SOUTH WEBER CITY COUNCIL AGENDA

PUBLIC NOTICE is hereby given that the **City Council of SOUTH WEBER CITY**, Utah, will meet in a regular public meeting on **Tuesday, 25 July 2017** at the **City Council Chambers, 1600 E. South Weber Dr.,** commencing at **6:00 p.m.**

WORK MEETING:

5:00 p.m. Discussion of agenda items, correspondence, and/or future agenda items

COUNCIL MEETING:

6:00 p.m. PLEDGE OF ALLEGIANCE – Council Member Winsor
PRAYER - Council Member Sjoblom
APPROVAL OF AGENDA
DECLARATION OF CONFLICT OF INTEREST

1. CONSENT AGENDA:
- ♦ Approval of June 11, 2017 Meeting and Work Meeting Minutes

6:05 p.m.

2. ACTIVE AGENDA:
- *a.* **RES 17-33** Final Plat Ray Creek Estates (approx. 1350 E. Canyon Dr.)
- *b.* Westside Water Reservoir Project Report presented by Jones & Associates
- *c.* Discuss Future of US-89 and trails
- *d.* Discuss possible replacement of the wood fence at and re-location of the Posse Grounds (approx. 475 E. 6650 S.)

7:45 p.m.

3. PUBLIC COMMENT: Please keep public comments to 3 minutes or less per person (no action to be taken)

7:50 p.m.

4. REPORTS:
- *a.* Mayor – on designated committee responsibilities
- *b.* City Council – on designated committee responsibilities
- *c.* City Manager – on current events and future agenda items
- *d.* Planning Commission Liaison – meeting and current development update

8:00 p.m.

5. ADJOURN

THE UNDERSIGNED DULY APPOINTED CITY RECORDER FOR THE MUNICIPALITY OF SOUTH WEBER CITY HEREBY CERTIFIES THAT A COPY OF THE FOREGOING NOTICE WAS MAILED, EMAILED, OR POSTED TO:

CITY OFFICE BUILDING — EACH MEMBER OF THE GOVERNING BODY — UTAH PUBLIC NOTICE WEBSITE www.pmn.utah.gov

CITY WEBSITE www.southwebercity.com — THOSE LISTED ON THE AGENDA

DATE: July 20, 2017 **CITY RECORDER: Elyse Greiner**

IN COMPLIANCE WITH THE AMERICANS WITH DISABILITIES ACT, INDIVIDUALS NEEDING SPECIAL ACCOMMODATIONS DURING THIS MEETING SHOULD NOTIFY THE CITY RECORDER, 1600 EAST SOUTH WEBER DRIVE, SOUTH WEBER, UTAH 84405 (801-479-3177) AT LEAST TWO DAYS PRIOR TO THE MEETING.

Agenda times are approximate and may be moved in order, sequence and time to meet the needs of the Council

SOUTH WEBER CITY
CITY COUNCIL MEETING

DATE OF MEETING: 11 July 2017 **TIME COMMENCED: 6:00 p.m.**

PRESENT: MAYOR: **Tammy Long**

COUNCILMEMBERS:
Scott Casas
Kent Hyer (via electronically)
Merv Taylor
Jo Sjoblom (excused)
Wayne Winsor

CITY RECORDER: **Elyse Greiner**

CITY MANAGER: **Tom Smith**

Transcriber: Minutes transcribed by Michelle Clark

VISITORS: Dak Maxfield, Roney Ketts, Cole Fessler, Jake Goodliffe, Jon Winkfield, Nil Winkfield, Marshall Weaver, Simeon Pope, Ethan Buckner, Blayne Cooper, Nate Reeve, and Trent Bristol.

Mayor Long called the meeting to order and welcomed those in attendance including Troop #433. She excused Council Member Sjoblom.

PLEDGE OF ALLEGIANCE: Council Member Casas

PRAYER: Council Member Taylor

AGENDA: Council Member Winsor moved to approve the agenda as written. Council Member Taylor seconded the motion. Elyse called for the vote. Council Members Casas, Hyer, Taylor, and Winsor voted yes. The motion carried.

CONFLICT OF INTEREST: None

CONSENT AGENDA:

- **Approval of June 20, 2017 Meeting Minutes**
- **Approval of June 27, 2017 Meeting and Work Meeting Minutes**
- **Approval of June 2017 Check Register**

Council Member Taylor moved to approve the consent agenda as written. Council Member Casas seconded the motion. Elyse called for the vote. Council Members Casas, Hyer, Taylor and Winsor voted yes. The motion carried.

QUARTERLY REPORT: Staker Parsons Co.: Dak Maxfield, of Staker Parsons, approached the City Council and presented the quarterly report. Council Member Winsor asked what dust mitigation plans have taken place in the last six months and what it will be for the future. Council Member Casas said residents are concerned about a vast majority of trees that are dying. He said there is herbicide damage to the trees on the west end from the landscape contractor using weed killer. Dak said he appreciated that information. Council Member Winsor asked about the importing of materials. Dak said concerning dust mitigation in the last six months, he said they put down a chemical magnesium sulfite twice a year on the roads, they run a water wagon on the roads daily on every road, which starts at 4 am. He said the water wagon also sprays stock piles. Dak said on a daily basis they run a device called the "dust boss". He said it does not function very well during high winds. He said this equipment sprays a mist in the air. He said during hot times of the year, it is not as effective. He reported that the wind fences are in need of repair. He said they have tried to strategically place them. Dak introduced Jake Goodliffe who is vice-president of this location. Jake said he appreciates the long-standing partnership with South Weber City. Council Member Casas asked about what is going in on the west rim. Jake said it is a wet slurry. Dak addressed future dust mitigation and discussed planting more trees along the west end of the pit. He then discussed elevation and time. He said they have always imported material. He said this pit and geography limits them in producing so many products. He said material is brought in that will blend with materials that can be sold. He said anything imported shouldn't be adding to the dust problem, only on the stock piles at the back end. He said elevation is down on the north side contained in the agreement. They have other materials they are filling in behind. They have been filling along the northwest corner more than they have intended to secure the slope. He said since the down turn in economy they are not in agreement with the time frame in the agreement. He then discussed the pond finds that have been used for dust mitigation. He said this has been placed on a lot of the finished slopes. Dak estimated 12 to 15 years to get down to the elevation agreement. He said they want to be community minded and responsible. He said they are willing to explore ideas. Mayor Long suggested Dak contacted Wasatch Integrated Waste concerning what they put on their roads. She said they just started using a product this spring. Dak reported on phasing and said they are finishing out the north side and still going a little bit south. Concerning air sampling, Dak reported their air sampler went down, it has been fixed, and they have two months of air sampling reports. Tom said he will need help in reading that data.

STATE WILDFIRE PRESENTATION by the Utah Division of Forestry: Trent Bristol, representing Utah Division of Forestry, approached the City Council. He said they have been charged with coming up with a plan to help reduce wild fires. In the past, they have worked with counties and come up with a budget and insurance fund. He said they are currently working with municipalities. He said they are asking cities to invest back into the communities by 50% fuel reduction, service projects, etc. He said the community needs to have a wildlife prevention plan. He would like the plan to be community driven. He said they have a fire warden who can help make sure the Fire Department meets their training responsibilities. He will send a copy of the packet to the City. He said they are asking approximately $6,000 from South Weber City to commit with the plan. He said it is a voluntary agreement. He said there is an opt out form. He said current legislation has strengthened the language for cost recovery. Roney Ketts said Chief Tolman supports this.

RESOLUTION 17-31 Appointment of Primary Election Poll Workers

Elyse said the City has contracted with Davis County for elections. They have conducted interviews and hired poll workers for 15 August 2017. It is recommended that the following be appointed as poll workers: Kim Egginton, Melissa Goertzen, Tracy Goertzen, and Joni Phillips.

Council Member Casa moved to approve Resolution 17-31 appointment of Primary Election Poll Workers as written. Council Member Hyer seconded the motion. Elyse called for the vote. Council Members Casas, Hyer, Taylor and Winsor voted yes. The motion carried.

RESOLUTION 17-30 Final Acceptance Canyon Vistas Subdivision

Tom reported that Jones and Associates, Consulting Engineers for South Weber City, has conducted an inspection of the Canyon Vistas Subdivision and it has been determined that the improvements in the subdivision have been completed satisfactorily to meet minimum requirements according to city standards and specifications.

Jones and Associates recommends Final Acceptance of the Canyon Vistas Subdivision with the following conditions:

1. Escrow be released to the City in the amount of $8,460.00 for chip and seal.
2. All remaining escrow funds for the Canyon Vistas Subdivision including the 10% contingency warranty fund shall be released upon payment in full of any fees due to the City.
3. Upon final release of escrow funds, the City will assume full responsibility for ownership and maintenance of improvements.

Council Member Casas moved to approve Resolution 17-30 Final Acceptance of Canyon Vistas Subdivision. Council Member Winsor seconded the motion. Elyse called for the vote. Council Members Casas, Hyer, Taylor and Winsor voted yes. The motion carried.

PUBLIC COMMENTS:

Nate Reeve, 2319 E. 7975 S., said he was here several months ago and discussed the Staker Parsons Company pit. He is representing a large group that will be conducting a Class Action Lawsuit concerning violation of the Clean Water Act and Clear Air Act against the City and Staker Parsons. He said on a windy day, approximately 8,000 lbs. of sand is leaving the pit each day. He has read the City's agreement with Staker Parsons. He discussed the residents and property that have been affected by the dust from the pit. He encouraged the City to take a look at what is being done for mitigation. He said other cities would not allow this. He said there are mitigation measures that have been used in the industry and he would encourage the City to take a look at them.

REPORTS:

Mayor Long: She attended the Wasatch Integrated Waste meeting and dumping fees will not change for those living in the district. There are fees for uncovered loads. This has been a big problem. They are in the process of decontaminating the burn plant before demolition.

Council Member Hyer: He reported that Country Fair Days is less than a month away. The fireworks will go off in the Poll family property and he thanked them for allowing the City to use that property. He also thanked Tom and the City staff for all their support and help.

Council Member Casas: He suggested a closed meeting next week to discuss possible litigation against the City.

Fire Department: Cole Fessler reported on different calls they have recently been on. He said they have been very busy. He said they have had as many as nine or more on the calls. Roney Ketts said when they have gone out on the City, they were able to maintain or staff their brush truck. He reassured the Council that South Weber City is covered.

ADJOURNED: Council Member Winsor moved to adjourn the meeting at 7:08 p.m. Council Member Taylor seconded. Elyse called for the vote. Council Members Casas, Hyer, Taylor and Winsor voted yes. The motion carried.

APPROVED:______________________________ **Date**
Mayor: Tammy Long

____
Transcriber: Michelle Clark

____
Attest: City Recorder: Elyse Greiner

SOUTH WEBER CITY COUNCIL
WORK MEETING

DATE OF MEETING: **11 July 2017** **TIME COMMENCED:** **5:00 p.m.**

PRESENT: **MAYOR:** **Tammy Long**

COUNCILMEMBERS: **Scott Casas**
Kent Hyer (via electronically)
Jo Sjoblom (excused)
Merv Taylor
Wayne Winsor

CITY MANAGER: **Tom Smith**

CITY RECORDER: **Elyse Greiner**

Transcriber: Minutes transcribed by Michelle Clark

VISITORS: Mark McRae

QUARTERLY REPORT: Staker Parsons Co. (no discussion on this item)

STATE WILDFIRE PRESENTATION by the Utah Division of Wildlife Resources: (no discussion on this item)

CONSENT AGENDA:

- **Approval of June 20, 2017 Meeting Minutes**
- **Approval of June 27, 2017 Meeting and Work Meeting Minutes**
- **Approval of June 2017 Check Register**

Council Member Casas asked about the playground equipment purchase for Central Park. Tom said a few items were purchased to go with the equipment the city had in storage.

ACTIVE AGENDA:

RESOLUTION 17-31 Appointment of Primary Election Poll Workers
Elyse Greiner, City Recorder, said the County hires the poll workers. She said the resolution includes that the Council will authorize the replacement of any of these poll workers if the need should arise It is recommended that the following be appointed as poll workers: Kim Egginton, Melissa Goertzen, Tracy Goertzen, and Joni Phillips. It was stated that the poll workers must be residents of Davis County.

RESOLUTION 17-30 Final Acceptance Canyon Vistas Subdivision
Tom Smith, City Manager, said Jones and Associates, Consulting Engineers for South Weber City, has conducted an inspection of the Canyon Vistas Subdivision and it has been determined that the improvements in the subdivision have been completed satisfactorily to meet minimum requirements according to city standards and specifications.

Jones and Associates recommends Final Acceptance of the Canyon Vistas Subdivision with the following conditions:
1. Escrow be released to the City in the amount of $8,460.00 for chip and seal.
2. All remaining escrow funds for the Canyon Vistas Subdivision including the 10% contingency warranty fund shall be released upon payment in full of any fees due to the City.
3. Upon final release of escrow funds, the City will assume full responsibility for ownership and maintenance of improvements.

ADDITIONAL ITEMS:

1250 East Update: Tom reported that 1250 East is on schedule and should be completed approximately the second week in August.

Water Tank Project: Council Member Casas asked when Jones & Associates will be presenting the plan. He would like to have a project presentation and summary report from Jones & Associates in August. Tom will follow-up.

Fireworks: Tom reported there is a fire hydrant on 1375 East that has been blocked off by a chain link fence. The Code Enforcer asked the property owner to remove the fence from blocking the hydrant. The same individual is not willing to allow the City to use their property for fireworks for County Fair Days. Council Member Hyer said Tawny Lynch has normally worked with the Poll family to coordinate the fireworks in the past and will continue to do so this year. He will report back to Tom what the plan is.

Central Park Playground: Council Member Winsor is concerned about a possible slippery slope if the Council continues to approve additions to the park. He understands the project came in below bid, but doesn't feel money should be spent because of that.

Possible Firework Ordinance: Council Member Taylor is concerned about the violations taking place in the City with fireworks. He would like to limit the time frame for use and have an ordinance in place that can be used for enforcement. Mayor Long said she is concerned about fire safety.

Poster for 50-year celebration of Fire Department: Council Member Casas is working on a poster for the 50 year celebration of the South Weber City Fire Department.

Country Fair Days Parade: Discussion took place regarding walking along the parade route and giving out candy verses sitting in a vehicle and throwing it out. Council Member Hyer will discuss this idea with Holly Williams, Chairperson.

Adjourned at 5:45 p.m.

APPROVED: ______________________________ **Date**
Mayor: Tammy Long

____
Transcriber: Michelle Clark

____
Attest: City Recorder: Elyse Greiner

SOUTH WEBER CITY
PLANNING COMMISSION MEETING

DATE OF MEETING: **8 June 2017** **TIME COMMENCED:** **6:32 p.m.**

PRESENT: **COMMISSIONERS:** **Tim Grubb**
Debi Pitts
Rob Osborne
Wes Johnson
Taylor Walton

CITY PLANNER: **Barry Burton**

CITY ENGINEER: **Brandon Jones**

CITY RECORDER: **Elyse Greiner**

CITY MANAGER: **Tom Smith**

Transcriber: Minutes transcribed by Michelle Clark

***A PUBLIC WORK MEETING was held at 6:00 p.m. to* REVIEW AGENDA ITEMS**

PLEDGE OF ALLEGIANCE: Commissioner Grubb

VISITORS: Ivan Ray, Bob Edwards, Kody Holker, Chris Tremea, Brent Petersen, Lisa Porter, Orson Porter, Allison Carciche, Nicholas Carciche, Rex Feustel, Lisa Gidley, Stephen Bott, John Grubb, Kira Knight, Brad Knight, Nate Knight, Tony Tapia, and Melanie Tapia.

APPROVAL OF MEETING MINUTES

- **May 11, 2017**

Commissioner Grubb moved to approve the meeting minutes of 11 May 2017 as written. Commissioner Walton seconded the motion. Commissioners Grubb, Johnson, Osborne, and Walton voted yes. Commissioner Pitts abstained. The motion carried.

APPROVAL OF THE AGENDA: **Commissioner Johnson moved to approve the agenda as written. Commissioner Pitts seconded the motion. Commissioners Grubb, Johnson, Osborne, Pitts and Walton voted yes. The motion carried.**

Brent Petersen, 6810 S. 475 E., said they have visited these types of facilities and noticed that there were four vehicles for a 30-bed facility. Tim said the employee count is typically two to four.

Barry Burton, City Planner, said this is a needed facility not only in this city but everywhere. He complimented Tim and his people on the design. He feels the developer is trying to accommodate the landscape recommendations. He said the city ordinance does not allow private signs on public property. He said there is an option for the city to vacate the property for the sign or going through the appeal authority and get a variance. Tim said regardless of whether or not the property is vacated, they will maintain the corner. He then decided they will move the sign onto their property. Commissioner Walton discussed possible noise from Hill Air Force Base.

Commissioner Johnson moved to approve the Conditional Use Permit: application for an assisted living facility, Country Lane at South Weber, located at approx. 475 E. and South Weber Dr. (Parcels 13-023-0163, 13-024- 0006, & 13-018-0066), approx. 1.44 acres, by applicant Tim Grubb subject to the following:

1. **Approval of the subdivision**
2. **No signage on public property.**

Commissioner Walton seconded the motion. Commissioners Johnson, Osborne, and Walton voted yes. The motion carried.

Commissioner Grubb moved to open the public hearing. Commissioner Johnson seconded the motion. Commissioners Grubb, Johnson, Osborne, Pitts, and Walton voted yes. The motion carried.

*** * * * * * * * * * PUBLIC HEARING * * * * * * * * * ***

Public Hearing on Preliminary/Final Subdivision: application for Ray Creek Estates (11 lots) located at approx. 1350 E. Canyon Dr. (Parcel 13-011-0104), approx. 3.96 acres, by applicant Rob Edwards: Steven Bott, engineer for this project, approached the Planning Commission.

Orson Porter, 7228 S. 1300 E., read a statement concerning his home and various homes in Cottonwood Cove Subdivision. He said as a homeowner adjacent to the proposed Ray Creek Estates development, he would like to provide insight to help the Planning Commission and City Council make an informed decision before approving plans, as well as to provide a public record that may assist potential builders and homebuyers consider costs and future risk. He said there has been a water main breaking due to sinking, sprinkler systems breaking, basement flooding, landscaping sinking, entire driveways and patios being pulled up, cracked and sunken patios, walkways, landscape edging etc., cracked stucco etc. He feels future homeowners need to be made aware of potential concerns with surrounding property.

Nicholas Cariche, 7212 S. 1300 E., said they have had issues with their house settling as well. He is concerned about drainage from this new subdivision. Mr. Bott said they have a drainage plan. Mr. Porter said there is standing water.

Kody Holker, 11148 Zealand Ave, Champion MN, said he is the property owner. He said they will be bonded. He said some of the concerns are premature with this application.

Commissioner Grubb moved to close the public hearing. Commissioner Johnson seconded the motion. Commissioners Grubb, Johnson, Osborne, Pitts, and Walton voted yes. The motion carried.

*** * * * * * * * * * PUBLIC HEARING CLOSED * * * * * * * * * ***

Brandon said he wasn't aware of homes settling in the Cottonwood Cove Subdivision. He said he relies on the geotechnical report and the developer being compliant to that report. Barry said the geotech report does reference the type of soils. Commissioner Johnson discussed the location of where the soil sample was taken. He would recommend getting a new geotech report to see what is going on. Brandon recommended getting the geotech involved and look at some of these items that have been brought up tonight. Barry said the proposal tonight is for preliminary and final. He said we can look at going with preliminary and holding off on final.

Commissioner Grubb questioned the layout of Lot 5. Brandon said the right of way is slightly off set. Barry said this is a trail access to the Weber River. Commissioner Grubb asked about the requirement for a concrete wall along Interstate 84. Barry said that is a requirement. It was stated that the motion can include the requirement that the concrete wall match the existing concrete wall in Cottonwood Cove Subdivision.

Brandon referenced item #13 in his memo of 31 May 2017 concerning upsizing of the sewer main. Commissioner Grubb asked about item #1 of Brandon's memo. Rob Edwards explained the plan for the water and said they are working with South Weber Water Improvement District. Commissioner Grubb said this needs to be resolved before the subdivision can move forward.

Ivan Ray, 7268 S. 1600 E., discussed the existing lines that may help. Commissioner Osborne doesn't feel this is ready to go to the City Council. He is concerned about the secondary water concerns as well as getting the information from the geotech.

Brandon Jones, City Engineer, project review of 31 May 2017 is as follows:

Our office has completed a review of the Final Plat and Improvement Plans for the Ray Creek Estates subdivision received, May 23, 2017. We recommend approval, subject to the following comments and items being addressed prior to final approval from the City Council:

GENERAL

1. It is our understanding that there is some disagreement between the developer and the South Weber Water Improvement District on the infrastructure required for the development. This

needs to be resolved and a Plan Review Approval Letter from the SWWID needs to be obtained and submitted to the City.
2. A simple cost-share agreement is needed in order to address the City's participation in upsizing the sewer main from 15" RCP to 18" RCP (see item #13).

PLAT

3. Addresses for the lots need to be added and will be provided by our office.
4. The Rocky Mountain Power and South Weber Irrigation Company easements along the north side of Lots 1 – 5 need to be depicted and noted accordingly.
5. The street lights should be taken off the plat.
6. The signature blocks for the South Weber Irrigation Company and the South Weber Water Improvement District need to be verified that the correct language is associated with the correct Company/District.
7. The canal easement referenced needs to be shown on the plat and labeled something like this, "South Weber Irrigation Company canal easement – any part or portion located within the subdivision boundary to be vacated with the recordation of this plat." 8. The existing sewer easement should be shown with a note indicating that the easement will be vacated with the recordation of this plat.

IMPROVEMENT PLANS

9. The water service to Lot 7 needs to come from the line in 1375 East (not along Lot 6).
10. The waterline needs to be replaced all the way to the tee in the Canyon Dr. / 1375 East intersection, and a new valve installed on the west leg of the tee.
11. The water and irrigation mains need to be added to the profiles in order avoid conflicts. If a loop is needed, it should be called out.
12. The inlet box at the corner of Lot 8 needs to be located at the end of the radius on the upstream side of the ADA ramp (where it was shown in the Sketch Plan drawing).
13. As mentioned in the Sketch Plan meeting, the City would like to participate in upsizing the relocated sewer main to 18" PVC. The grade of the pipe is critical as additional piping both upstream and downstream will be needed in order to accommodate all future flows. We have surveyed the entire alignment that needs upsizing and would like to work with the developer's engineer on the vertical design of this section of relocated sewer.
14. The existing street light in front of Lot 6 on 1375 East needs to be relocated to the intersection of Canyon Drive and 1375 East, or a new street installed at that intersection.
15. There is a new street light shown at the corner of Lot 8 by the fire hydrant. This is a good location. There is also a new street light shown between Lots 2 and 3. This street light is not needed.

Barry Burton, City Planner's, project review of Ray Creek Estates of 26 May 2017 is as follows:

General:
This proposal for preliminary/final approval of an 11 lot subdivision. The subdivision incorporates a section of Canyon Drive that will close the gap between 1375 East and the Cottonwood Cove Subdivision.
Layout: The layout of this development look okay; the lots meet minimum area and width requirements and the development meets the maximum density restriction of the R-M zone. There is a 32' gas line easement running through the property, but it is mostly contained within the road right-of-way and does not impact the buildability of the lots. Five of the lots back onto the I-84 right-of-way. Cottonwood Cove developers were required to install a precast concrete

wall along this property line. I have not seen construction drawings, but I know the City Engineer has, so I will let him address any issues he may find there.
Geotechnical Study/Title Report: Neither the geotech study nor the title report produced any red flags.
Plat: Addresses need to be added to the lots and those will be provided by the City Engineer.
Recommendation: I recommend approval of the Preliminary/final Plat with the provision that the developers be required to install a minimum 6' high masonry/sound wall along the I-84 right-of-way property line. This is providing there are no other issues with the construction drawings.

Commissioner Grubb moved to recommend approval of the Preliminary and not the Final Subdivision: application for Ray Creek Estates (11 lots) located at approx. 1350 E. Canyon Dr. (Parcel 13-011-0104), approx. 3.96 acres, by applicant Rob Edwards.

1. **Conditions completed in Barry Burton's memo of 26 May 2017.**
2. **Conditions completed in Brandon Jones memo of 31 May 2017.**
3. **Review geotechnical report from Cottonwood Cove Subdivision as it relates to geotechnical report from Ray Creek.**
4. **Concrete wall to match Cottonwood Cove Subdivision**
5. **Response from South Weber Improvement District meeting.**
6. **City Engineer consider Commission Johnson's comments concerning more testing on the south side with the geotechnical report.**

Commissioner Walton seconded the motion. Commissioners Grubb, Osborne, and Walton voted yes. Commissioner Johnson voted no. The motion carried 4 to 1.

Commissioner Grubb moved to open the public hearing. Commissioner Johnson seconded the motion. Commissioners Grubb, Johnson, Osborne, Pitts, and Walton voted yes. The motion carried.

* * * * * * * * * * PUBLIC HEARING * * * * * * * * * *

Public Hearing on Conditional Use Permit: application for a temporary business, Olympus Fireworks, located at approx. 2539 E. South Weber Dr. (Parcel 13-306-0202), approx. 1 acres, by applicant Brad Knight: Mr. Knight said he is applying for a temporary business license for a firework stand. He said Maverik has allowed them to use their restrooms of which he has a letter from them.

Commissioner Osborne asked if there was any public comment. There was none.

Commissioner Grubb moved to close the public hearing. Commissioner Johnson seconded the motion. Commissioners Grubb, Johnson, Osborne, Pitts, and Walton voted yes. The motion carried.

* * * * * * * * * * PUBLIC HEARING CLOSED * * * * * * * * * *

Captain Chris Tremea, South Weber City Fire Department, discussed improvements that need to be made to the property where a 25ft. perimeter outside of the tent area needs to be weed free and maintained. Also, there is a signage requirement. Mr. Knight said they will clear the entire

SOUTH WEBER CITY
PLANNING COMMISSION MEETING

DATE OF MEETING: **13 July 2017** **TIME COMMENCED:** **6:32 p.m.**

PRESENT:	**COMMISSIONERS:**	**Tim Grubb (excused)** **Debi Pitts** **Rob Osborne** **Wes Johnson** **Taylor Walton**
	CITY PLANNER:	**Barry Burton**
	CITY ENGINEER:	**Brandon Jones**
	CITY RECORDER:	**Elyse Greiner**
	CITY MANAGER:	**Tom Smith**

Transcriber: Minutes transcribed by Michelle Clark

***A PUBLIC WORK MEETING was held at 6:00 p.m. to* REVIEW AGENDA ITEMS**

PLEDGE OF ALLEGIANCE: Commissioner Walton

VISITORS: Peter Matson, Dale Winterton, Wayne Winsor, Shirley Edwards, Louise Cooper, Mike Ford, Diane Ford, Shauna Edwards, Rob Edwards, and Thomas Hunt.

APPROVAL OF MEETING MINUTES

- **8 June 2017**

Commissioner Johnson moved to approve the meeting minutes of 8 June 2017 to include the letter submitted by the resident. Commissioner Walton seconded the motion. Commissioners Johnson, Osborne, Pitts, and Walton voted yes. The motion carried.

APPROVAL OF THE AGENDA: Commissioner Walton moved to approve the agenda as written. Commissioner Johnson seconded the motion. Commissioners Johnson, Osborne, Pitts and Walton voted yes. The motion carried.

DECLARATION OF CONFLICT OF INTEREST: **None**

Final Subdivision: application for Ray Creek Estates (11 lots) located at approx. 1350 E. Canyon Dr. (Parcel 13-011-0104), approx. 3.96 acres, by applicant Rob Edwards: Commissioner Osborne asked if there were any questions from the Planning Commission. Commissioner Johnson asked about the fencing. It was stated the masonry wall will be the same as Cottonwood Cove.

Brandon Jones, of Jones & Associates, project review of 27 June 2017 is as follows: Our office has completed a review of the Final Plat and Improvement Plans for the Ray Creek Estates subdivision received. We recommend approval, and offer the following comments for your information.

GENERAL

1. South Weber Water Improvement District has issued an approval letter, dated June 16, 2017. No additional documentation is needed.
2. According to the Sewer Capital Facilities Plan that our office has just completed, the sewer through this section of Canyon Drive needs to be upsized from a 15"to an 18". The City is responsible for the upsize cost. An Agreement and related exhibits have been prepared and are attached. The funds should come from sewer impact fees. The amount the City owes to the developer for the requested upsizing is $14,311.00.

PLAT

3. I-84 should be labeled.

IMPROVEMENT PLANS

All previous comments have been addressed. No additional comments.

Barry Burton, City Planner's, project review of 6 July 2017 is as follows:

General:

This is a proposal for final approval of an 11 lot subdivision. The proposal meets all zoning requirements and is ready for approval.

Plat:

Addresses need to be added to the lots and those will be provided by the City Engineer.

Recommendation:

I recommend the Planning Commission recommend approval of the Final Plat to the City Council once addresses are added to the plat

Commissioner Johnson moved to recommend approval of Final Subdivision: application for Ray Creek Estates (11 lots) located at approx. 1350 E. Canyon Dr. (Parcel 13-011-0104), approx. 3.96 acres, by applicant Rob Edwards subject to completion of the items listed in Brandon Jones, City Engineer's review of 27 June 2017 and Barry Burton, City Planner's, review of 6 July 2017, and all appropriate fees paid to the City. Commissioner Walton seconded the motion. Commissioners Johnson, Osborne, Pitts and Walton voted yes. The motion carried.

Commissioner Johnson moved to open the public hearing for Preliminary Subdivision application for Old Maple Farms Townhomes (87 lots) located at approximately NE corner of 475 E. and 6650 S. (Parcels 13-006-0025 and 13-006-0031) approximately 8.17 acres, by applicant Peter Matson. Commissioner Pitts seconded the motion. Commissioners Johnson, Osborne, Pitts, and Walton voted yes. The motion carried.

RESOLUTION 17-33

A RESOLUTION OF THE SOUTH WEBER CITY COUNCIL APPROVING FINAL PLAT: RAY CREEK ESTATES

WHEREAS, the South Weber City Planning Commission held a public hearing for the Ray Cree Estates Subdivision (11 lots), located at approximately 1350 E. Canyon Dr. with 3.96 acres, on the 8th of June 2017, and reviewed said final plat on the 13th of July 2017, and have given a favorable recommendation to approve; and

WHEREAS, the South Weber City Council has reviewed the final plat in a regular public meeting on the 25th day of July 2017 and has approved of said final plat subject to the upsizing of sewer line in Canyon Dr. from a 15" to an 18" according to the Sewer Capital Facilities Plan conducted by Jones & Associates.

BE IT THEREFORE RESOLVED by the South Weber City Council that the final plat of Ray Creek Estates Subdivision is hereby approved in conjunction with the attached Agreement Regarding the Upsizing of a Sewer Line on Canyon Dr.

PASSED AND APPROVED by the City Council of South Weber this **25th day of July 2017.**

____
Tamara Long, Mayor

ATTEST:

____
Elyse Greiner, City Recorder

<u>Roll call vote was as follows</u>:

Mr. Taylor	yes	no
Mrs. Sjoblom	yes	no
Mr. Hyer	yes	no
Mr. Casas	yes	no
Mr. Winsor	yes	no

AGREEMENT REGARDING THE UPSIZING OF A SEWER LINE

THIS AGREEMENT is made and entered into this ____ day of ___________, 2017, between South Weber City, 1600 East South Weber Drive, South Weber, UT 84405 ("City") and Kody Holker, of Ray Creek Development LLC, 11148 Zealand Ave N, Champlin, MN 55316 ("Developer").

WHEREAS, Developer is required to relocate a 15" public sewer line currently located in property outside of the proposed roadway being developed in association with the Ray Creek Estates subdivision; and

WHEREAS, City desires to have the 15" sewer line upsized to 18" to better serve the community in accordance with its Capital Facilities Plan, and is willing to pay the Developer for the total cost of upsizing the pipe;

NOW, THEREFORE, the Parties hereto agree as follows:

1. Developer agrees, as part of its responsibility to relocate the 15" public sewer line associated with development of its Ray Creek Estates Subdivision, to increase the size of the sewer line to 18", based upon the City's request, conceptually depicted in Exhibit B. The Developer agrees to be responsible for the actual construction of the work and all associated management and payment of Developer's selected contractor.

2. City agrees to pay Developer fourteen thousand three hundred eleven dollars ($14,311.00), which represents the increased cost of the 18" sewer line over a 15" line based on complete installation costs, as shown in Exhibit A. City shall pay Developer such amount upon their request and completion of said sewer line.

