No. 3 - New WTP at Raw Water Intake

Item	Cost
Raw Water Pump Station	$ 2,637,000
16 MGD Membrane Filtration Plant	$ 32,253,000
High Service Pump Station	$ 2,032,000
24-inch Finished Water Pipeline	$ 6,229,000
WTP Project Cost	**$ 43,151,000**

5.4 Operational and Maintenance Costs

Although at this stage of project development it is not practical to determine the proposed plant operation and maintenance costs precisely, general industry trends provide some insight into the projected operational and maintenance costs for the three proposed treatment plant alternatives. The proposed improvements to the existing WTP in Alternative No. 1 will not significantly change the existing plant operational costs. While some of the new process equipment will add to the plant power costs, replacing existing equipment and lighting with higher efficiency motors, VFDs, and fixtures are expected to largely offset the higher operating cost of the new equipment.

The chemical feed costs for pre-oxidation, disinfection, fluoride, and corrosion prevention chemicals and the plant operational and maintenance personnel costs were assumed to be functionally equivalent for all three alternatives. The cost for coagulation chemicals is expected to be lower for the two new membrane filtration plants, Alternative Nos. 2 and 3. Electrical costs for the two membrane filtration treatment plant alternatives will be the same, but their electrical costs are expected to be higher than the existing conventional treatment plant. Total pumping costs for all three alternatives are projected to be same as each other, but will likely be lower than the existing plant through the addition of higher efficiency pumps, motors, and VFDs.

5.5 Non-Cost Factors

Just as important as cost, there are other factors that should be considered in the selection of a water plant alternative. Several of the key non-cost factors include: accessibility, security, operation, and reliability of the treatment plant. Table 5-4 presents an example of the non-cost factors considered in the water plant evaluation.

Table 5-4 - Example Non-cost Evaluation Criteria

Criteria Category	Criteria
Safety	Overall Safety
	Storage and Handling Hazards
	Liability
	Transportation Risk
Public Relations	Community Perception
	Customer Support
Operability and Maintainability	Ease of Maintenance
	Ease of Operation
	Frequency of Maintenance
	Operational Attention
	Frequency of Parts Replacement
Reliability	System Reliability
	Reliability of Technology
	Raw Material Delivery Reliability
	Potential Degradation of Product
	Manufacturer Experience
Impact on Site Space	Additional Footprint

6. Recommendations

6.1 Proposed Water Treatment Improvements

Alternative No. 3, constructing a new WTP located at the RWPS is the preferred alternative, based on the lowest capital cost and the operational flexibility and security offered by having all of COR's treatment infrastructure at the same location. The existing plant will require some basic maintenance work to remain in service while the new plant is being constructed, but no major improvements are necessary.

6.2 Schedule

A proposed timeline for the preliminary engineering, design, permitting, bidding, award, and construction of the new WTP is as follows:

Preliminary Engineering	6 months
Detailed Design and Permitting	12 months
Bidding and Award	4 months
Construction	24 months
Commissioning/Start-up	2 months

Portions of the work, such as the 24-inch finished water line, can be phased or constructed in separate contracts from the proposed WTP. The work on the RWPS improvements will have to be planned and phased to not interrupt service to the existing WTP.

Appendix A. Geotechnical Evaluation

GEOS

GEOServices, LLC-Geotechnical and Materials Engineers

August 16, 2016

City of Oak Ridge
100 Woodbury Lane
Oak Ridge, Tennessee 37830

ATTENTION: Ms. Susan Fallon – *Administrative Manager*
sfallon@oakridgetn.gov

Subject: **REPORT OF LIMITED GEOTECHNICAL EXPLORATION**
Oak Ridge Water Treatment Plant Geotechnical Evaluation
Oak Ridge, Tennessee
GEOServices Project No. 21-16310

Dear Ms. Fallon:

GEOServices, LLC has completed the report of limited geotechnical exploration performed for the subject project. Our services were performed, as authorized by you, in accordance with our Proposal No. 11-16136, dated May 3, 2016. The purpose of this exploration was to observe the subsurface conditions in the vicinity of the existing slope failure(s) and to provide recommendations regarding the nature of the failure(s) as well as potential remediation options.

PROJECT INFORMATION

The project site is the existing Oak Ridge Water Treatment Plant (WTP) located in the northern borderer of the existing Y-12 National Security Complex located at 301 Bear Creek Road in Oak Ridge, Tennessee. Based on our site visit and discussion with JACOBS, a geotechnical evaluation was requested to evaluate several slopes that are showing distress. In addition to slope distress, the corners of the filter building foundations have undermined as a result of the slope distress. It appears the slope distress has been present for a period of time.

The existing WTP was constructed in the 1940s-1950s and is situated on Pine Ridge. From a review of historical topographic maps and aerial imagery, it appears that the WTP was constructed in the 1940s-

1950s and straddles Pine Ridge, with the center of the WTP likely bearing on natural material and the extents bearing on fill material. It also appears that multiple "draws" (i.e. terrain feature formed by two parallel ridges with low ground in between them and with the low ground perpendicular to Pine Ridge) located on both the north and south side of Pine Ridge were filled in the facilitate construction of the WTP.

Multiple attempts to remediate the slope movement appeared to have been undertaken in the past (with no known historical documentation). These apparent remediation attempts appear to consist of either driven concrete piles and/or soldier pile walls and berm construction located along the existing slopes. The condition, stability, and effectiveness of the existing slope remediation structures could not be verified due to the heavily overgrown nature of the slope.

FIELD EXPLORATION

The site subsurface conditions were explored with three (3) soil test borings performed in the immediate vicinity of the slope failures and adjacent to the undermined portions of the WTP. It should be noted that fourth boring, planned to be located near an undermined portion of the existing WTP access road (located adjacent and north of the WTP), was not conducted due to conflict with existing utilities. The boring locations were selected by GEOServices. All depths in this report reference the ground surface that existed at the time of this exploration; however, ground surface elevations were not provided. The approximate locations of the test borings performed on site and detailed logs for soil test borings are referenced in Appendix A of this report.

Drilling was performed on May 24 to 26, 2016. The borings were advanced using a 3.25-inch inside diameter hollow stem augers (HSA) and a CME-55 truck-mounted drill rig. The drill crew worked in general accordance with ASTM D 6151 (HSA Drilling). Rock coring to explore auger refusal material was performed in accordance with ASTM D 2113. Sampling of overburden soils was accomplished using the standard penetration test procedure (ASTM D 1606).

After completion of the field drilling and sampling phase of this project, the soil samples were returned to our laboratory where they were visually classified in general accordance with the

Unified Soil Classification System (USCS – ASTM D 2487) by a GEOServices geotechnical professional. Select samples were then tested for moisture content (ASTM D 2216) and atterberg limits. Testing of the relatively undisturbed soil sample obtained consisted of a consolidated undrained triaxial shear test (ASTM D 4767). The laboratory test results are further discussed in the following sections of this report and a summary is provided as an attachment to this report.

GEOLOGIC CONDITIONS

The project site, as most of east Tennessee, lies in the Appalachian Valley and Ridge Physiographic Province. The Province is characterized by elongated, northeasterly-trending ridges formed on highly resistant sandstones and shales. Between ridges, broad valleys and rolling hills are formed primarily on less resistant limestones, dolomites and shales. Published geologic information indicates that the project site is underlain by bedrock of both the Rome Formation and the Nolichucky Shale formation of the Conasauga Group.

The Rome Formation generally consists of variegated (red, green, and yellow) shale and siltstone with beds of fine-grained sandstone and minor beds of limestone and dolomite. The sandstone and siltstone portions of the Rome typically weather to produce a shallow, rocky residuum while the carbonate members weather to produce a thicker reddish brown and yellow silty clay residuum. The Nolichucky Shale formation is primarily composed of thin-bedded shale and calcareous siltstone with minor amounts of limestone. The Nolichucky Shale formation typically weathers to produce a reddish-brown or faintly green shaly soil containing red clay from limestone units.

FINDINGS

The conclusions and recommendations presented in this report are based on our site reconnaissance and the results of this exploration. Actual subsurface conditions may vary between or away from the boring location. If it becomes apparent during remediation that encountered conditions vary substantially from those presented herein, this office should be notified at once. At that time, the conditions can be evaluated and the recommendations of this report can modified in written form if necessary.

The results of the subsurface exploration indicate that the site is generally underlain by soft to very hard existing fill material. Samples of the existing fill material appeared relatively free of deleterious material. It should be noted that the stiff, or better, fill material was generally encountered in the presence of abundant rock fragments, likely inflating the SPT N-counts. Therefore, the consistency of the existing fill material was generally soft to firm. Underlying the fill material encountered, weathered siltstone was encountered in each of the borings. Wire-line rock coring conducted in two borings of the weathered siltstone indicated the presence of sandstone lenses. Rock core recoveries and rock quality designations of zero percent indicate the existing bedrock was of poor quality. However, the high downhole pressure and return of all core water indicate that the bedrock encountered is likely very high quality and competent. It is our opinion that the low rock quality observed in rock coring is likely related to the mechanical degradation of the rock caused by the coring action.

ENGINEERING EVALUATION

It is our opinion that the observed undermining distress is related to the slow downward movement of the existing fill soils placed within the previously mentioned "draws" and not related to an overall "global" slope failure of natural material. The majority of the existing facility is bearing in natural material (likely bearing on siltstone/sandstone/shale bedrock) with portions extended over the previously mentioned filled-in "draws". The overdesigned construction (i.e. very thick reinforced concrete) of the WTP is likely allowing the portions of the facility bearing on competent material to provide enough resistance/strength to hold/cantilever the portions bearing on unsuitable fill material, limiting distress to the actual facility. In the event that the structural capacity of the existing facility to cantilever portions of the clarifiers is exceeded, it is likely that structural distress will appear rather quickly. If the clarifiers develop internal cracking, such that water is allowed to escape into the existing fill and residual subgrade, the slope failure and movement will likely be worsened/increased considerably.

Global Stability of Existing Slope

A global stability of the existing western most undermined clarifier has been conducted. Based on our review of various reports prepared in the 1990s, it is our understanding that portions of this

slope located near the 4 million gallon reservoir (located less than approximately 10 feet west of the clarifiers) have failed multiple times in the past. Information regarding previous slope repairs was not provided. The following assumptions and/or data was utilized in the global stability calculations;

1. Slope Stability geometry (topography) is based on a topographic drawing titled "Y-12 Water Treatment Plant Slope Stability Study" prepared by Odgen Environmental and Energy Services and dated November 16, 1992
2. Slope geometry has not changed drastically as compared to the above mentioned topographic survey
3. Total weight transferred to bearing material utilizing a bearing pressure of approximately 3,000 pounds per square foot (psf)
4. Natural material (i.e. weathered rock) will be encountered where the existing topography matches that of the pre-development (i.e. pre 1940s) topographic quad maps.

Slope stability calculations (conducted using STEDwin PCStable) indicate the existing slope geometry supporting the clarifier exists with a safety factor between 1.3 and 1.4. Industry standard for slope stability typically call for a factor of safety of 1.3 for temporary slopes and 1.5 for permanent slopes.

Global Stability of Existing Slope with Respect to Seismic Considerations

In accordance with the previously mentioned slope stability calculations conducted during the 1990s, we have evaluated the effect of seismic loading (i.e. earthquakes) on the stability of the slope. Based on horizontal ground accelerations, our calculations indicate that under extreme seismic loading the slope exists with a factor of safety of 0.85, which would indicate an imminent failure during seismic loading. This factor of safety was calculated using a coefficient of earthquake acceleration of 0.26, as recommended by LGT in the previously mentioned 1990's reports. It should be noted that this failure mode is deep-seated (i.e. failed soil wedge is thicker than 25 feet in some locations) and would likely result is catastrophic property damage and life loss.

RECOMMENDATIONS

We recommend the remediation of the plant occur in two phases. Phase I should consist of the underpinning of the existing undermined portions of the plant and Phase II should consist of remediation and stabilization of the existing slopes and includes the construction of a large concrete/soil/rip-rap buttress or a slope anchor system.