"OWNER"
RAY CREEK DEVELOPMENT LLC
ATTN: Kody Holker
11148 Zealand Ave N, Champlin, MN 55316

By: ______________________________

"CITY"
SOUTH WEBER CITY, a municipal corporation and political subdivision of the state of Utah

By: ______________________________

Name: ______________________

Title: __________________

ATTEST:

____
City Recorder

EXHIBIT A

COST EXHIBIT

<u>Exhibit "A"</u>

~ UPSIZE COST ANALYSIS ~

Ray Creek Estates Subdivision

I. Sewer line - Upsized Portion

Item	Description	Qua.	Unit	Unit Price	Total
1	Furnish and install 15" PVC Sewer (Required for Development)	353	l.f.	$53.00	$18,709.00
2	Furnish and install 18" PVC Sewer (Required for Future Growth)	353	l.f.	$62.00	$21,886.00
				Upsize Cost =	**$3,177.00**

II. Sewer line - Replacement Portion

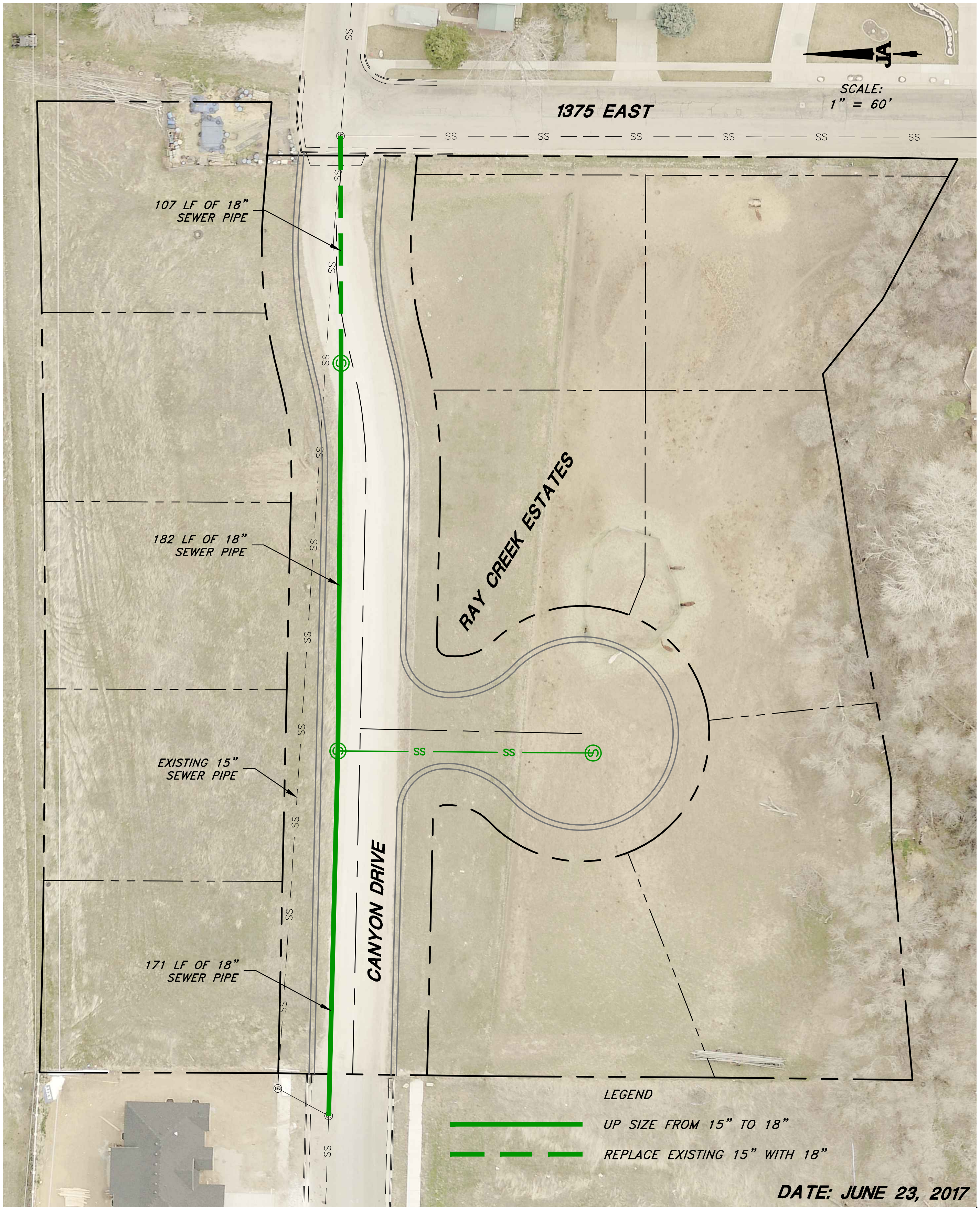
Item	Description	Qua.	Unit	Unit Price	Total
3	Furnish and install 18" PVC Sewer	107	l.f.	$62.00	$6,634.00
4	Remove existing sewer manhole	1	ea	$1,000.00	$1,000.00
5	Furnish and install 5' sewer manhole	1	ea	$3,500.00	$3,500.00
				Replacement Cost =	**$11,134.00**

TOTAL OWED TO DEVELOPER =	**$14,311.00**

** City to pay Developer upon completion of the work.*

EXHIBIT B

DRAWING EXHIBIT



JONES & ASSOCIATES

CONSULTING ENGINEERS

1716 East 5600 South
South Ogden, Utah 84403 (801) 476-9767

SOUTH WEBER CITY CORPORATION

RAY CREEK ESTATES

EXHIBIT B

SHEET: 1 OF 1 SHEETS

0

RAY CREEK ESTATES

A PART OF THE SOUTHWEST QUARTER OF SECTION 27, TOWNSHIP 5 NORTH, RANGE 1 WEST, SALT LAKE BASE AND MERIDIAN, SOUTH WEBER CITY, DAVIS COUNTY, UTAH
JULY, 2017 R-M ZONING

LEGEND

PROPERTY LINE			PROPOSED STREET MONUMENT
LOT LINE			SECTION CORNERS
CENTER / SECTION LINE			PROPOSED STREETLIGHT
EASEMENT LINE		PU&DE	PUBLIC UTILITY & DRAINAGE EASEMENT
BUILDING SETBACK LINE			SET 5/8" REBAR WITH A ORANGE PLASTIC CAP, OR NAIL & WASHER STAMPED PINNACLE ENG. & LAND SURV.
ADJOINING LOT LINE			

SCALE: 1"=50'

REFER TO GEOTECHNICAL INVESTIGATION COMPLETED BY CHRISTENSEN GEOTECHNICAL DATED JUNE 17, 2017

NOTES:

1- PUBLIC UTILITY AND DRAINAGE EASEMENTS ARE 10 FEET WIDE AROUND SUBDIVISION BOUNDARY AND ALONG ROAD FRONTAGES AND 5 FEET WIDE ON SIDE LOT LINES FOR A TOTAL OF 10 FEET WHERE SHOWN ON THIS PLAT.

2- BUILDABLE AREA ENVELOPES ARE AS FOLLOWS:

FOR LOTS 6 & 7 (FRONTING 1375 W)

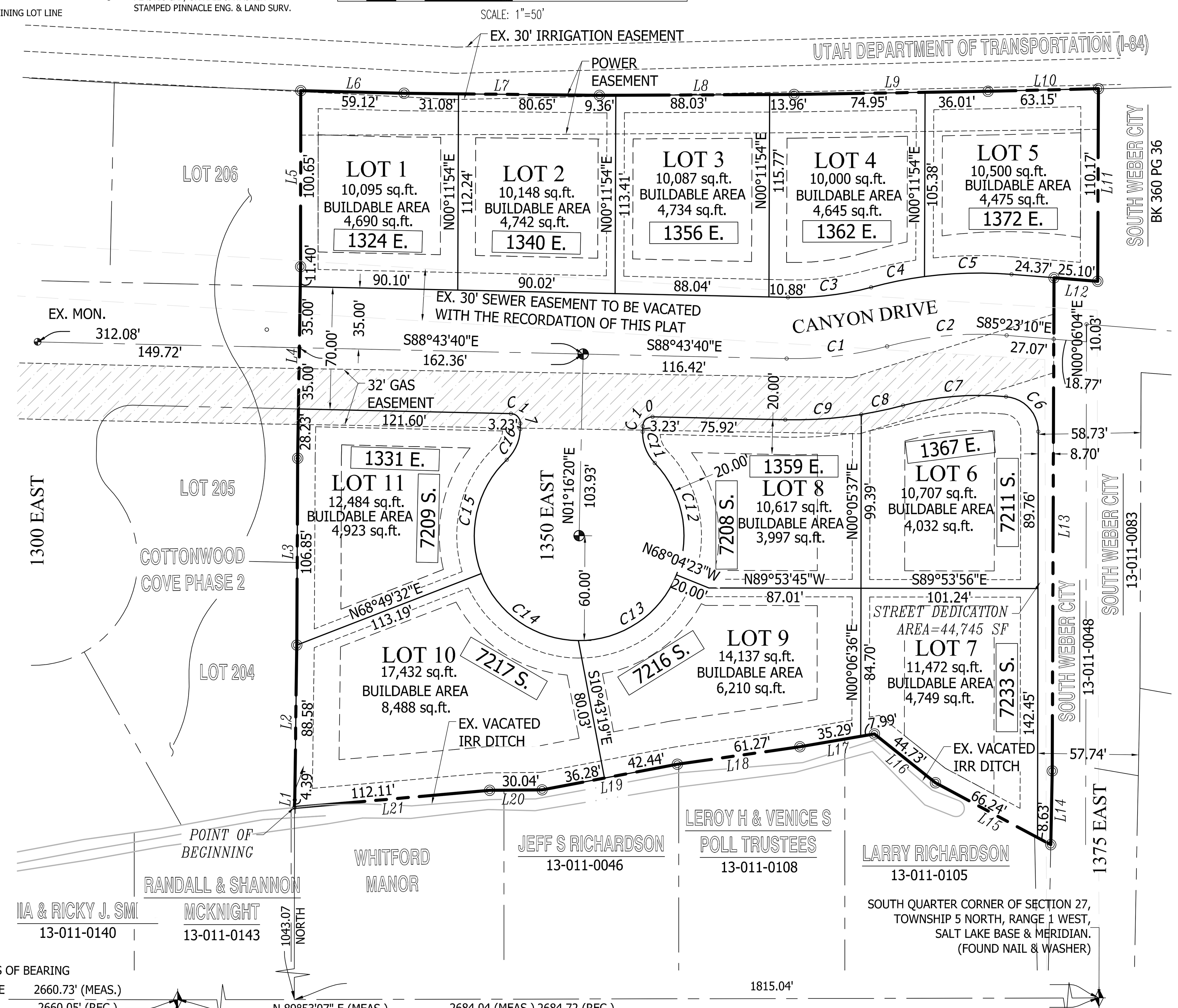
25 FOOT FRONT YARD SETBACK
30 FOOT REAR YARD SETBACK
10 FOOT SIDE YARD SETBACK
20 FOOT SIDE YARD SETBACK ON CORNER LOTS

70' RIGHT OF WAY

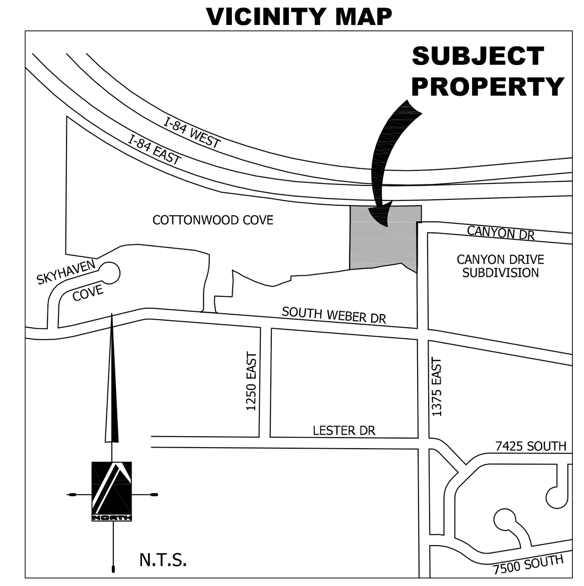
20 FOOT FRONT YARD SETBACK
25 FOOT REAR YARD SETBACK
10 FOOT SIDE YARD SETBACK
20 FOOT SIDE YARD SETBACK ON CORNER LOTS

3- ALL LOTS ARE SUBJECT TO THE REQUIREMENTS OF THE GEOTECHNICAL REPORT PREPARED BY CHRISTENSEN GEOTECHNICAL, DATED JUNE 17, 2017. THIS INCLUDES EXCAVATION OBSERVATIONS ON EACH LOT BY THE GEOTECHNICAL ENGINEER AFTER THE EXCAVATION IS COMPLETE BUT BEFORE THE FOUNDATIONS ARE POURED OR STRUCTURAL FILL IS PLACED

4- ABANDONED PIPES ARE LOCATED ON LOTS 1,2,3,6,8 & 11. THE HOMEOWNER WILL BE RESPONSIBLE TO REMOVE THESE PIPES UNDER ANY NEW STRUCTURE AND PLUG THE EXPOSED ENDS WITH CONCRETE.



VICINITY MAP



CURVE TABLE					
CURVE	LENGTH	RADIUS	DELTA	CHORD BRG	CHORD DIST
C1	58.11	202.84	16°24'52"	N83°03'54"E	57.91
C2	68.96	200.00	19°45'22"	S84°44'09"W	68.62
C3	48.08	167.84	16°24'52"	N83°03'54"E	47.92
C4	31.12	235.00	7°35'11"	S78°39'04"W	31.09
C5	49.91	235.00	12°10'11"	S88°31'45"W	49.82
C6	29.84	20.00	85°29'14"	N42°38'33"W	27.15
C7	59.43	165.58	20°33'49"	S85°09'25"W	59.11
C8	24.51	237.84	5°54'13"	N77°48'35"E	24.50
C9	43.63	237.84	10°30'38"	N86°01'01"E	43.57
C10	8.64	5.50	90°00'00"	S46°16'20"W	7.78
C11	19.68	25.00	45°05'57"	S21°16'38"E	19.17
C12	68.86	60.00	65°45'14"	N10°57'00"W	65.14
C13	71.68	60.00	68°26'57"	N56°09'06"E	67.49
C14	71.68	60.00	68°26'57"	S55°23'57"E	67.49
C15	70.73	60.00	67°32'45"	S12°35'55"W	66.71
C16	19.68	25.00	45°05'57"	N23°49'18"E	19.17
C17	8.64	5.50	90°00'00"	N43°43'40"W	7.78

LINE TABLE		
LINE	LENGTH	BEARING
L1	4.39	N02°57'32"E
L2	88.58	N00°44'19"E
L3	106.85	N00°17'36"E
L4	109.63	N00°50'44"E
L5	100.65	N00°04'13"E
L6	59.12	S88°34'13"E
L7	111.73	S89°23'04"E
L8	111.34	N89°44'08"E
L9	110.96	N89°04'32"E
L10	63.15	N88°38'08"E
L11	110.17	S00°12'00"W
L12	25.10	N85°23'10"W
L13	282.11	S00°12'00"W
L14	42.17	S01°08'00"W
L15	74.86	N61°46'39"W
L16	44.73	N51°18'17"W
L17	43.29	S80°12'14"W
L18	70.79	S81°52'58"W
L19	78.72	S79°16'41"W
L20	30.04	S89°28'16"W
L21	112.11	S84°57'44"W

SURVEYOR'S CERTIFICATE

I, STEPHEN J FACKRELL DO HEREBY CERTIFY THAT I AM A LICENSED LAND SURVEYOR, AND THAT I HOLD CERTIFICATE NO. 191517 AS PRESCRIBED UNDER LAWS OF THE STATE OF UTAH. I FURTHER CERTIFY THAT BY AUTHORITY OF THE OWNERS, I HAVE MADE A SURVEY OF THE TRACT OF LAND SHOWN ON THIS PLAT AND DESCRIBED BELOW, AND HAVE SUBDIVIDED SAID TRACT OF LAND INTO LOTS AND STREETS, HEREAFTER TO BE KNOWN AS

RAY CREEK ESTATES

AND THAT THE SAME HAS BEEN CORRECTLY SURVEYED AND STAKED ON THE GROUND AS SHOWN ON THIS PLAT. I FURTHER CERTIFY THAT ALL LOTS MEET FRONTAGE WIDTH AND AREA REQUIREMENTS OF THE APPLICABLE ZONING ORDINANCES.

BOUNDARY DESCRIPTION

PART OF THE SOUTHWEST QUARTER OF SECTION 27, TOWNSHIP 5 NORTH, RANGE 1 WEST, SALT LAKE BASE & MERIDIAN, SOUTH WEBER CITY, DAVIS COUNTY, STATE OF UTAH, DESCRIBED AS FOLLOWS:

BEGINNING AT A POINT ON THE NORTH BANK OF A DITCH, SAID POINT BEING LOCATED SOUTH 89°53'07" WEST ALONG QUARTER SECTION LINE 1815.04 FEET AND NORTH 1043.07 FEET FROM THE SOUTH QUARTER OF SAID SECTION 27, AND RUNNING THENCE NORTHERLY ALONG A BOUNDARY LINE AGREEMENT RECORDED AT THE DAVIS COUNTY RECORDERS OFFICE 12/20/2012 AS ENTRY #2708692 THE FOLLOWING (5) COURSES: (1) NORTH 02°57'32" EAST 4.39 FEET, (2) NORTH 00°44'19" EAST 88.58 FEET, (3) NORTH 00°17'36" EAST 106.85 FEET, (4) NORTH 00°50'44" EAST 109.63 FEET, AND (5) NORTH 00°04'13" EAST 100.65 FEET TO A POINT ON THE SOUTHERLY LINE OF INTERSTATE HIGHWAY 84 AS DEPICTED ON THE OFFICIAL RIGHT OF WAY MAP FOR UTAH DEPARTMENT OF TRANSPORTATION PROJECT NUMBER I-80N-6(7)46, ON SHEET 11, SAID POINT BEING LOCATED SOUTH 07°27'55" EAST 507.55 FEET FROM A POINT ON THE SURVEY LINE OF SAID HIGHWAY AT ENGINEERS STATION 214+10.24 AT A POINT OF TRANSITION FROM CONCENTRIC CURVE TO SPIRAL CURVE, AT WHICH POINT SAID CONCENTRIC CURVE HAS A RADIUS OF 2864.79 FEET, A SPIRAL LENGTH OF 1100 FT, & A SPIRAL ANGLE OF 11°00'00", AT WHICH POINT THE CENTER OF SAID CONCENTRIC CURVE BEARS NORTH 09°22'44" EAST; THENCE SOUTHEASTERLY ALONG THE SOUTHERLY LINE OF SAID HIGHWAY FOLLOWING A LINE OFFSET 100 FEET SOUTHERLY FROM SAID SURVEY LINE FOLLOWING A SPIRAL CURVE TO THE LEFT APPROXIMATED BY THE FOLLOWING (5) COURSES: (1) SOUTH 88°34'13" EAST 59.12 FEET, (2) SOUTH 89°23'04" EAST 111.73 FEET, (3) NORTH 89°44'08" EAST 111.34 FEET, (4) NORTH 89°04'32" EAST 110.96 FEET, AND (5) NORTH 88°38'08" EAST 63.15 FEET TO THE WEST LINE OF A STREET AS CONVEYED IN BOOK 360 AT PAGE 36 AND LOCATED ON THE GROUND RELATIVE TO CANYON DRIVE SUBDIVISION, A PLAT RECORDED AT THE DAVIS COUNTY RECORDERS OFFICE, SAID SUBDIVISION HAVING BEEN POSITIONED ON THE GROUND RELATIVE TO EXISTING STREET IMPROVEMENTS; THENCE SOUTH 00°12'00" WEST 110.17 FEET ALONG THE WEST LINE OF SAID STREET TO THE PROLONGATION OF THE NORTH LINE OF CANYON DRIVE, A 50 FOOT WIDE STREET DEPICTED ON SAID SUBDIVISION PLAT; THENCE NORTH 85°23'10" WEST ALONG THE PROLONGATION OF THE NORTH LINE OF SAID STREET 25.10 FEET TO AND ALONG THE NORTH LINE OF THAT PARCEL CONVEYED TO SOUTH WEBER CITY IN BOOK 619, AT PAGE 406 WHEN PLACED ON THE GROUND RELATIVE TO SAID SUBDIVISION STREET IMPROVEMENTS; THENCE SOUTH 00°12'00" WEST 282.11 FEET ALONG THE WESTERLY LINE OF SAID SOUTH WEBER CITY PARCEL; THENCE SOUTH 01°08'00" WEST 42.17 FEET ALONG THE WESTERLY LINE OF SAID SOUTH WEBER CITY PARCEL TO THE PROLONGATION OF THE NORTHERLY LINE OF AN EXISTING DITCH; THENCE WESTERLY ALONG THE NORTHERLY BANK OF AN EXISTING DITCH AND THE PROLONGATION THEREOF THE FOLLOWING (7) COURSES: (1) NORTH 61°46'39" WEST 74.86 FEET, (2) NORTH 51°18'17" WEST 44.73 FEET, (3) SOUTH 80°12'14" WEST 43.29 FEET, (4) SOUTH 81°52'58" WEST 70.79 FEET, (5) SOUTH 79°16'41" WEST 78.72 FEET, (6) SOUTH 89°28'16" WEST 30.04 FEET, AND (7) SOUTH 84°57'44" WEST 112.11 FEET TO THE POINT OF BEGINNING.

CONTAINS: 172,489 SQ.FT. (3.96 ACRES)

DATE

STEPHEN J. FACKRELL
LICENSE NO. 191517

OWNER'S DEDICATION

WE THE UNDERSIGNED OWNERS OF THE HEREON DESCRIBED TRACT OF LAND, HEREBY SET APART AND SUBDIVIDE THE SAME INTO LOTS AND STREETS, AS SHOWN ON THIS PLAT AND NAME SAID TRACT OF LAND

RAY CREEK ESTATES

AND HEREBY DEDICATE, GRANT AND CONVEY TO SOUTH WEBER CITY, DAVIS COUNTY, UTAH ALL THOSE PARTS OR PORTIONS OF SAID TRACT OF LAND DESIGNATED AS STREETS, THE SAME TO BE USED AS PUBLIC THOROUGHFARES FOREVER , AND ALSO DEDICATE TO SOUTH WEBER CITY THOSE CERTAIN STRIPS AS EASEMENTS FOR PUBLIC UTILITY AND DRAINAGE PURPOSES, AS SHOWN HEREON, THE SAME TO BE USED FOR THE INSTALLATION, MAINTENANCE AND OPERATION OF PUBLIC UTILITY SERVICE INSTALLATION, MAINTENANCE AND OPERATION OF PUBLIC UTILITY SERVICE LINES AND DRAINAGE, AS MAY BE AUTHORIZED BY SOUTH WEBER CITY.

THE UNDERSIGNED HEREBY CERTIFY THAT THIS SUBDIVISION HAS MET THE ALL THE REQUIREMENTS OF SOUTH WEBER CITY ORDINANCES.

SIGNED THIS __________ DAY OF ____________________, 20____.

RAY CREEK DEVELOPMENT LLC

ACKNOWLEDGMENT

STATE OF UTAH)
County of Davis

On the ______ day of ____________ A.D., 20____, personally appeared before me, the undersigned Notary public, in and for said County of Davis in said State of Utah, the signer ( ) of the above Owner's dedication,____ in number, who duly acknowledged to me that signed it freely and voluntarily and for the uses and purposes therein mentioned.

MY COMMISSION EXPIRES: __________

NOTARY PUBLIC
RESIDING IN DAVIS COUNTY

RAY CREEK ESTATES

A PART OF THE SOUTHWEST QUARTER OF SECTION 27, AND THE SOUTHEAST QUARTER OF SECTION 28, TOWNSHIP 5 NORTH, RANGE 1 WEST, SALT LAKE BASE AND MERIDIAN, SOUTH WEBER CITY, DAVIS COUNTY, UTAH

PINNACLE Engineering & Land Surveying Inc
LAYTON • ST. GEORGE • MT. PLEASANT • W. BOUNTIFUL
327 West Gordon Ave., Suite #3
LAYTON, UT 84041
Phone: (801) 773-1910
Fax: (801) 719-6738

SOUTH WEBER WATER IMPROVEMENT DISTRICT

APPROVED THIS______DAY OF__________ , 20____, BY THE SOUTH WEBER WATER IMPROVEMENT DISTRICT.

SOUTH WEBER WATER IMPROVEMENT DISTRICT REPRESENTATIVE

ROCKY MOUNTAIN POWER

APPROVED THIS______DAY OF__________ , 20____, BY A REPRESENTATIVE OF ROCKY MOUNTAIN POWER.

ROCKY MOUNTAIN POWER REPRESENTATIVE

QUESTAR GAS COMPANY

APPROVED THIS______DAY OF__________ , 20____, BY A REPRESENTATIVE OF QUESTAR GAS COMPANY.

QUESTAR GAS COMPANY REPRESENTATIVE

SOUTH WEBER IRRIGATION CO.

THE RECORDATION OF THIS PLAT WILL VACATE THE EXISTING EASEMENT AND/OR RIGHT-OF-WAY OWNED BY THE SOUTH WEBER IRRIGATION COMPANY FOR THE CANAL ALIGNMENT THAT HAS BEEN ABANDONED. THIS ACTION IS HEREBY SANCTIONED AND MADE PERMANENT BY THE SIGNATURE OF THE AUTHORIZED REPRESENTATIVE OF SAID COMPANY HEREON CONTAINED.

APPROVED THIS______DAY OF__________ , 20____, BY A REPRESENTATIVE OF SOUTH WEBER WATER IMPROVEMENT DISTRICT.

SOUTH WEBER IRRIGATION CO. REPRESENTATIVE

CITY ATTORNEY'S APPROVAL

APPROVED THIS______DAY OF__________ , 20____, BY THE SOUTH WEBER CITY ATTORNEY.

SOUTH WEBER CITY ATTORNEY

PLANNING COMMISSION APPROVAL

APPROVED THIS______DAY OF__________ , 20____, BY THE SOUTH WEBER CITY PLANNING COMMISSION.

CHAIRMAN, SOUTH WEBER CITY PLANNING COMMISSION

CITY ENGINEER'S APPROVAL

APPROVED THIS______DAY OF__________ , 20____, BY THE SOUTH WEBER CITY ENGINEER.

SOUTH WEBER CITY ENGINEER

CITY COUNCIL APPROVAL

APPROVED THIS______DAY OF__________ , 20____, BY THE SOUTH WEBER CITY COUNCIL.

ATTEST:

SOUTH WEBER CITY RECORDER   SOUTH WEBER CITY MAYOR

DAVIS COUNTY RECORDER

ENTRY NO.____________FEE PAID_____FILED FOR RECORD AND RECORDED THIS ______ DAY OF ________, 20___ AT ______ IN BOOK ________ OF OFFICIAL RECORDS PAGE ________

DAVIS COUNTY RECORDER

BY:________________________________

DEPUTY RECORDER

11-010

SOUTH WEBER city

Technical Memorandum

July 19, 2017

To: Mayor, Council Members, and City Staff
South Weber City

From: Dana Q. Shuler, P.E.
Jones & Associates

PROFESSIONAL ENGINEER 7/20/17 No. 6578621 DANA Q. SHULER STATE OF UTAH

Re: Westside Water Reservoir Project
Phases 2 and 4 – Remediation Design (Existing Reservoir) and Alternative Site Selection (Replacement Reservoir Siting)

Jones & Associates, along with their subconsultants, IGES and ARW Engineers, has been hired by South Weber City for the Westside Water Reservoir Project. Following the completion of Phase 1 of this project which included assessing the existing reservoir, the scopes of proposed Phases 2 and 4 were revised and authorized. Phases 2 and 4 include the remediation design recommendations for the reservoir and an alternative site selection of a replacement reservoir, respectively. Deliverables include this technical memorandum, geotechnical/geological report, cost estimates, and preliminary design drawings.

1. Property and Access Assessment

The one-million gallon (1 MG) reservoir is situated on a 1.5585 acre parcel owned by South Weber City. It shares the site with a 100,000 gallon above-ground reservoir. The property was conveyed via warranty deed from Luella H Byram on March 23, 1976. Abutting properties are Hill Air Force Base and Dad's Farm LLC (Darrell Byram).

Beginning at South Weber Drive, access to the site is obtained via a private road (7150 S) and dirt driveway. Although no formal survey was performed, parcels traversed may include:

1. 13-020-0002 – Mountain Fuel
2. 13-020-0051 – Goates, Jeffrey & Kim C
3. 13-020-0052 – Cook, Scott S & Savannah H – Trustees
4. 13-246-0002 – Cook, Ryan J & Stephanie A
5. 13-246-0001 – Cook, Scott S & Savannah H
6. 13-020-0025 – Bigler, Barrey J – Trustee
7. 13-020-0026 – Coy, Lynn T & Judy M – Trustees
8. 13-020-0028 – East South Weber LLC

9. 13-020-0053 – Cook , Scott S & Savannah H – Trustees
10. 13-024-0004 – Davis & Weber Counties Canal Company
11. 13-024-0005 – Davis & Weber Counties Canal Company
12. 13-024-0003 – Cook, Stanley R & Bonnie B
13. 13-020-0047 – Dad's Farm LLC, c/o J Darrell Byram, Indian Springs LLC

Based on conversations with Mark Larsen (Public Works Director) and Mr. Byram (adjacent property owner), no access easements or agreements are known to exist. Additionally, the drain line from the tanks leaves the City's property and heads due-north through Mr. Byram's property down to the canal. According to Mr. Byram, no easement was obtained for the drain line.

In-depth deed research was not included in this task.

1.1. Property and Access Recommendations

It is recommended that the City have the area formally surveyed to determine where property lines lie, and therefore which properties are affected. Then, the City should obtain access easements from the affected property owners. Recording these easements will ensure the City's access rights if and when parcels are sold and/or developed. On the south side of the Davis and Weber Counties Canal Company (DWCCC) canal, the City may be able to trade road and bridge improvements for no-cost easements.

2. Geotechnical Investigation

2.1. Investigation

Under this task, IGES performed a subsurface investigation to assess the geologic and geotechnical conditions in the area of the 1MG tank. The physical investigation included three (3) geologic trenches and five (5) soil borings. Engineering analysis consisted of performing slope stability modeling of the hillside north of the tank under existing conditions. Both static and pseudo-static (seismic) loading conditions were evaluated. Consideration was also given to possible fluctuations in soil moisture content as a result of tank seepage or seasonal climatic variations.

2.2. Findings

IGES' conclusions are as follows:

1. Based on observations, testing and modeling, the hillside will be globally stable under existing conditions.
2. Smaller ancillary slides or local stability failures may occur.
3. Increased soil moisture will elevate the risk for local and global slope failures.
4. The seismic performance of the existing hillside under observed conditions is considered acceptable, but is not acceptable if saturated moisture conditions or buildup of excess pore pressure coincide with a seismic event.

For further information, please see IGES' full report contained in Attachment A.

2.3. Geotechnical Recommendations

IGES' recommendations are as follows:

1. Provide adequate surface drainage to manage storm water at the site, limiting infiltration of surface water into the near surface soils downhill of the tank.
2. Repair tank leaks to prevent infiltration of moisture from the tank into the soil.
3. Monitor the slope for future movement. Monitoring should include observations and surveying to document any surficial mass movements.
4. Install an inclinometer to monitor potential movement at greater depth. The exact location of inclinometer casing can be somewhat flexible, however it should be located on the slope between the existing landslide headscarp and the tank.

3. Reservoir Remediation Investigation (Leak Investigation)

3.1. Previous Studies

In 2010, South Weber City retained ARW Engineers to perform a limited investigation of the leaking reservoir. With no drawings of the tank or known construction methods, ARW could not evaluate the structural integrity of the tank. Based on their findings, they concluded that the tank was most likely leaking through cracks in the floor or the floor-wall joint possibly caused by unstable subsoils or poor structural design. ARW recommended hiring a geotechnical engineer to investigate the subsurface soils. They also stated that "polymer injections into the subgrade might be an option" if the slab needed additional support. Attachment B contains the letter with their findings.

Subsequently, in 2011, South Weber City contracted with GeoStrata Engineering and Geosciences to investigate the floor of the 1 MG reservoir. GeoStrata used a combination of ground penetrating radar (GPR), a manometer survey, and floor cores to evaluate the reservoir's floor. Overall, they found:

1. Numerous "anomalies" under the floor slab, indicative of voids filled with water or air;
2. The floor slab had 8-inches of elevation difference from the high side to the drain; and
3. Four (4) 6- to 13-inch long cores of the floor revealed a 1-inch void under the slab.

Additionally, GeoStrata investigated the general geology of the area. While noting that the tank is built upon an old landslide, and a new landslide scarp is evident nearby, they do not believe this to be affecting the tank. GeoStrata recommended pressure grouting under the floor for stabilization. The full assessment can be found in Attachment C.

3.2. Previous Remedies

Following that investigation, the City opted to seal the cracks in the floor and approximately one (1) foot either side of the wall-floor joint. At that time, it was assumed that the reservoir would be replaced, so expenditures were kept to a minimum. The leak rate subsided temporarily, but then increased over time, likely due to floor movement/settling.

Based on the information contained in the aforementioned reports and provided by City personnel, previous remedies for the leak have included sealing floor cracks and sealing the floor slab.

3.3. Leak Remediation Recommendations

Based on our observations and current and past investigations, we recommend the following in order to best control leaking of the tank:

1. Pressure grout under floor slab to fill voids under the floor and stabilize the floor slab. Without this stabilization measure, sealing cracks is futile because the floor will continue to settle.
2. Remove, via sandblasting, existing deteriorated coatings. Rout out and seal cracks and joints with new joint sealer.
3. While the tank is offline, it would be prudent to apply sealant to the entire floor and walls (to 1' below lid).

4. Criticality Assessment

Asset criticality is the relative risk of a high cost arising from failure of that asset. A criticality assessment prioritizes which assets are most important to monitor and maintain. Components of criticality include:[1]

1. Modes of Asset Failure – physical (deterioration, structural); capacity/utilization; level of service; obsolescence; cost or economic impact
2. Cost of Failure – cost of replacement; cost from loss of service; cost from legal liability
3. Risk of Asset Failure – design life; maintenance program; operations; external factors
    - ✓ "Risk equals Cost of Failure times Probability of Failure."[1]
4. Relative Importance – for which assets is it most important to avoid failure?

Evaluating the criticality of the 1 MG reservoir using the above components:

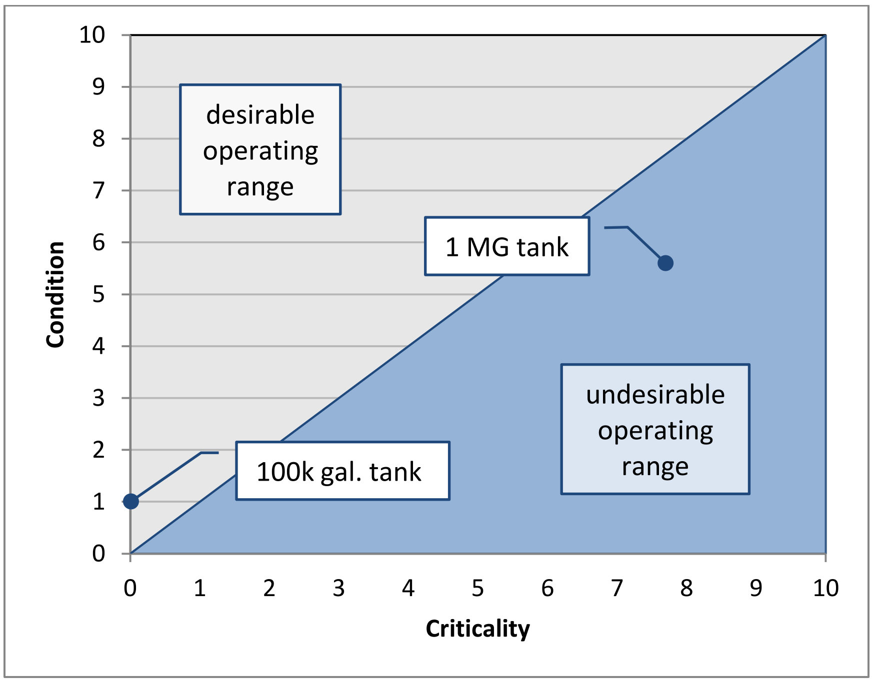
1. Modes of Asset Failure – The reservoir is in average physical condition with capacity that contributes to the City's ability to provide a level of service meeting the Division of Drinking Water regulations. The tank is not obsolete in its use.
2. Cost of Failure – Should the tank catastrophically fail, significant costs are associated with replacement and loss of service, as the water system would operate very inefficiently during such time. Some costs from legal liability may occur, although small. Should development occur downhill of the tank, this liability will increase.
3. Risk of Asset Failure – With an unknown design and erection date, it is difficult to identify the probability of failure. Recent inspections find the reservoir to be in average condition, but it is unknown if the structure was designed to withstand seismic events. Operation and

[1] Trilogics Technologies, Inc. (2005, November 30). *Criticality: A Key Idea in Asset Management.* Retrieved April 2017, from International City/County Management Association: www.icma.org

maintenance costs of the asset are relatively low. External factors that may contribute to failure include natural or manmade disasters, such as earthquake or sabotage.

4. Relative Importance – Relative to the overall operation of the water system, this reservoir is of medium-high importance, meaning, while the water system can continue to operate without this tank, it will do so ineffectively and with a decline in the customers' level of service.

Smaller towns and cities typically do not have unnecessary redundancy built in to their water systems. Most of the infrastructure components are of medium-to-high importance to the overall workings of the system, and therefore must be kept in good working order. Deterioration occurs rapidly once a component is neglected or out of use. The more critical the structure to the workings of a system, the better condition it needs to be kept. This is pictorially shown in the following figure.