Phase I - Underpinning

As previously mentioned, portions of the facilities foundations were exposed by the loss of overburden soil related to the slope movement. We recommend that the existing foundation along the slope face (or parallel to slope) be underpinned via micropiles (or a similar system) to reduce the risk of structural distress caused by consolidation and/or continued movement of the soil beneath the foundation. Regardless if the City of Oak Ridge elects to accept the risk associated with the stability of the existing slope, we recommend a minimum remediation program consisting of underpinning the distress/undermined portions of the existing building be conducted. If only the underpinning program is enacted, we recommend the micro-piles be designed for down drag and lateral forces associated with the slow downward movement of the fill material.

Micro-piles are installed by drilling a steel pipe (i.e., casing) to the underlying bedrock. The hole is then extended, without casing, through competent bedrock creating a socket (the pile bond length). Once the appropriate socket is penetrated (a function of rock quality and design bond strength), a steel reinforcing bar is centered in the casing which extends from the bottom of the socket to the pile cut-off length. Finally, the entire cased length is pumped full of grout using the tremie method. Construction techniques and methods associated with micro-piles are very flexible and may vary from this general description in some ways.

The casing used for the design of micro-piles is typically 4 to 8-inch diameter steel that meets ASTM standards (ASTM A 252 Grade 3) and which has a minimum yield strength of 80 kips per square inch (ksi). GEOServices recommends an allowable bond strength of 20 pounds per square inch (psi) between the grout and bedrock within the socket is also recommended. The refusal depths encountered during the subsurface exploration were generally consistent (around 20 feet beneath the

existing ground surface). Additionally, voids were not encountered during rock coring operations. However, in this geology it is possible to encountered voids and/or sandy layers that may decompose during micro-pile installation, the project budget should include contingencies for such variances during construction and it's likely that several feet (in some areas 5 to 10 feet) of weathered rock penetration will be required to reach competent bedrock where the micro-pile socket will bear. Micro-piles are typically installed on 5 to 10 foot spacing. However, the final size and design of the micro-pile system will control the spacing.

Phase II Option A - Buttresses

This remediation option should consist of the construction of buttresses within the failing portions of the observed slopes (likely constructed of rip-rap stone). The remediation area should cover the existing fill material and failed portions of the slopes and extend a minimum of 10 feet horizontally on either side of the failures. The existing slope should be benched to facilitate the proper placement of the buttress material. A layer of geotextile fabric should then be placed on the exposed subgrade to eliminate the migration of soil fines. The benches shall measure a minimum of 5 feet tall and 10 feet wide. Prior to placement of the buttress material, all loose mobilized fill soil in the immediate area of the distress should be removed. If this option is chosen, we highly recommend that GEOServices be retained to perform a buttress geometry design. This remediation option will require the development of an up-to-date existing slope topographic survey of the entire portion of the failing slopes. This option can be designed with or without addressing seismic loads.

Phase II Option B - Soil Anchor System

This option would consist of the construction of a soil anchor system. The soil anchor system would consist of several concrete reaction blocks installed at a designed spacing across the face of the existing slope. A soil anchor would then be installed through the blocks, anchored into competent bedrock, and tensioned, to apply an active force into the slope face. The advantage to using a soil anchor system is that once installed, little to no additional work would be necessary. Furthermore, very little (by percentage) of the slope would be occupied by this remediation program (i.e. concrete blocks) and, therefore, the aesthetics of the slope and vegetation can be retained. However, this option should only be performed by a qualified geotechnical specialty contractor with experience

drilling, installing, and testing bar/tendon anchors. This option can be designed with or without addressing seismic loads.

LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. This report is for our geotechnical work only. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

We appreciate the opportunity to provide these services. If you have any questions please feel free to contact us at your convenience.

Sincerely,

GEOServices, LLC

Matt T. Bible, E.I.T.
Geotechnical Professional

W. Ros Kingery III, P.E.
Vice President

Appendix A: Site Vicinity Map, Boring Location Map, and Boring Logs
Appendix B: Lab Summary and Slope Stability

APPENDIX A

Figures and Boring Logs

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

N

NOTES:

1.) BASE MAP: USGS QUADRANGLE (BETHEL VALLEY, TENNESSEE)

GEOS
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2561 Willow Point Way
Knoxville, Tennessee 37931
Office: 865-539-8242
Fax: 865-539-8252

SITE VICINITY MAP

OAK RIDGE WASTE WATER TREATMENT PLANT

OAK RIDGE, TENNESSEE

DRAWN BY:	MTB
APPROVED BY:	WRK
SCALE:	N.T.S.
JOB NO.:	21-16310
DATE:	8-4-2016

FIGURE 1

GEOS

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2501 Willow Point Way
Knoxville, Tennessee 37931
office: 865-539-8262
fax: 865-539-8262

DRAWN BY:	MTB
APPROVED BY:	ACA
SCALE:	N.T.S.
JOB NO.:	21-16310
DATE:	6-3-2016

BORING LOCATION PLAN
AERIAL IMAGERY

OAK RIDGE WASTE WATER TREATMENT PLANT

OAK RIDGE, TENNESSEE

NOTES:
1.) BORING LOCATIONS ARE SHOWN IN GENERAL ARRANGMENT ONLY.
2.) DO NOT USE BORING LOCATIONS FOR DETERMINATIONS OF DISTANCES OR QUANTITIES
3.) BASE MAP PROVIDED BY: Google Earth

⊕ LOCATION OF SOIL TEST BORING

FIGURE 2.1

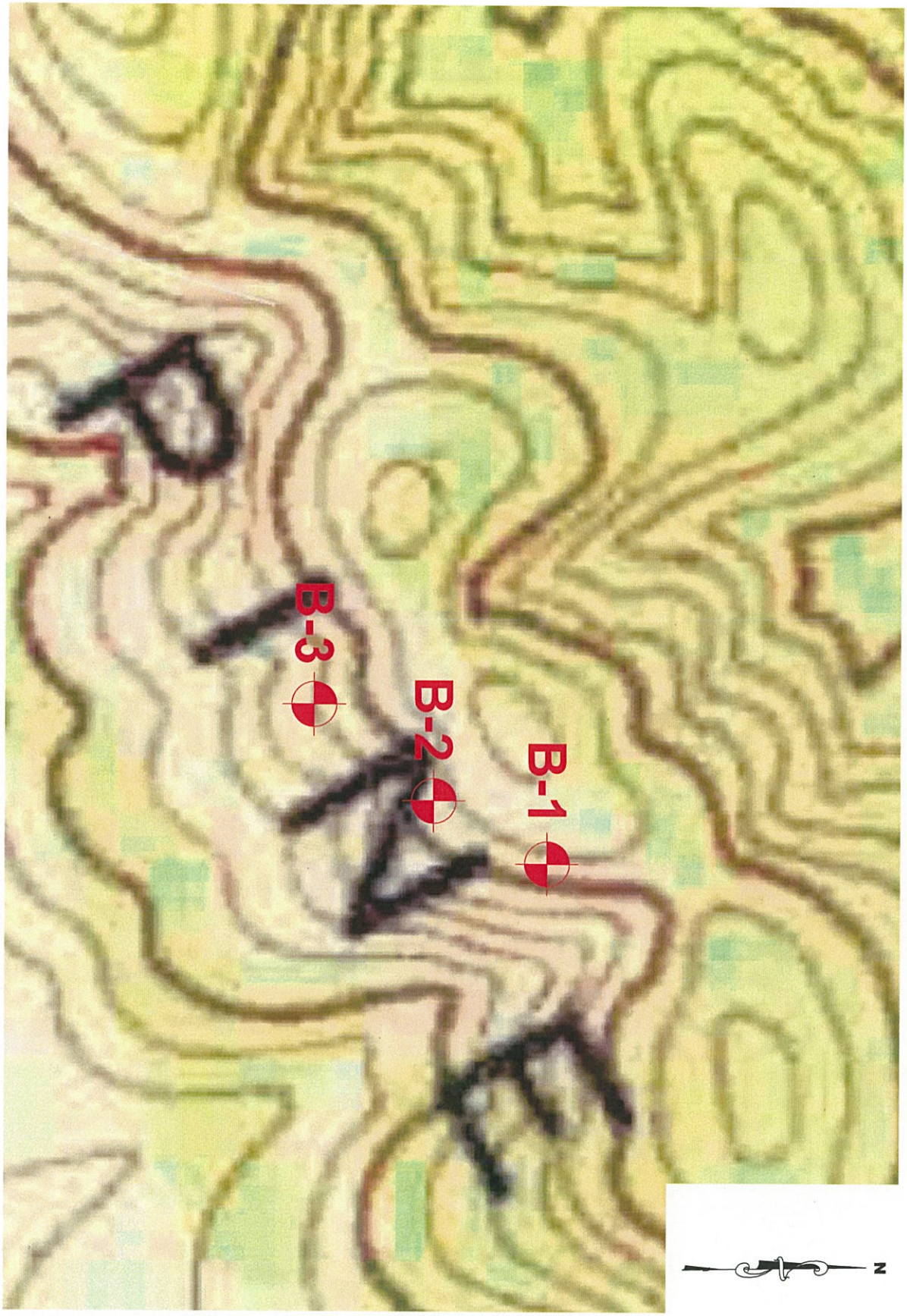

FIGURE 2.2

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Knoxville, Tennessee 37931
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Fax: 865-539-8252

DRAWN BY:	MTB
APPROVED BY:	ACA
SCALE:	N.T.S.
JOB NO.:	21-16310
DATE:	6-3-2016

BORING LOCATION PLAN
1941 TOPOGRAPHIC MAP

OAK RIDGE WASTE WATER TREATMENT PLANT

OAK RIDGE, TENNESSEE

NOTES:

1.) BORING LOCATIONS ARE SHOWN IN GENERAL ARRANGMENT ONLY.
2.) DO NOT USE BORING LOCATIONS FOR DETERMINATIONS OF DISTANCES OR QUANTITIES.
3.) BASE MAP PROVIDED BY: Google Earth

LOCATION OF SOIL TEST BORING

FIGURE 2.3

GEOS
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Knoxville, Tennessee 37931
Office: 865-539-8242
Fax: 865-539-8252

DRAWN BY:	MTB
APPROVED BY:	ACA
SCALE:	N.T.S.
JOB NO.:	21-16310
DATE:	6-3-2016

BORING LOCATION PLAN
1968 TOPOGRAPHIC MAP

OAK RIDGE WASTE WATER TREATMENT PLANT

OAK RIDGE, TENNESSEE

NOTES:

1.) BORING LOCATIONS ARE SHOWN IN GENERAL ARRANGMENT ONLY.
2.) DO NOT USE BORING LOCATIONS FOR DETERMINATIONS OF DISTANCES OR QUANTITIES.
3.) BASE MAP PROVIDED BY: Google Earth

⊕ LOCATION OF SOIL TEST BORING

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Oak Ridge Water Treatment Plant
Oak Ridge, Tennessee
GEOServices Project # 21-16310

LOG OF BORING B-1
SHEET 1 OF 2

DRILLER Andrew Pelfrey
ON-SITE REP.

BORING NO. / LOCATION B-1
DRY ON COMPLETION ? Yes

DATE May 26, 2016
SURFACE ELEV. ____ FT.
REFUSAL: Yes DEPTH 19.5 FT. ELEV. -19.5 FT.
SAMPLED 29.5 FT. 9.0 M
TOP OF ROCK DEPTH 19.5 FT. ELEV. -19.5 FT.
BEGAN CORING DEPTH 19.5 FT. ELEV. -19.5 FT.
FOOTAGE CORED (LF) 10.0 FT.
BOTTOM OF HOLE DEPTH 29.5 FT. ELEV. -29.5 FT.
BORING ADVANCED BY: POWER AUGERING X

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 1 HRS: DEPTH TNP FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH TNP FT. ELEV. ____ FT.