Currently, the 1MG reservoir is medium-to-high on the criticality scale and in average condition. As shown in the figure, this puts the asset in the undesirable operating range. Additionally, if one of the other reservoirs should go offline for maintenance or an emergency problem, this reservoir's criticality would increase, pushing its current evaluation even further into the undesirable operating range. Therefore, it would be beneficial to increase the condition of the tank in order to stay in the desirable operating range.

Also shown is the 100k gallon reservoir. This reservoir is not needed for the operation of the water system and is in poor condition, therefore falling in the lower left portion of the graph.

5. Remediation Design Recommendations

After assessing the site and reservoir using past and current data, the following remediation measures are recommended in order of priority:

1. 1 MG Reservoir
    a. See previous section (leak remediation)
    b. Replace ladders with new; add ladder-ups (safety device)
    c. Blast and paint interior pipes
2. Site Improvements. The following site improvements are based on safety and security:
    a. Grading for drainage around and away from reservoirs
    b. Grade and add base course for parking
    c. Replace gate with new 16' wide gate
    d. As funds allow, add intruder resistance (barbed wire)
3. Upgrade SCADA
    a. Ultrasonic sensors (pressure transducers)
    b. Hatch alarms
    c. Coordination with Weber Basin Water Conservancy District well (meter and valve status readability)
4. North Vault
    a. Revise piping
    b. New gauge and transducer
    c. Replace air/vacuum valve
    d. Add drain piping
5. East Vault
    a. Abandon in place
6. 1 MG Tank Exterior
    a. Replace both hatches with new spring-assisted lids
7. Bridge across canal
    a. Replace with pre-fabricated bridge
    b. Enter in agreement with DWCCC, possibly landowners
8. Access Improvements. This 1 MG reservoir should be considered a critical facility for the City. Therefore, safe access to/from the site should be traversable in all weather conditions.
    a. Grade and add base course to access road for all-weather surface
    b. Add drainage improvements

Concept plans showing these recommendations are included in Attachment D.

6. Budgetary Estimates

Budgetary estimates have been developed for each of the above eight (8) items. Engineering and contingencies have been figured based on the total of all the items. The estimated grand total for the rehabilitation of this tank is $400,000. Details of this cost estimate can be found in Attachment E. Additionally, preparation and obtainment of easements is estimated at $90,000.

For comparison, a budgetary estimate was developed for a replacement reservoir, assuming that the location would be adjacent to the existing site. This is estimated at $1.6M and includes the same off-site improvements as the rehabilitation estimate, as well as the demolition of the 100,000 gallon reservoir and new site work and piping. $240,000 is estimated to be the cost of the land and easements. Please note that the costs for components included in a new tank can fluctuate drastically depending on the economy; therefore, this estimate should only be used as a reference for future budgeting proposes.

7. Cost/Benefit Analysis

Below is a summary table comparing the rehabilitation and replacement options.

Rehabilitation	Replacement
$400,000 – Engineering and Construction $90,000 – Survey and Easement Acquisition 15-20 year design life • $32,700/year capital cost	$1,600,000 – Engineering and Construction $240,000 – Survey, Easement and Property Acquisition 50-60 year design life • $36,800/year capital cost
Unknown design and construction standards	Up-to-date design and construction standards • Structural/seismic • Geotechnical/geological
Safety upgrades	Safety considerations incorporated
No additional land needed (utilize existing site)	Additional land needed
Access and utility easements needed	Access and utility easements needed
Off-site improvements recommended • Can also be used for future replacement reservoir	Off-site improvements needed
-	May keep 1MG reservoir for emergency purposes

8. Alternative Site Evaluation

8.1. Geologic/Geotechnical Reconnaissance

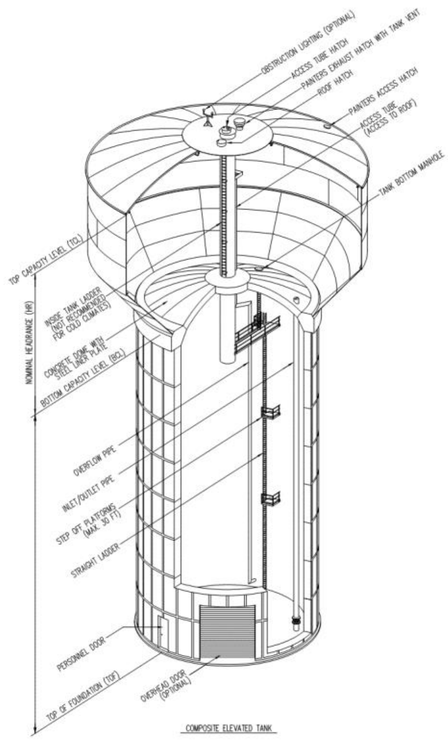
Based on the geologic map[2] for the South Weber area, all of hillside in the vicinity of the reservoir is landslide deposit (geologic unit Q_{ms}, either older or younger), scattered with scarps. Some scarps are visible to the naked eye. South Weber Drive generally follows the boundary of two geological units: Q_{ms} and Q_{al}. (Q_{al} is stream alluvium.)

8.2. Property Search (Elevation/Proximity/Accessibility)

The site of a replacement buried or ground reservoir would need to approximately match the ground elevation of the existing reservoir. The elevation contour of the current tank only traverses private property in the immediate vicinity of the existing reservoir; otherwise, that elevation falls within Hill Air Force Base boundaries and/or property.

8.3. Alternative Configuration

An alternative to replacing the existing ground storage tank with another ground storage tank would be to construct an elevated tank, likely located near South Weber Drive. While not prevalent in Utah, elevated storage tanks are common across the United States. They vary in volume from tens of thousands to many million gallons. The most common sizes are 200,000 to 2,000,000 gallons. The figure to the right shows a cross-section of composite elevated water tank.[3]



COMPOSITE ELEVATED TANK

Benefits of an elevated storage tank include a small footprint and flexible location due to height variability. Drawbacks include slightly higher maintenance costs and the unfamiliarity of operation and maintenance personnel. Elevations would have to be more closely examined, but an elevated tank may be considered.

8.4. Recommendations

For the purposes of this report, we have assumed that the City favors ground storage over elevated storage. Since no other suitable property exists, we recommend obtaining property, about 1.5 acres, on land adjacent (east-south) of the existing site.

a. Site will have access to existing transmission line and drain line.
b. Demolishing the existing 100,000 gallon reservoir will provide additional area.

[2] Yonkee and Lowe (2004). Geologic Map of the Ogden 7.5' Quadrangle, Weber and Davis Counties, Utah. Utah Geological Survey.

[3] ©CB&I (2017). www.cbi.com

c. Assuming access and utility easements for the existing reservoir are obtained, no additional easements would be needed.
d. While this location won't improve the pressure or flows at west end of town, development with looped water lines will help improve service.

9. Overall Recommendations – Summary

9.1. Property and Access

a. Obtain easements/agreements for legal access and existing pipelines

9.2. Geotechnical

a. Install and monitor piezometers
b. Other recommendations incorporated into Section 9.3 – Improvements below

9.3. Improvements, in order of priority

a. 1 MG tank interior improvements (pressure grout under floor; crack seal; surface sealant)
b. Site Improvements (grade for positive drainage, driveway, 1 MG drain air gap)
c. SCADA upgrades
d. North vault improvements
e. East vault abandonment
f. 1 MG tank exterior improvements (hatches)
g. Bridge replacement
h. Access improvements (off-site)

9.4. Alternate Site Evaluation

a. Consider purchasing land adjacent to existing site for future replacement reservoir (about 1.5 acres)

Attachments

A – IGES Report (2017)
B – ARW Investigation Letter (2010)
C – GeoStrata Assessment (2011)
D – Concept Plans
E – Budgetary Estimate

ATTACHMENT A

IGES REPORT (2017)

4153 Commerce Drive
Salt Lake City, UT 84107
Ph: 801.270.9400
Fx: 801.270-9401

Geologic/Geotechnical Evaluation for:

Westside Reservoir, South Weber, Utah

IGES Job No. 01747-002

February 21, 2017

Prepared for:

Jones & Associates

c/o Dana Shuler, P.E.

THIS DOCUMENT WAS PREPARED FOR USE ONLY BY THE CLIENT, ONLY FOR THE PURPOSES STATED, AND WITHIN A REASONABLE TIME FROM ITS ISSUANCE. PLEASE READ THE "LIMITATIONS" SECTION OF THIS REPORT.

IGES®
Intermountain GeoEnvironmental Services, Inc.
4153 South 300 West, Salt Lake City, Utah 84107 ~ T: (801) 270-9400 ~ F: (801) 270-9401

Prepared for:

Jones & Associates
c/o Dana Shuler, P.E. | Senior Engineer
1716 East 5600 South,
South Ogden, UT 84403.

Geologic/Geotechnical Evaluation for:

Westside Reservoir
South Weber, Utah

IGES Job No. 01747-002

Prepared by:

Jared A. Hawes, P.E.
Senior Engineer

Peter E. Doumit, P.G., C.P.G.
Senior Geologist

IGES, Inc.
4153 South 300 West
Salt Lake City, Utah 84107
(801) 270-9400

February 21, 2017

TABLE OF CONTENTS

APPENDIX

1.0 EXECUTIVE SUMMARY

This report presents the results of a subsurface geologic/geotechnical investigation conducted to support evaluation of the existing Westside Reservoir (Water Tank) located in South Weber, Utah. The tank is located in the northwest quarter of Section 33, Township 5 North, Range 1 West, S.L.B.M (USGS, 2014) in an area that has been mapped as being underlain by Holocene-aged landslide deposits (Yonkee & Lowe, 2004). The purposes of this investigation were to assess the geologic and geotechnical conditions in the area of the tank and to assist Jones & Associates (JA) in understanding how these conditions could impact slope stability and the tank itself. In particular, field investigation, laboratory testing and slope stability modeling were performed to: 1) evaluate the possible origins of the geomorphological features mapped as landslides; 2) assess the nature, age, and current stability of the mapped landslide mass; and 3) determine the potential for future movement of the mass.

A preliminary geologic hazards assessment, including site reconnaissance and surface mapping of landslide evidence was completed by IGES in September of 2016. Subsurface investigation of the site was performed by IGES between December 5 and 13, 2016. Exploration of the subsurface soil conditions was accomplished by excavating three near-surface trenches and advancing five soil borings at select locations surrounding the tank. Trenches were completed with the aid of a Hitachi Zaxis 160 LC tracked excavator. They varied in length from 79 to 167 feet and depth from 12 to 18 feet. Approximate trench locations are shown on the Site/Exploration Location Map (Plate A-3). The five borings were completed to depths of 46.5 to 51.5 feet below the existing site grade and are also shown on the Site/Exploration Location Map. Drilling was accomplished with a Geoprobe 7822 DT track-mounted drill-rig equipped with percussion hammer and 7-inch hollow-stem augers for continuous and conventional geotechnical sampling, respectively.

Our engineering analysis consisted of performing slope stability modeling of the hillside north of the existing tank under existing conditions. Both static and pseudo-static (seismic) loading conditions were evaluated. Consideration was also given to possible fluctuations in soil moisture content as a result of tank seepage or seasonal climatic variations.

Our conclusions and recommendations are summarized below:

- Based on our observations, testing and modeling we assert that the hillside will be globally stable under existing conditions.
- Smaller ancillary slides or local stability failures may occur.
- Increased soil moisture will elevate the risk for local and global slope failures.
- The seismic performance of the existing hillside under observed conditions is considered acceptable, but is not acceptable if saturated moisture conditions or buildup of excess pore pressure coincide with a seismic event.
- Repair of tank leaks is recommended to prevent infiltration of moisture from the tank into the soil.
- We recommend adequate surficial drainage be provided to manage storm water at the site, limiting infiltration of surface water into the near surface soils downhill of the tank.
- If the tank is to remain in service, we anticipate that leak repairs and other structural upgrades will be made.
- We recommend that the slope be monitored for future movement. Monitoring should include observations and surveying to document any surficial mass movements.
- We also recommend that an inclinometer be installed to monitor potential movement at greater depth.
- Inclinometer casing is usually installed in a borehole. The exact location of inclinometer casing can be somewhat flexible, but it should be located on the slope between the existing headscarp and the tank.

NOTICE: The scope of services provided within this report are limited to the assessment of the subsurface conditions for the proposed residential development. This executive summary is not intended to replace the

report of which it is part and should not be used separately from the report. The executive summary is provided solely for purposes of overview. The executive summary omits a number of details, any one of which could be crucial to the proper application of this report.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a subsurface geologic/geotechnical investigation conducted to support evaluation of the existing Westside Reservoir located in South Weber, Utah. The tank is located in the northwest quarter of Section 33, Township 5 North, Range 1 West, S.L.B.M (USGS, 2014) in an area that has been mapped as being underlain by Holocene-aged landslide deposits (Yonkee & Lowe, 2004). The purposes of this investigation were to assess the geologic and geotechnical conditions in the area of the tank and to assist Jones & Associates (JA) in understanding how these conditions could potentially impact slope stability surrounding the tank. In particular, field investigation, laboratory testing and slope stability modeling were performed to: 1) evaluate the possible origins of the geomorphological features mapped as landslides; 2) assess the nature, age, and current stability of the mapped landslide mass; and 3) determine the potential for future movement of the mass.

This report documents the follow-up subsurface investigation to a preliminary geologic hazard assessment conducted for the property in September of 2016 (IGES, 2016). The scope of work completed for this study included subsurface exploration, soil sampling, laboratory testing, engineering analyses, and preparation of this report. Our services were performed in accordance with our proposals and signed authorizations, dated November 2, 2016. The recommendations contained in this report are subject to the limitations presented in the "Limitations" section of this report.

2.2 PROJECT DESCRIPTION

It is believed that the Westside Reservoir water tank was originally constructed sometime in the 1950's by the federal government for use by Hill Air Force Base, but was purchased by South Weber City and has been used as part of the City water system ever since. The tank is known to leak and South Weber is currently evaluating it for continued use or possible replacement.

The tank sits on a natural slope above the Weber River floodplain. Geologic mapping of the area shows the entire slope to be comprised of Quaternary-aged landslide deposits. Young landslides (Holocene) are mapped at several locations along the hillside east and west of the tank site, with one slide being located immediately downslope of the tanks. Slope failure in the vicinity of the tank could cause not only damage to the tank and the water supply, but to the Davis-Weber Canal and other homes located downhill of the tank.

3.0 METHOD OF STUDY

3.1 PREVIOUS INVESTIGATION

In Phase I of our investigation an engineering geologist investigated the geologic conditions within the area of the tank. Geologic research consisted of reviewing existing aerial photographs, previous geologic reports of the area, and other available geologic literature pertinent to the site. A field geologic reconnaissance was conducted to observe existing geologic conditions and site geomorphology. Detailed findings of the preliminary geologic investigation were presented in a letter report (IGES, 2016) and additional details from this work are summarized in Sections 4.0 and 5.0 of this report.

3.2 SUBSURFACE INVESTIGATION

Based on the previous mapping and site observations, three locations were selected for near-surface investigation using trenching and five locations were selected for deeper investigation with soil borings. The subsurface exploration locations are shown on Figure A-1 in Appendix A.

3.2.1 Trenches

Between December 6 and December 7, 2016, three exploration trenches were excavated at representative locations across the property, where potential landslide hazards had been identified during the site reconnaissance and field mapping. The trenches were excavated to depths ranging between 12 and 18 feet below existing grade and 79 and 167 feet long with the aid of a Hitachi Zaxis 160 LC tracked excavator. Detailed hand logs for each of the trenches are displayed in Figures A-2 through A-4 in Appendix A, and a discussion of the findings from each of the trenches is presented in Section 5.0. In general, the subsurface profile consisted of distinct A and B topsoil horizons forming upon several different Lake Bonneville deposits (both shoreline sands and gravels, as well as deeper water silts and clays) that have been modified by mass-movement processes. Groundwater was not encountered in any of the trenches.

3.1.2 Soil Borings

IGES conducted deeper subsurface investigation of the site on December 12 and 13, 2016. Exploration of the subsurface soil conditions was accomplished by advancing five soil borings at select locations near the existing tank and hillside north of the tank. The approximate locations of the borings are also shown on Figure A-1. The borings were completed to depths of 40 to 55 feet below the existing site grade. Drilling was accomplished with a GeoProbe 7822 DT track-mounted drill-rig equipped with both percussion hammer for continuous sampling and 7-inch hollow-stem augers which were utilized to collect conventional disturbed and relatively undisturbed geotechnical soil samples.

The materials encountered during drilling were observed and logged by our field engineer and are presented on the Boring Logs in Appendix A (Figures A-5 to A-9). A key to Soil Symbols and Terms is located on Plate A-10.

3.3 LABORATORY INVESTIGATION

Representative soil samples were tested in the laboratory to evaluate pertinent physical and engineering properties. Laboratory soil tests consisted of moisture, density, gradation analyses and Atterberg limits tests, to aid in characterizing the soils encountered. Consolidated undrained direct shear tests were performed to assess the strength characteristics of the soils. The results of all laboratory tests are presented on the Boring Logs in Appendix A, and in the Summary of Laboratory Test Results Table (Figure B-1) and lab results data sheets in Appendix B.

3.4 ENGINEERING ANALYSIS

Global slope stability analyses were performed to assess stability concerns for the slope adjacent to the tank. Within the global modeling scenario, additional models were developed to potential conditions such as groundwater fluctuations, and performance under seismic or pseudodynamic loading conditions. The software Slide version 7.0 (by Rocscience), which expresses the stability in terms of a factor of safety against sliding, was used to model the global and local stability concerns for the existing hillside. Considering the favorable results of preliminary tank structural assessment, we have not accounted for any potential changes to the tank or the grading surrounding the tank. If any changes to site grading are proposed, IGES should be notified so that we can assess potential impacts on slope stability.

Soil parameters used in the existing and proposed analyses were derived from the in situ sampling and laboratory testing completed for this investigation. Topographic and stratigraphic parameters for the existing landslide mass were generated from maps of the surrounding topography, field observations, and sampling and testing of soils encountered within the trench and boring explorations.

4.0 GEOLOGIC CONDITIONS

4.1 PREVIOUS STUDIES

A detailed discussion of local geology was provided during Phase I, Geologic Hazards Assessment of this project (IGES, 2016). Previous work included a thorough review of geologic literature, historical aerial photography and site reconnaissance to assess and document the general geologic conditions present across the property, with specific interest in those areas identified by literature and aerial imagery reviews as potential geologic hazard areas. Our 2016 report can be reviewed for detailed assessment of faults, debris-flows, rockfall hazard and liquefaction potential. The intent of this report is to provide greater detail on potential landslides/mass-movement hazard associated with this property.

4.1 LANDSLIDES/MASS MOVEMENT

Landslides and mass movement hazards pose the most risk to the tanks located on the property. The property is entirely within an area previously mapped as landslide deposits (Yonkee and Lowe, 2004; Coogan and King, 2016), aerial imagery indicated hummocky topography and associated scarps, and the site reconnaissance observed hummocky topography, several landslide scarps (including fresh scarps), and buried modern topsoil. The project area and associated water tanks are located within the Washington Terrace Landslide Complex. Additionally, multiple historic landslide events have occurred within ½ mile of the property and the aerial imagery review and site reconnaissance documented evidence of ongoing upslope propagation of an active landslide headscarp located approximately 300 feet to the northeast of the larger water tank.

4.2 SURFACE-FAULT RUPTURE AND EARTHQUAKE-RELATED HAZARDS

No faults are known to be present on or projecting towards the property, and the closest active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 3.1 miles to the west of the property (USGS and UGS, 2006). Given this information, the risk associated with surface-fault-rupture on the property is considered low.

The entire property and associated water tanks are subject to earthquake-related ground shaking from a large earthquake generated along the active Wasatch Fault. Given that the tanks are situated upon already marginally stable landslide deposits, seismic energy from an earthquake is likely to induce movement of these deposits. This could result in significant damage to the tanks. Therefore, the risk associated with earthquake-related ground shaking is considered high. The expected maximum ground acceleration from a large earthquake at the subject site with a two (2) percent probability of exceedance in 50 years is 0.56g. Based on our field investigation, it is our opinion the subsurface stratum and soils at this site are representative of a "stiff soil" profile having an average shear-wave velocity of $600 \leq \bar{\upsilon}_S \leq 1{,}200$ (ft/sec) in the top 100 feet, best represented by IBC Site Class D, having Site Coefficients of F_a= 1.0 and F_v=1.51.

5.0 GENERALIZED SITE CONDITIONS

5.1 SURFACE CONDITIONS

The hillside surrounding the tank property consists of a gradual northeast trending slope vegetated with brush and grasses. More substantial tree growth is sparse. The head of the mapped landslide is located in a north, northeast-facing “U” shaped scarp. The head wall of this scarp has the general appearance of a steep slope vegetated with native brush, grass and scrub oak. The surface of the landslide mass is not as steep as the “U” shaped scarp, and is similarly vegetated with native grasses and brush. Similar vegetation is present near the existing tanks.

5.2 SUBSURFACE CONDITIONS

As previously mentioned, the subsurface soil conditions were explored on the landslide during two phases of investigation. During the first phase three relatively shallow trenches were excavated and logged. Five relatively deep borings were completed in the second phase. The subsurface soil conditions encountered were logged at the time of trenching and drilling and are included in Appendix A (Figures A-2 to A-9). The soil and moisture conditions encountered during our investigation are discussed below.

5.2.1 Soils

Near-surface soils were sampled at selected locations within the trench excavation as well as in the five borings advanced for this investigation. Soil depth was observed to the maximum depth of boring excavation (55 feet in Boring B-4), and bedrock was not encountered in any of the trench or boring investigations performed for this project. The soils encountered in these exploration locations consisted of Lean CLAY (CL), GRAVEL (GM, GP-GM) and SAND (SP, SM). These soils may consist of both locally-derived sediments and layers of Lake Bonneville deposits.

Near-surface conditions encountered during trenching are described in the following sections.

5.2.1.1 Trench 1

TR-1 was the longest (167 feet) and deepest (up to 18 feet) of the three trenches excavated. The trench was spotted north of the City tank property, with the southern end of the trench located approximately 140 feet north of the Westside Reservoir (see Figure A-1). The trench cut through the active landslide headscarp that was observed north of the property during the site reconnaissance, and extended upslope to near the base of the older landslide headscarp found immediately north of the northern margin of the property.

As many as 11 distinct lithologic units were identified within the trench, representing facies[1] changes from shoreline sands and gravels to near-shore, shallow-water sands to off-shore, deeper-water silts and clays (Figure A-2). Evidence of landsliding was prevalent throughout the trench. Near the northern (downslope) margin of the trench, the active landslide headscarp was observed to have a conspicuous slide plane striking at N50°W and dipping at approximately 60-65°NE. The slide plane appeared to be listric[2], exhibiting a shallower dip angle with depth, and was observed to pass through individual lithologic units as opposed to along the contact between them. In large part due to the presence of granular materials, slickensides[3] and other evidence of shear were not observed along the slide plane. Vertical offset of subsurface units along the slide plane was approximately 3 feet.

Unit 4, denoted as Bonneville Sand and Gravel 1, was the most prevalent unit within the trench, and displayed several characteristics indicative of mass-movement. The top and bottom contacts were very sharp, but highly undulatory and irregular. Bedding was found to have a wide variety of orientations, with apparent dips ranging from steeply dipping downslope to the north to subhorizontal to gently dipping upslope to the south. Several small unit-confined faults with as much as 3 feet of offset and abundant other fractures with calcium carbonate cement were

---

[1] Facies: The aspect, appearance, and characteristics of a rock unit, usually reflecting the conditions of its origin; esp. as differentiating the unit from adjacent or associated units. (AGI, 2005)

[2] Listric fault: A curved downward-flattening fault, generally concave upward. (AGI, 2005)

[3] Slickenside: Originally, a polished fault surface formed by frictional wear during sliding, but now used to denote any of several types of lineated fault surfaces. (AGI, 2005)

observed within the unit, suggestive of continual minor adjustments being made within the unit to accommodate slow downslope movement.

The southern end of the trench exhibited a highly irregular assemblage of lithologic units, showing undulatory, unorthodox contacts and chaotic bedding orientations that was interpreted to be indicative of a discrete episode of shallow landsliding (Unit 10). However, a distinct slide plane was not observed, despite the southern end of the trench being located near an older, inactive headscarp.

5.2.1.2 Trench 2

TR-2 was spotted in the southeastern corner of the City property, approximately 80 feet southeast of the Westside Reservoir (see Figure A-1). The trench was 87 feet long, and was excavated to a maximum depth of 13 feet below existing grade.

Four distinct lithologic units were identified within the trench, including a thin topsoil (Unit 1) forming upon a fill unit (Unit 2) that was likely local material utilized to level the ground surface preceding the emplacement of the existing water tanks at the site (Figure A-2). Distinct evidence of landsliding was not observed within the trench, though a highly irregular contact between a sandy silt deposit (Unit 3) and an underlying sand and gravel deposit (Unit 4) was observed. Bedding within Unit 3 was found to be horizontal to subhorizontal.

5.2.1.3 Trench 3

TR-3 was the shortest (79 feet) and shallowest (up to 12 feet) of the three trenches excavated. The trench was spotted in the central portion of the Weber City property, approximately 75 feet northwest of the Westside Reservoir. The southern end of the trench located approximately 140 feet southwest of the Westside Reservoir (see Figure A-1).

Six distinct lithologic units were identified within the trench, with the characteristics of the lithologic units more consistent with TR-1 than TR-2 (Figure A-2). Like TR-1, evidence of landsliding was prevalent throughout the trench. Two slide planes were observed at opposite ends of the trench, and dipping in opposite directions. The northern slide plane was much more conspicuous, having abundant associated calcite cement/infilling and a stony trace, and was found to be striking at S80°E and dipping listrically at 70°SW (upslope). The southern slide plane had an apparent dip of 64°N. Similar to as seen in TR-1, these slide planes were observed to pass through individual lithologic units as opposed to along the contact between them, and no slickensides or evidence of shear were observed. The amount of vertical offset associated with these slide planes was unable to be determined, though bedding observed in Unit 6b was entirely dipping to the south. This suggests the slide planes are connected as part of a generally shallow rotational slump plane, and that the material between the two slide planes has been back-rotated.

Most of the trench was encompassed by silty sand deposits (Units 5 and 6), though the basal contact of these deposits with underlying sand and gravel deposits (Unit 3) was highly irregular. In the southern end of the trench, an isolated block of silty clay was found within a package of sand and gravel, and the block had been rotated such that the bedding was vertical. South of the southern slide plane, multiple Unit 3 sand and gravel packages were found to be in anomalous contact with the silty sands of Units 6a and 6b.

5.2.1.4 Deep Soils

To explore beneath the safe limits of trench exploration, five additional borings were completed. The approximate location of these explorations is also shown on Figure A-1.

Beneath the soils described in the previous trench sections, explorations typically encountered fine-grained soils. Lean CLAY (CL) with occasional to frequent seams of fine sand (SP) and silty-sand (SM) were encountered throughout the depth of each exploration. Bedding of sediments appeared to be horizontal to subhorizontal. Most sand seams were dry and relatively thin (<1/4 inch). However, less-frequent, moist and loose sand seams up to 3 feet in thickness were encountered in some of the explorations. Boring logs with detailed descriptions of the conditions encountered are included as Figures A-5 to A-9. The stratification lines shown on the boring logs represent the approximate boundary between soil types. The actual in-situ transition may be gradual. Due to the nature and depositional characteristics of the landslide deposits, care should be taken in interpolating subsurface conditions between and beyond the exploration locations.

5.2.2 Bedrock

Bedrock was not observed to outcrop in the area of the tank property, and was not encountered in any of the trench or boring explorations.

5.2.3 Groundwater/Moisture Content Conditions

The soil moisture content ranged from a low of 2.8% to a high of 28.8%. Seasonal fluctuations in precipitation, surface runoff, or other on or offsite sources may also increase moisture conditions within the soils. Groundwater was not encountered near the surface in any of the open trench excavations; however, perched water was confined in some sand and clayey sand seams located at greater depth within the hillside clay deposits. Based on discussions with South Weber City personnel, water has been encountered in near-surface excavations at various locations and depths along the hillside below the tank. We anticipate that moisture levels within the near-surface sands and gravel will fluctuate seasonally with precipitation and snowmelt.

6.0 ENGINEERING ANALYSIS AND CONCLUSIONS

6.1 GENERAL CONCLUSIONS

Our engineering analysis consisted of performing slope stability modeling of the hillside under existing conditions and loads. Additional modeling was performed in an effort to understand potential impacts of seismic activity and variations in moisture to stability. As with other large slides, smaller ancillary landslides are often present within the larger slide complex. Our slope stability modeling considered the presence of smaller and shallower slides within the slide complex. To assess movement of any type both around and within the slide, an engineering geologist visually inspected the area, including an active internal scarp located downslope of the water tank for signs of recent distress and/or movement. The active scarp was observed to be stepped upslope with fresh soil exposures, indicating ongoing upslope propagation of the scarp. However, mature vegetation including large scrub oak was present in these areas, indicating that no recent large-scale movement has occurred.

6.2 SLOPE STABILITY

6.2.1 Topography

The existing topography of the terrace slope was approximated from site topographic maps and Google Earth Pro. Some topography data was provided by Jones & Associates, but the topography of the entire slope was not generated from a site survey performed specifically for this study.

A two-dimensional slope section was generated from this estimated surface topography, taking into account the steepest portions of the slope and the locations of the existing tank and observed internal scarp north/downhill of the tank. This section was then modeled using Slide 7.0 by Rocscience, a two-dimensional geotechnical software application which compares slope geometry, stratigraphy and soil strengths to evaluate slope stability.

6.2.2 Soil Strength Parameters

Soil strength parameters for the static stability evaluations are based on laboratory analysis and in-situ testing of the soil samples taken during both phases of our field investigation. Additionally, published strength data values were utilized for similarly classified soil types. Several soil types were used in the slope stability models. The soil parameters used in the slope stability assessment are listed below.

Model Soil Type	Total Unit Wt (pcf)	Saturated Unit Wt. (pcf)	Cohesion (psf)	Friction Angle (deg)
Surface Sand & Gravel	120	130	0	25
Tank Backfill	120	130	0	32
Native Clay	120	127	300	32
Loose Silty Sand	100	110	0	18
Native Clay 2	120	125	300	32
Loose Sand 2	100	110	0	24
Native Clay 3	120	128	500	32
Loose Sand 3	110	120	0	26
Native Clay 4	126	135	400	32

As described in section *5.2.1 Soils* and shown Appendix A, a wide range of soil types were encountered in relatively shallow excavations. Determination of the engineering properties for each soil type identified on site is beyond the scope of this investigation. Given the observed variability of soils, the limited exploration of the site conducted for this investigation may not accurately predict all geomechanical behavior to be expected at the site.

6.2.3 Stratigraphy

In creating a geologic section for use in the global slope stability model it was necessary to make assumptions regarding the deeper subsurface stratigraphy between the exploratory borings.

Because soils are deposited by natural, uncontrolled processes, extrapolation of our observations is not likely to produce an exact representation of the deeper stratigraphy.

Based on our observations, the soils that comprise the majority of the terrace deposit are fine-grained in nature with occasional seams of moist to wet sand and silt. Sand seams of varying thickness were noted in continuous sampling, but despite repeated attempts, we were not able to collect suitable "undisturbed" samples for laboratory strength analysis from auger borings. Given the variation in depth and thickness, we cannot be certain that these lenses/layers are continuous, but have modeled them as such. We observed near horizontal bedding of fine-grained clay deposits and that the sandier zones were typically wet/moist relative to the clay. We conservatively modeled the entire slope utilizing the strength parameters obtained for the soils observed, confining the water to a few discrete, relatively horizontal sand seams, assuming that they would be the most likely to move in static and seismic conditions.

The soil strength parameters are also listed in the Slope Stability Analysis in Appendix D (Plates D-1 to D-6). The laboratory test results are presented in Appendix B.

6.2.4 Stability Analysis

The majority of the hillside surrounding the Westside Reservoir has been mapped as landslide deposits (Yonkee & Lowe, 2004). The purpose of our investigation was to assess the condition of the landslide under current static and anticipated seismic conditions, and provide an opinion as to whether the site is suitable to support the existing water tank.

6.2.4.1 Static Stability

Global stability of the existing slope was modeled using the surface topography directly downhill of the larger tank according to contour maps. In the model, groundwater was intentionally confined within the sandy seams to reflect the conditions observed. Given the generally horizontal bedding observed within the deeper clay deposits, we do not believe that a previous deep circular-type mass movement event has occurred in the soils beneath, or immediately downhill of the tank. It is our opinion that the saturated sand and silty sand zones represent the most likely failure plane along which a future deep slide could occur. Based on our exploration, we cannot be certain if these layers are continuous; however, given the relatively high moisture content within these zones we assume they are, as they must be connected to transmit moisture from locations uphill. The safety factor against sliding along the uppermost sand seam has been evaluated to be between 1.5 and 1.7. Typically a safety factor of at least 1.5 is desired for slopes under static loading conditions. Given the reports by South Weber personnel of water encountered in near surface excavations, IGES also performed sensitivity analysis by modeling the global stability under increased moisture conditions. In these cases, moisture was still confined to the sandy zones, but a reduction to effective stress was manually created in those areas. Under these modified static loading conditions, the slope was shown to be slightly less stable (safety factor 1.3-1.4). Considering that our investigation was performed at the end of a relatively dry season, the potential impacts of increased moisture should be considered. Water from a leaking tank, or increased precipitation could adversely impact the slope stability. Graphical representations of the static stability modeling results are shown in Appendix D, Figures D-1 to D-2.

6.2.4.2 Pseudo-Static Slope Stability

Pseudo-static slope stability analyses were also performed for the existing hillside under dynamic conditions, induced by seismic ground motion.

A key difference in seismic stability analysis compared to static analysis is that undrained strength parameters are typically used for the strength of saturated soils subjected to cyclic loading because of the relatively rapid rate of earthquake loading. The behavior of cohesive soils (clay) can be much different than for cohesionless soils (silt, sand and gravel). Some research indicates that there is little reason to reduce shear strength of low to intermediate sensitivity cohesive soils. Based on our observation that moisture is largely confined to a few discrete sandy layers, we have not reduced strength properties for clay soils in our pseudo-static analyses.

For saturated cohesionless soils, even relative modest cyclic shear stresses can lead to pore pressure rise and a significant loss of undrained strength. Direct evaluation of the potential for shear strength reduction in saturated or nearly saturated cohesionless soils subjected to cyclic loading would require sophisticated cyclic laboratory testing. We were not able to collect appropriate samples for such testing of these soils. As an alternative, residual strength values for sandy soils were assigned based on in situ test results (SPT) using methods outlined by Idriss & Boulanger (2007) and Olson & Johnson (2008).

The results from this analysis indicate the existing slope will be subject to deformation and possible mass movement during or just after a seismic event. These results are found in Appendix D (Figure D-3 and D-4). Reductions in shear strength anticipated as a result of seismic loading under existing and increased moisture conditions resulted in factors of safety less than 1.0 for global mass stability models. Therefore, there is significant risk of slope movement resulting from a seismic event.

6.2.4.3 Near-surface Stability

While we did not observe evidence of "deep" movement along the hillside in the immediate vicinity of the tank, trenching exploration showed evidence of near-surface mass movements adjacent to and down slope of the existing tanks (see Sections 5.2.1.1 and 5.2.1.3).