PROPOSED FFE: ____ FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qu	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											Asphalt (2 Inches) - Basestone (3 Inches)
		1.0	2.5	1	ST	3				13.5	
2.5	-2.5										
		3.5	5.0	2	SS	5				10.6	
5.0	-5.0										
		6.0	7.5	3	SS	4				15.8	Lean CLAY (CL) - with rock fragments (limestone and shale), sand, and trace silt - dark brown and dark reddish brown - slightly mois to moist (FILL)
7.5	-7.5										
		8.0	10.0	ST-1	ST						
10.0	-10.0										
12.5	-12.5										
		13.5	15.0	4	SS	31				9.7	
15.0	-15.0										
17.5	-17.5										Weathered Siltstone - with abundant sand, abundant silt, and trace shale like structure - dry - hard
		18.5	20.0	5	SS	50/5"				10	
20.0	-20.0										

Continued

REMARKS:

GEOS
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Oak Ridge Water Treatment Plant
Oak Ridge, Tennessee
GEOServices Project # 21-16310

LOG OF BORING B-1
SHEET 2 OF 2

DRILLER Andrew Pelfrey
ON-SITE REP.

BORING NO. / LOCATION B-1
DRY ON COMPLETION ? Yes

DATE May 26, 2016
SURFACE ELEV. ____ FT.
REFUSAL: Yes DEPTH 19.5 FT. ELEV. -19.5 FT.
SAMPLED 29.5 FT. 9.0 M
TOP OF ROCK DEPTH 19.5 FT. ELEV. -19.5 FT.
BEGAN CORING DEPTH 19.5 FT. ELEV. -19.5 FT.
FOOTAGE CORED (LF) 10.0 FT.
BOTTOM OF HOLE DEPTH 29.5 FT. ELEV. -29.5 FT.
BORING ADVANCED BY: POWER AUGERING X

WATER LEVEL DATA (IF APPLICABLE)

COMPLETION:	DEPTH	Dry	FT.
	ELEV.		FT.
AFTER 1 HRS:	DEPTH	TNP	FT.
	ELEV.		FT.
AFTER 24 HRS.	DEPTH	TNP	FT.
	ELEV.		FT.

PROPOSED FFE: ____ FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qu	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											(cont.)
											Auger Refusal at 19.5 Feet
											Begin Coring at 19.5 Feet
											Run #1 (19.5 to 29.5 Feet)
22.5	-22.5										REC - 0% RQD - 0%
25.0	-25.0										No recovery on core - all core water returned to surface with shale fragments and sand - high downhole pressure during coring - core likely decomposed due to mechanical action of coring
27.5	-27.5										
30.0	-30.0										Coring Termianted at 29.5 Feet
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Oak Ridge Water Treatment Plant
Oak Ridge, Tennessee
GEOServices Project # 21-16310

LOG OF BORING B-2
SHEET 1 OF 1

DRILLER Andrew Pelfrey
ON-SITE REP.

BORING NO. / LOCATION B-2
DRY ON COMPLETION ? Yes

DATE May 24, 2016
SURFACE ELEV. ____ FT.
REFUSAL: Yes DEPTH 22.2 FT. ELEV. -22.2 FT.
SAMPLED 22.2 FT. 6.8 M
TOP OF ROCK DEPTH ____ FT. ELEV. ____ FT.
BEGAN CORING DEPTH ____ FT. ELEV. ____ FT.
FOOTAGE CORED (LF) ____ FT.
BOTTOM OF HOLE DEPTH 22.2 FT. ELEV. -22.2 FT.

BORING ADVANCED BY: POWER AUGERING X

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT. ELEV. ____ FT.
AFTER 1 HRS: DEPTH TNP FT. ELEV. ____ FT.
AFTER 24 HRS. DEPTH TNP FT. ELEV. ____ FT.

PROPOSED FFE: ____ FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qu	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											Topsoil (2 Inches)
		1.0	2.5	1	ST	4				16.9	Lean CLAY (CL) - with rock fragments (shale and trace limestone) and sand - brown and dark brown - slightly moist to moist (FILL)
2.5	-2.5										
		3.5	5.0	2	SS	10				15.2	
5.0	-5.0										
		6.0	7.5	3	SS	39				11.9	
7.5	-7.5										
		8.5	10.0	4	SS	64				17.8	Weathered Siltstone - with abudant sand, silt, and trace shale like structure and depth - orangisj brown, reddish brown, and brown - dry - very hard
10.0	-10.0										
12.5	-12.5										
		13.5	14.3	5	SS	50/4"				13.3	
15.0	-15.0										
17.5	-17.5										
		18.5	18.5	6	SS	50/0				10.4	
20.0	-20.0										

Auger Refusal at 22.2 Feet

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Oak Ridge Water Treatment Plant
Oak Ridge, Tennessee
GEOServices Project # 21-16310

LOG OF BORING B-3
SHEET 1 OF 2

DRILLER: Andrew Pelfrey
ON-SITE REP.:

BORING NO. / LOCATION: B-3
DRY ON COMPLETION ?: Yes

DATE: May 26, 2016
SURFACE ELEV.: ____ FT.
REFUSAL: Yes — DEPTH 17.3 FT. — ELEV. -17.3 FT.
SAMPLED 29.5 FT. — 9.0 M
TOP OF ROCK — DEPTH 19.5 FT. — ELEV. -19.5 FT.
BEGAN CORING — DEPTH 19.5 FT. — ELEV. -19.5 FT.
FOOTAGE CORED (LF): 10.0 FT.
BOTTOM OF HOLE DEPTH: 29.5 FT. — ELEV. -29.5 FT.
BORING ADVANCED BY:
POWER AUGERING: X

WATER LEVEL DATA (IF APPLICABLE)

COMPLETION:	DEPTH	Dry FT.
	ELEV.	____ FT.
AFTER 1 HRS:	DEPTH	TNP FT.
	ELEV.	____ FT.
AFTER 24 HRS.	DEPTH	TNP FT.
	ELEV.	____ FT.

PROPOSED FFE: ____ FT.

STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qu	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											Topsoil (4 Inches)
		1.0	2.5	1	ST	5				9.7	Lean CLAY (CL) - with rock fragments (abundant shale fragments and limestone fragments) - dark brown and brown - slightly moist (FILL)
2.5	-2.5										
		3.5	5.0	2	SS	7				11.4	
5.0	-5.0										
		6.0	7.5	3	SS	5				10.4	
7.5	-7.5										
		8.5	10.0	4	SS	17				11.6	
10.0	-10.0										
12.5	-12.5										
		13.5	13.9	5	SS	50/5"				9.9	
15.0	-15.0										
17.5	-17.5										Auger Refusal at 17.3 Feet Begin Coring at 17.5 Feet Run #1 (17.5 to 27.5 Feet) No recovery on core - all core water returned to surface with shale fragments and sand - high downhole pressure during coring ...
20.0	-20.0										

Continued

REMARKS:

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers

Oak Ridge Water Treatment Plant
Oak Ridge, Tennessee
GEOServices Project # 21-16310

LOG OF BORING B-3
SHEET 2 OF 2

DRILLER Andrew Pelfrey
ON-SITE REP.

BORING NO. / LOCATION B-3
DRY ON COMPLETION ? Yes

DATE May 26, 2016
SURFACE ELEV. FT.
REFUSAL: Yes DEPTH 17.3 FT. ELEV. -17.3 FT.
SAMPLED 29.5 FT. 9.0 M
TOP OF ROCK DEPTH 19.5 FT. ELEV. -19.5 FT.
BEGAN CORING DEPTH 19.5 FT. ELEV. -19.5 FT.
FOOTAGE CORED (LF) 10.0 FT.
BOTTOM OF HOLE DEPTH 29.5 FT. ELEV. -29.5 FT.

WATER LEVEL DATA (IF APPLICABLE)
COMPLETION: DEPTH Dry FT.
ELEV. FT.
AFTER 1 HRS: DEPTH TNP FT.
ELEV. FT.
AFTER 24 HRS. DEPTH TNP FT.
ELEV. FT.

BORING ADVANCED BY: POWER AUGERING X
PROPOSED FFE: FT.

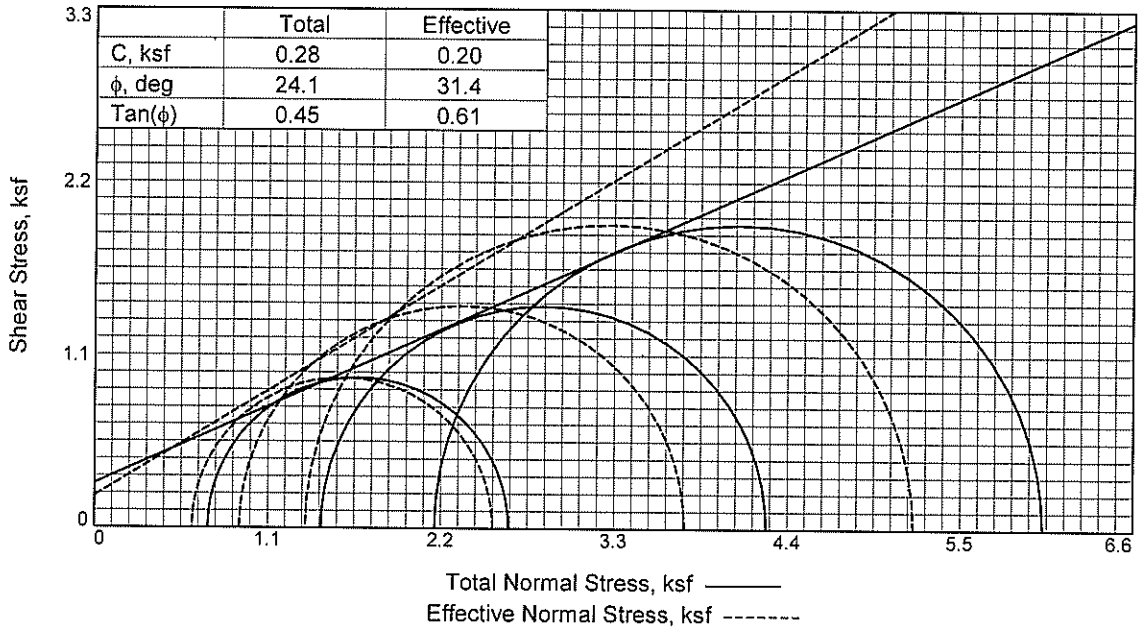
STRATUM DEPTH FT.	STRATUM DEPTH ELEV.	SAMPLE DEPTH FROM FT.	SAMPLE DEPTH TO FT.	SAMPLE OR RUN NO.	SAMPLE TYPE	FIELD RESULTS N-Value	FIELD RESULTS Qu	LABORATORY RESULTS LL	LABORATORY RESULTS PI	LABORATORY RESULTS %M	STRATUM DESCRIPTION
											(cont.)
22.5	-22.5										No recovery on core - all core water returned to surface with shale fragments and sand - high downhole pressure during coring - core likely decomposed due to mechanical action of coring
25.0	-25.0										
27.5	-27.5										Coring Terminated at 27.5 Feet
30.0	-30.0										
32.5	-32.5										
35.0	-35.0										
37.5	-37.5										
40.0	-40.0										

REMARKS:

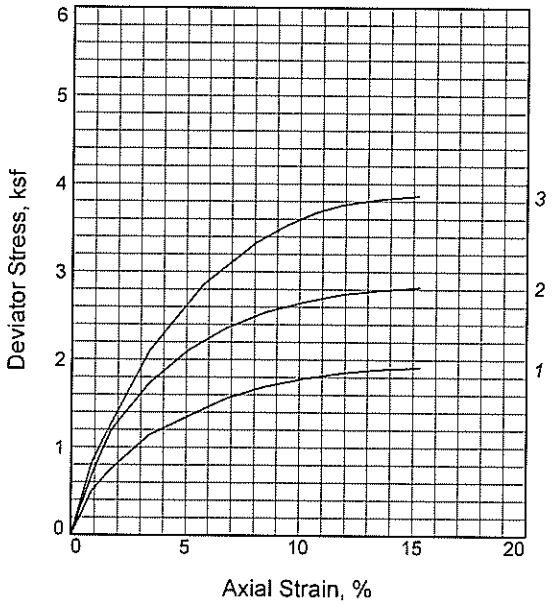
APPENDIX B

Laboratory Test Results

GEOS
GEOServices, LLC-Geotechnical and Materials Engineers



	Total	Effective
C, ksf	0.28	0.20
ϕ, deg	24.1	31.4
Tan(ϕ)	0.45	0.61



Sample No.		1	2	3
Initial	Water Content, %	17.9	17.8	17.7
	Dry Density, pcf	110.3	110.3	110.7
	Saturation, %	98.9	97.9	99.1
	Void Ratio	0.4715	0.4720	0.4657
	Diameter, in.	2.870	2.870	2.870
	Height, in.	5.890	5.900	5.950
At Test	Water Content, %	17.8	17.6	16.8
	Dry Density, pcf	110.9	111.3	113.0
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.4640	0.4585	0.4363
	Diameter, in.	2.865	2.861	2.851
	Height, in.	5.880	5.882	5.910
Strain rate, in./min.		0.003	0.003	0.003
Back Pressure, psi		30.00	30.00	30.00
Cell Pressure, psi		35.00	40.00	45.00
Fail. Stress, ksf		1.91	2.83	3.86
Total Pore Pr., ksf		4.42	4.84	5.14
Ult. Stress, ksf				
Total Pore Pr., ksf				
$\bar{\sigma}_1$ Failure, ksf		2.53	3.75	5.20
$\bar{\sigma}_3$ Failure, ksf		0.62	0.92	1.34

Type of Test:
CU with Pore Pressures
Sample Type: Shelby Tube Specimens
Description: Clay, silty, sandy, brown w/rock

LL= 24 **PL=** 20 **PI=** 4
Assumed Specific Gravity= 2.60
Remarks:

Client: GEOServices, LLC

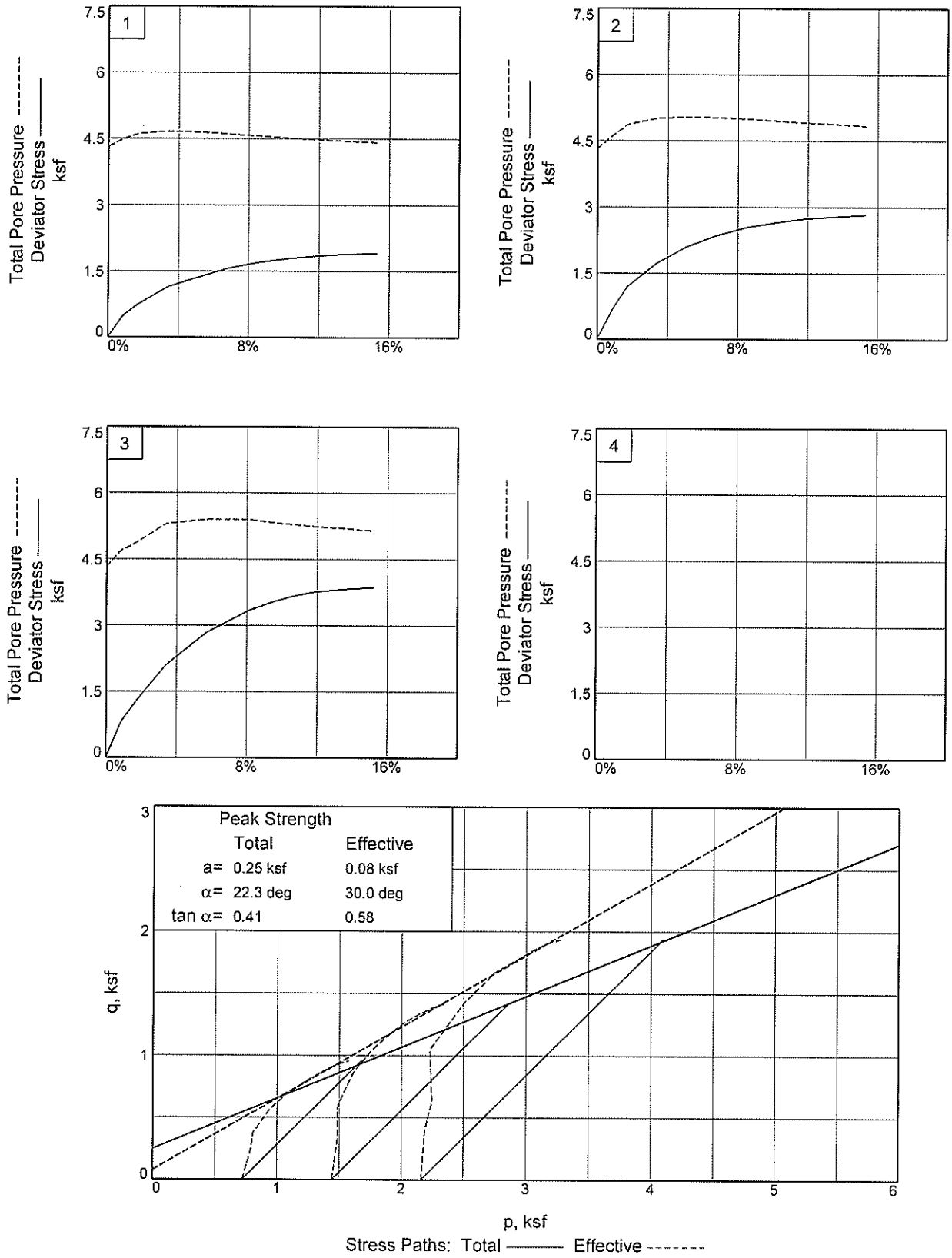
Project: Oak Ridge WTP

Sample Number: B1 **Depth:** 3-5

Proj. No.: 21-16310 **Date Sampled:** 06/06/16

TRIAXIAL SHEAR TEST REPORT
Schnabel Engineering, LLC
Knoxville, Tennessee

Figure 1



Client: GEOServices, LLC
Project: Oak Ridge WTP
Depth: 3-5 **Sample Number:** B1
Project No.: 21-16310

Figure 2

Schnabel Engineering, LLC

SOIL DATA SUMMARY
Oak Ridge Water Treatment Plant
GEOServices Project No. 21-16310
June 2, 2016

Boring Number	Sample Number	Depth (feet)	Natural Moisture Content	Atterberg Limits			Soil Type
				LL	PL	PI	
B-1	1	1.0-2.5'	13.5%				
	2	3.5-5.0'	10.6%				
	3	6.0-7.5'	15.8%				
	4	13.5-15.0'	9.7%				
	5	18.5-20.0	10.0%				
B-2	1	1.0-2.5'	16.9%				
	2	3.5-5.0'	15.2%				
	3	6.0-7.5'	11.9%				
	4	8.5-10.0'	17.8%				
	5	13.5-15.0'	13.3%				
	6	18.5-20.0'	10.4%				
B-3	1	1.0-2.5'	9.7%				
	2	3.5-5.0'	11.4%				
	3	6.0-7.5'	10.4%				
	4	8.5-10.0'	11.6%				
	5	13.5-15.0'	9.9%				

Oak Ridge WTP 21-16310

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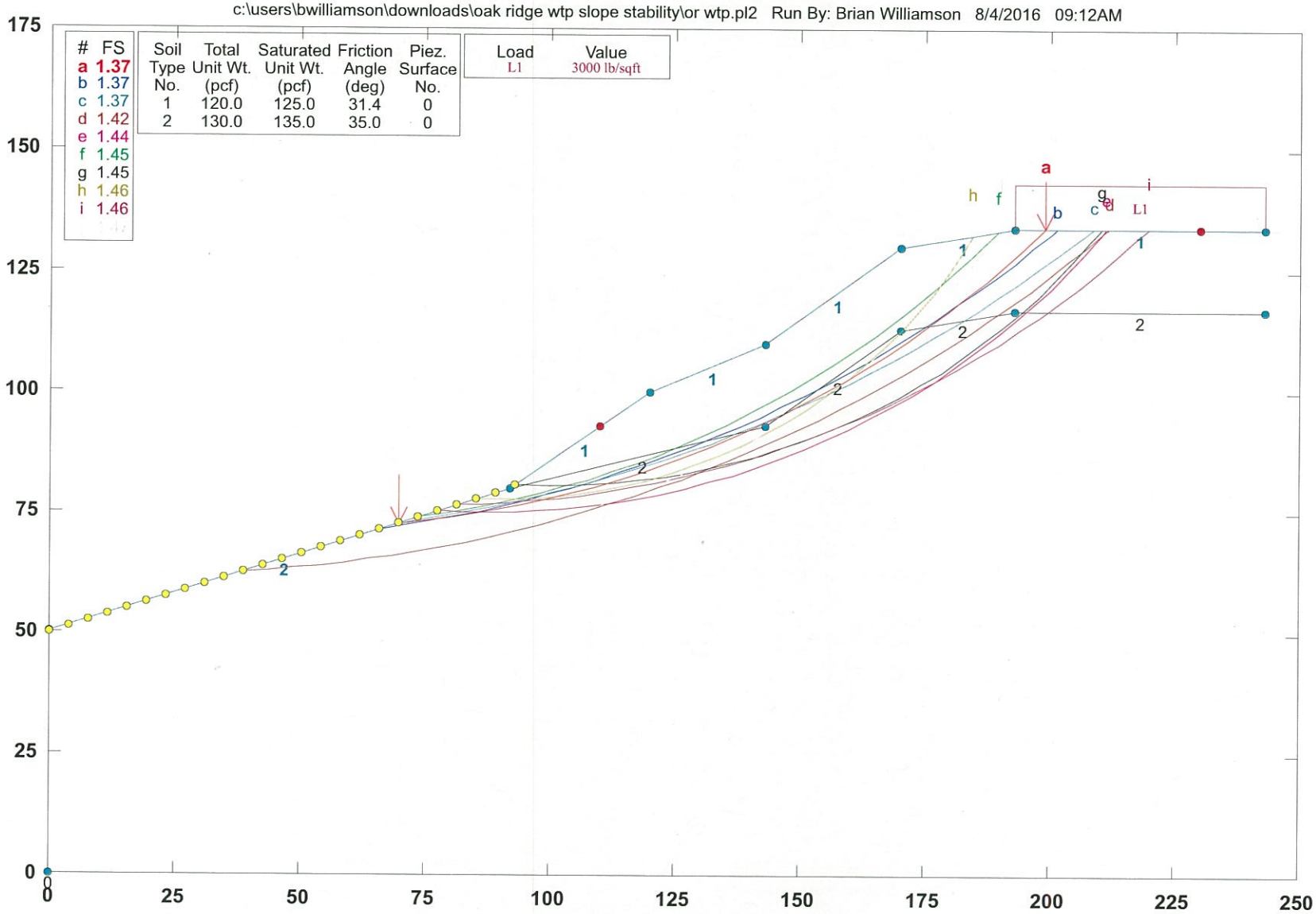