IGES performed additional static stability modeling under observed and potentially increased saturation levels which allowed for failure of near-surface sands and gravels. Resulting safety factors of less than 1.5 under observed moisture conditions, and less than 1.0 with increased moisture indicate that the upper soils are marginally stable at best. It is possible that continued shallow failures will occur, particularly if soil moisture increases as a result of tank seepage, or during wet climatic periods.

Table 6.2.4 presents a brief summary of each model condition, calculated safety factors and our interpretation of the results. Graphical representations of each modeled condition, including soil strength parameters, are presented in Appendix D (Plates D-1 to D-16). Pseudo static models utilize the same residual strength parameters.

Table 6.2.4 – Slope Stability Modeling Results

Plate	Category	Static/ Pseudo-static	Safety Factor	Interpretation of Stability
D-1	Global (Existing)	Static	1.5-1.7	Acceptable
D-2	Global (Increased Water)	Static	1.3-1.4	Poor
D-3	Global (Existing)	Pseudo-static	1.0-1.1	Acceptable
D-4	Global (Increased Water)	Pseudo-static	0.9-1.0	Unacceptable
D-5	Shallow (Existing)	Static	1.1-1.2	Poor
D-6	Shallow (Increased Water)	Static	0.6-0.7	Unacceptable

6.3 CONCLUSIONS

Based on our observations, testing and modeling we assert that the hillside will be globally stable under existing conditions. However, smaller ancillary slides or local stability failures may occur, likely beginning near the existing active internal scarp and propagating uphill toward the tank. Additionally, increased soil moisture will elevate the risk for local and global slope failures, as indicated by our modeling. The seismic performance of the hillside under observed conditions is considered marginally acceptable, but is not acceptable if saturated moisture conditions or excess pore pressure buildup coincide with a seismic event. Additional modeling of shallow failures under seismic loading was not performed as it is already considered poor during static loading.

Under the relatively dry conditions encountered at the time of our investigation, stability modeling has shown that the site will be stable both locally and globally under static loading conditions. However, previous excavations performed by South Weber personnel indicate that near-surface soils on the hillside have been at least partially saturated in the past. It is imperative to take precaution to prevent excessive infiltration of moisture from the tank into the soil. We recommend adequate drainage also be provided to manage storm water at the tank site, limiting run-off and infiltration of surface water into the near-surface soils.

If the tank is to remain in service at its' current location, we anticipate that leak repairs and other structural upgrades are likely. In addition to review and improvements to the site drainage, we recommend that the slope be monitored for future movement. Monitoring should include surficial observations and surveying to document any mass movements. We also recommend that an inclinometer be installed to monitor potential movement at greater depth. The following table indicates the minimum recommended frequency and duration of monitoring, the need and frequency of continued monitoring should be reevaluated at the end of the initial monitoring period.

Table 6.3 – Slope Stability Monitoring Recommendations

Type	Minimum Frequency	Minimum Duration
Survey	Annual	Twice (Begin/end of year)
Observation	Quarterly	18 months
Inclinometer	Monthly	18 months

Inclinometers are used to monitor subsurface movements and deformations; they also assist in establishing whether movement is constant or accelerating, and how the movement may be impacted by fluctuations in moisture. An inclinometer system has two components: (1) inclinometer casing and (2) an inclinometer measurement system. Inclinometer casing provides access for subsurface measurements. Grooves inside the casing control the orientation of the inclinometer sensor and provide a uniform surface for measurements. Inclinometer casing is usually installed in a borehole. The exact location of inclinometer casing can be somewhat flexible, but it should be located on the slope between the existing active internal scarp and the tank. This could mean securing an easement for installation and monitoring of the slope from the property owner. Options for data collection vary. Traditionally, the measurements were taken manually at specific intervals. Newer technologies exist that can allow for continuous monitoring and reporting to better understand the slope and its' response to changing conditions.

In-place inclinometer sensors could also provide early warning of changing conditions and potential slope failure.

7.0 CLOSURE

7.1 LIMITATIONS

The recommendations contained in this report are based on limited field exploration, laboratory testing, and our understanding of site conditions. The subsurface data used in the preparation of this report were obtained from the explorations made for this investigation. It is possible that variations in the soil and groundwater conditions exist between and beyond the points explored. The nature and extent of variations may not be evident unless additional earthwork/excavation occurs. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed tank upgrades changes from that described in this report, our firm should also be notified.

The concept of risk is a significant consideration of geotechnical analyses. The analytical means and methods used in performing geotechnical analyses and development of resulting recommendations do not constitute an exact science. Analytical tools used by geotechnical engineers are based on limited data, empirical correlations, engineering judgment and experience. As such the solutions and resulting recommendations presented in this report cannot be considered risk-free, but do constitute IGES's best professional opinions and recommendations based on the available data and other design information available at the time they were developed. IGES has developed the preceding analyses, recommendations and designs, at a minimum, in accordance with generally accepted professional geotechnical engineering practices and care being exercised in the project area at the time our services were performed. No warrantees, guarantees or other representations are made.

It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

7.2 ADDITIONAL SERVICES

IGES can assist in determining an acceptable solution for instrumentation and monitoring of the slope. We can also assist in installation, measurement, documentation and interpretation and data collected on the slope. We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please do not hesitate to contact us at your convenience at (801) 270-9400.

8.0 REFERENCES CITED

American Geological Institute (AGI), 2005, Glossary of Geology, Fifth Edition, revised, Neuendorf, K.K.E., Mehl, Jr. J.P., and Jackson, J.A., editors: American Geological Institute, Alexandria, Virginia, 783 p.

Blake, T.F., Hollingsworth, R.A., Stewart, J.P., 2002, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Landslide Hazards in California, Southern California Earthquake Center, 132 p.

Coogan, J.C., and King, J.K., 2016, Interim Geologic Map of the Ogden 30' x 60' Quadrangle, Box Elder, Cache, Davis, Morgan, Rich, and Summit Counties, Utah, and Uinta County, Wyoming: Utah Geological Survey Open-File Report 653DM, 1 Plate, 151 p., Scale 1:62,500.

Federal Emergency Management Agency [FEMA], 2007, Flood Insurance Rate Map, Davis County, Utah: Map Number 49011C0089E, Effective June 18, 2007.

Idriss, I.M. and Boulanger, R.W. (2007) "SPT and CPT-based relationships for the residual shear strength of liquefied soils." Earthquake Geotechnical Engineering, 4th International Conference on Earthquake Geotechnical Engineering – Invited Lectures, K.D. Pitilakis, ed., Springer, The Netherlands, 1-22.

IGES, 2016, Reconnaissance-Level (Phase I) Geologic Hazards Assessment, South Weber Westside Reservoir, South Weber, Utah: Unpublished consultant report dated September 26, 2016, submitted to Jones & Associates; IGES Project No. 01747-002.

Lund, W.R., 1984, Inspection of landslides adjacent to Hill Air Force Base in Davis County: Utah Geological Survey Applied Geology, Job No. 84-009, 2 p., accessed from https://geodata.geology.utah.gov/

Olson, S.M. and Johnson, C.I (2008) "Analyzing Liquefaction-Induced Lateral Spreads Using Strength Ratios," J. Geotech. And Geoenvir. Engrg. Volume 134, Issue 8, pp. 1035-1049

Stark, T.D., Hisham, T.E., 1994, Drained Residual Strength of Cohesive Soils, Journal of Geotechnical Engineering, Vol. 120, No. 5.

U.S. Department of Transportation – Federal Highway Administration, 2012, "LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations," Publication No. FHWA-NHI-11-032, Reference Manual: NHI Course No. 130094, Geotechnical Engineering Circular No. 3

U.S. Geological Survey, 2014, Topographic Map of the Ogden Quadrangle, Ogden, Utah: Scale 1:24,000.

U.S. Geological Survey and Utah Geological Survey, 2006, Quaternary fault and fold database for the United States, accessed 8-26-16, from the USGS website: http://earthquakes.usgs.gov/regional/qfaults

Yonkee, A., and Lowe, M., 2004, Geologic Map of the Ogden 7.5' Quadrangle, Weber and Davis Counties, Utah: Utah Geological Survey Map 200, 2 Plates, 42 p., Scale 1:24,000.

AERIAL PHOTOGRAPHS

Data Set	Date	Flight	Photographs	Scale
1937 AAJ-AAK	September 26, 1937	2	14, 15, 16	1:20,000

*https://geodata.geology.utah.gov/imagery/

APPENDIX A

LEGEND

TRENCH TRACE

BOREHOLE LOCATION

SOUTH WEBER CITY PROPERTY

LANDSLIDE SCARP (OLDER)

LANDSLIDE SCARP (ACTIVE)

BASE IMAGE FROM GOOGLE EARTH DATED 7/8/2016

N

0 50 100

FEET

FIGURE A-1

EXCAVATION LOCATION MAP

WESTSIDE RESERVOIR

GEOTECHNICAL AND GEOLOGIC HAZARD ASSESSMENT

SOUTH WEBER CITY, UTAH

DATE: 01/24/2017

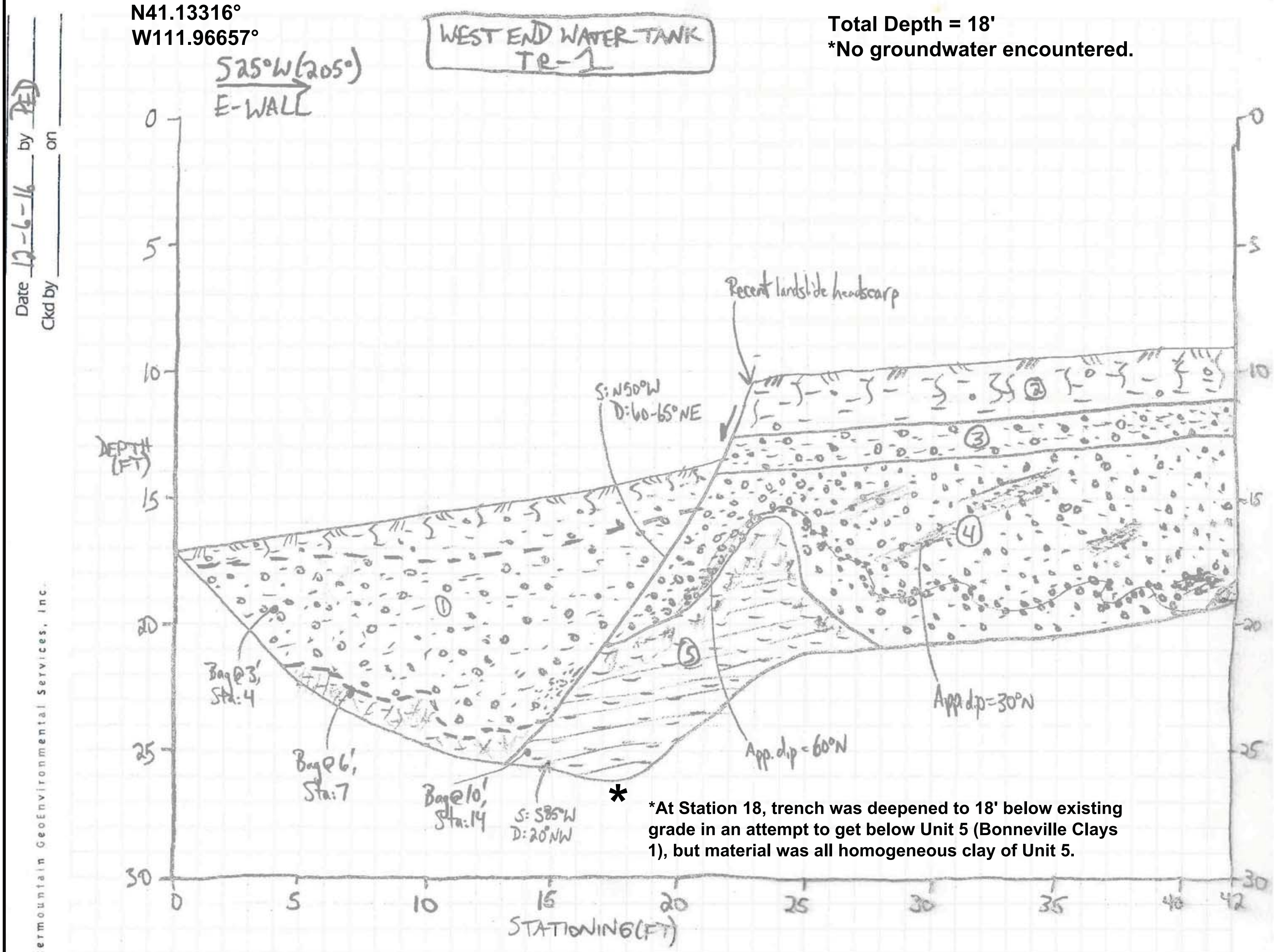
FILE: 01747-002

SCALE: 1"=100'

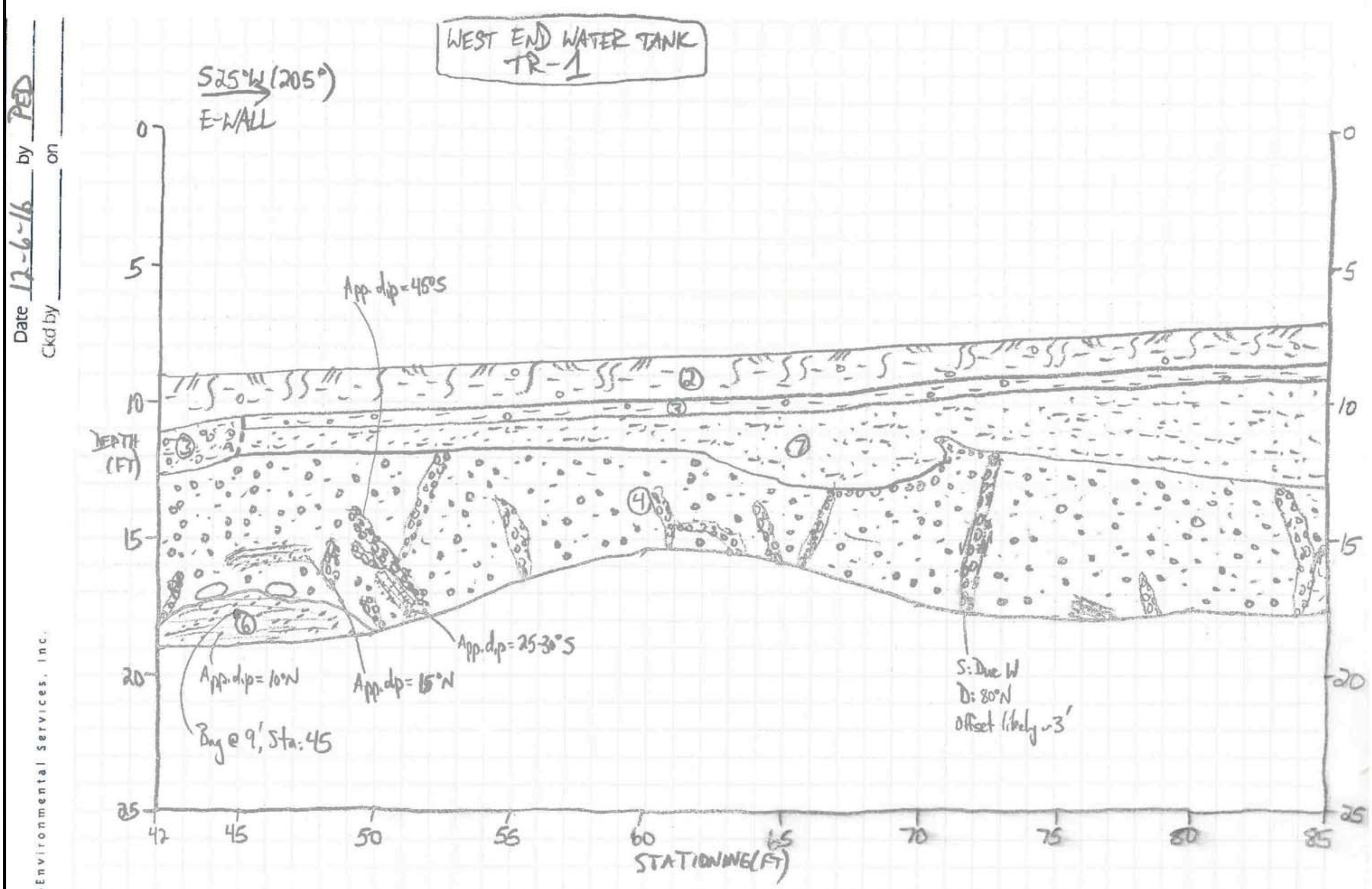
IGES

N41.13316°
W111.96657°

Total Depth = 18'
*No groundwater encountered.



*At Station 18, trench was deepened to 18' below existing grade in an attempt to get below Unit 5 (Bonneville Clays 1), but material was all homogeneous clay of Unit 5.

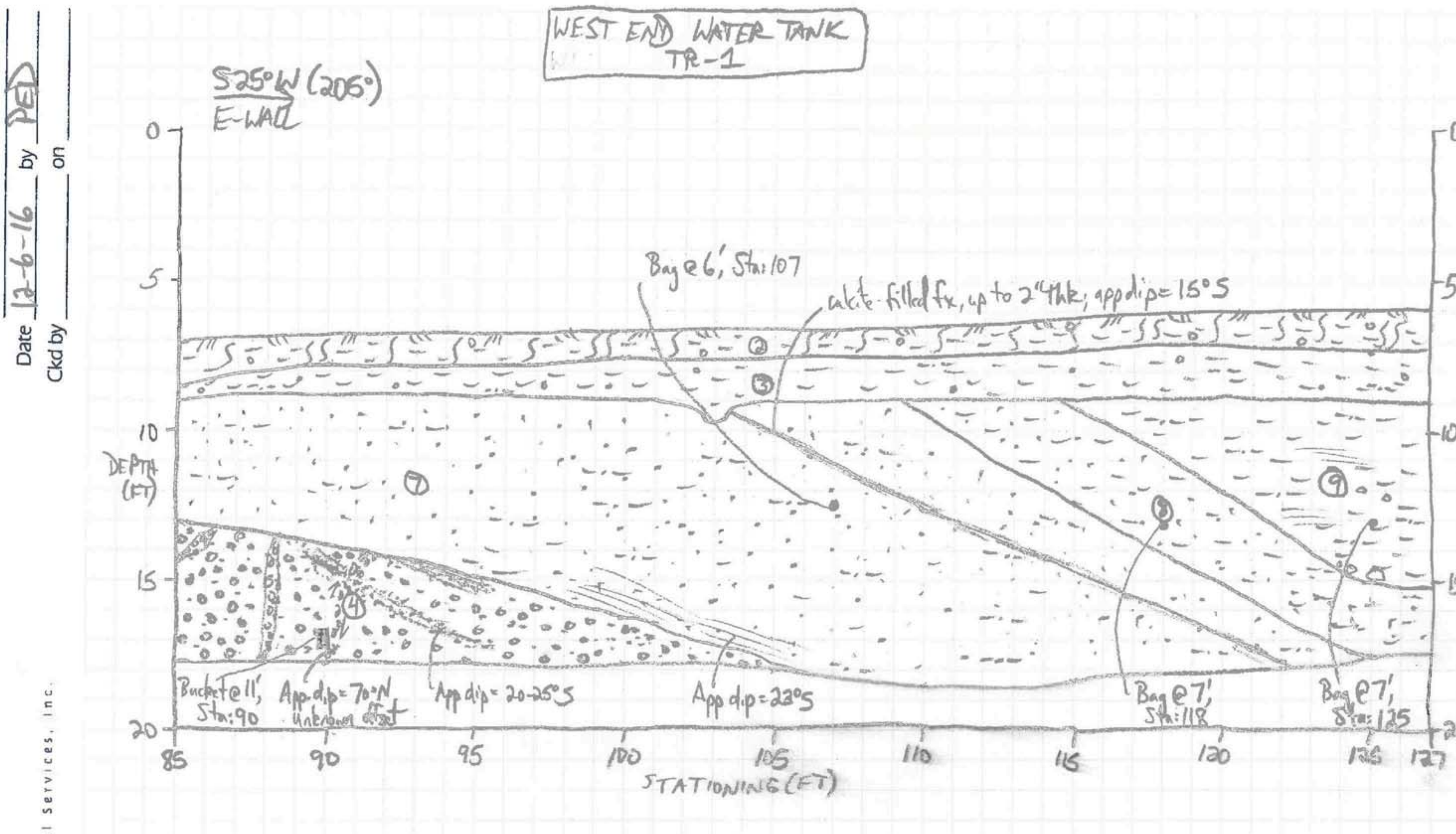


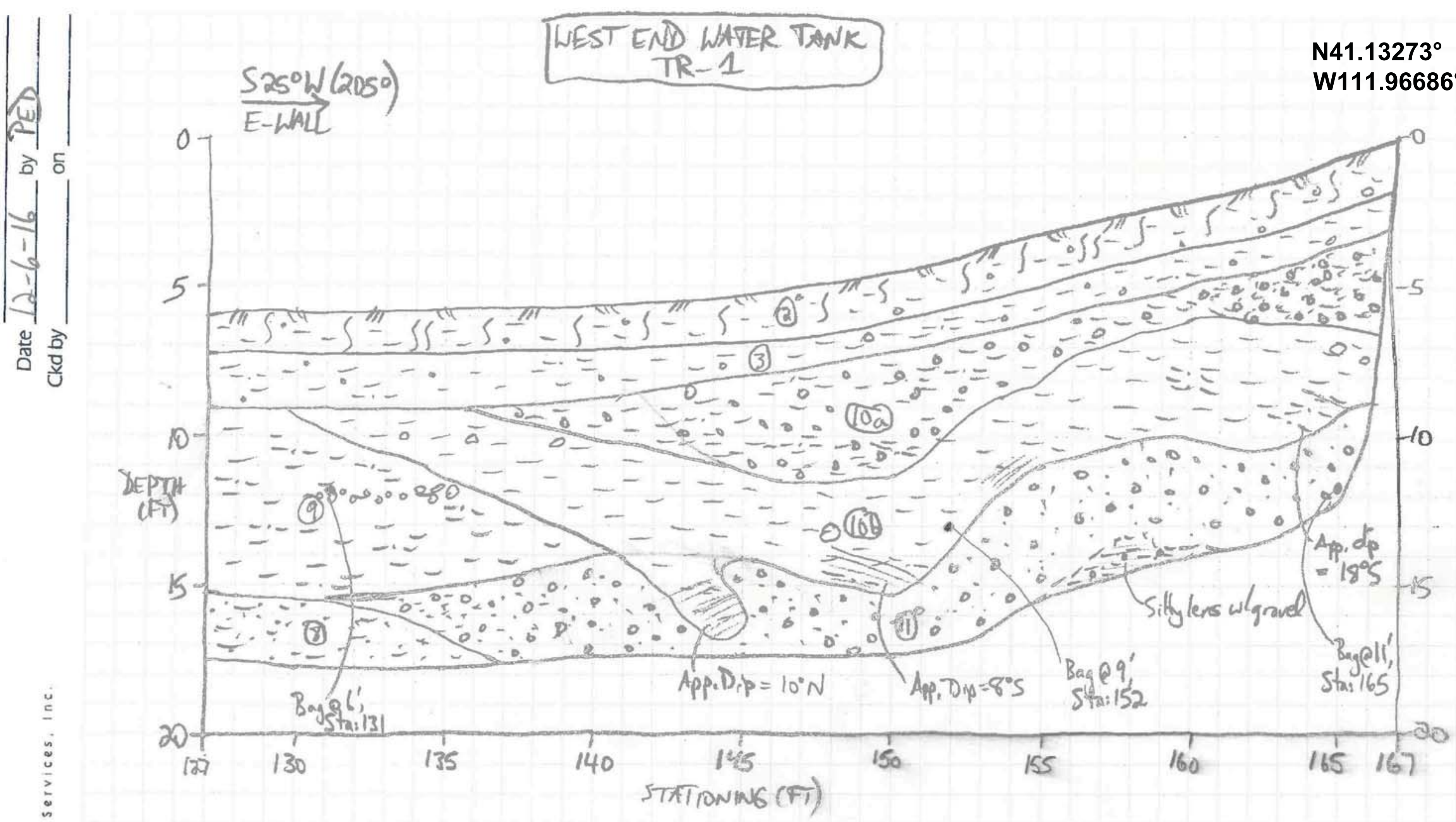
LITHOLOGIC UNIT DESCRIPTIONS ON FIGURE A-2c

WESTSIDE RESERVOIR
SOUTH WEBER CITY
GEOLOGIC HAZARD ASSESSMENT

FIGURE A-2a
TRENCH-1 LOG

DATE: 01/23/2017
PROJECT: 01747-002
SCALE: 1"=5'
IGES





N41.13273°
W111.96686°

Total Depth = 18'
***No groundwater encountered.**

LITHOLOGIC UNIT DESCRIPTIONS ON FIGURE A-2c	WESTSIDE RESERVOIR SOUTH WEBER CITY GEOLOGIC HAZARD ASSESSMENT	FIGURE A-2b TRENCH-1 LOG DATE: 01/23/2017 PROJECT: 01747-002 SCALE: 1"=5' IGES

LITHOLOGIC UNIT DESCRIPTIONS:

1. Landslide 1: >8' thick; varicolored, because comprised of a mix of A/B soil horizons (Units 2 and 3), Bonneville Sand and Gravel 1 (Unit 4), and Bonneville Clays 1 (Unit 5); unit is jumbled mix of these units, with A/B soil horizons containing a higher proportion of clasts (~10-15%) than seen elsewhere in trench, sand and gravel containing topsoil mixed in, and clays entirely highly broken and with a distinct calcium carbonate coating/infilling absent to the south of the scarp; more common plant and tree roots than elsewhere in trench; very stiff to loose, slightly moist, chaotic structure; definite high-angle scarp noted on both sides of trench, though no shear/slickensides present due to highly granular nature of soil materials.

2. A-Horizon: ~1-1.5' thick; brownish black (5YR 2/1) lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of unit; clasts are medium gray (N5) rounded to subrounded quartzite and granodiorite up to 1.5" in diameter, though mode size ~1/2"; abundant plant and tree roots; abundant large worm holes; gradational, irregular basal contact.

3. B-Horizon: ~1-1.5' thick; grayish brown (5Y 3/2) to dark yellowish brown (10YR 4/2) to moderate yellowish brown (10YR 5/4) lean CLAY with gravel (CL), stiff, moist, low plasticity, massive, though blocky texture; gravel and larger sized clasts comprise <5% of unit; clasts are medium gray (N5) rounded to subrounded quartzite and granodiorite up to 1" in diameter; common pinhole voids (1 mm diameter); occasional to common plant and tree roots; lightens in color with depth; sharp, irregular basal contact.

4. Bonneville Sand and Gravel 1: ~6' thick; mottled in appearance, due to abundant varicolored gravel; matrix is medium gray (N5) to dark yellowish brown (10YR 4/2); Lake Bonneville well-graded sandy GRAVEL (GW), loose to medium-dense, slightly moist, massive to finely bedded; gravel and larger sized clasts comprise ~70-80% of unit; clasts all rounded to subrounded medium gray (N5) quartzite and granodiorite up to 6" in diameter, though mode size ~1"; matrix is medium to coarse-grained sand; occasional sand lenses, which are finely bedded; weak calcite cement; poorly sorted; common white partially cemented subvertical unit-controlled faults; occasional plant and tree roots; sharp, highly undulatory basal contact.

5. Bonneville Clays 1: >10' thick; brownish gray (5YR 4/1) to moderate reddish brown (10R 4/6) Lake Bonneville lean CLAY (CL), very stiff, dry to slightly moist, low to moderate plasticity, finely to medium-bedded and varved; devoid of clasts; blocky jointing; uppermost ~2-3' of unit is highly broken and appears to have been severely stressed; common dark yellowish orange (10YR 6/6) silt interbands up to 1 cm thick; occasional fine-grained sand lenses.

6. Bonneville Sand 1: >2' thick; light brown (5YR 6/4) to pale yellowish orange (10YR 8/6) Lake Bonneville sandy SILT (ML), medium-dense to dense, dry to slightly moist, finely bedded; sand is very fine-grained and gradational to silt; devoid of clasts; common small subvertical fractures with calcite infilling; found at the bottom of the trench in the northern 1/3 of the trench.

7. Bonneville Sand 2: ~6' thick; medium light gray (N6) to light gray (N7) Lake Bonneville silty SAND (SM), medium-dense, dry to slightly moist, massive to finely bedded; clayey/silty in part, and pinholed (1-2 mm diameter) where fines component present; devoid of clasts; weak calcite cement; occasional white calcite-filled fractures; sand if fine to very fine-grained; small-scale cross-bedding seen at base of unit; few plant and tree roots; sharp, wavy basal contact.

8. Transitional 1: ~2-2.5' thick; dark yellowish brown (10YR 4/2) lean CLAY with sand (CL), medium-stiff, moist, low plasticity, massive; largely devoid of clasts, though rare quartzite clasts up to 1" diameter; common pinhole voids throughout (1-2 mm diameter); sharp, curvilinear basal contact.

9. Transitional 2: ~2' thick; light brown (5YR 6/4) to moderate yellowish brown (10YR 5/4) silty CLAY with gravel (CL-ML), very stiff, slightly moist, low plasticity, discontinuously thinly bedded; unit appears as a combination of both subunits of Landslide 1 (Unit 10), as it is finely bedded, though bedding is commonly disrupted by mottling as seen in Unit 10, and the unit contains occasional gravel clasts; gravel and larger sized clasts comprise ~5% of unit; clasts all quartzite as above, up to 4" in diameter; common pinhole voids (1-2 mm diameter); gravel common near base of unit; occasional to few small plant roots; sharp, wavy basal contact.

10. Landslide 2: Up to 8' thick; light brownish gray (5YR 6/1) to brownish gray (5YR 4/1) to dark yellowish orange (10YR 6/6); contains 2 subunits:

10a. Bonneville Sand and Gravel 2: >6' thick; medium light gray (N6) to light brown (5YR 6/4) Lake Bonneville well-graded gravelly SAND (SW), loose, slightly moist, massive to weakly finely bedded; poorly sorted sand, largely medium-grained, but some fine-grained and coarse-grained; very weak silica cement; sand grains angular to subrounded, with ~75% quartz, with common quartzite and granodiorite grains; gravel and larger sized clasts comprise ~40-50% of the unit; clasts are rounded to subrounded quartzite and granodiorite up to 4" in diameter, though mode size ~1/2-1"; contains some very fine-grained sand and silt lenses; sharp, irregular basal contact.

10b. Bonneville Clays 2: ~3' thick; brownish gray (5YR 4/1) Lake Bonneville lean CLAY (CL), very stiff, slightly moist, low plasticity, finely laminated, though contorted bedding; occasional to common pinhole voids throughout (1 mm diameter); devoid of clasts; occasional small plant roots, largely along bedding planes; common dark yellowish orange (10YR 6/6) silt interbands up to 1 cm thick; contains several several loose gravel lenses that appear like underlying unit and are cemented with a clay matrix; chaotic appearance; sharp, wavy basal contact.

11. Bonneville Sand and Gravel 3: >6' thick; light brown (5YR 6/4) to moderate yellowish brown (10YR 5/4) well-graded sandy GRAVEL (GW), loose to medium-dense, slightly moist, massive to finely bedded; gravel and larger sized clasts comprise ~50% of unit; clasts are rounded to subrounded medium gray (N5) to purple to pale yellowish orange (10YR 8/6) granodiorite and quartzite up to 5" in diameter, though mode size ~1"; finely bedded silt lens in base of trench.

FIGURE A-2c

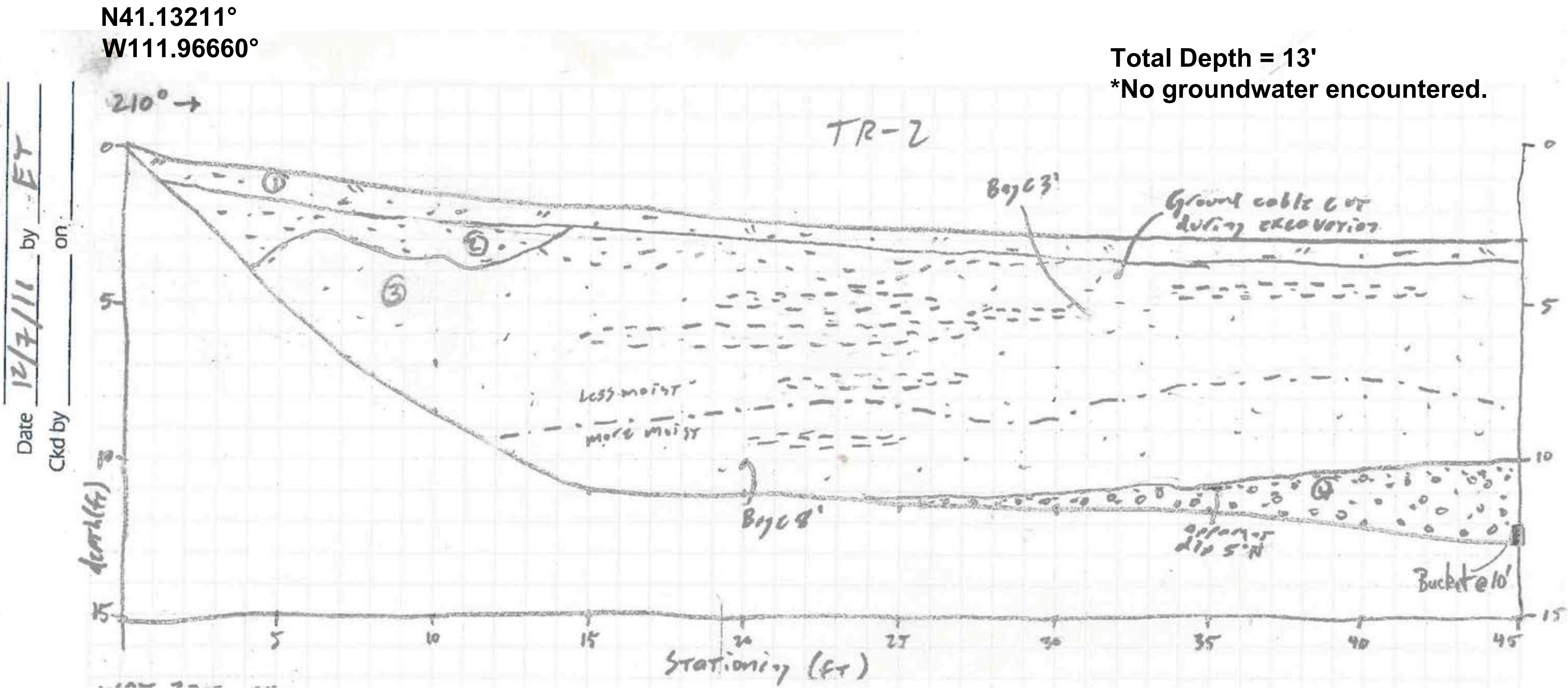
IGES®

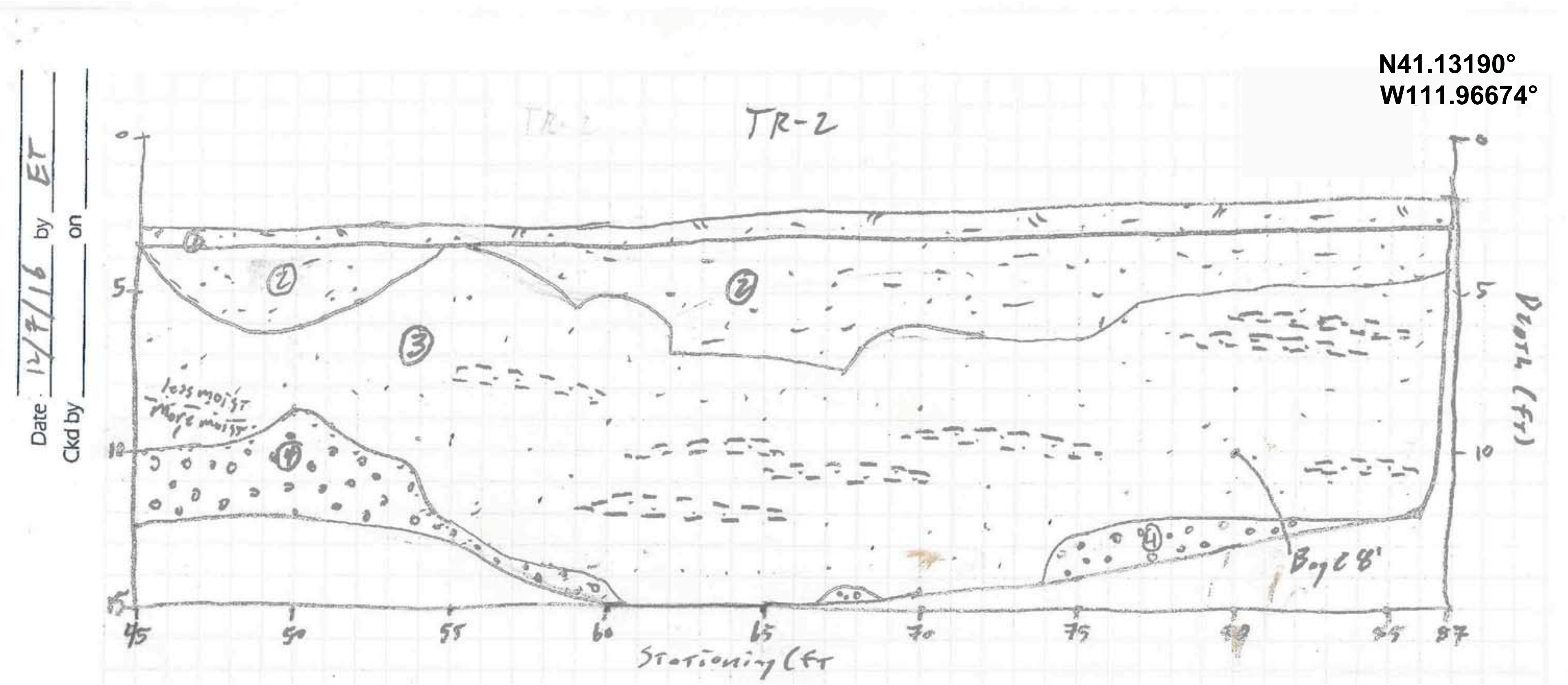
WESTSIDE RESERVOIR
SOUTH WEBER CITY
GEOLOGIC HAZARD ASSESSMENT

TRENCH-1 LOG

PROJECT NO: 01747-002

DATE: 01/23/2017
PROJECT:01747-002
SCALE: 1"=5'
IGES





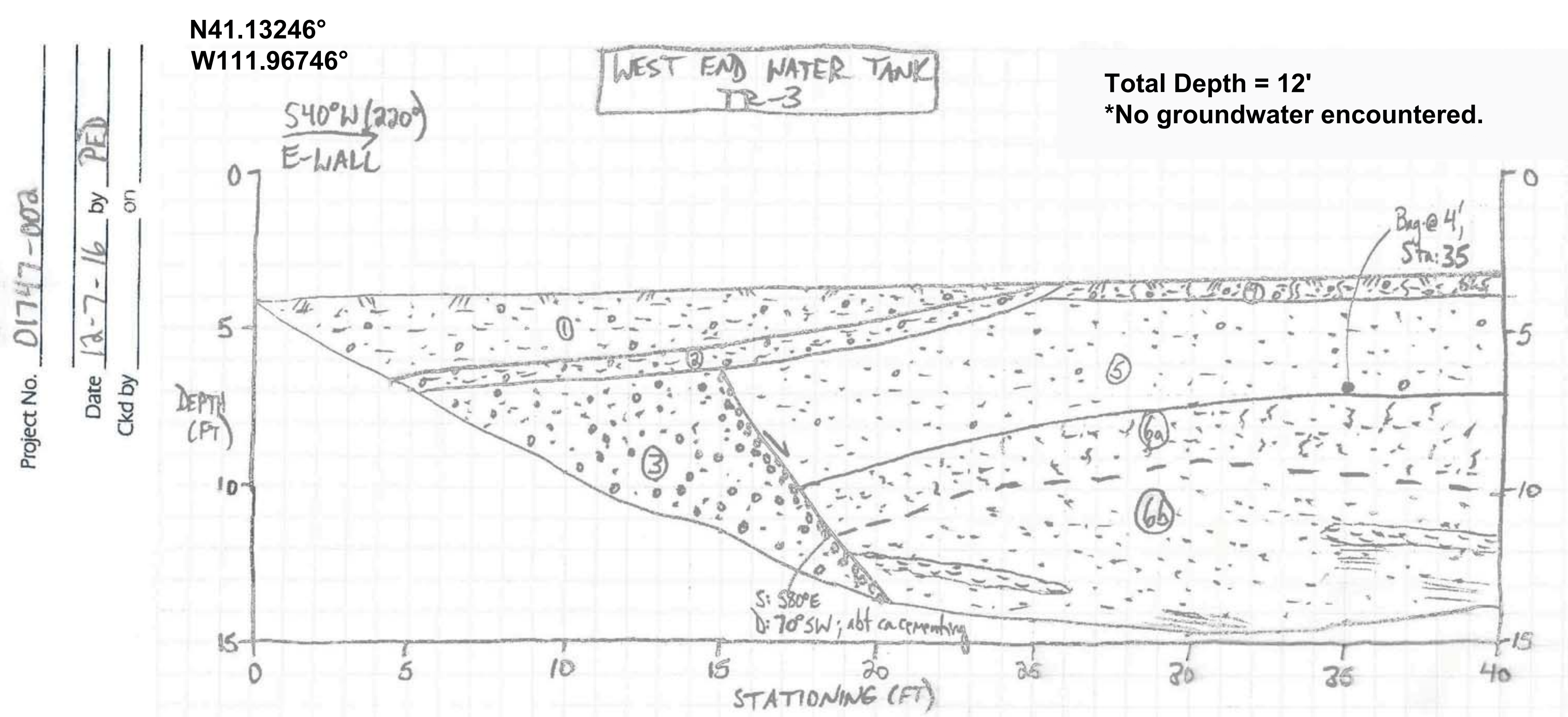
LITHOLOGIC UNIT DESCRIPTIONS:

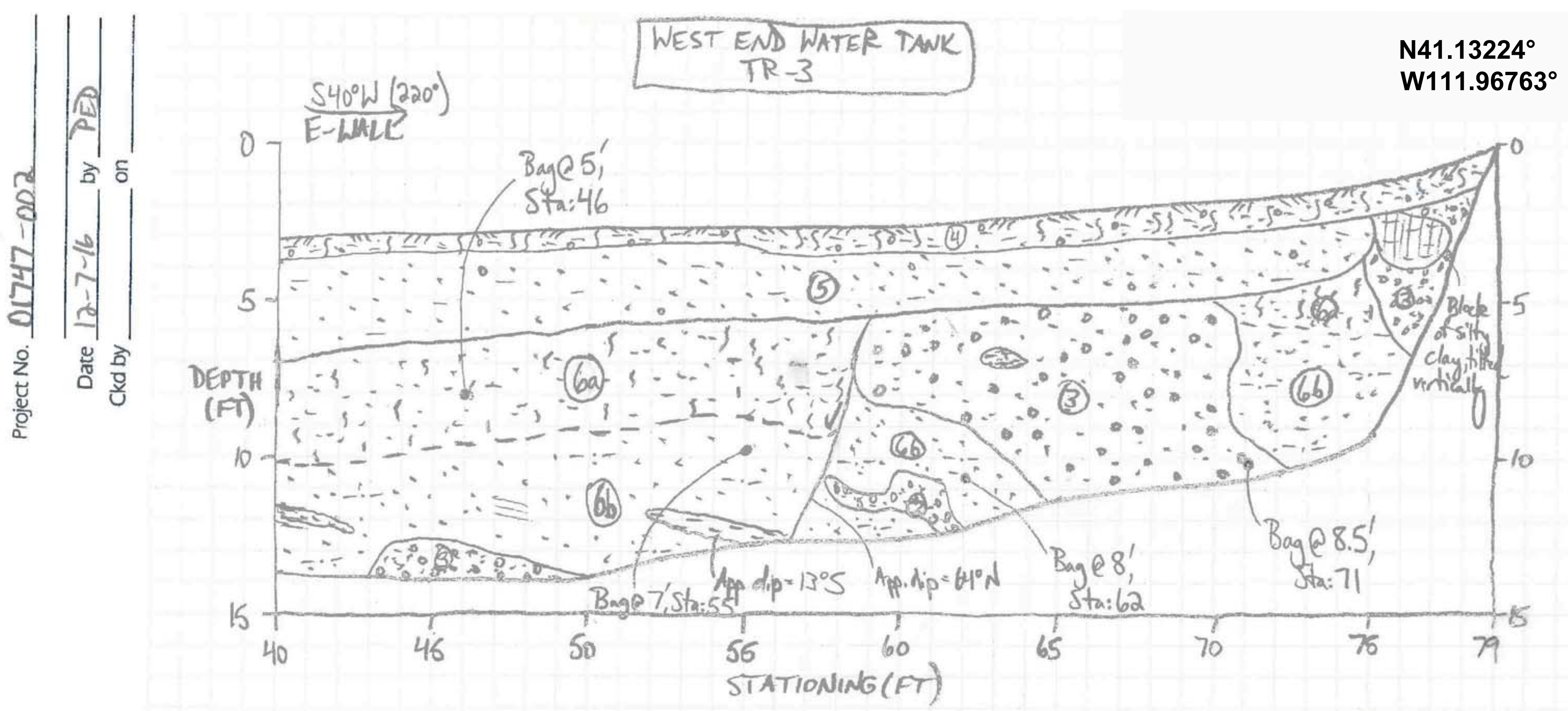
1. A/B Soil Horizon: ~1/2-1' thick topsoil; dark yellowish brown (10YR 4/2) to brownish black (5YR 2/1) sandy lean CLAY (CL), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise <5% of unit; clasts entirely subrounded quartzite up to 1" in diameter; A and B horizons distinguishable throughout most of unit; unit thins away from north end of trench; occasional plant and tree roots; sharp, largely planar basal contact.

2. Fill: ~1-4' thick, though highly variable; dark yellowish brown (10YR 4/2) to moderate yellowish brown (10YR 5/4) sandy lean CLAY (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise <3% of unit; clasts entirely subrounded quartzite up to 1.5" in diameter; lateral extents of unit highly variable, likely local material used as fill to level ground preceding tank emplacement; sharp, highly irregular basal contact.

3. Bonneville Silt and Sand: ~5-8' thick; light brown (5YR 6/4) Lake Bonneville sandy SILT (ML) gradational to silty SAND (SM), medium stiff, slightly moist but becomes moist with depth, low plasticity, faint bedding possible throughout unit; contains no visible gravel clasts; contains lenticular sandy lean clay lenses throughout unit with a blocky texture; calcium carbonate flour found to be concentrated around clay lenses; sharp increase in moisture content near the base of the unit between stations 10 and 48; sharp, irregular basal contact.

4. Bonneville Sand and Gravel: >3' thick; light gray (N7) Lake Bonneville well-graded sandy GRAVEL (GW), loose, slightly moist, massive, though occasional subhorizontal sand lenses; gravel and larger sized clasts comprise ~65% of unit; clasts all well rounded to subrounded medium gray (N5) quartzite up to 4" in diameter, though mode size ~1"; at upper contact is ~3-4" sand lens with a fine sand similar to the sandy matrix of this unit and contains subhorizontal laminae and trough cross-stratification.





LITHOLOGIC UNIT DESCRIPTIONS:

1. Fill: >2' thick; dark yellowish brown (10YR 4/2) clayey SAND with gravel (SC), medium-dense to loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of unit; clasts entirely medium gray (N5) to pale yellowish orange (10YR 8/6) rounded to subrounded quartzite up to 5" in diameter, though mode size ~1"; likely derived from native materials; abundant plant and tree roots in uppermost ~3", otherwise occasional; unit thickens downslope; sharp, planar basal contact.

2. Buried Topsoil: ~6" thick, buried by fill; brownish black (5YR 2/1) clayey SAND with gravel (SC), medium-dense, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of unit; clasts all quartzite as above up to 2" in diameter; occasional plant and tree roots; becomes more gravelly downslope to northwest; sharp, largely planar basal contact.

3. Bonneville Sand and Gravel: >6' thick; moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2) matrix, though mottled due to varicolored clasts; Lake Bonneville sandy GRAVEL (GW) gradational to gravelly SAND (SW), loose to medium-dense, except dense where calcium carbonate present, slightly moist, massive to faintly bedded; gravel and larger sized clasts comprise ~50-75% of unit; clasts consist of roughly equal proportions of pale yellowish orange (10YR 8/6) to medium gray (N5) granodiorite and quartzite up to 3" in diameter, though mode size ~1/2"; sandy matrix is medium to coarse-grained, as seen in TR-1; occasional calcium carbonate cement; occasional plant and tree roots.

4. A/B Soil Horizon: ~3-6" thick; dark yellowish brown (10YR 4/2) to brownish black (5YR 2/1) clayey SAND with gravel (SC), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of unit; clasts entirely granodiorite and quartzite as above up to 1" in diameter; abundant plant and tree roots; gradational, planar basal contact.

5. Bonneville Sand: ~4' thick; dark yellowish brown (10YR 4/2) Lake Bonneville silty SAND (SM),medium-dense, moist, low plasticity, massive; gravel and larger sized clasts comprise ~2% of unit; clasts are granodiorite and quartzite as above up to 2" in diameter, though mode size ~1/2"; reversely graded; common pinhole voids (1 mm diameter); occasional to common plant and tree roots; sharp, irregular basal contact.

6. Bonneville Silt and Sand: >8' thick; Lake Bonneville silt and sand deposits; north side of trench displays dark yellowish orange (10YR 6/6) oxidation due to recent groundwater flow, though no groundwater present at time of logging; consists of 2 subunits:

6a: ~2-3' thick; moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2) silty SAND (SM),dense to very dense due to abundant calcium carbonate fill and stringers, slightly moist to moist, low plasticity, massive to finely bedded; fine-grained to very fine-grained sand gradational to silt; devoid of clasts.

6b: >6' thick; light gray (N7) to moderate yellowish brown (10YR 5/4) silty, clayey SAND (SW-SC), medium-dense to loose, slightly moist to moist, low plasticity, massive to finely bedded; devoid of clasts; occasional clay lenses with calcium carbonate infilling up to 5" thick; few plant and tree roots.

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir Landslide Evaluation

South Weber, Utah

Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO: **BH-1**

LOCATION
NORTHING 3,572,524.09 EASTING 1,511,796.36 ELEVATION 4,688 feet
Lower Road - west of trench 1

DEPTH (METERS)	DEPTH (FEET)	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0	0	CL	Lean CLAY - medium stiff, moist, brown.							
		SP	Poorly-graded SAND - medium dense, dry, light brown							
	5	SP	Poorly-graded SAND with gravel - loose-medium dense, dry, light yellowish-brown; rounded-subrounded gravel≤3/4-in diam.							
	15		- gravel in tip, NO RECOVERY							
6									31	13
	20	CL	Varved lean CLAY - soft-medium stiff, moist, reddish brown; occasionally wet and sandy							
7		SC	Clayey-SAND - loose, wet, reddish brown							
		CL	Sandy Lean CLAY - medium stiff, moist, brown; sandy seams every 1-1.5-in. (≤1/4-in thick)							

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (scale 10 20 30 40 50 60 70 80 90)

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 5a

DATE		
STARTED:	12/12/16	
COMPLETED:	12/12/16	
BACKFILLED:	12/12/16	

Westside Reservoir Landslide Evaluation

South Weber, Utah

Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO: **BH-1**

Sheet 2 of 2

LOCATION

NORTHING 3,572,524.09 EASTING 1,511,796.36 ELEVATION 4,688 feet

Lower Road - west of trench 1

DEPTH METERS	DEPTH FEET	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
9		CL								
	30	SP-SM	Poorly-graded SAND with silt - loose (flowing), wet, brown							
		CLS	Sandy lean CLAY - medium stiff, moist, brown; occasional sand seams ≤1/4-in thick.							
10								0		
11	35									
		SP-SM	Poorly-graded SAND with silt - loose (flowing), wet, brown					51		
12	40		Sandy lean CLAY - medium stiff, moist, brown; occasional sand seams ≤1/4-in thick.							
13		CL	Sandy lean CLAY - medium stiff, moist, brown; occasional sand seams ≤1/4-in thick.							
14	45									
15	50		Bottom of Boring @ 50 Feet							
16										
17	55									

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (10 20 30 40 50 60 70 80 90)

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 5b

BORING LOG

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 6-in HSA

BORING NO: **BH-2**
Sheet 1 of 2

LOCATION
NORTHING 3,572,418.01 EASTING 1,511,952.39 ELEVATION 4,700 feet
Lower Road - east of trench 1

Depth (Meters)	Depth (Feet)	Samples	Unified Soil Classification	Material Description	N	Water Level	Dry Density (pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0–2.6	0–8.5		CL	Lean CLAY - stiff, dry, light brown							
2.6	8.5		SP	Poorly-graded SAND with gravel - loose, dry, tan							
3	10	Modified California		- no recovery	11 11 12						
4	13			-rounded gravel ≤2-in diam in cuttings							
4.6	15	Modified California		- no recovery	4 8 19						
6.1	20	Modified California	SP	Poorly-graded SAND with gravel - medium dense, dry, brown	14 23 21		126.2	3			

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (scale 10 20 30 40 50 60 70 80 90)

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. "U" Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 6a

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 6-in HSA

BORING NO:
BH-2

LOCATION
NORTHING 3,572,418.01 EASTING 1,511,952.39 ELEVATION 4,700 feet
Lower Road - east of trench 1

DEPTH (METERS)	DEPTH (FEET)	SAMPLES	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
9	30	Modified California	CL	Varved lean CLAY - medium stiff, moist, brown; near horizontal bedding of altenating clay and sand seams.	5 7 7		103.8	22	84	41	21
10–11	35	Modified California	CL		4 5 8		94.4	29		36	17
12–14	40–45	Modified California	CL	Lean CLAY - med. stiff-stiff, moist, brown; occiasional fine sand seams, clay is frequently wet/soft near seams.	5 7 9		100.8	24		37	20
				Bottom of Boring @ 46.5 Feet							

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (scale 10 20 30 40 50 60 70 80 90)

Depth scale: Meters 9–17; Feet 30, 35, 40, 45, 50, 55

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. "U" Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 6b

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO:
BH-3
Sheet 1 of 2

LOCATION
NORTHING 3,572,168.60 EASTING 1,511,818.39 ELEVATION 4,739 feet
south of small tank, west of trench 2

DEPTH METERS	DEPTH FEET	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0	0		Topsoil (~6-in)							
		GP	Poorly-graded GRAVEL - medium dense, moist, gray							
		CL	Lean CLAY - medium stiff, dry, tan; powder							
1										
	5									
2										
3	10	SP								
		SP	Poorly-graded SAND with gravel - medium dense, dry, tan; pebble gravel only in sampler (≤1-in diam)							
4										
	15	SP	<3' recovery							
5										
6	20	SP								
7										
	25									
8										
		CL	Lean CLAY - stiff, moist, reddish brown; occasional sand seams 1/4 - 2 in thick					84	38	21

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure
A - 7a

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir Landslide Evaluation

South Weber, Utah

Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO: **BH-3**

Sheet 2 of 2

LOCATION
NORTHING 3,572,168.60 EASTING 1,511,818.39 ELEVATION 4,739 feet
south of small tank, west of trench 2

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (10 20 30 40 50 60 70 80 90)

Depth (Meters)	Depth (Feet)	Unified Soil Classification	Material Description	N	Water Level	Dry Density (pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
9	30		- lost 30-32' sample							
10								71		
	35	CL	Lean CLAY with sand seams - stiff-hard, moist, brown							
11–12			-sample liner compressing in stiff clay, expanding in casing and unable to retrieve.							
	40		Bottom of Boring @ 40 Feet							

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 7b

DATE	
STARTED:	12/13/16
COMPLETED:	12/13/16
BACKFILLED:	12/13/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO:
BH-4
Sheet 1 of 2

LOCATION
NORTHING 3,572,340.81 EASTING 1,511,737.20 ELEVATION 4,729 feet
north of large tank

DEPTH METERS	DEPTH FEET	SAMPLES	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0–4.6	0–15.5			SP	Poorly-graded SAND with gravel - loose-medium dense, dry, light brown -sampling in upper 15 feet is not accurate for depth, attempted to over puxh and pack sampler in order to keep loose/dry sand from falling into casing.					75	28	11
				CL	Lean CLAY - hard, dry, reddish brown							
					sand seam							
				CL								
				SM	Silty SAND - loose-medium dense, moist, reddish brown.							
	20			CL	Lean CLAY with frequent sand seams - stiff, moist, reddish brown							
				SM	Silty SAND - medium dense, moist, reddish brown							
				CL						38	NP	NP

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:
abandonned hole at 40 ft, liner continuing to break and get stuck in casing

WATER LEVEL
▼- MEASURED ▽- ESTIMATED

Figure
A - 8a

DATE	
STARTED:	12/13/16
COMPLETED:	12/13/16
BACKFILLED:	12/13/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO:
BH-4
Sheet 2 of 2

LOCATION
NORTHING 3,572,340.81 EASTING 1,511,737.20 ELEVATION 4,729 feet
north of large tank

DEPTH METERS	DEPTH FEET	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
		SM	Silty SAND - loose, wet (flowing), reddish brown							
9	30	CL	Lean CLAY with sand seams - medium stiff, moist, reddish brown; sand seams≤1/4-in thick							
10			clay transition to grayish-brown color							
	35	SM	Silty SAND - loose, wet, reddish brown;							
11										
12			Silty SAND with clay lenses							
	40	CL	Lean CLAY - stiff, moist, alternating brown & reddish brown seams; some fine sand seams							
13								93	35	16
		CL	Sandy Lean CLAY							
	45	CL	Lean CLAY - medium stiff, moist, brown with black staining; frequent sand seams≤1/8-in thick							
14			Lean CLAY - soft-medium stiff, moist; alternating brown/reddish-brown and black seams 1/8-3/8-in thick							
15	50									
			loose, wet silty SAND seam							
16		CL	Lean CLAY medium stiff-stiff, moist, alternating red/black/brown clay seams with frequent moist sand seams							
	55									
17			Bottom of Boring @ 55 Feet							

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:
abandonned hole at 40 ft, liner continuing to break and get stuck in casing

WATER LEVEL
▼- MEASURED ▽- ESTIMATED

Figure
A - 8b

DATE			
STARTED:	12/13/16		
COMPLETED:	12/13/16		
BACKFILLED:	12/13/16		

Westside Reservoir Landslide Evaluation

South Weber, Utah

Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 6-in HSA

BORING NO: **BH-5**

Sheet 1 of 2

LOCATION
NORTHING 3,572,313.83 EASTING 1,511,578.85 ELEVATION 4,728 feet
west of large tank and Trench 3

Depth (METERS)	Depth (FEET)	SAMPLES	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density (pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0	0										
			CL-ML	Silty lean CLAY with sand - medium stiff, dry, reddish brown							
1	5			-frequent sand seams							
2											
3	10	Modified California	CL	Lean CLAY with sand seams - stiff, dry, reddish brown	9 10 20		106.3	11			
			SM	Silty SAND - medium dense, dry, reddish brown							
4	15	Split Spoon	CL	Lean CLAY with sand seams - soft-medium stiff, moist, brown-reddish brown	1 2 4						
5											
6	20	Modified California	CL	Varved lean CLAY - stiff, moist, reddish brown; some sand seams (1/2 - 3/4-in thick) are wet	5 9 6		27.1				
7											
8	25	Modified California	CL	Lean CLAY - soft-medium stiff, moist, brown-grayish brown	3 4 4		26.2				

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. "U" Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 9a

DATE	
STARTED:	12/13/16
COMPLETED:	12/13/16
BACKFILLED:	12/13/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 6-in HSA

BORING NO: **BH-5**

LOCATION
NORTHING 3,572,313.83 EASTING 1,511,578.85 ELEVATION 4,728 feet
west of large tank and Trench 3

Depth (Meters)	Depth (Feet)	Samples	Unified Soil Classification	Material Description	N	Water Level	Dry Density (pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
9	30	2" O.D./1.38" I.D. Split Spoon Sampler	CL	Lean CLAY - medium stiff, moist, alternating brown/reddish-brown/black seams with occasional seams of fine sand (≤1/4-in thick)	2 4 6					41	22
10–11	35	Modified California Sampler	CL		2 4 8		104.5	21			
12	40	2" O.D./1.38" I.D. Split Spoon Sampler	CL	alternating seams of red/black/brown/gray CLAY and fine SAND (1/8-3/8-in thick)	3 3 6						
13–14	45	Modified California Sampler		- soft-medium stiff	1 4 4		23.7				
15	50	Modified California Sampler		- sand seams≤1/2-in thick	7 12 11		27.9				
	51.5			Bottom of Boring @ 51.5 Feet							

Moisture Content and Atterberg Limits (Plastic Limit — Moisture Content — Liquid Limit; scale 10 20 30 40 50 60 70 80 90)

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. "U" Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 9b

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (More than half of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid limit less than 50)		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

LOG KEY SYMBOLS

BORING SAMPLE LOCATION

TEST-PIT SAMPLE LOCATION

WATER LEVEL (level after completion)

WATER LEVEL (level where first encountered)

CEMENTATION

DESCRIPTION	DESCRIPTION
WEAKLY	CRUMBLES OR BREAKS WITH HANDLING OR SLIGHT FINGER PRESSURE
MODERATELY	CRUMBLES OR BREAKS WITH CONSIDERABLE FINGER PRESSURE
STRONGLY	WILL NOT CRUMBLE OR BREAK WITH FINGER PRESSURE

OTHER TESTS KEY

C	CONSOLIDATION	SA	SIEVE ANALYSIS
AL	ATTERBURG LIMITS	DS	DIRECT SHEAR
UC	UNCONFINED COMPRESSION	T	TRIAXIAL
S	SOLUBILITY	R	RESISTIVITY
O	ORGANIC CONTENT	RV	R-VALUE
CBR	CALIFORNIA BEARING RATIO	SU	SOLUBLE SULFATES
COMP	MOISTURE/DENSITY RELATIONSHIP	PM	PERMEABILITY
CI	CALIFORNIA IMPACT	-200	% FINER THAN #200
COL	COLLAPSE POTENTIAL	Gs	SPECIFIC GRAVITY
SS	SHRINK SWELL	SL	SWELL LOAD

MODIFIERS

DESCRIPTION	%
TRACE	<5
SOME	5 - 12
WITH	>12

MOISTURE CONTENT

DESCRIPTION	FIELD TEST
DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL BELOW WATER TABLE

STRATIFICATION

DESCRIPTION	THICKNESS	DESCRIPTION	THICKNESS
SEAM	1/16 - 1/2"	OCCASIONAL	ONE OR LESS PER FOOT OF THICKNESS
LAYER	1/2 - 12"	FREQUENT	MORE THAN ONE PER FOOT OF THICKNESS

GENERAL NOTES

1. Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
2. No warranty is provided as to the continuity of soil conditions between individual sample locations.
3. Logs represent general soil conditions observed at the point of exploration on the date indicated.
4. In general, Unified Soil Classification designations presented on the logs were evaluated by visual methods only. Therefore, actual designations (based on laboratory tests) may vary.

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPT (blows/ft)	MODIFIED CA. SAMPLER (blows/ft)	CALIFORNIA SAMPLER (blows/ft)	RELATIVE DENSITY (%)	FIELD TEST
VERY LOOSE	<4	<4	<5	0 - 15	EASILY PENETRATED WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
LOOSE	4 - 10	5 - 12	5 - 15	15 - 35	DIFFICULT TO PENETRATE WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
MEDIUM DENSE	10 - 30	12 - 35	15 - 40	35 - 65	EASILY PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
DENSE	30 - 50	35 - 60	40 - 70	65 - 85	DIFFICULT TO PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
VERY DENSE	>50	>60	>70	85 - 100	PENETRATED ONLY A FEW INCHES WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER

CONSISTENCY - FINE-GRAINED SOIL

CONSISTENCY	SPT (blows/ft)	TORVANE UNTRAINED SHEAR STRENGTH (tsf)	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH (tsf)	FIELD TEST
VERY SOFT	<2	<0.125	<0.25	EASILY PENETRATED SEVERAL INCHES BY THUMB. EXUDES BETWEEN THUMB AND FINGERS WHEN SQUEEZED BY HAND.
SOFT	2 - 4	0.125 - 0.25	0.25 - 0.5	EASILY PENETRATED ONE INCH BY THUMB. MOLDED BY LIGHT FINGER PRESSURE.
MEDIUM STIFF	4 - 8	0.25 - 0.5	0.5 - 1.0	PENETRATED OVER 1/2 INCH BY THUMB WITH MODERATE EFFORT. MOLDED BY STRONG FINGER PRESSURE.
STIFF	8 - 15	0.5 - 1.0	1.0 - 2.0	INDENTED ABOUT 1/2 INCH BY THUMB BUT PENETRATED ONLY WITH GREAT EFFORT.
VERY STIFF	15 - 30	1.0 - 2.0	2.0 - 4.0	READILY INDENTED BY THUMBNAIL.
HARD	>30	>2.0	>4.0	INDENTED WITH DIFFICULTY BY THUMBNAIL.

IGES

Project Number 01747-002

APPENDIX B

SUMMARY OF LABORATORY TEST RESULTS TABLE

West Side Reservoir - Landslide Evaluation (South Weber, UT) Project Number: 01747-002

Sample Location ID	Station (ft)	Depth (ft)	Dry Density (pcf)	Water Content (%)	% Gravel >#4 & <3"	% Sand >#200 & <#4	% Fines <#200	Liquid Limit	PI	Direct Shear (c) (psf)	Direct Shear ϕ' (degrees)
BH-1		19.5						31	13		
BH-1		30			0	99.6	0.4				
BH-1		37			0	49.1	50.9				
BH-2		20	126.2	2.8							
BH-2		30	103.8	22			84.0	41	21	0	39
BH-2		35						36	17		
BH-2		36	94.4	28.8							
BH-2		46	100.8	24				37	20		
BH-3		27		20.6			84.4	38	21		
BH-3		33.5		17.52			70.5				
BH-4		15		15.8			74.6	28	11		
BH-4		27.5		22.0			37.9	NP	NP		
BH-4		43		22.29			92.6	35	16		
BH-5		10	106.3	10.7							
BH-5		21		27.1							
BH-5		26		26.2							
BH-5		30						41	22		
BH-5		36	104.5	21						354	33
BH-5		46		23.7							
BH-5		51		27.9							
TR-1	4	3			52.1	38.3	9.6				
TR-1	7	6			0	3.7	96.3				
TR-1	14	9						46	25		
TR-1	45	9			0.2	29.9	69.9				
TR-1	90	11			63.9	33.9	2.2				
TR-1	107	6			0	65.8	34.2				
TR-1	118	7			0	21.7	78.3	29	13		
TR-1	125	7					71.0				
TR-1	131	6						33	14		
TR-1	165	11			49.6	48.7	1.7				
TR-2	20	8			0.5	13.6	85.9				
TR-2	45	10			64.6	33.2	2.2				
TR-2	80	8			0.5	7.4	92.1				
TR-3	35	4			2.3	61.6	36.1				
TR-3	46	5			0	58.3	41.7				
TR-3	62	8			67.8	29.6	2.6				
TR-3	71	8.5			7.1	89.7	3.2				

Water Content and Unit Weight of Soil

(In General Accordance with ASTM D7263 Method B and D2216)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 12/29/2016
By: BSS

Sample Info.	Boring No.	BH-2	BH-2	BH-5	BH-5	BH-5	BH-5	BH-5	BH-2
	Sample:								
	Depth:	36.0'	46.0'	10.0'	21.0'	26.0'	46.0'	51.0'	20.0'
Unit Weight Info.	Sample height, H (in)	6.000	5.000	6.000	5.000	5.000	5.000	5.000	5.150
	Sample diameter, D (in)	2.416	2.416	2.416	2.416	2.416	2.416	2.416	2.416
	Sample volume, V (ft^3)	0.0159	0.0133	0.0159	0.0133	0.0133	0.0133	0.0133	0.0137
	Mass rings + wet soil (g)	1142.30	974.13	1114.32	960.43	966.50	955.88	962.75	1764.82
	Mass rings/tare (g)	264.30	222.09	264.63	218.25	224.35	221.14	217.81	960.90
	Moist soil, Ws (g)	878.00	752.04	849.69	742.18	742.15	734.74	744.94	803.92
	Moist unit wt., γ_m (pcf)	121.60	124.99	117.68	123.35	123.34	122.11	123.81	129.72
Water Content	Wet soil + tare (g)	627.87	505.03	478.81	480.08	498.39	474.33	486.94	1024.53
	Dry soil + tare (g)	516.04	432.10	444.54	403.39	415.80	407.91	408.00	1003.15
	Tare (g)	128.00	127.87	123.30	120.89	123.44	127.08	124.77	227.27
	Water Content, w (%)	**28.8**	**24.0**	**10.7**	**27.1**	**28.2**	**23.7**	**27.9**	**2.8**
	Dry Unit Wt., γ_d (pcf)	**94.4**	**100.8**	**106.3**	**97.0**	**96.2**	**98.8**	**96.8**	**126.2**

Comments:

BH-2 20.0': Specimen changed from DSCD to M&D

Entered by:___________

Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: DKS

Boring No.: BH-1
Station:
Depth: 19.5'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