STABL6H FSmin=1.37

Safety Factors Are Calculated By The Modified Bishop Method

STED

Oak Ridge WTP 21-16310

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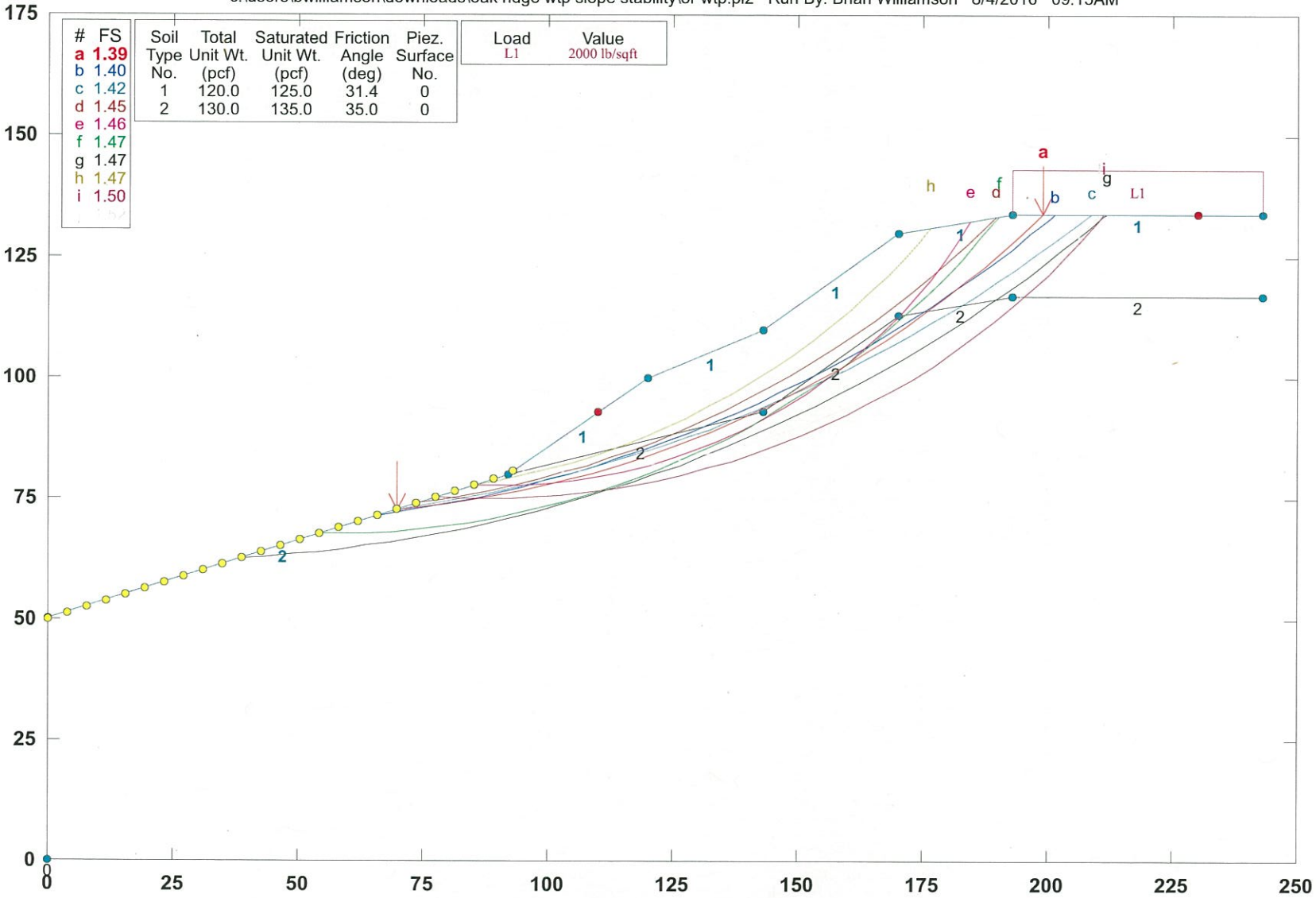

STABL6H FSmin=1.39

Safety Factors Are Calculated By The Modified Bishop Method

STED

Oak Ridge WTP 21-16310

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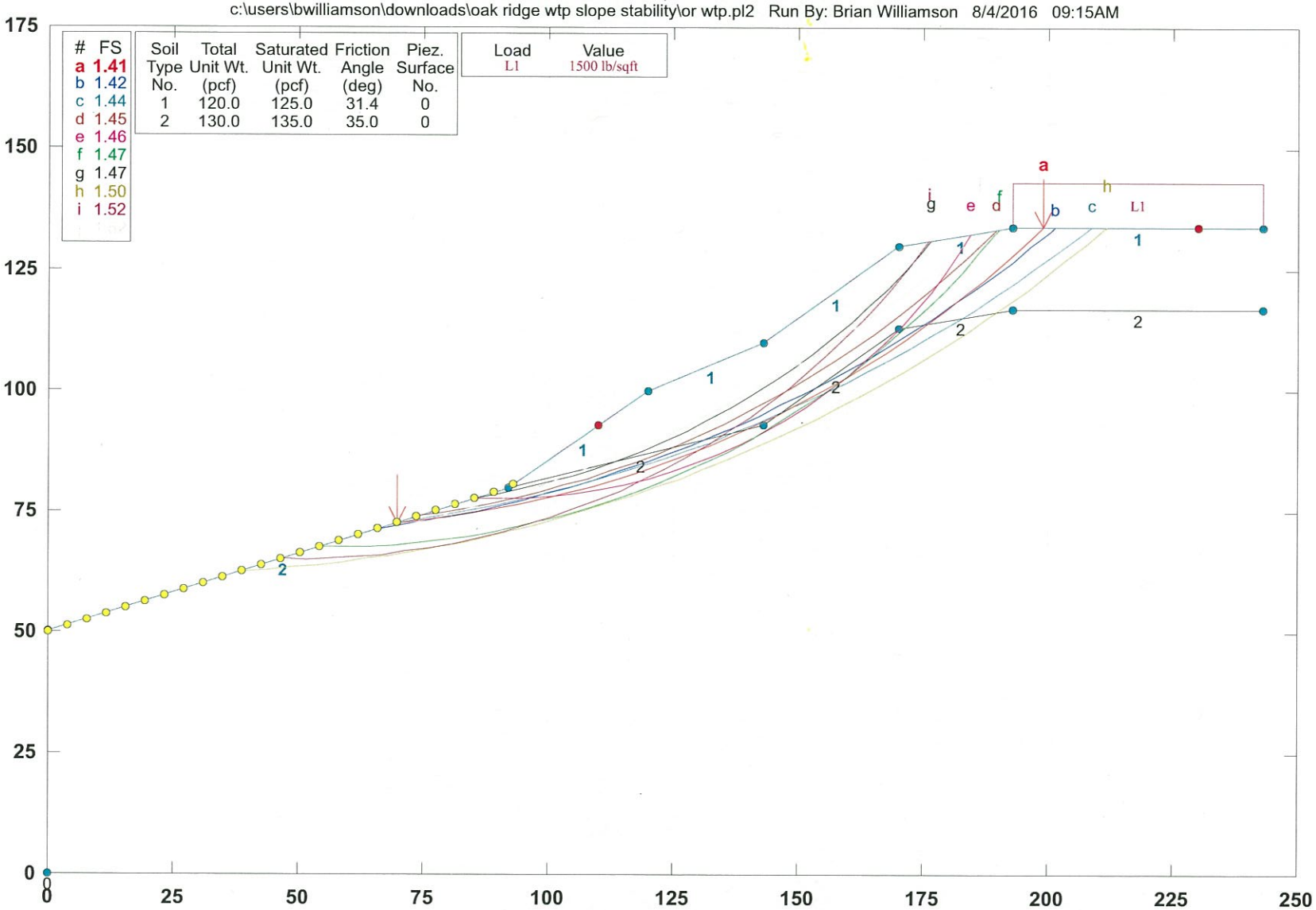

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Safety Factors Are Calculated By The Modified Bishop Method

STED

Oak Ridge WTP 21-16310

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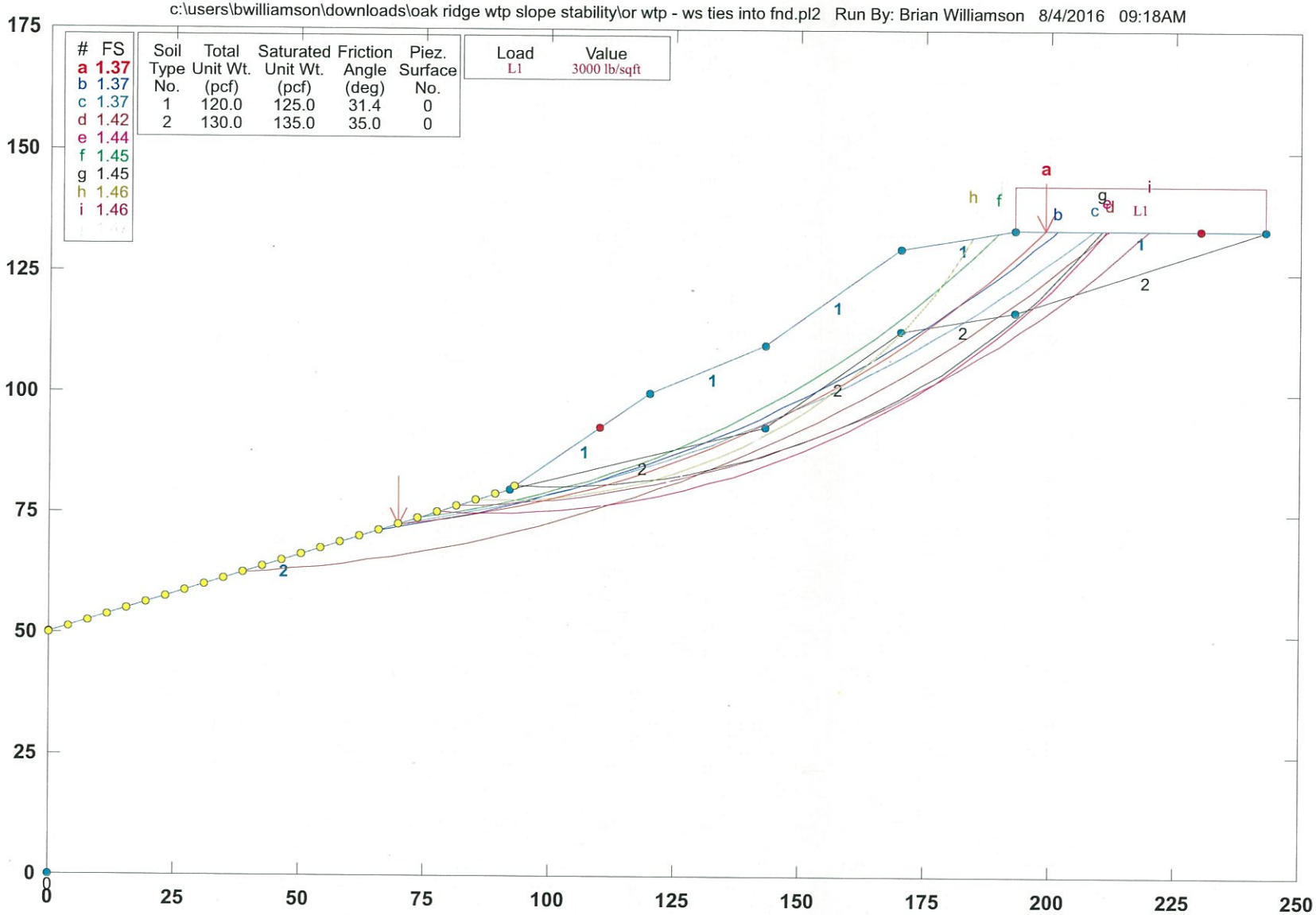