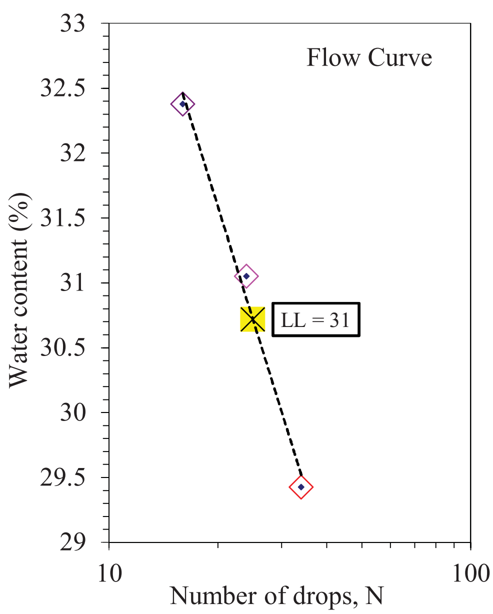
Plastic Limit

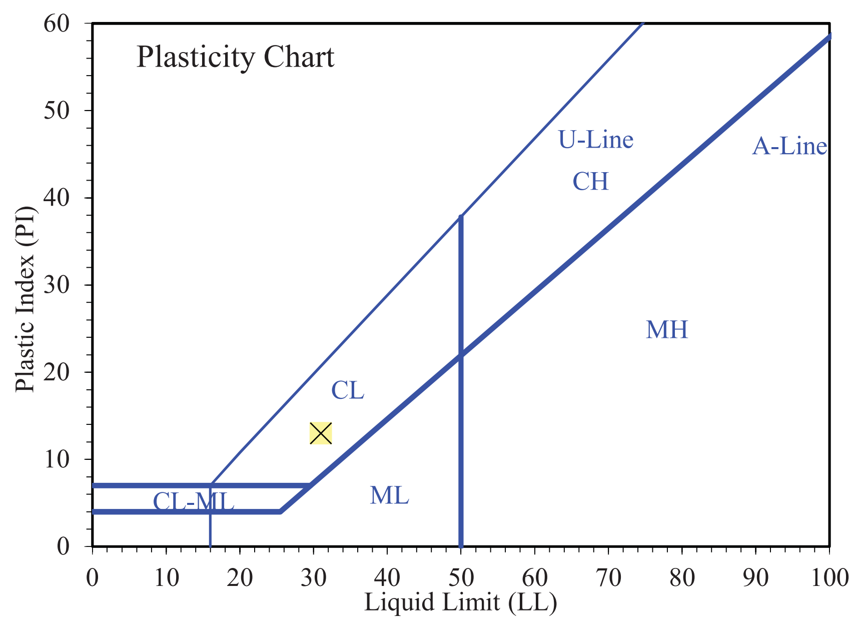
Determination No	1	2				
Wet Soil + Tare (g)	32.78	33.07				
Dry Soil + Tare (g)	31.09	31.37				
Water Loss (g)	1.69	1.70				
Tare (g)	21.81	21.95				
Dry Soil (g)	9.28	9.42				
Water Content, w (%)	18.21	18.05				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	24	16			
Wet Soil + Tare (g)	32.45	32.81	32.88			
Dry Soil + Tare (g)	29.94	30.27	30.17			
Water Loss (g)	2.51	2.54	2.71			
Tare (g)	21.41	22.09	21.80			
Dry Soil (g)	8.53	8.18	8.37			
Water Content, w (%)	29.43	31.05	32.38			
One-Point LL (%)		31				

Liquid Limit, LL (%)	**31**
Plastic Limit, PL (%)	**18**
Plasticity Index, PI (%)	**13**





Entered by:____________
Reviewed:____________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]1

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 12/30/2016
By: DKS

Boring No.: BH-2
Station:
Depth: 30.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

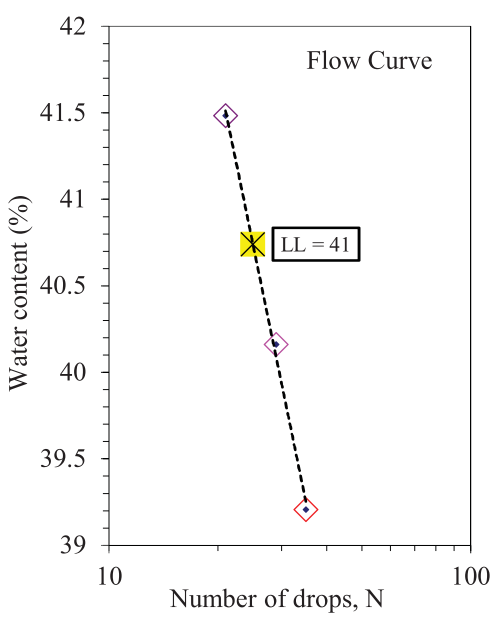
Plastic Limit

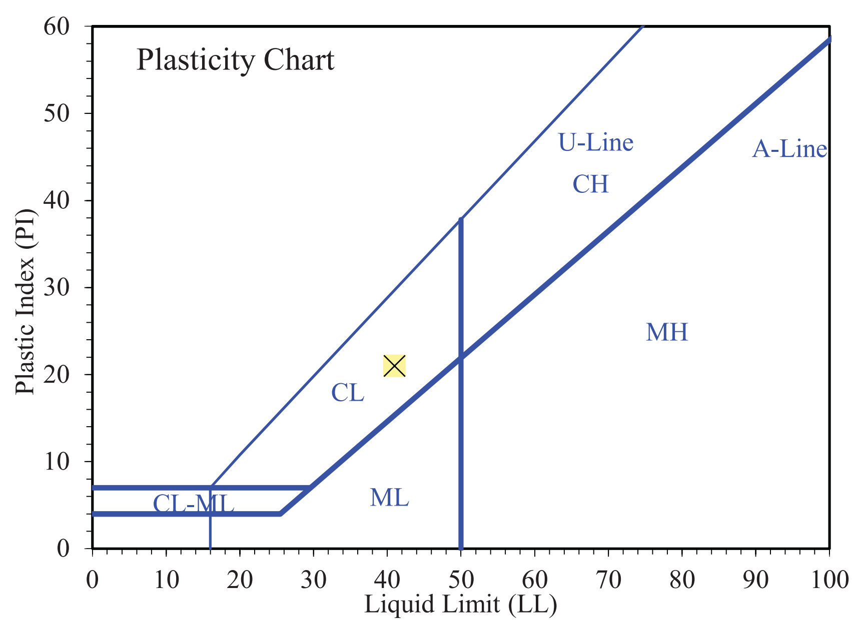
Determination No	1	2				
Wet Soil + Tare (g)	31.43	33.69				
Dry Soil + Tare (g)	29.75	31.79				
Water Loss (g)	1.68	1.90				
Tare (g)	21.28	22.07				
Dry Soil (g)	8.47	9.72				
Water Content, w (%)	19.83	19.55				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	29	21			
Wet Soil + Tare (g)	30.83	32.45	32.35			
Dry Soil + Tare (g)	28.36	29.45	29.33			
Water Loss (g)	2.47	3.00	3.02			
Tare (g)	22.06	21.98	22.05			
Dry Soil (g)	6.30	7.47	7.28			
Water Content, w (%)	39.21	40.16	41.48			
One-Point LL (%)		41	41			

Liquid Limit, LL (%)	**41**
Plastic Limit, PL (%)	**20**
Plasticity Index, PI (%)	**21**





Entered by:___________
Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 12/30/2016
By: DKS

Boring No.: BH-2
Station:
Depth: 35.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

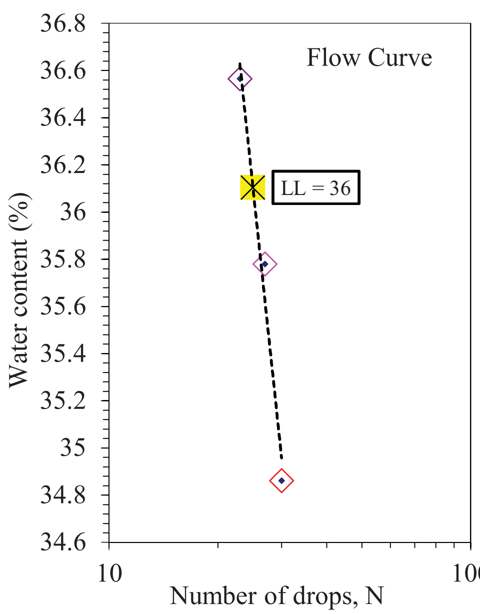
Plastic Limit

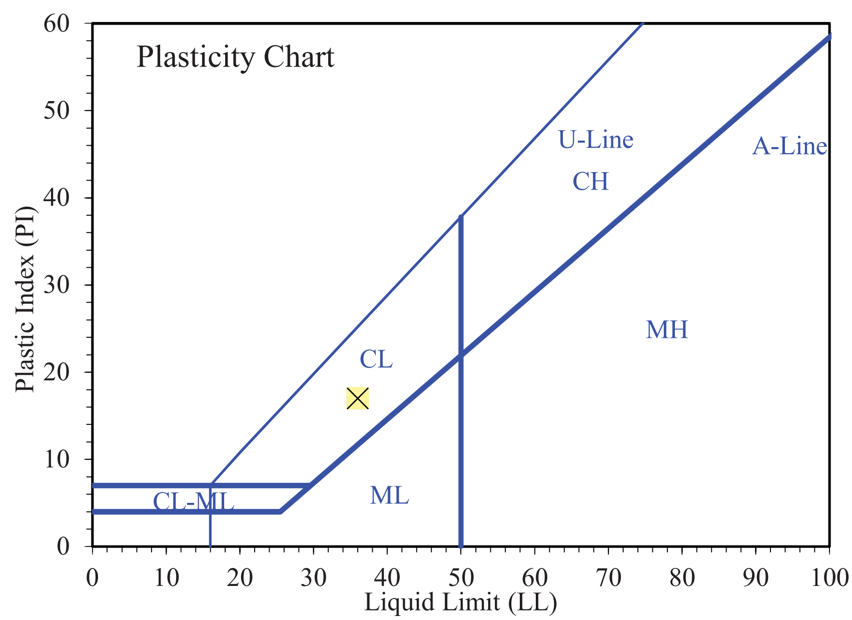
Determination No	1	2				
Wet Soil + Tare (g)	31.56	34.33				
Dry Soil + Tare (g)	29.94	32.30				
Water Loss (g)	1.62	2.03				
Tare (g)	21.52	21.78				
Dry Soil (g)	8.42	10.52				
Water Content, w (%)	19.24	19.30				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	30	27	23			
Wet Soil + Tare (g)	33.28	32.22	33.67			
Dry Soil + Tare (g)	30.39	29.49	30.54			
Water Loss (g)	2.89	2.73	3.13			
Tare (g)	22.10	21.86	21.98			
Dry Soil (g)	8.29	7.63	8.56			
Water Content, w (%)	34.86	35.78	36.57			
One-Point LL (%)	36	36	36			

Liquid Limit, LL (%)	**36**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**17**





Entered by:____________
Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/6/2017
By: BRR

Boring No.: BH-2
Station:
Depth: 46.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

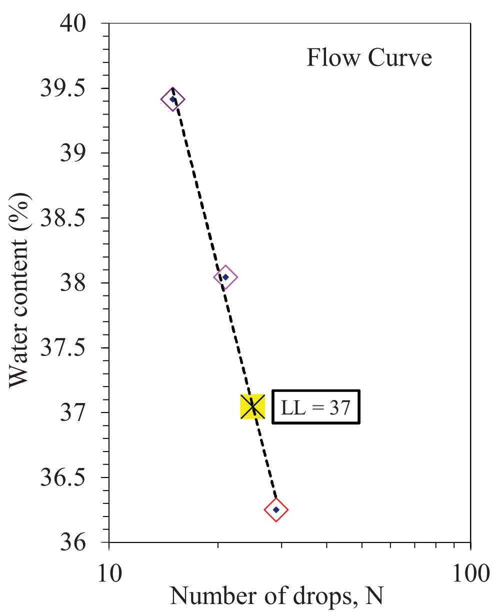
Plastic Limit

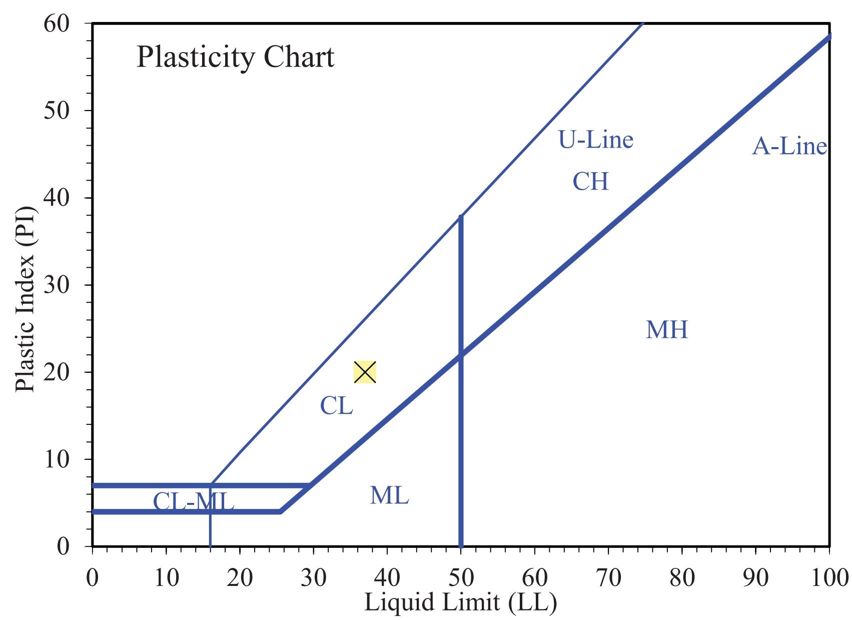
Determination No	1	2				
Wet Soil + Tare (g)	27.80	28.03				
Dry Soil + Tare (g)	26.92	27.13				
Water Loss (g)	0.88	0.90				
Tare (g)	21.60	21.83				
Dry Soil (g)	5.32	5.30				
Water Content, w (%)	16.54	16.98				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	29	21	15			
Wet Soil + Tare (g)	31.53	30.58	32.46			
Dry Soil + Tare (g)	28.92	28.13	29.50			
Water Loss (g)	2.61	2.45	2.96			
Tare (g)	21.72	21.69	21.99			
Dry Soil (g)	7.20	6.44	7.51			
Water Content, w (%)	36.25	38.04	39.41			
One-Point LL (%)	37	37				

Liquid Limit, LL (%)	**37**
Plastic Limit, PL (%)	**17**
Plasticity Index, PI (%)	**20**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]4

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/9/2017
By: BRR

Boring No.: BH-3
Station:
Depth: 27.0'
Description: Reddish brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

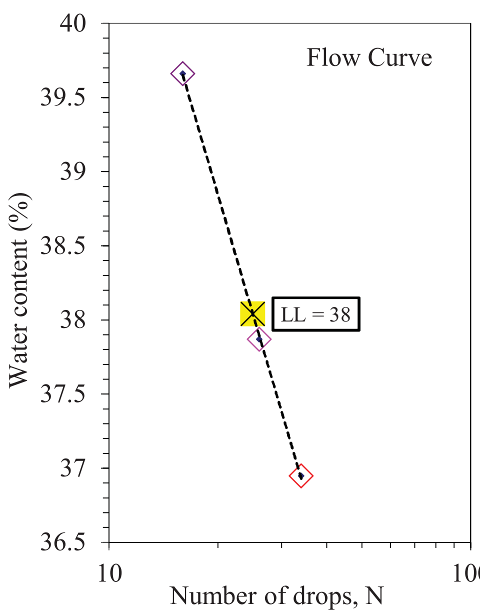
Plastic Limit

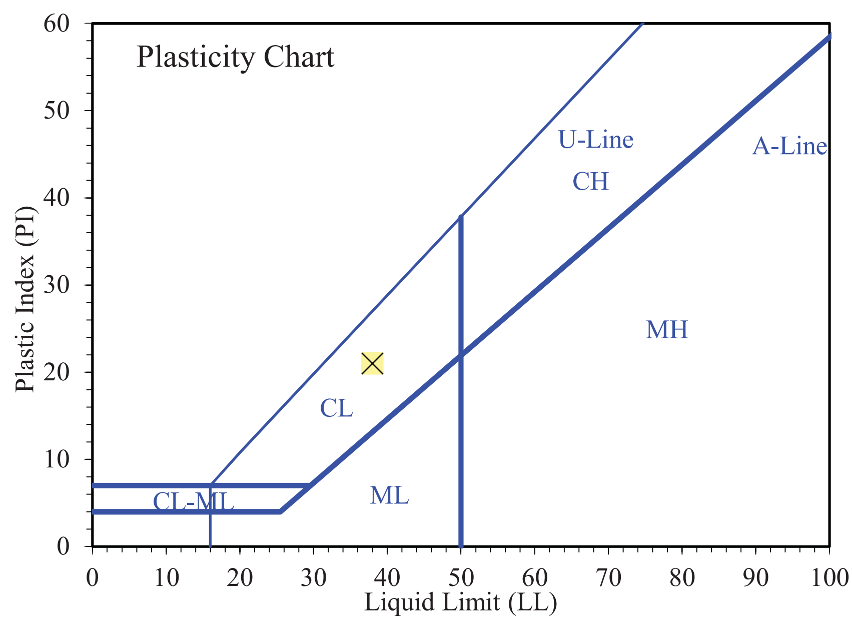
Determination No	1	2				
Wet Soil + Tare (g)	27.57	29.54				
Dry Soil + Tare (g)	26.66	28.41				
Water Loss (g)	0.91	1.13				
Tare (g)	21.43	21.84				
Dry Soil (g)	5.23	6.57				
Water Content, w (%)	17.40	17.20				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	26	16			
Wet Soil + Tare (g)	29.59	30.32	30.49			
Dry Soil + Tare (g)	27.58	28.01	28.15			
Water Loss (g)	2.01	2.31	2.34			
Tare (g)	22.14	21.91	22.25			
Dry Soil (g)	5.44	6.10	5.90			
Water Content, w (%)	36.95	37.87	39.66			
One-Point LL (%)		38				

Liquid Limit, LL (%)	**38**
Plastic Limit, PL (%)	**17**
Plasticity Index, PI (%)	**21**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]5

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/9/2017
By: BRR

Boring No.: BH-4
Station:
Depth: 15.0'
Description: Reddish brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

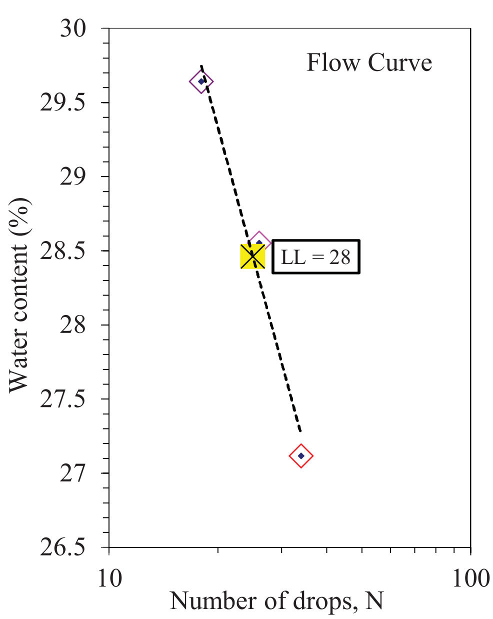
Plastic Limit

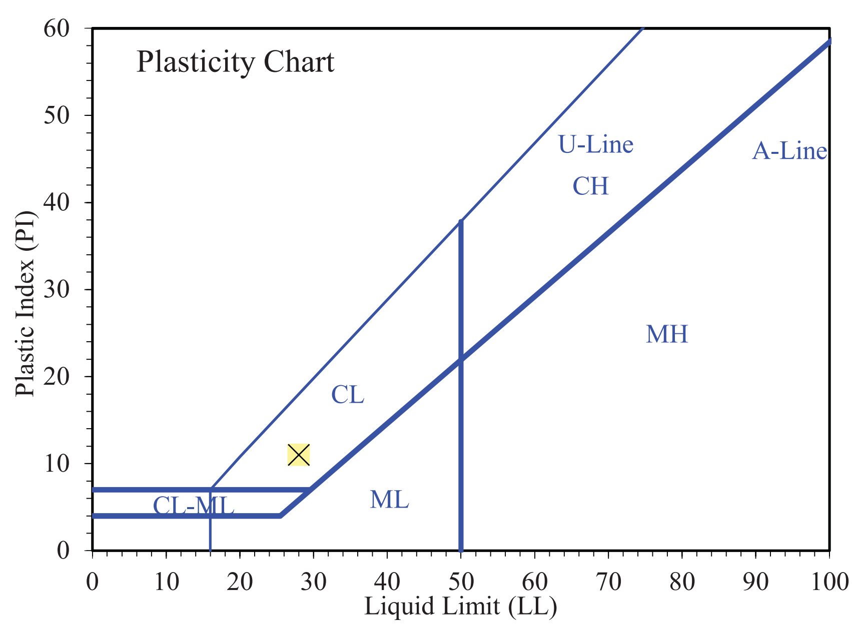
Determination No	1	2				
Wet Soil + Tare (g)	28.95	28.10				
Dry Soil + Tare (g)	27.91	27.18				
Water Loss (g)	1.04	0.92				
Tare (g)	21.77	21.71				
Dry Soil (g)	6.14	5.47				
Water Content, w (%)	16.94	16.82				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	26	18			
Wet Soil + Tare (g)	30.63	31.19	30.33			
Dry Soil + Tare (g)	28.74	29.14	28.43			
Water Loss (g)	1.89	2.05	1.90			
Tare (g)	21.77	21.96	22.02			
Dry Soil (g)	6.97	7.18	6.41			
Water Content, w (%)	27.12	28.55	29.64			
One-Point LL (%)		29				

Liquid Limit, LL (%)	**28**
Plastic Limit, PL (%)	**17**
Plasticity Index, PI (%)	**11**





Entered by:___________

Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]6

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: DKS

Boring No.: BH-4
Station:
Depth: 27.5'
Description: Brown silt

Preparation method: Wet
Liquid Limit: Could not be determined (N.P.)

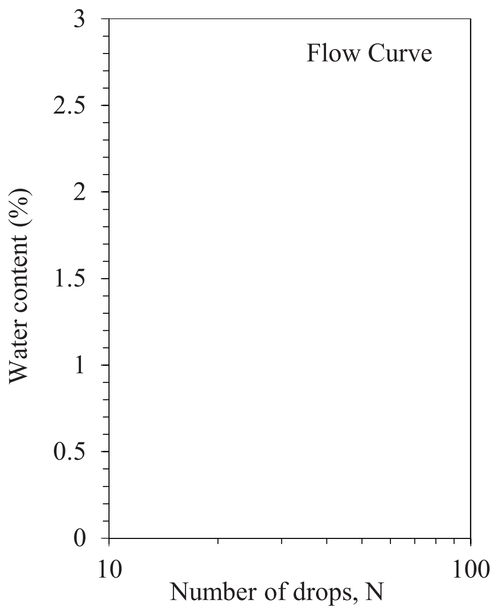
Plastic Limit

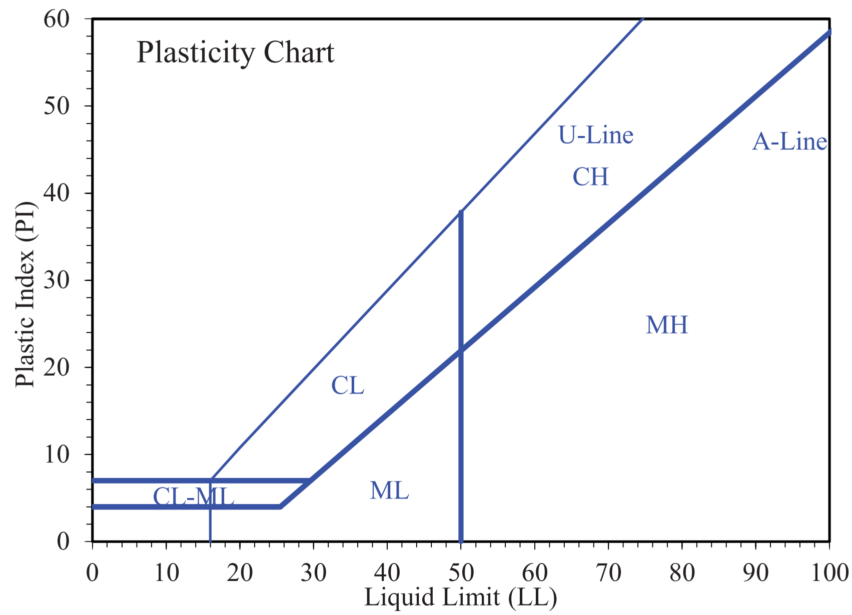
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]7

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: DKS

Boring No.: BH-4
Station:
Depth: 43.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

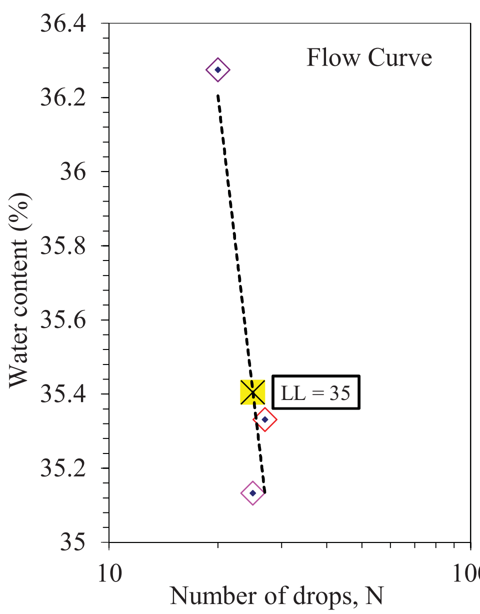
Plastic Limit

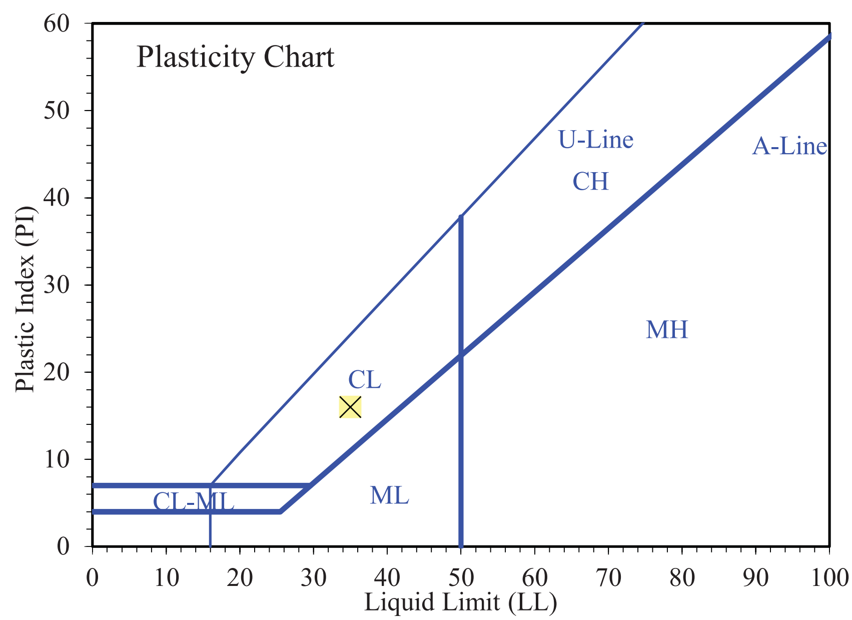
Determination No	1	2				
Wet Soil + Tare (g)	32.20	30.38				
Dry Soil + Tare (g)	30.60	28.97				
Water Loss (g)	1.60	1.41				
Tare (g)	22.05	21.45				
Dry Soil (g)	8.55	7.52				
Water Content, w (%)	18.71	18.75				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	27	25	20			
Wet Soil + Tare (g)	34.90	35.95	34.74			
Dry Soil + Tare (g)	31.54	32.37	31.41			
Water Loss (g)	3.36	3.58	3.33			
Tare (g)	22.03	22.18	22.23			
Dry Soil (g)	9.51	10.19	9.18			
Water Content, w (%)	35.33	35.13	36.27			
One-Point LL (%)	36	35	35			

Liquid Limit, LL (%)	**35**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**16**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]8

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/6/2017
By: BRR

Boring No.: BH-5
Station:
Depth: 30.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

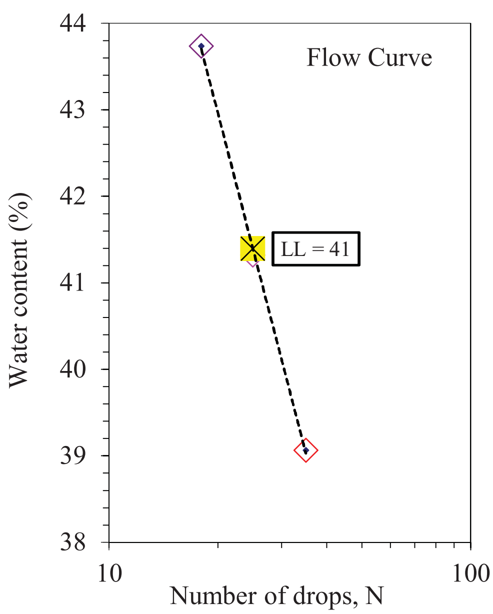
Plastic Limit

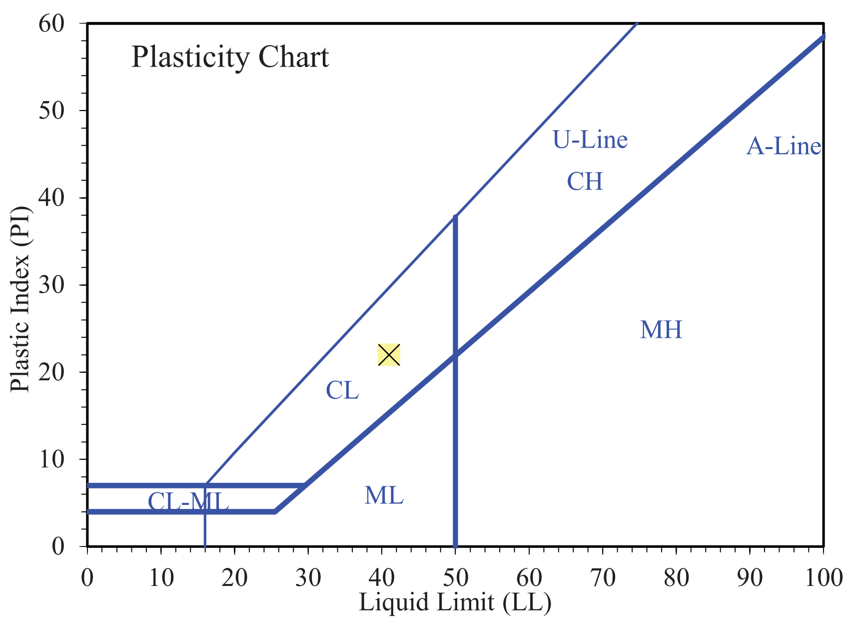
Determination No	1	2				
Wet Soil + Tare (g)	29.19	28.98				
Dry Soil + Tare (g)	28.06	27.79				
Water Loss (g)	1.13	1.19				
Tare (g)	22.11	21.58				
Dry Soil (g)	5.95	6.21				
Water Content, w (%)	18.99	19.16				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	25	18			
Wet Soil + Tare (g)	27.99	31.09	29.22			
Dry Soil + Tare (g)	26.15	28.40	27.02			
Water Loss (g)	1.84	2.69	2.20			
Tare (g)	21.44	21.89	21.99			
Dry Soil (g)	4.71	6.51	5.03			
Water Content, w (%)	39.07	41.32	43.74			
One-Point LL (%)		41				

Liquid Limit, LL (%)	**41**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**22**





Entered by:___________
Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: DKS

Boring No.: TR-1
Station: 131'
Depth: 6.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

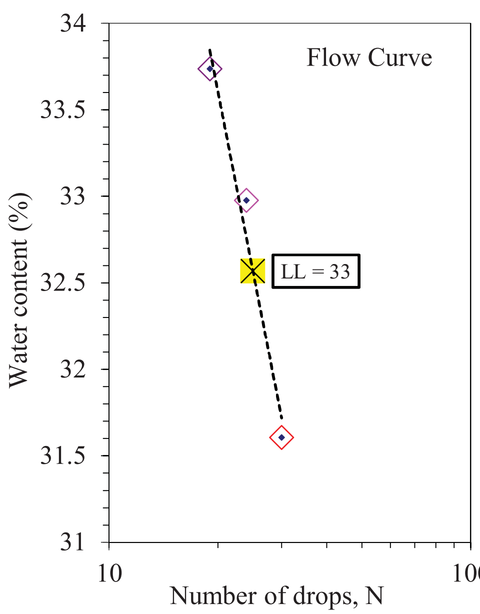
Plastic Limit

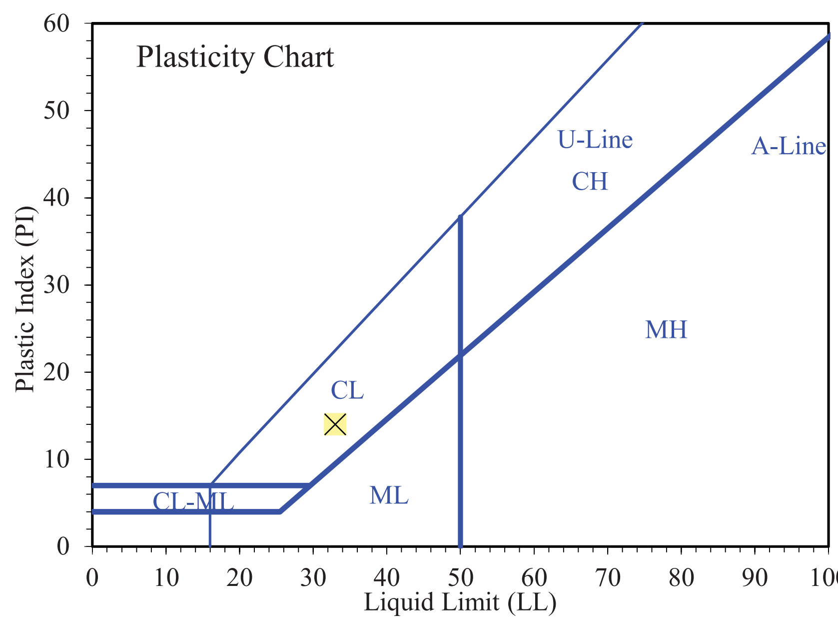
Determination No	1	2			
Wet Soil + Tare (g)	33.56	33.05			
Dry Soil + Tare (g)	31.74	31.20			
Water Loss (g)	1.82	1.85			
Tare (g)	21.97	21.15			
Dry Soil (g)	9.77	10.05			
Water Content, w (%)	18.63	18.41			

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	30	24	19			
Wet Soil + Tare (g)	34.84	35.90	33.19			
Dry Soil + Tare (g)	31.79	32.50	30.41			
Water Loss (g)	3.05	3.40	2.78			
Tare (g)	22.14	22.19	22.17			
Dry Soil (g)	9.65	10.31	8.24			
Water Content, w (%)	31.61	32.98	33.74			
One-Point LL (%)	32	33				

Liquid Limit, LL (%)	**33**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**14**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]10

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: DKS

Boring No.: TR-1
Station: 118'
Depth: 7.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

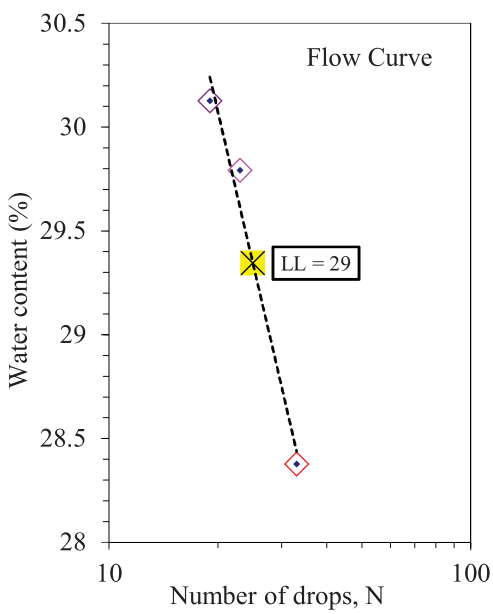
Plastic Limit

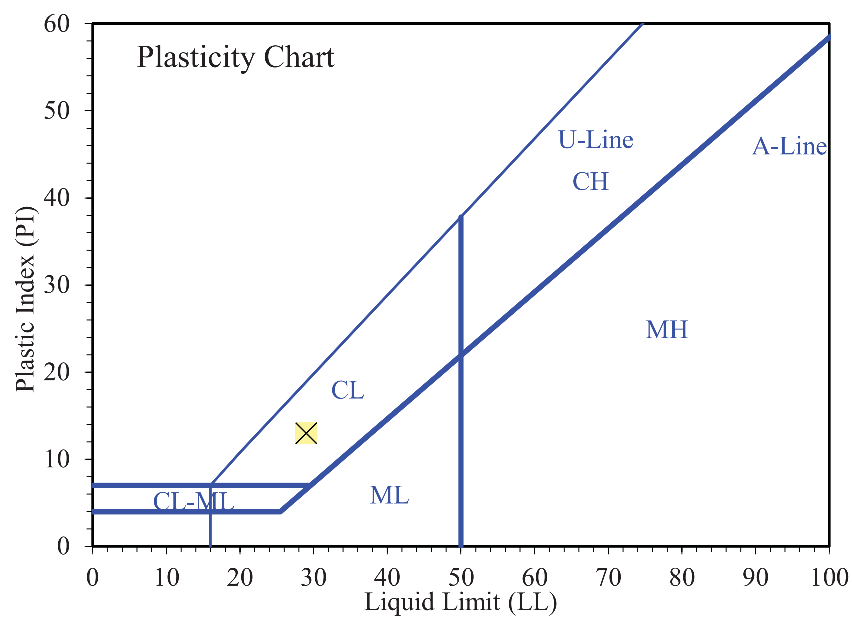
Determination No	1	2				
Wet Soil + Tare (g)	32.26	32.88				
Dry Soil + Tare (g)	30.80	31.35				
Water Loss (g)	1.46	1.53				
Tare (g)	21.71	21.78				
Dry Soil (g)	9.09	9.57				
Water Content, w (%)	16.06	15.99				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	33	23	19			
Wet Soil + Tare (g)	35.17	32.23	34.37			
Dry Soil + Tare (g)	32.25	29.79	31.52			
Water Loss (g)	2.92	2.44	2.85			
Tare (g)	21.96	21.60	22.06			
Dry Soil (g)	10.29	8.19	9.46			
Water Content, w (%)	28.38	29.79	30.13			
One-Point LL (%)		29				

Liquid Limit, LL (%)	**29**
Plastic Limit, PL (%)	**16**
Plasticity Index, PI (%)	**13**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]11

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/6/2017
By: DKS

Boring No.: TR-1
Station: 14'
Depth: 9.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

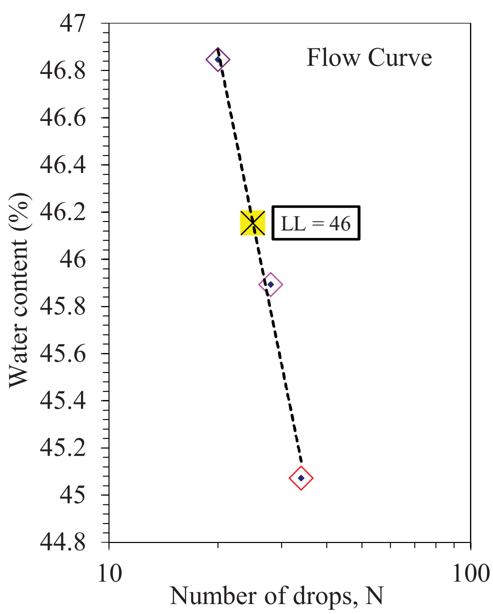
Plastic Limit

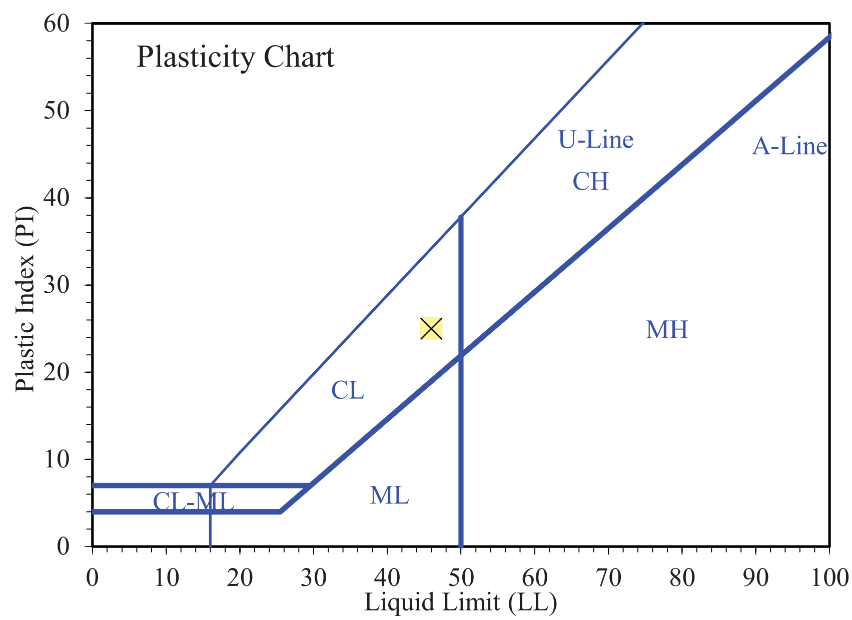
Determination No	1	2				
Wet Soil + Tare (g)	33.45	32.91				
Dry Soil + Tare (g)	31.37	31.06				
Water Loss (g)	2.08	1.85				
Tare (g)	21.43	22.29				
Dry Soil (g)	9.94	8.77				
Water Content, w (%)	20.93	21.09				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	28	20			
Wet Soil + Tare (g)	32.02	32.31	33.56			
Dry Soil + Tare (g)	28.91	29.07	29.92			
Water Loss (g)	3.11	3.24	3.64			
Tare (g)	22.01	22.01	22.15			
Dry Soil (g)	6.90	7.06	7.77			
Water Content, w (%)	45.07	45.89	46.85			
One-Point LL (%)		47	46			

Liquid Limit, LL (%)	**46**
Plastic Limit, PL (%)	**21**
Plasticity Index, PI (%)	**25**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]12

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

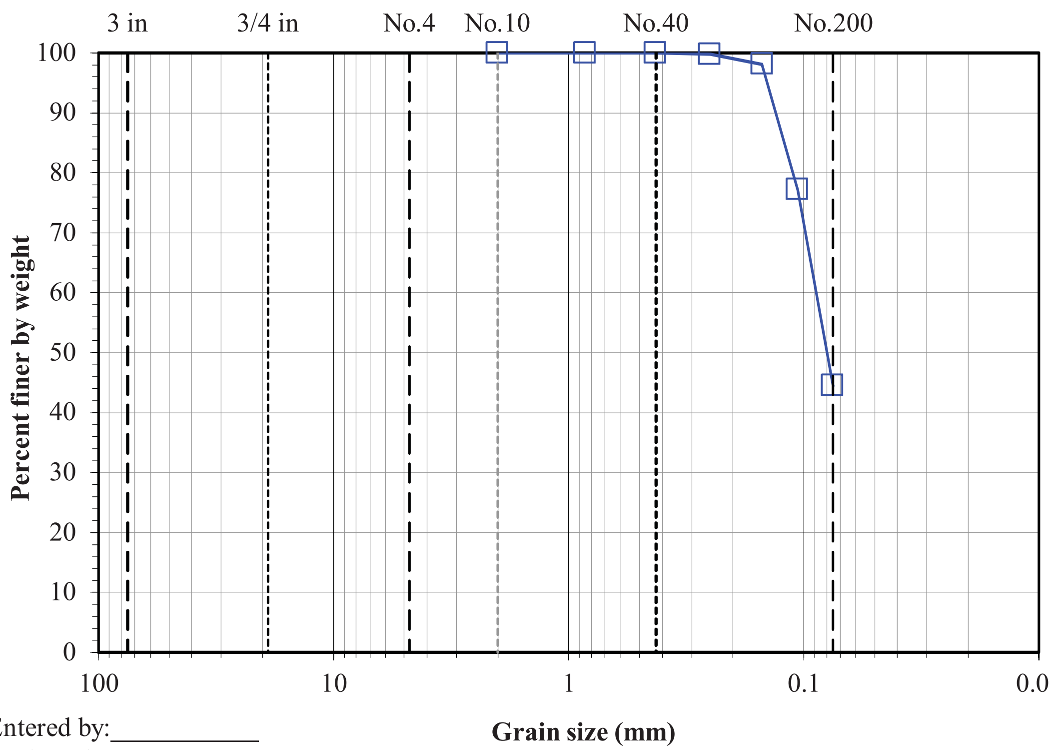
Boring No.: BH-1
Sample:
Depth: 30.0'
Description: Brown silty sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	161.94	142.30
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	435.18
Dry soil + tare (g):	-	415.54
Tare (g):	-	273.24
Water content (%):	0.0	13.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	-
No.10	-	2	100.0
No.20	0.02	0.85	100.0
No.40	0.04	0.425	100.0
No.60	0.34	0.25	99.8
No.100	2.68	0.15	98.1
No.140	32.53	0.106	77.1
No.200	78.96	0.075	44.5



Gravel (%): 0.0
Sand (%): 55.5
Fines (%): 44.5

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]1

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

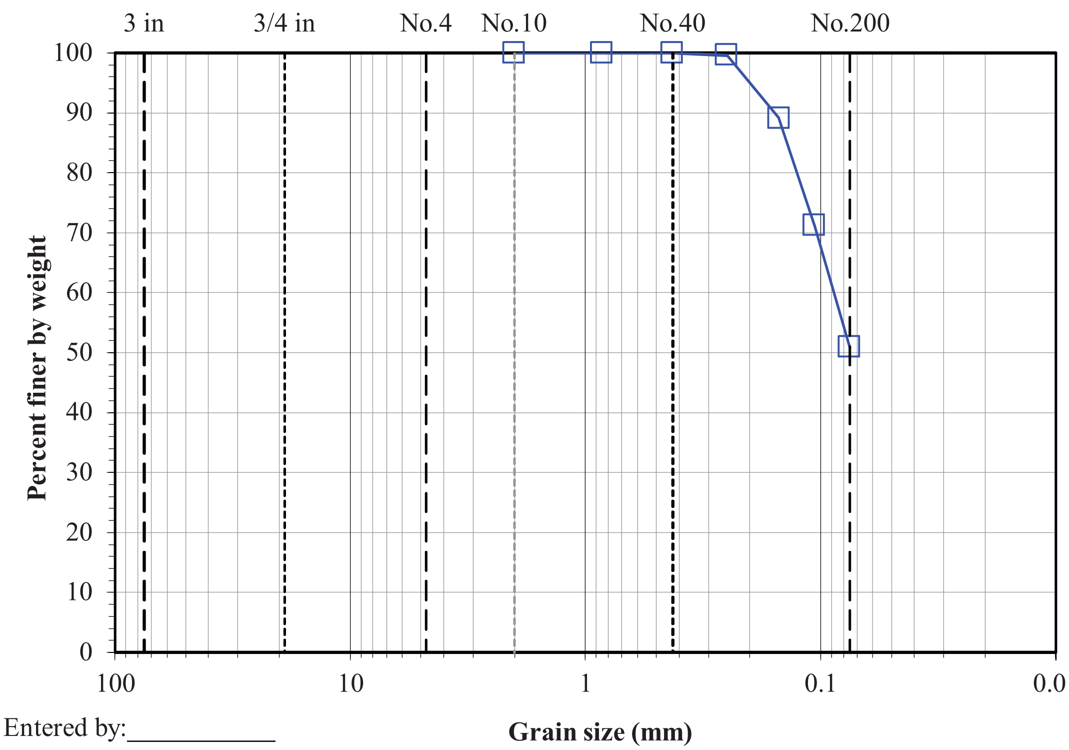
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: BH-1
Sample:
Depth: 37.0'
Description: Brown sandy silt

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	219.21	195.79
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	346.53
Dry soil + tare (g):	-	323.11
Tare (g):	-	127.32
Water content (%):	0.0	12.0

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	-
No.10	-	2	100.0
No.20	0.02	0.85	100.0
No.40	0.05	0.425	100.0
No.60	0.79	0.25	99.6
No.100	21.34	0.15	89.1
No.140	56.42	0.106	71.2
No.200	96.21	0.075	50.9



Gravel (%): 0.0
Sand (%): 49.1
Fines (%): 50.9

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]2

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

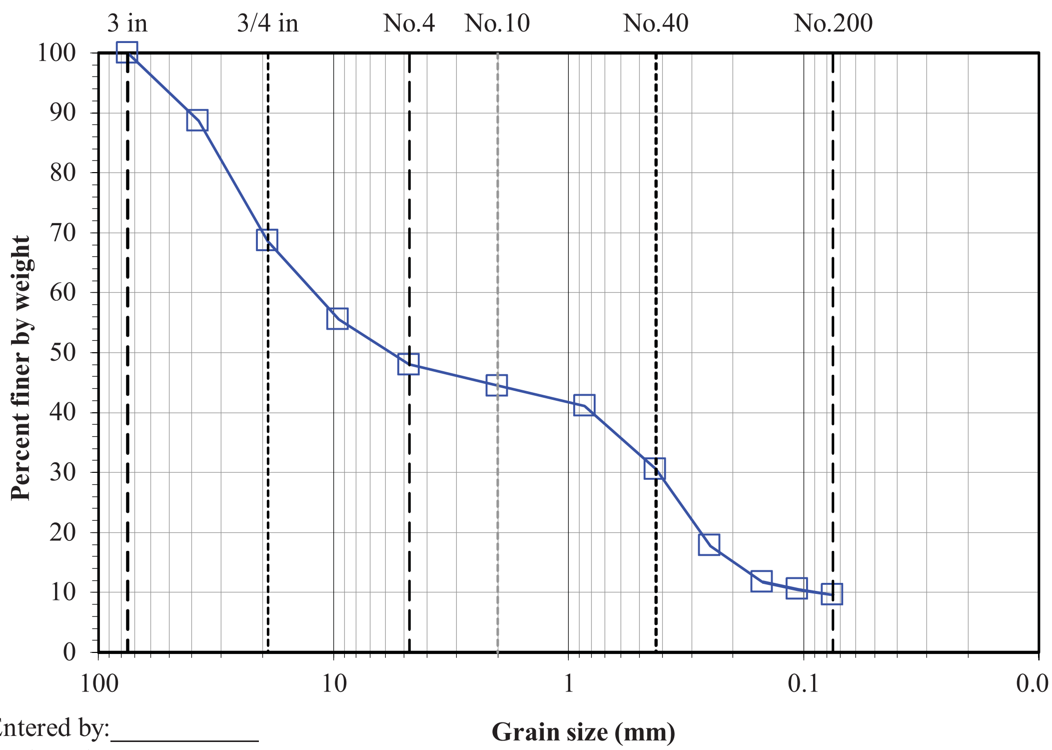
(ASTM D6913)

Project:	West End Reservoir	Boring No.:	TR-1
No:	01747-002	Station:	4'
Location:	South Weber, Utah	Depth:	3.0'
Date:	1/3/2017	Description:	Brown gravel with silt and sand
By:	BSS		

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	3923.90	3746.15
+3/8" Coarse fraction (g):	1691.50	1666.88
-3/8" Split fraction (g):	264.74	246.58
Split fraction:	0.555	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	2100.05	486.76
Dry soil + tare (g):	2075.43	468.60
Tare (g):	408.55	222.02
Water content (%):	1.5	7.4

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	424.53	37.5	88.7	
3/4"	1175.14	19	68.6	
3/8"	1666.88	9.5	55.5	←Split
No.4	33.65	4.75	47.9	
No.10	49.37	2	44.4	
No.20	64.31	0.85	41.0	
No.40	111.03	0.425	30.5	
No.60	167.66	0.25	17.8	
No.100	194.55	0.15	11.7	
No.140	200.01	0.106	10.5	
No.200	204.06	0.075	9.6	



Gravel (%): 52.1
Sand (%): 38.4
Fines (%): 9.6

Entered by:___________

Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]3

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

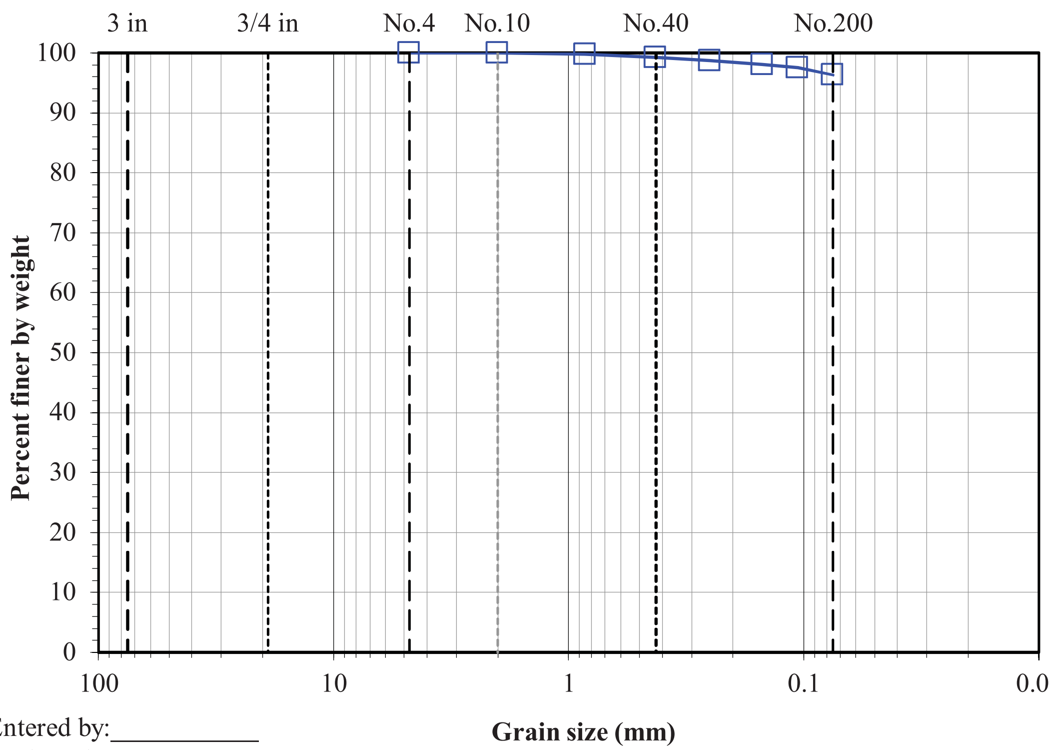
Boring No.: TR-1
Station: 7'
Depth: 6.0'
Description: Brown clay

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	279.33	251.05
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	501.58
Dry soil + tare (g):	-	473.30
Tare (g):	-	222.25
Water content (%):	0.0	11.3

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	100.0
No.10	0.13	2	99.9
No.20	0.66	0.85	99.7
No.40	1.90	0.425	99.2
No.60	3.24	0.25	98.7
No.100	4.83	0.15	98.1
No.140	6.21	0.106	97.5
No.200	9.33	0.075	96.3



Gravel (%): 0.0
Sand (%): 3.7
Fines (%): 96.3

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]4

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

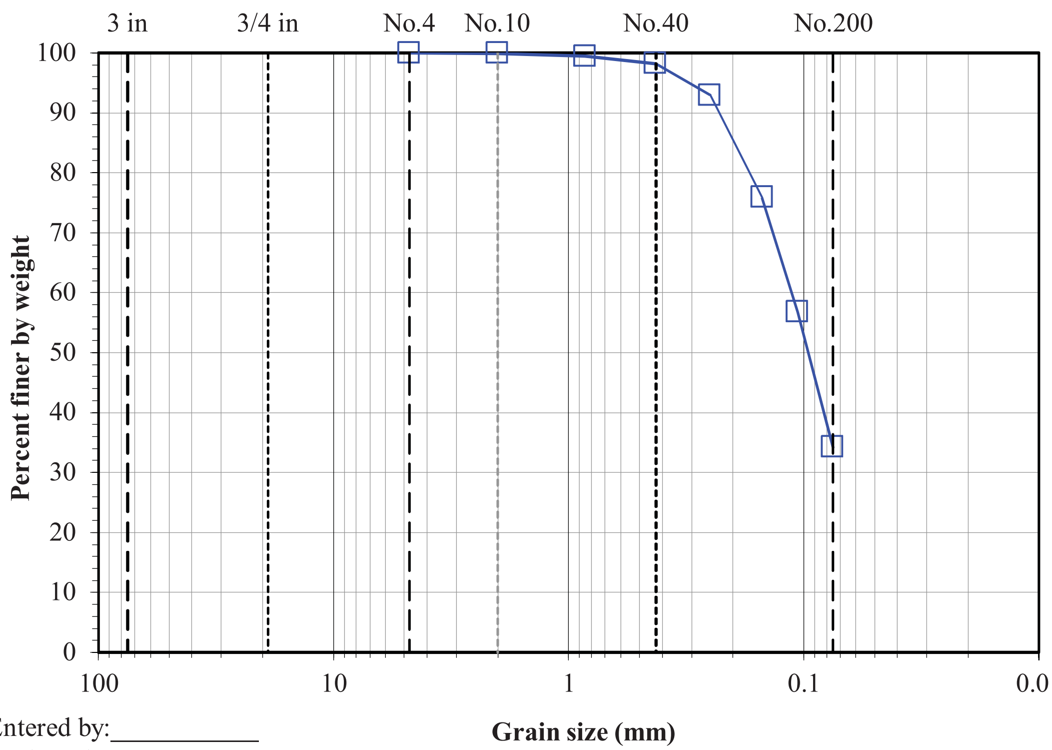
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-1
Station: 107'
Depth: 6.0'
Description: Light brown silty sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	276.65	268.59
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	492.01
Dry soil + tare (g):	-	483.95
Tare (g):	-	215.36
Water content (%):	0.0	3.0

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	100.0
No.10	0.28	2	99.9
No.20	1.49	0.85	99.4
No.40	4.78	0.425	98.2
No.60	18.95	0.25	92.9
No.100	64.76	0.15	75.9
No.140	116.16	0.106	56.8
No.200	176.63	0.075	34.2



Gravel (%): 0.0
Sand (%): 65.8
Fines (%): 34.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]5

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

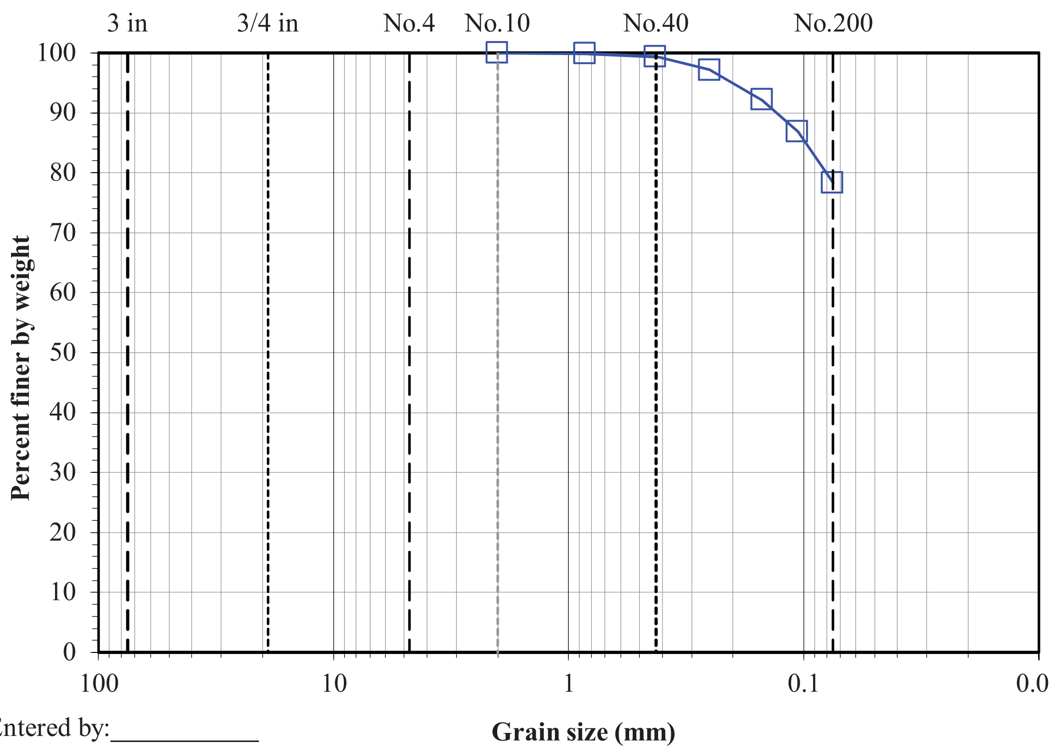
Boring No.: TR-1
Station: 118'
Depth: 7.0'
Description: Light brown clay with sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	230.33	217.49
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	381.08
Dry soil + tare (g):	-	368.24
Tare (g):	-	150.75
Water content (%):	0.0	5.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	-
No.10	-	2	100.0
No.20	0.31	0.85	99.9
No.40	1.43	0.425	99.3
No.60	6.35	0.25	97.1
No.100	17.08	0.15	92.1
No.140	28.65	0.106	86.8
No.200	47.21	0.075	78.3



Gravel (%): 0.0
Sand (%): 21.7
Fines (%): 78.3

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]6

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

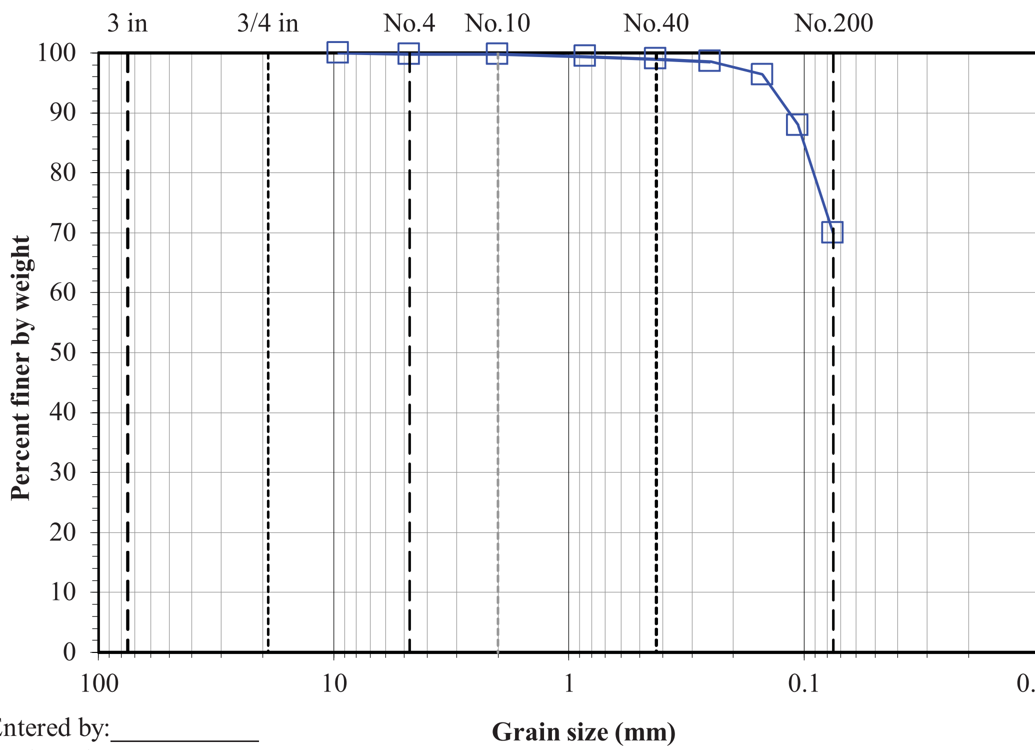
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-1
Station: 45'
Depth: 9.0'
Description: Brown silt with sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	147.80	143.22
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	268.77
Dry soil + tare (g):	-	264.19
Tare (g):	-	120.97
Water content (%):	0.0	3.2

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	100.0
No.4	0.31	4.75	99.8
No.10	0.37	2	99.7
No.20	0.89	0.85	99.4
No.40	1.51	0.425	98.9
No.60	2.10	0.25	98.5
No.100	5.25	0.15	96.3
No.140	17.34	0.106	87.9
No.200	43.11	0.075	69.9



Gravel (%): 0.2
Sand (%): 29.9
Fines (%): 69.9

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]7

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

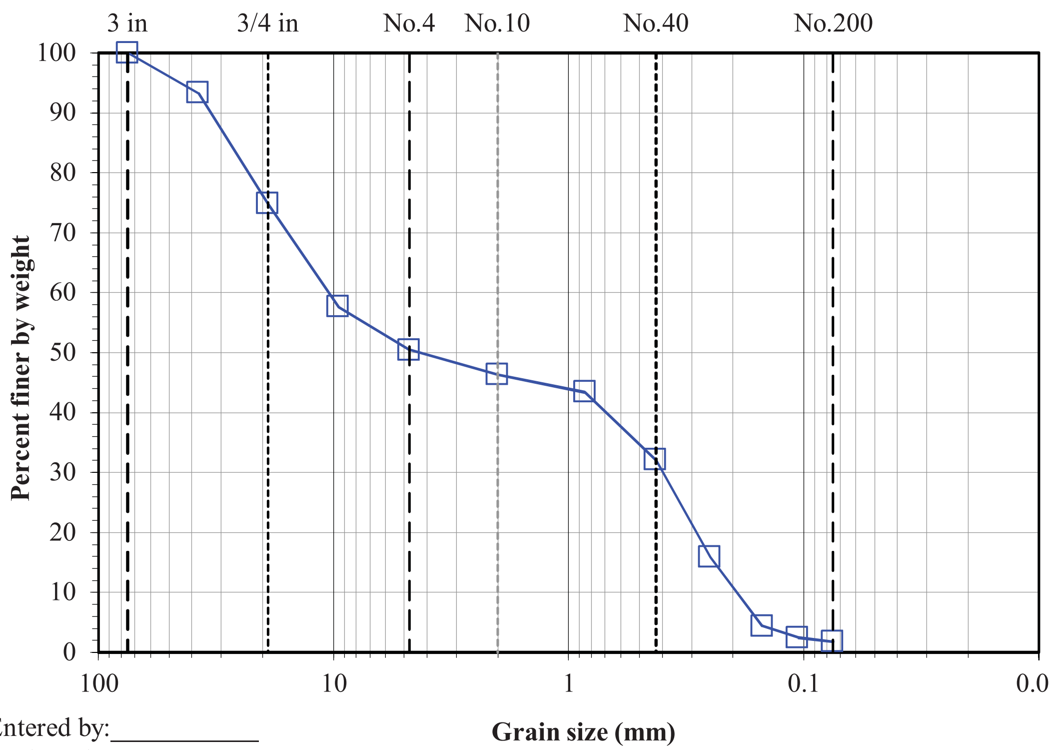
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/7/2017
By: BSS

Boring No.: TR-1
Station: 165'
Depth: 11.0'
Description: Brown gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	6289.41	6213.47
+3/8" Coarse fraction (g):	2654.01	2632.97
-3/8" Split fraction (g):	204.63	201.54
Split fraction:	0.576	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	3389.18	344.87
Dry soil + tare (g):	3368.14	341.78
Tare (g):	735.17	140.24
Water content (%):	0.8	1.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	100.0
1.5"	415.08	37.5	93.3
3/4"	1560.63	19	74.9
3/8"	2632.97	9.5	57.6 ←Split
No.4	25.34	4.75	50.4
No.10	39.65	2	46.3
No.20	49.70	0.85	43.4
No.40	89.42	0.425	32.1
No.60	146.22	0.25	15.8
No.100	186.25	0.15	4.4
No.140	193.07	0.106	2.4
No.200	195.49	0.075	1.7



Gravel (%): 49.6
Sand (%): 48.6
Fines (%): 1.7

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]8

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

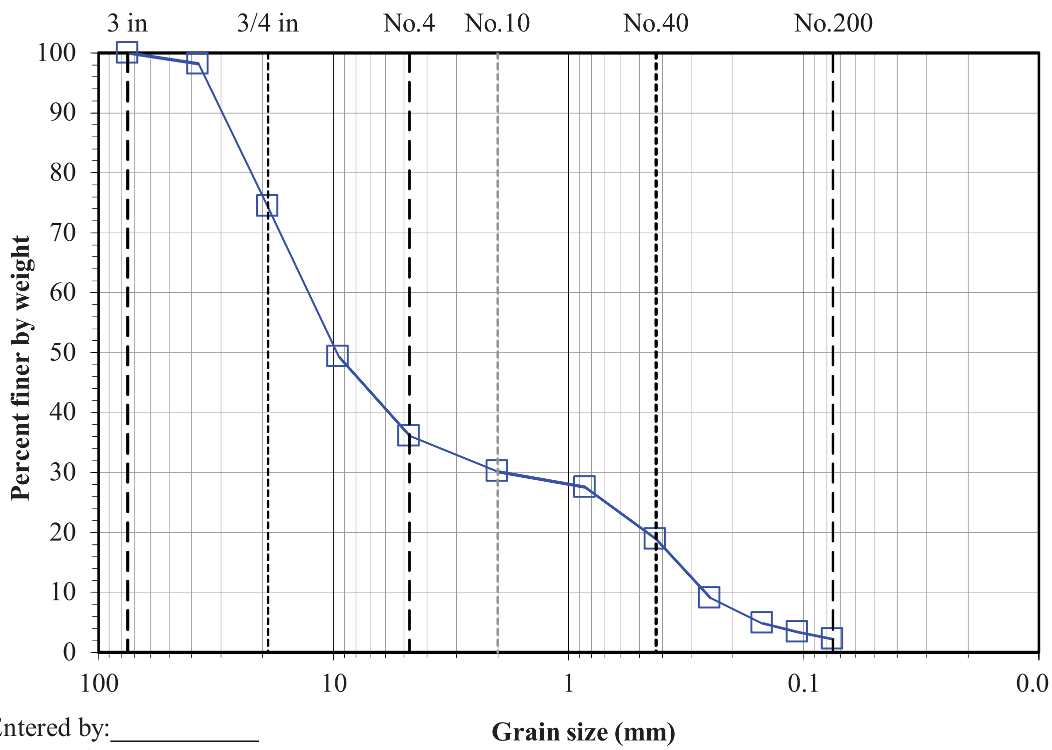
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: BSS

Boring No.: TR-1
Station: 90'
Depth: 11.0'
Description: Brown gravel with sand

	Moist	Dry
Split:	Yes	
Split sieve:	3/8"	
Total sample wt. (g):	29970.50	29804.29
+3/8" Coarse fraction (g):	15157.30	15095.39
-3/8" Split fraction (g):	343.70	341.28
Split fraction:	0.494	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	4119.80	563.09
Dry soil + tare (g):	4105.88	560.67
Tare (g):	711.54	219.39
Water content (%):	0.4	0.7

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	546.66	37.5	98.2	
3/4"	7626.42	19	74.4	
3/8"	15095.39	9.5	49.4	←Split
No.4	91.67	4.75	36.1	
No.10	132.66	2	30.2	
No.20	150.69	0.85	27.6	
No.40	210.78	0.425	18.9	
No.60	278.85	0.25	9.0	
No.100	307.96	0.15	4.8	
No.140	318.26	0.106	3.3	
No.200	325.93	0.075	2.2	