STABL6H FSmin=1.37

Safety Factors Are Calculated By The Modified Bishop Method

STED

Oak Ridge WTP 21-16310

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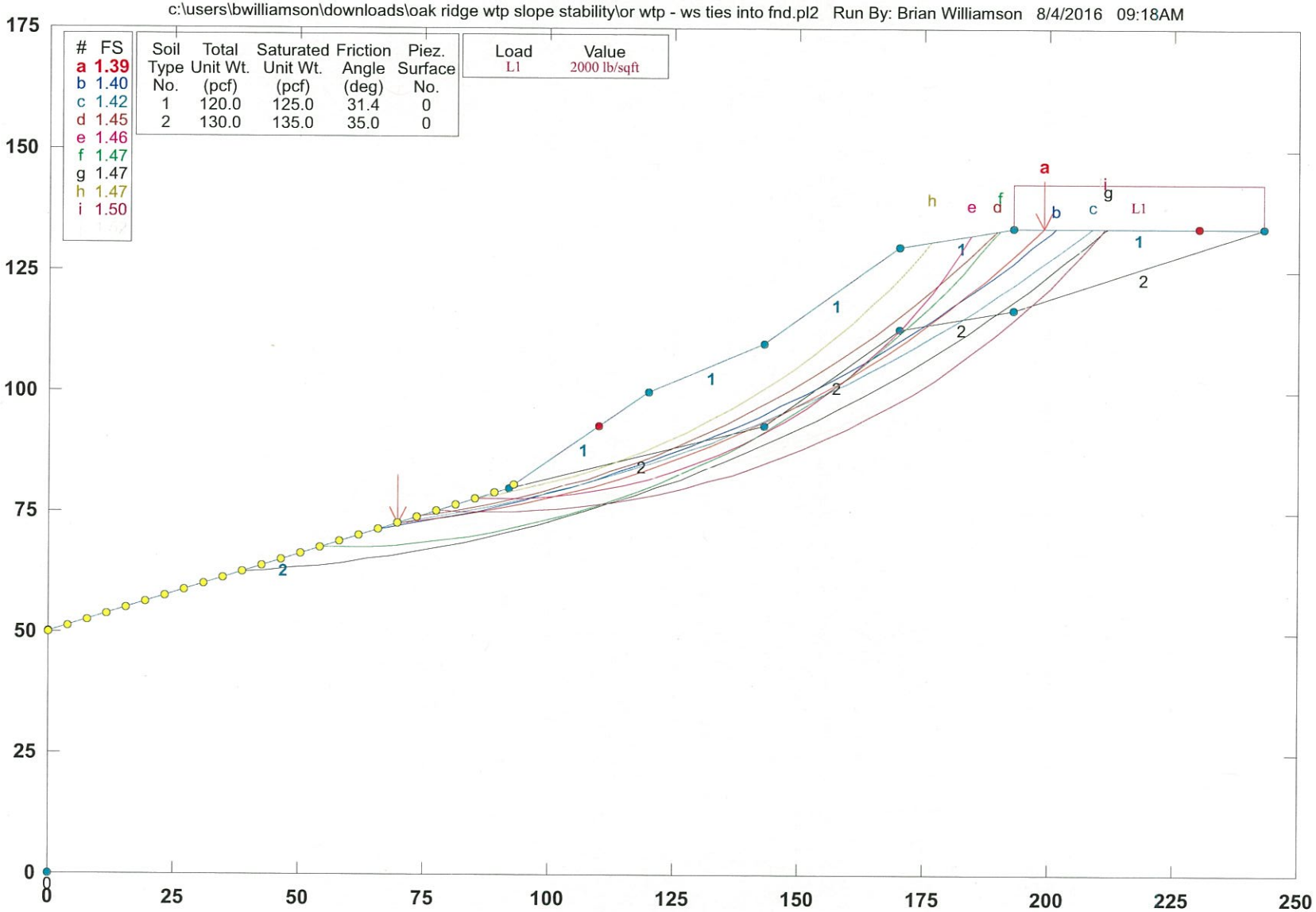

STABL6H FSmin=1.39

Safety Factors Are Calculated By The Modified Bishop Method

STED

Oak Ridge WTP 21-16310

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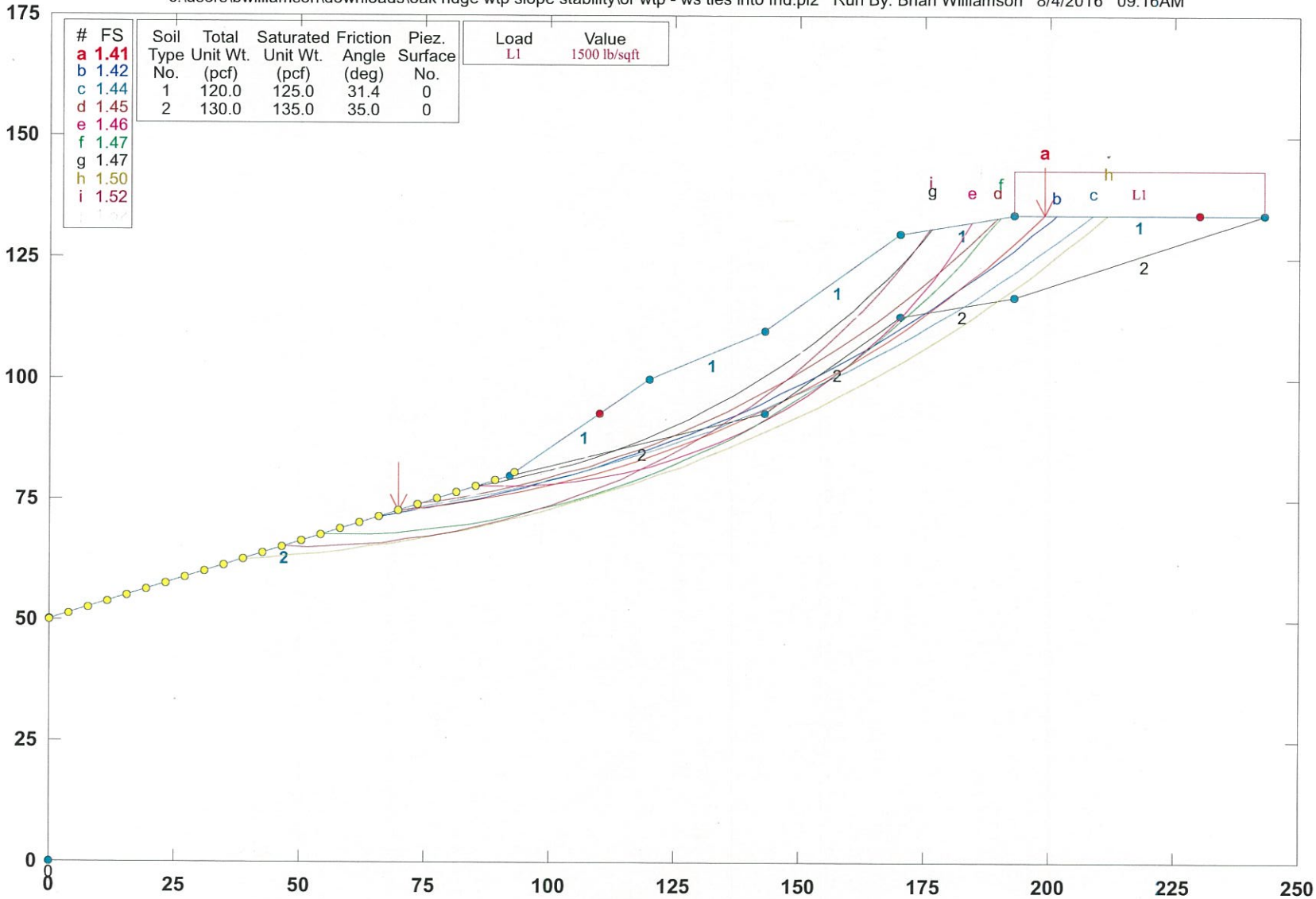

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Safety Factors Are Calculated By The Modified Bishop Method

STED

Oak Ridge WTP 21-16310

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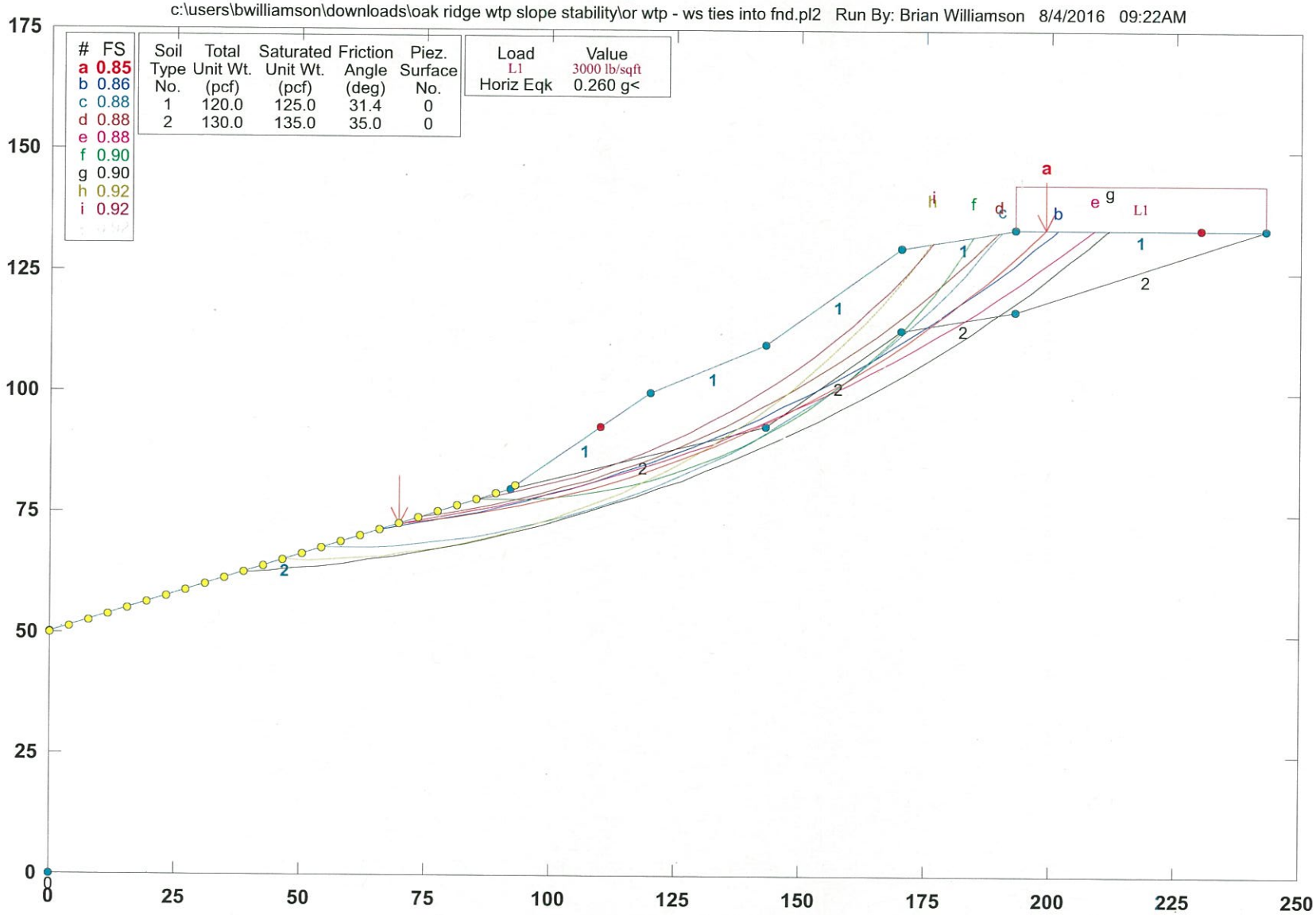

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Safety Factors Are Calculated By The Modified Bishop Method

STED

Appendix B. Conceptual Cost Estimates

Oak Ridge WTP Improvements
Conceptual Cost Estimate

November 18, 2016

Item	Alternative 1 Rehabilitate Existing WTP Cost	Alternative 2 New WTP at Intermediate PS Site Cost	Alternative 3 New WTP at Raw Water Intake Cost
Raw Water Pump Station	$ 5,929,000	$ 5,929,000	$ 2,637,000
24" Raw Water Pipeline	$ 3,494,000	$ 3,494,000	
Intermediate Pump Station	$ 3,726,000		
24" Intermediate Water Pipeline	$ 3,055,000		
Existing Water Treatment Plant	$ 23,750,000		
16 MGD Membrane Water Filtration Plant		$ 24,129,000	$ 24,370,000
High Service Pump Station		$ 3,726,000	$ 2,032,000
24" Finished Water Pipeline		$ 3,055,000	$ 6,229,000
Finished Water Storage	$ 6,545,000	$ 6,545,000	$ 7,883,000
WTP Project Cost	**$ 46,499,000**	**$ 46,878,000**	**$ 43,151,000**

Jacobs

City of Oak Ridge, TN
WTP Improvements
Alternative 1 - Existing WTP Rehab
Conceptual Cost Estimate

Item Description	Quantity	Unit		Unit Cost $		Total Cost $
Raw Water Pump Station						
Earthwork						
Structural excavation	400	cu yd	$	20	$	8,000
Compacted fill	100	cu yd	$	25	$	2,500
Granular fill	50	cu yd	$	35	$	1,750
Filter Fabric	200	sq yd	$	3	$	500
Painting	1	Lump Sum	$	15,000	$	15,000
Equipment						
Traveling Screens	2	each	$	200,000	$	400,000
Vertical Turbine Pumps, 4,200 gpm @ 325' TDH, VFD	4	each	$	180,000	$	720,000
Equipment Installation	20%				$	224,000
Electrical						
Engine Generator, 2000kW w/ Fuel Tank, Sound Enclosur	1	each	$	600,000	$	600,000
Motor Control Center, 460v, VFDs, A/C, Pre-Engineered	1	LS	$	500,000	$	500,000
Transformer, 13.8kv-480V, 2000kW, Pad Mount	1	LS	$	75,000	$	75,000
Equipment Installation	20%				$	235,000
Electrical Conduit, rigid, galv steel	1,200	LF	$	50	$	60,000
Electrical Cable, 500MCM	3,200	LF	$	5	$	16,000
Mechanical						
Demolition	1	LS	$	40,000	$	40,000
Process piping						
Flowmeter, magnetic, 24-inch	1	LS	$	60,000	$	60,000
Ductile iron pipe	8,000	pound	$	6	$	48,000
Valves						
Butterfly						
HW- 16", Class 150	4	each	$	10,000	$	40,000
Pump Control Valve						
16", Rotary, Electric Actuator, Class 150	4	each	$	20,000	$	80,000
Air Release						
2"	4	each	$	5,000	$	20,000
Surge Anticipator Valve	1	each	$	15,000	$	15,000
Pipe supports					$	10,000
SubTotal - Raw Water Pump Station					$	3,171,000
Sitework	0%				$	-
Instrumentation	6%				$	190,000
Electrical	15%				$	476,000
HVAC/Building Mechanical	3%				$	95,000
					$	3,932,000
Contractor General Requirements						
Mobilization	2%				$	79,000
Supervision	3%				$	118,000
Temporary facilities	2%				$	79,000
Bonds and Insurance	1%				$	39,000
Equipment rental & misc.	1%				$	39,000
Profit	6%				$	236,000
Subtotal - Contractor General Requirements	15%				$	590,000
Contingencies	20%				$	904,000
Total Construction Cost					$	5,426,000
Preliminary Engineering/Studies	1	LS	$	-	$	-
Engineering Design and Permitting	5%		$	5,426,000	$	271,000
Bidding and Contract Award	1	LS	$	15,000	$	15,000

Construction Administration	9	MONTHS	$	8,000	$	72,000
Construction Inspection	9	MONTHS	$	15,000	$	135,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000
Total Project Cost					$	**5,929,000**

Raw Water Pipeline

Connection to 42" RW Pipeline at RWPS	1	Lump Sum	$	50,000	$	50,000
24-inch DIP Water Line	8,700	Linear Feet	$	250.00		2,175,000
Connection to Intermediate PS/Tank	1	Lump Sum	$	50,000	$	50,000
SubTotal - Raw Water Pipeline					$	**2,275,000**
Contractor General Requirements						
Mobilization	2%				$	46,000
Supervision	3%				$	68,000
Temporary facilities	2%				$	46,000
Bonds and Insurance	1%				$	23,000
Equipment rental & misc.	1%				$	23,000
Profit	6%				$	137,000
Subtotal - Contractor General Requirements	15%				$	343,000
Contingencies	20%				$	524,000
Total Construction Cost					$	3,142,000
Preliminary Engineering/Studies	1	LS	$	-	$	-
Engineering Design and Permitting	6%		$	3,142,000	$	189,000
Bidding and Contract Award	1	LS	$	15,000	$	15,000
Construction Administration	6	MONTHS	$	8,000	$	48,000
Construction Inspection	6	MONTHS	$	15,000	$	90,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000
Total Project Cost					$	**3,494,000**

Intermediate Pump Station and Storage Tank

Earthwork						
Structural excavation	400	cu yd	$	20	$	8,000
Compacted fill	100	cu yd	$	25	$	2,500
Granular fill	50	cu yd	$	35	$	1,750
Filter Fabric	200	sq yd	$	3	$	500
Painting	1	Lump Sum	$	15,000	$	15,000
Tank Cleaning and Painting	1	Lump Sum	$	75,000	$	75,000
Equipment						
Horizontal Split Case Pumps, 5,000 gpm @ 175' TDH, VFI	3	each	$	130,000	$	390,000
Equipment Installation	20%				$	78,000
Electrical						
Engine Generator, 1500kW w/ Fuel Tank, Sound Enclosur	1	each	$	500,000	$	500,000
Motor Control Center, 460v, VFDs, A/C, Pre-Engineered	1	LS	$	400,000	$	400,000
Transformer, 480V, Pad Mount	1	LS	$	75,000	$	75,000
Equipment Installation	20%				$	195,000
Mechanical						
Demolition	1	LS	$	20,000	$	20,000
Process piping						
Flowmeter, magnetic, 24-inch	1	LS	$	60,000	$	60,000
Ductile iron pipe	6,000	pound	$	6	$	36,000
Valves						
Butterfly						
HW- 12", Class 150	3	each	$	3,000	$	9,000
HW- 10", Class 150	3	each	$	2,500	$	7,500

Check Valve						
10", Spring Check, Class 150	3	each	$	4,000	$	12,000
Air Release						
2"	3	each	$	5,000	$	15,000
Surge Anticipator Valve	1	each	$	15,000	$	15,000
Pipe supports					$	10,000
SubTotal - Intermediate PS					$	1,925,000
Sitework	0%				$	-
Instrumentation	6%				$	116,000
Electrical	15%				$	289,000
HVAC/Building Mechanical	3%				$	58,000
					$	2,388,000
Contractor General Requirements						
Mobilization	2%				$	48,000
Supervision	3%				$	72,000
Temporary facilities	2%				$	48,000
Bonds and Insurance	1%				$	24,000
Equipment rental & misc.	1%				$	24,000
Profit	6%				$	143,000
Subtotal - Contractor General Requirements	15%				$	359,000
Contingencies	20%				$	549,000
Total Construction Cost					$	3,296,000
Preliminary Engineering/Studies	1	LS	$	-	$	-
Engineering Design and Permitting	6%		$	3,296,000	$	198,000
Bidding and Contract Award	1	LS	$	15,000	$	15,000
Construction Administration	9	MONTHS	$	8,000	$	72,000
Construction Inspection	9	MONTHS	$	15,000	$	135,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000
Total Project Cost					**$**	**3,726,000**
Intermediate Water Pipeline						
Connection to Intermediate PS	1	Lump Sum	$	50,000	$	50,000
24-inch DIP Water Line	7,500	Linear Feet	$	250.00		1,875,000
Connection to WTP Piping	1	Lump Sum	$	50,000	$	50,000
SubTotal - Raw Water Pipeline					$	1,975,000
Contractor General Requirements						
Mobilization	2%				$	40,000
Supervision	3%				$	59,000
Temporary facilities	2%				$	40,000
Bonds and Insurance	1%				$	20,000
Equipment rental & misc.	1%				$	20,000
Profit	6%				$	119,000
Subtotal - Contractor General Requirements	15%				$	298,000
Contingencies	20%				$	455,000
SubTotal Construction Cost					$	2,728,000
Preliminary Engineering/Studies	1	LS	$	-	$	-
Engineering Design and Permitting	6%		$	2,728,000	$	164,000
Bidding and Contract Award	1	LS	$	15,000	$	15,000
Construction Administration	6	MONTHS	$	8,000	$	48,000
Construction Inspection	6	MONTHS	$	15,000	$	90,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000

Total Project Cost					$	3,055,000

Water Treatment Plant

Metal						
Alum Handrail - 3 Rail Top Mount	1,000	lin ft	$	50	$	50,000
Alum Grating -(2")	500	sq ft	$	50	$	25,000
Miscellaneous	1	Lump Sum			$	-
Building						
Painting	1	Lump Sum	$	60,000	$	60,000
Replace Doors, Ceiling Modifications	1	Lump Sum	$	50,000	$	50,000
Office Renovations	1	Lump Sum	$	60,000	$	60,000
Process Equipment						
Rapid Mix						
Rapid Mixer	1	LS	$	45,000	$	45,000
Flocculation Basins						
Flocculators	2	LS	$	120,000	$	240,000
Sedimentation Basins						
Sludge Collectors	4	ea	$	100,000	$	400,000
Tube Settlers	2	ea	$	500,000	$	1,000,000
Filters						
Filter Media Replacement	14	ea	$	60,000	$	840,000
Air Scour, Blower	1	ea	$	400,000	$	400,000
Backwash Pumps	3	ea	$	75,000	$	225,000
Process Equipment Installation	20%				$	630,000
Mechanical						
Process piping						
Cone Valves						
24", Electric Actuator	14	each	$	10,000	$	140,000
16 x 24 Rect DIP Spool	14	each	$	7,000	$	98,000
Butterfly						
HW- 20", Class 150	3	each	$	5,000	$	15,000
HW- 16", Class 150	0	each	$	2,500	$	-
Check Valve						
20", Swing Check, Class 150	3	each	$	7,500	$	22,500
Air Release						
2"	3	each	$	5,000	$	15,000
Pipe supports					$	10,000
Flume Slide Gates	4	each	$	5,000	$	20,000
Chemical Feed and Storage						
Coagulant						
Storage Tanks	3	each	$	10,000	$	30,000
Metering Pumps	5	each	$	5,000	$	25,000
Piping	1	Lump Sum	$	10,000	$	10,000
Corrosion Inhibitor						
Storage Tanks	2	each	$	10,000	$	20,000
Metering Pumps	2	each	$	5,000	$	10,000
Piping	1	Lump Sum	$	10,000	$	10,000
Existing Equipment Demolition	1	Lump Sum	$	50,000	$	50,000
Structural						
Existing Structure Demoliton - SuperPulsator Tanks	1	Lump Sum	$	75,000	$	75,000
Linear Crack Repair	500	LF	$	400	$	200,000
Concrete Surface Repairs	1	Lump Sum	$	50,000	$	50,000
Sedimentation Basins						
Flume Modifications	2	ea	$	50,000	$	100,000
Electrical						
Engine Generator, 500kW w/ Fuel Tank, Sound Enclosure	1	each	$	350,000	$	350,000
Motor Control Center	1	Lump Sum	$	350,000	$	350,000
Electrical Equipment Installation	20%				$	140,000
Bldg Power Distribution	1	Lump Sum	$	750,000	$	750,000
SubTotal					$	6,515,500
Sitework	4%				$	261,000
Instrumentation	6%				$	391,000

Electrical	15%				$	977,000
HVAC/Building Mechanical	3%				$	195,000
Geotechnical						
Underpinning Existing Structures	1,800	LF	$	125	$	225,000
WTP North Slope Stabilization - Buttress/Soil Anchors	53,000	sq ft	$	50	$	2,650,000
WTP South Slope Stabilization - Buttress/Soil Anchors	80,000	sq ft	$	50	$	4,000,000
SubTotal - Construction					$	15,215,000
Contractor General Requirements						
Mobilization	2%				$	304,000
Supervision	3%				$	456,000
Temporary facilities	2%				$	304,000
Bonds and Insurance	1%				$	152,000
Equipment rental & misc.	1%				$	152,000
Profit	6%				$	913,000
Subtotal - Contractor General Requirements	15%				$	2,281,000
Contingencies	20%				$	3,499,000
Total Construction Cost					**$**	**20,995,000**
Preliminary Engineering/Studies	1	LS	$	100,000	$	100,000
Engineering Design and Permitting	9%		$	20,995,000	$	1,890,000
Bidding and Contract Award	1	LS	$	35,000	$	35,000
Construction Administration	12	MONTHS	$	25,000	$	300,000
Construction Inspection	12	MONTHS	$	35,000	$	420,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000
Total Project Cost					**$**	**23,750,000**
Water Treatment Plant						
Geotechnical						
4MG Slope Stabilization - Buttress/Soil Anchors	70,000	sq ft	$	50	$	3,500,000
3MG Tank Slope Stabilization - Buttress/Soil Anchors	17,000	sq ft	$	50	$	850,000
SubTotal - Construction					$	4,350,000
Contractor General Requirements						
Mobilization	2%				$	87,000
Supervision	3%				$	131,000
Temporary facilities	2%				$	87,000
Bonds and Insurance	1%				$	44,000
Equipment rental & misc.	1%				$	44,000
Profit	6%				$	261,000
Subtotal - Contractor General Requirements	15%				$	654,000
Contingencies	20%				$	1,001,000
Total Construction Cost					**$**	**6,005,000**
Preliminary Engineering/Studies	0	LS	$	100,000	$	-
Engineering Design and Permitting	9%		$	6,005,000	$	540,000
Bidding and Contract Award	0	LS	$	35,000	$	-
Construction Administration	0	MONTHS	$	25,000	$	-
Construction Inspection	0	MONTHS	$	35,000	$	-
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	0	LS	$	10,000	$	-
Total Project Cost					**$**	**6,545,000**
Alternative No. 1 - Existing WTP Rehab - Total Project Cost					**$**	**46,499,000**

Jacobs

City of Oak Ridge, TN
WTP Improvements
Alternative 2 - New WTP at Intermediate PS
Conceptual Cost Estimate

Item Description	Quantity	Unit		Unit Cost $		Total Cost $
New Water Treatment Plant						
Membrane Water Filtration Plant						
Pressure membrane, metal building, slab on grade	16,000,000	per Gallon	$	0.65	$	10,400,000
2.0 MG Ground Storage Reservoir	1	LS	$	1,200,000	$	1,200,000
SubTotal - Water Treatment Plant Process					$	11,600,000
Sitework	5%				$	580,000
Instrumentation	6%				$	696,000
Electrical	15%				$	1,740,000
HVAC/Building Mechanical	5%				$	580,000
					$	15,196,000
Contractor General Requirements						
Mobilization	2%				$	304,000
Supervision	3%				$	456,000
Temporary facilities	2%				$	304,000
Bonds and Insurance	1%				$	152,000
Equipment rental & misc.	1%				$	152,000
Profit	6%				$	912,000
Subtotal - Contractor General Requirements	15%				$	2,280,000
Contingencies	20%				$	3,495,000
Total Construction Cost					$	20,971,000
Preliminary Engineering/Studies	1	LS	$	150,000	$	150,000
Engineering Design and Permitting	9%		$	20,971,000	$	1,887,000
Bidding and Contract Award	1	LS	$	35,000	$	35,000
Construction Administration	18	MONTHS	$	25,000	$	450,000
Construction Inspection	18	MONTHS	$	35,000	$	630,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	6,000	$	6,000
Total Project Cost					**$**	**24,129,000**
Alternative No. 2 - New WTP at Intermediate PS - Total Project Cost					**$**	**46,878,000**

Jacobs

City of Oak Ridge, TN
WTP Improvements
Alternative 3 - New WTP at RW Intake
Conceptual Cost Estimate

Item Description	Quantity	Unit		Unit Cost $		Total Cost $
Raw Water Pump Station						
Earthwork						
Structural excavation	400	cu yd	$	20	$	8,000
Compacted fill	100	cu yd	$	25	$	2,500
Granular fill	50	cu yd	$	35	$	1,750
Filter Fabric	200	sq yd	$	3	$	500
Painting	1	Lump Sum	$	15,000	$	15,000
Equipment						
Traveling Screens	2	each	$	200,000	$	400,000
Vertical Turbine Pumps, 5,600 gpm @ 150' TDH, VFI	3	each	$	150,000	$	450,000
Equipment Installation	20%				$	170,000
Mechanical						
Demolition	1	LS	$	40,000	$	40,000
Process piping						
Flowmeter, magnetic, 24-inch	1	LS	$	60,000	$	60,000
Ductile iron pipe	8,000	pound	$	6	$	48,000
Valves						
Butterfly						
HW- 16", Class 150	3	each	$	10,000	$	30,000
Pump Control Valve						
16", Rotary, Electric Actuator, Class 150	3	each	$	20,000	$	60,000
Air Release						
2"	3	each	$	5,000	$	15,000
Surge Anticipator Valve	1	each	$	15,000	$	15,000
Pipe supports					$	10,000
SubTotal - Raw Water Pump Station					$	1,326,000
Sitework	0%				$	-
Instrumentation	6%				$	80,000
Electrical	15%				$	199,000
HVAC/Building Mechanical	3%				$	40,000
					$	1,645,000
Contractor General Requirements						
Mobilization	2%				$	33,000
Supervision	3%				$	49,000
Temporary facilities	2%				$	33,000
Bonds and Insurance	1%				$	16,000
Equipment rental & misc.	1%				$	16,000
Profit	6%				$	99,000
Subtotal - Contractor General Requirements	15%				$	246,000
Contingencies	20%				$	378,000
Total Construction Cost					$	2,269,000
Preliminary Engineering/Studies	1	LS	$	-	$	-
Engineering Design and Permitting	6%		$	2,269,000	$	136,000
Bidding and Contract Award	1	LS	$	15,000	$	15,000
Construction Administration	9	MONTHS	$	8,000	$	72,000
Construction Inspection	9	MONTHS	$	15,000	$	135,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000

Total Project Cost					$	**2,637,000**
New Water Treatment Plant at RWPS						
Membrane Water Filtration Plant						
Pressure membrane, metal building, slab on grade	16,000,000	per Gallon	$	0.65	$	10,400,000
Electrical						
Engine Generator, 2000kW w/ Fuel Tank, Sound Enc	1	each	$	600,000	$	600,000
Motor Control Center, 460v, VFDs, A/C, Pre-Engineei	1	LS	$	500,000	$	500,000
Equipment Installation	20%				$	220,000
SubTotal - Water Treatment Plant Process					$	11,720,000
Sitework	5%				$	586,000
Instrumentation	6%				$	703,000
Electrical	15%				$	1,758,000
HVAC/Building Mechanical	5%				$	586,000
					$	15,353,000
Contractor General Requirements						
Mobilization	2%				$	307,000
Supervision	3%				$	461,000
Temporary facilities	2%				$	307,000
Bonds and Insurance	1%				$	154,000
Equipment rental & misc.	1%				$	154,000
Profit	6%				$	921,000
Subtotal - Contractor General Requirements	15%				$	2,304,000
Contingencies	20%				$	3,531,000
Total Construction Cost					$	21,188,000
Preliminary Engineering/Studies	1	LS	$	150,000	$	150,000
Engineering Design and Permitting	9%		$	21,188,000	$	1,907,000
Bidding and Contract Award	1	LS	$	35,000	$	35,000
Construction Administration	18	MONTHS	$	25,000	$	450,000
Construction Inspection	18	MONTHS	$	35,000	$	630,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000
Total Project Cost					$	**24,370,000**
Finished Water Pump Station						
Earthwork						
Structural excavation	1,000	cu yd	$	20	$	20,000
Compacted fill	400	cu yd	$	25	$	10,000
Granular fill	200	cu yd	$	35	$	7,000
Filter Fabric	500	sq yd	$	5	$	2,500
Painting	1	Lump Sum	$	15,000	$	15,000
Building	2,000	sq ft	$	100	$	200,000
Equipment						
Horizontal Split Case Pumps, 5,600 gpm @ 325' TDH	3	each	$	150,000	$	450,000
Equipment Installation	20%				$	90,000
Mechanical						
Process piping						
Flowmeter, magnetic, 24-inch	1	LS	$	60,000	$	60,000
Ductile iron pipe	20,000	pound	$	6	$	120,000
Valves						
Butterfly						
HW- 12", Class 150	3	each	$	3,000	$	9,000

HW- 10", Class 150	3	each	$	2,500	$	7,500
Check Valve						
10", Spring Check, Class 150	3	each	$	4,000	$	12,000
Air Release						
2"	3	each	$	5,000	$	15,000
Surge Anticipator Valve	1	each	$	15,000	$	15,000
Pipe supports					$	10,000
SubTotal - Finished Water PS					$	1,043,000
Sitework	5%				$	52,000
Instrumentation	6%				$	63,000
Electrical	15%				$	156,000
HVAC/Building Mechanical	3%				$	31,000
					$	1,345,000
Contractor General Requirements						
Mobilization	2%				$	27,000
Supervision	3%				$	40,000
Temporary facilities	2%				$	27,000
Bonds and Insurance	1%				$	13,000
Equipment rental & misc.	1%				$	13,000
Profit	6%				$	81,000
Subtotal - Contractor General Requirements	15%				$	201,000
Contingencies	20%				$	309,000
Total Construction Cost					$	1,855,000
Preliminary Engineering/Studies	1	LS	$	-	$	-
Engineering Design and Permitting	9%		$	1,855,000	$	167,000
Bidding and Contract Award	0	LS	$	15,000	$	-
Construction Administration	0	MONTHS	$	8,000	$	-
Construction Inspection	0	MONTHS	$	15,000	$	-
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000
Total Project Cost					**$**	**2,032,000**
Finished Water Pipeline						
24-inch DIP Water Line	16,200	Linear Feet	$	250.00		4,050,000
Connection to Y-12 and COR Distribution Systems	1	Lump Sum	$	50,000	$	50,000
SubTotal - Finished Water Pipeline					$	4,100,000
Contractor General Requirements						
Mobilization	2%				$	82,000
Supervision	3%				$	123,000
Temporary facilities	2%				$	82,000
Bonds and Insurance	1%				$	41,000
Equipment rental & misc.	1%				$	41,000
Profit	6%				$	246,000
Subtotal - Contractor General Requirements	15%				$	615,000
Contingencies	20%				$	943,000
SubTotal Construction Cost					$	5,658,000
Preliminary Engineering/Studies	1	LS	$	-	$	-
Engineering Design and Permitting	6%		$	5,658,000	$	339,000
Bidding and Contract Award	1	LS	$	15,000	$	15,000
Construction Administration	9	MONTHS	$	8,000	$	72,000

Construction Inspection	9	MONTHS	$	15,000	$	135,000
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	1	LS	$	10,000	$	10,000
Total Project Cost					**$**	**6,229,000**
Finished Water Storage						
3.5 MG Ground Storage Reservoir	2	LS	$	2,000,000	$	4,000,000
Sitework	5%				$	200,000
Instrumentation	6%				$	240,000
Electrical	15%				$	600,000
HVAC/Building Mechanical	5%				$	200,000
					$	5,240,000
Contractor General Requirements						
Mobilization	2%				$	105,000
Supervision	3%				$	157,000
Temporary facilities	2%				$	105,000
Bonds and Insurance	1%				$	52,000
Equipment rental & misc.	1%				$	52,000
Profit	6%				$	314,000
Subtotal - Contractor General Requirements	15%				$	785,000
Contingencies	20%				$	1,205,000
Total Construction Cost					$	7,230,000
Preliminary Engineering/Studies	1	LS	$	2,000	$	2,000
Engineering Design and Permitting	9%		$	7,230,000	$	651,000
Bidding and Contract Award	0	LS	$	35,000	$	-
Construction Administration	0	MONTHS	$	25,000	$	-
Construction Inspection	0	MONTHS	$	35,000	$	-
Land/Easements	0	LS	$	-	$	-
Legal/Administrative	0	LS	$	10,000	$	-
Total Project Cost					**$**	**7,883,000**
Alternative No. 3 - New WTP at RW Intake - Total Project Cost					**$**	**43,151,000**