Gravel (%): 63.9
Sand (%): 33.9
Fines (%): 2.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]9

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

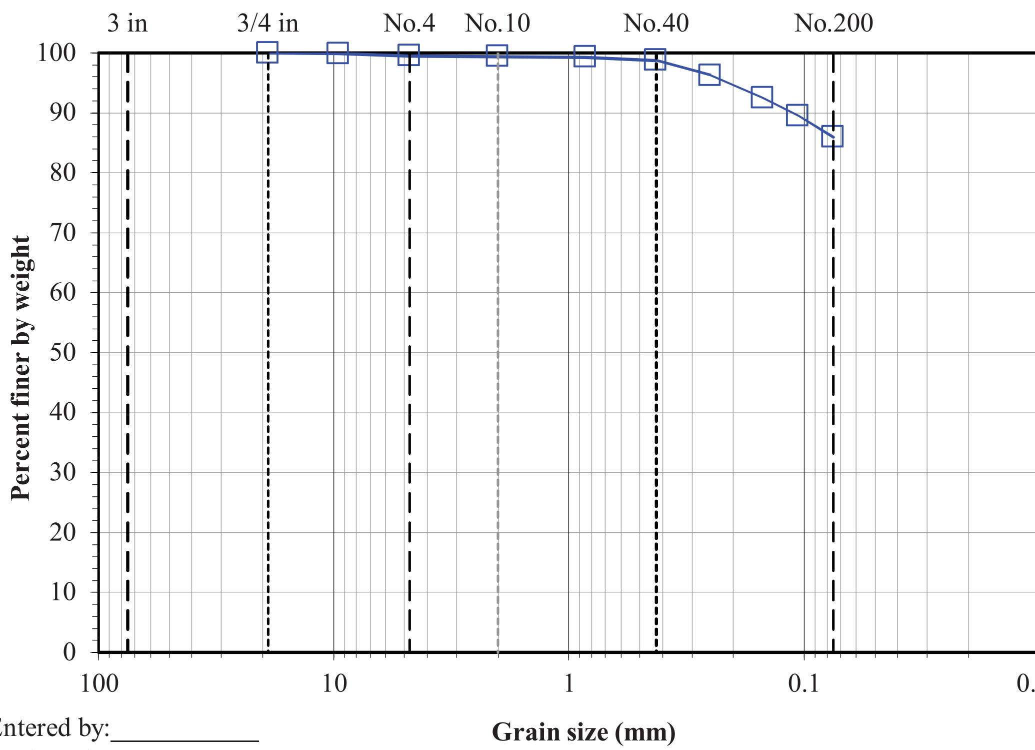
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-2
Station: 20'
Depth: 8.0'
Description: Brown silt

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	4102.61	3425.98
+3/8" Coarse fraction (g):	5.21	5.16
-3/8" Split fraction (g):	195.67	163.36
Split fraction:	0.998	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	133.44	322.50
Dry soil + tare (g):	133.39	290.19
Tare (g):	128.23	126.83
Water content (%):	1.0	19.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	-	
3/4"	-	19	100.0	
3/8"	5.16	9.5	99.8	←Split
No.4	0.56	4.75	99.5	
No.10	0.73	2	99.4	
No.20	0.97	0.85	99.3	
No.40	1.84	0.425	98.7	
No.60	5.92	0.25	96.2	
No.100	12.06	0.15	92.5	
No.140	16.97	0.106	89.5	
No.200	22.77	0.075	85.9	



Gravel (%): 0.5
Sand (%): 13.6
Fines (%): 85.9

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]10

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

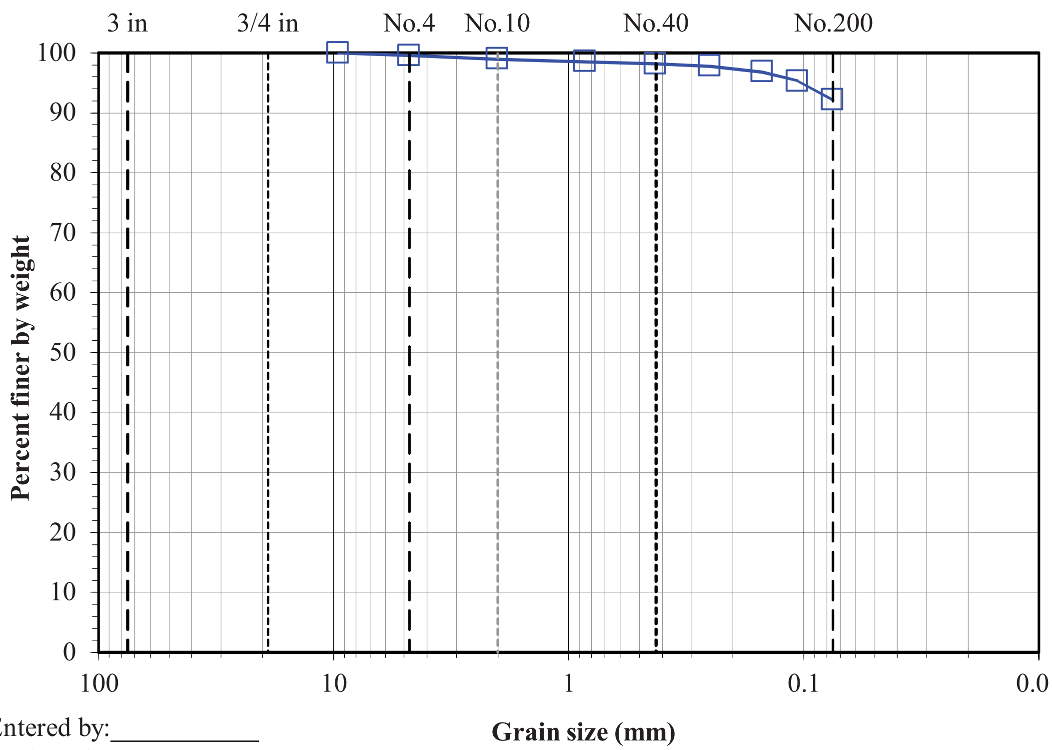
Boring No.: TR-2
Station: 80'
Depth: 8.0'
Description: Light brown silt

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	199.84	190.57
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	321.55
Dry soil + tare (g):	-	312.28
Tare (g):	-	121.71
Water content (%):	0.0	4.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	100.0
No.4	0.86	4.75	99.5
No.10	2.01	2	98.9
No.20	2.82	0.85	98.5
No.40	3.49	0.425	98.2
No.60	4.24	0.25	97.8
No.100	6.04	0.15	96.8
No.140	9.00	0.106	95.3
No.200	15.03	0.075	92.1



Gravel (%): 0.5
Sand (%): 7.4
Fines (%): 92.1

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]11

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

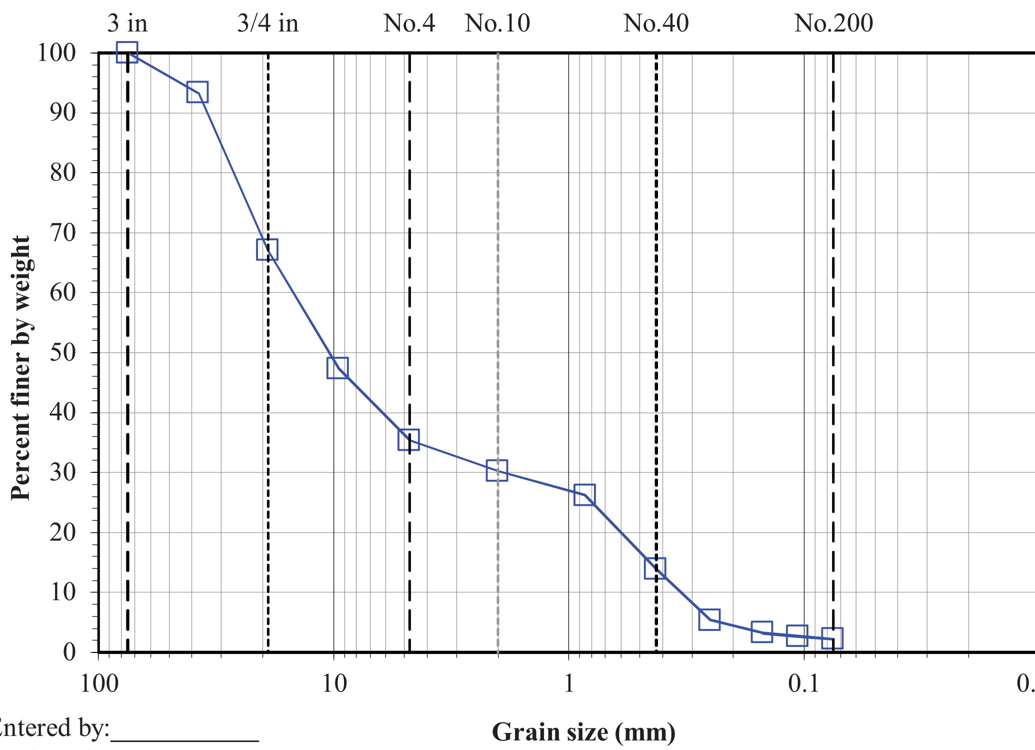
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/6/2017
By: BSS

Boring No.: TR-2
Station: 45'
Depth: 10.0'
Description: Brown gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	31540.70	31056.09
+3/8" Coarse fraction (g):	16543.60	16361.47
-3/8" Split fraction (g):	336.16	329.38
Split fraction:	0.473	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	4181.34	551.54
Dry soil + tare (g):	4143.47	544.76
Tare (g):	741.48	215.38
Water content (%):	1.1	2.1

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	2081.33	37.5	93.3	
3/4"	10224.20	19	67.1	
3/8"	16361.47	9.5	47.3	←Split
No.4	83.23	4.75	35.4	
No.10	119.18	2	30.2	
No.20	147.31	0.85	26.2	
No.40	232.95	0.425	13.9	
No.60	292.51	0.25	5.3	
No.100	306.72	0.15	3.3	
No.140	311.13	0.106	2.6	
No.200	314.39	0.075	2.2	



Gravel (%): 64.6
Sand (%): 33.2
Fines (%): 2.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]12

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

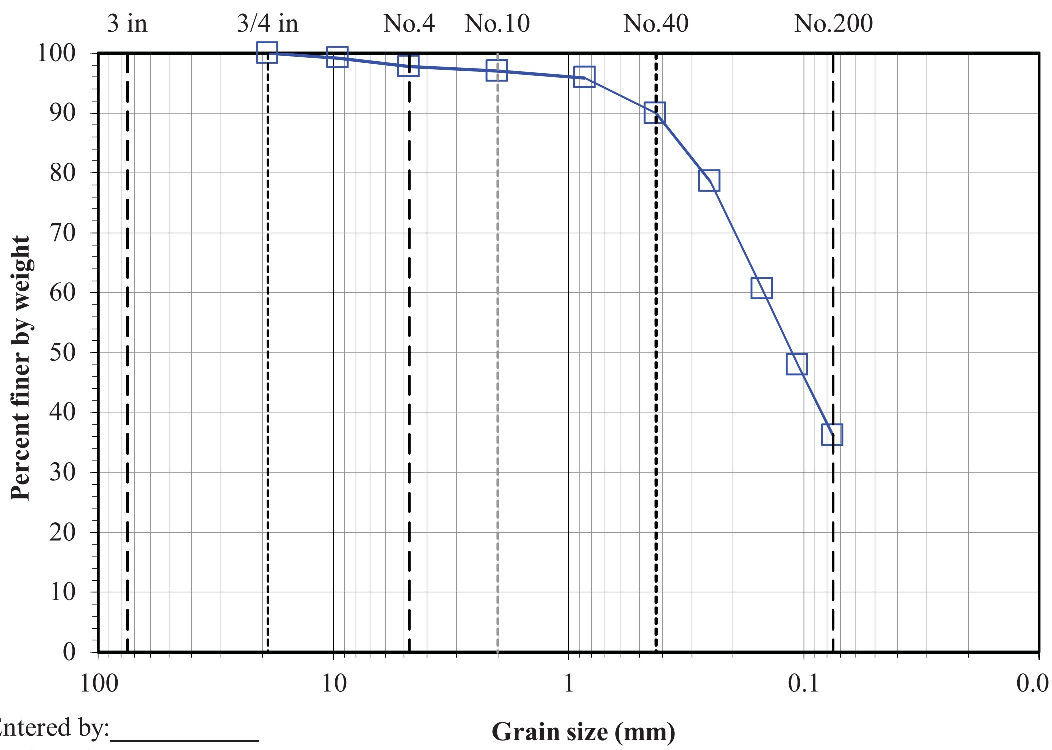
Boring No.: TR-3
Station: 35'
Depth: 4.0'
Description: Brown silty sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	168.54	154.88
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	290.41
Dry soil + tare (g):	-	276.75
Tare (g):	-	121.87
Water content (%):	0.0	8.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	100.0
3/8"	1.31	9.5	99.2
No.4	3.53	4.75	97.7
No.10	4.65	2	97.0
No.20	6.43	0.85	95.8
No.40	15.57	0.425	89.9
No.60	33.25	0.25	78.5
No.100	61.01	0.15	60.6
No.140	80.69	0.106	47.9
No.200	98.94	0.075	36.1



Gravel (%): 2.3
Sand (%): 61.6
Fines (%): 36.1

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]13

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

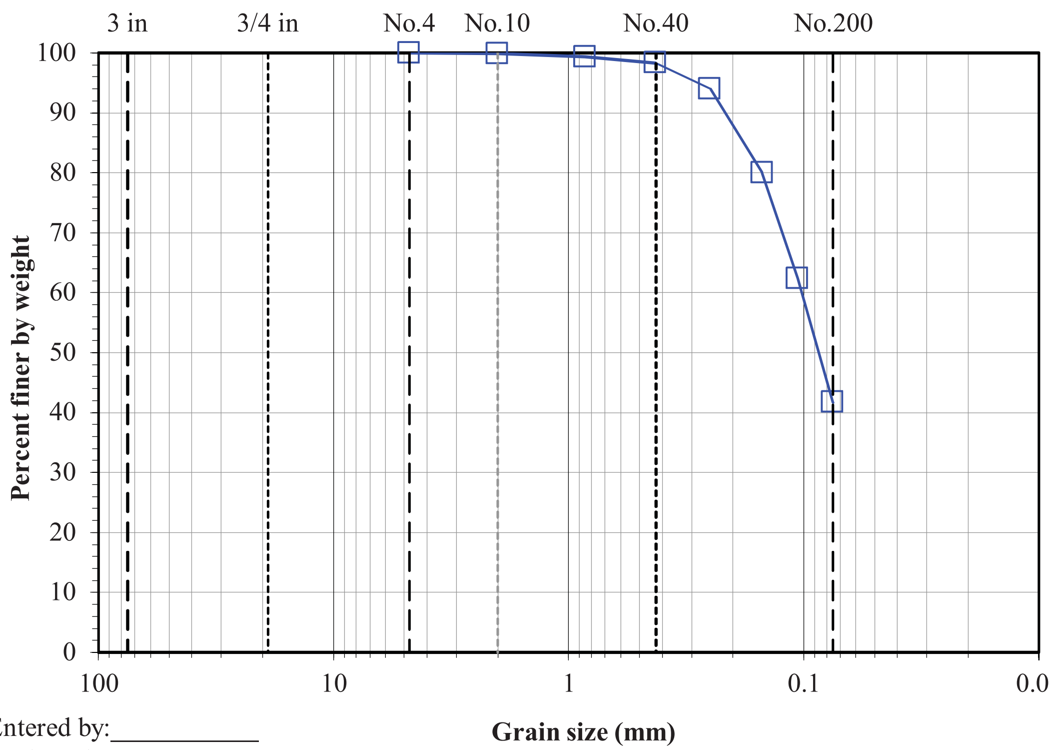
(ASTM D6913)

Project:	**West End Reservoir**	**Boring No.:**	**TR-3**
No:	**01747-002**	**Station:**	**46'**
Location:	South Weber, Utah	**Depth:**	**5.0'**
Date:	1/3/2017	Description:	Light brown silty sand
By:	BSS		

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	99.44	96.07
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	240.23
Dry soil + tare (g):	-	236.86
Tare (g):	-	140.79
Water content (%):	0.0	3.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	100.0
No.10	0.12	2	99.9
No.20	0.64	0.85	99.3
No.40	1.63	0.425	98.3
No.60	5.77	0.25	94.0
No.100	19.24	0.15	80.0
No.140	36.17	0.106	62.4
No.200	56.02	0.075	41.7



Gravel (%): 0.0
Sand (%): 58.3
Fines (%): 41.7

Entered by:___________

Reviewed:___________

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

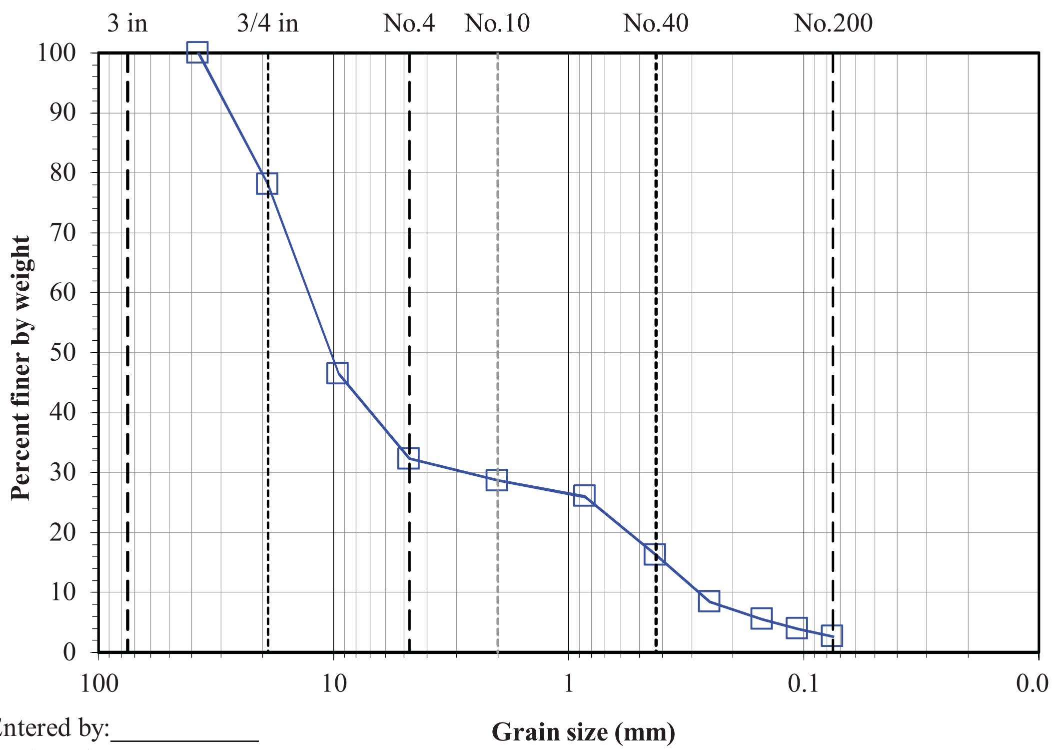
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-3
Station: 62'
Depth: 8.0'
Description: Light brown gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	5673.49	5599.34
+3/8" Coarse fraction (g):	3024.99	2997.48
-3/8" Split fraction (g):	339.55	333.57
Split fraction:	0.465	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	3766.51	466.33
Dry soil + tare (g):	3739.00	460.35
Tare (g):	741.52	126.78
Water content (%):	0.9	1.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	1229.02	19	78.1	
3/8"	2997.48	9.5	46.5	←Split
No.4	102.17	4.75	32.2	
No.10	128.13	2	28.6	
No.20	146.92	0.85	26.0	
No.40	217.35	0.425	16.2	
No.60	273.57	0.25	8.4	
No.100	294.16	0.15	5.5	
No.140	305.93	0.106	3.9	
No.200	314.82	0.075	2.6	



Gravel (%): 67.8
Sand (%): 29.6
Fines (%): 2.6

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]15

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

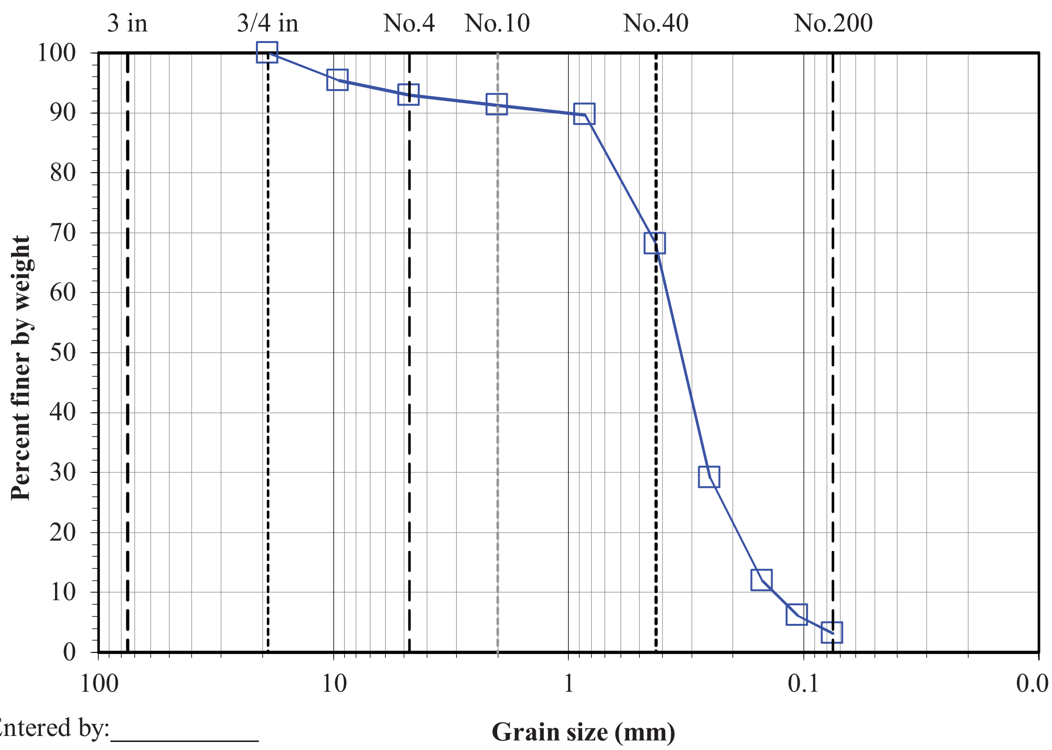
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-3
Station: 71'
Depth: 8.5'
Description: Light brown sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	1404.78	1391.93
+3/8" Coarse fraction (g):	65.38	64.68
-3/8" Split fraction (g):	163.20	161.72
Split fraction:	0.954	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	188.94	289.80
Dry soil + tare (g):	188.24	288.32
Tare (g):	123.56	126.60
Water content (%):	1.1	0.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	-	
3/4"	-	19	100.0	
3/8"	64.68	9.5	95.4	←Split
No.4	4.16	4.75	92.9	
No.10	6.95	2	91.3	
No.20	9.68	0.85	89.6	
No.40	46.25	0.425	68.1	
No.60	112.35	0.25	29.1	
No.100	141.48	0.15	11.9	
No.140	151.39	0.106	6.1	
No.200	156.36	0.075	3.2	



Gravel (%): 7.1
Sand (%): 89.7
Fines (%): 3.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]16

Amount of Material in Soil Finer than the No. 200 (75µm) Sieve

(ASTM D1140)

Project: **West End Reservoir**
No: **01747-002**
Location: South Weber, Utah
Date: 12/30/2016
By: BSS

Sample Info.	Boring No.	BH-2	BH-3	BH-3	BH-4	BH-4	BH-4	TR-1	
	Station							125'	
	Depth	30.0'	27.0'	33.5'	15.0'	27.5	43.0'	7.0'	
	Split	No	No	No	No	No	No	No	
	Split Sieve*								
	Method	B	B	B	B	B	B	B	
	Specimen soak time (min)	120	190	260	260	290	300	330	
	Moist total sample wt. (g)	205.94	121.94	216.49	170.90	119.21	182.60	122.14	
	Moist coarse fraction (g)								
	Moist split fraction + tare (g)								
	Split fraction tare (g)								
	Dry split fraction (g)								
	Dry retained No. 200 + tare (g)	150.84	138.16	195.18	161.24	182.59	132.34	186.63	
	Wash tare (g)	124.51	122.36	140.86	123.75	121.87	121.29	152.71	
	No. 200 Dry wt. retained (g)	26.33	15.80	54.32	37.49	60.72	11.05	33.92	
	Split sieve* Dry wt. retained (g)								
	Dry total sample wt. (g)	164.23	101.10	184.21	147.57	97.71	149.32	116.94	
Coarse Fraction	Moist soil + tare (g)								
	Dry soil + tare (g)								
	Tare (g)								
	Water content (%)								
Split Fraction	Moist soil + tare (g)	330.45	244.30	357.35	294.65	241.08	303.89	274.85	
	Dry soil + tare (g)	288.74	223.46	325.07	271.32	219.58	270.61	269.65	
	Tare (g)	124.51	122.36	140.86	123.75	121.87	121.29	152.71	
	Water content (%)	25.40	20.61	17.52	15.81	22.00	22.29	4.45	
	Percent passing split sieve* (%)								
	Percent passing No. 200 sieve (%)	**84.0**	**84.4**	**70.5**	**74.6**	**37.9**	**92.6**	**71.0**	

Entered by:___________
Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/9/2017
By: JDF

Boring No.: BH-2
Sample:
Depth: 30.0'
Sample Description: Brown clay with sand
Sample type: Undisturbed-trimmed from ring

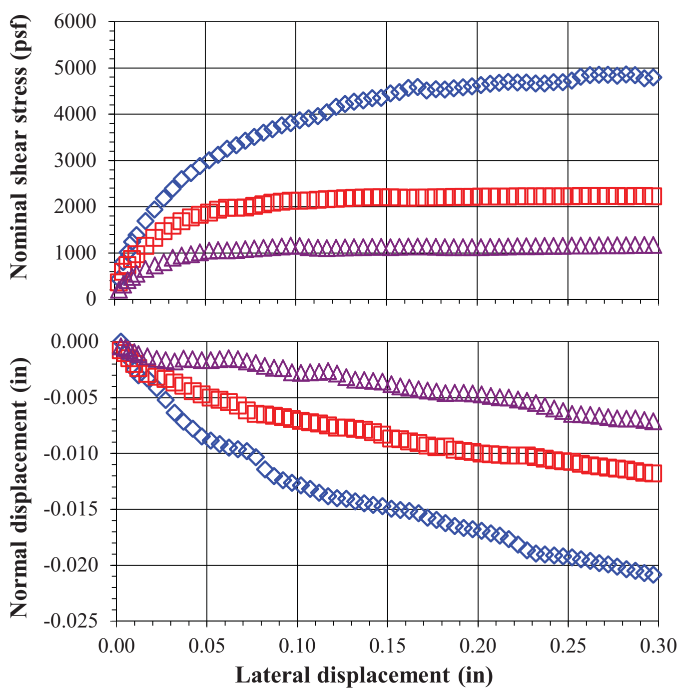
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0009
Specific gravity, Gs: 2.70 Assumed

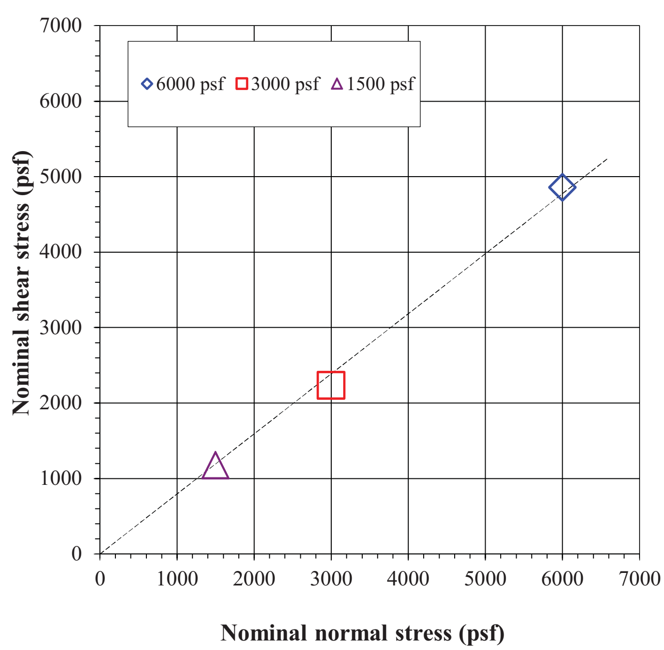
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	6000		3000		1500	
Peak shear stress (psf)	4858		2231		1174	
Lateral displacement at peak (in)	0.282		0.267		0.302	
Load Duration (min)	1017		1035		1048	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9362	1.0000	0.9453	1.0000	0.9723
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	196.30	192.67	199.60	196.63	196.55	195.44
Wt. rings (g)	43.73	43.73	46.99	46.99	43.58	43.58
Wet soil + tare (g)	305.00		305.00		305.00	
Dry soil + tare (g)	277.15		277.15		277.15	
Tare (g)	151.72		151.72		151.72	
Water content (%)	22.2	19.3	22.2	19.8	22.2	21.3
Dry unit weight (pcf)	103.7	110.8	103.8	109.7	104.0	106.9
Void ratio, e, for assumed Gs	0.62	0.52	0.62	0.54	0.62	0.58
Saturation (%)*	96.0	100.0	96.0	100.0	96.6	100.0

ϕ' (deg)	39
c' (psf)	0

Average of 3 samples	Initial	Pre-shear
Water content (%)	22.2	20.1
Dry unit weight (pcf)	103.8	109.1

*Pre-shear saturation set to 100% for phase calculations





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[DS_GCv4.xlsm]1

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah

Boring No.: BH-2
Sample:
Depth: 30.0'

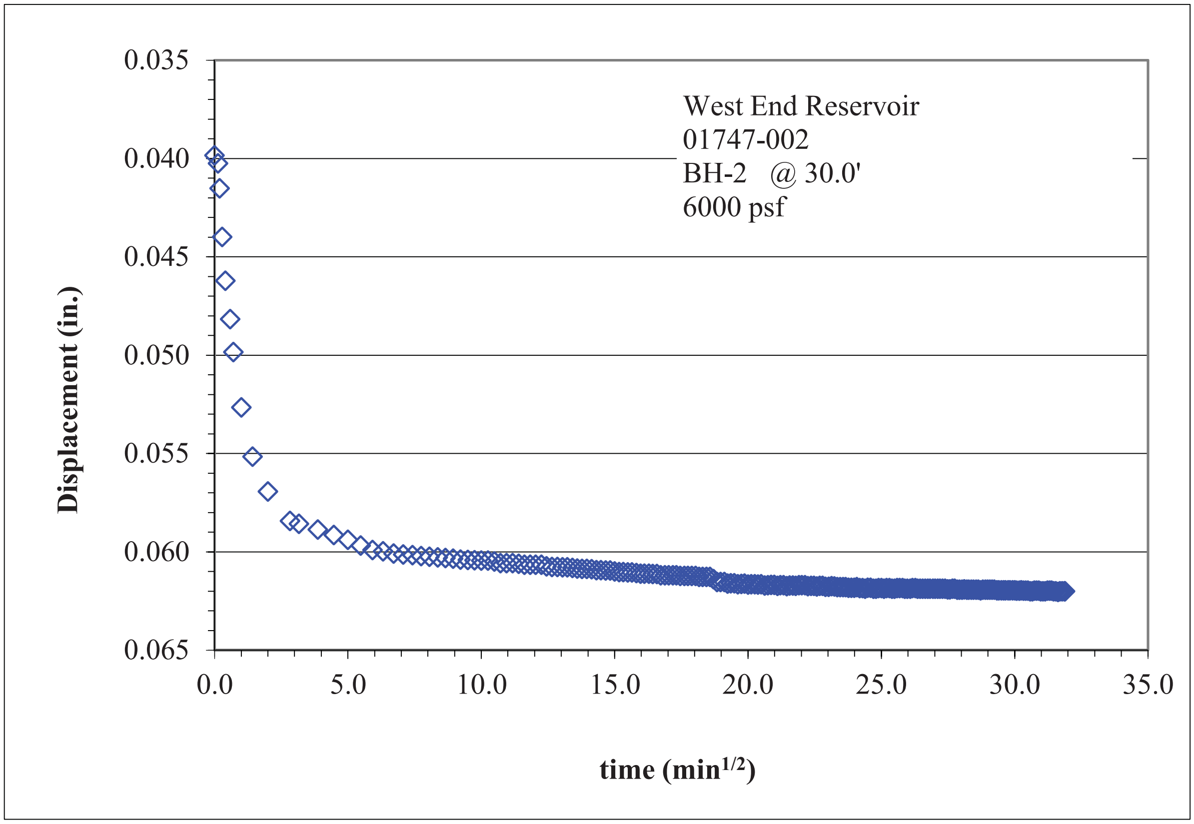
Nominal normal stress = 6000 psf			Nominal normal stress = 3000 psf			Nominal normal stress = 1500 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.002	440	0.000	0.002	364	-0.001	0.002	201	0.000
0.005	802	-0.001	0.005	589	-0.001	0.005	315	-0.001
0.007	1011	-0.002	0.007	735	-0.001	0.007	408	-0.001
0.010	1237	-0.003	0.010	866	-0.002	0.010	479	-0.001
0.012	1388	-0.003	0.012	971	-0.002	0.012	549	-0.001
0.017	1687	-0.003	0.017	1153	-0.003	0.017	651	-0.001
0.022	1938	-0.004	0.022	1322	-0.003	0.022	728	-0.002
0.027	2181	-0.005	0.027	1466	-0.003	0.027	798	-0.002
0.032	2390	-0.006	0.032	1587	-0.004	0.032	892	-0.002
0.037	2599	-0.007	0.037	1686	-0.004	0.037	942	-0.002
0.042	2725	-0.008	0.042	1764	-0.004	0.042	970	-0.002
0.047	2882	-0.008	0.047	1824	-0.005	0.047	1012	-0.002
0.052	3007	-0.009	0.052	1873	-0.005	0.052	1045	-0.002
0.057	3123	-0.009	0.057	1931	-0.005	0.057	1058	-0.002
0.062	3250	-0.009	0.062	1972	-0.005	0.062	1051	-0.001
0.067	3331	-0.010	0.067	1974	-0.006	0.067	1060	-0.002
0.072	3423	-0.010	0.072	1982	-0.006	0.072	1078	-0.002
0.077	3513	-0.010	0.077	2016	-0.006	0.077	1095	-0.002
0.082	3600	-0.011	0.082	2052	-0.007	0.082	1109	-0.002
0.087	3676	-0.012	0.087	2083	-0.007	0.087	1125	-0.002
0.092	3755	-0.012	0.092	2107	-0.007	0.092	1138	-0.002
0.097	3808	-0.013	0.097	2123	-0.007	0.097	1157	-0.003
0.102	3869	-0.013	0.102	2128	-0.007	0.102	1151	-0.003
0.107	3907	-0.013	0.107	2133	-0.007	0.107	1121	-0.003
0.112	3957	-0.014	0.112	2144	-0.007	0.112	1110	-0.003
0.117	4042	-0.014	0.117	2160	-0.008	0.117	1105	-0.003
0.122	4160	-0.014	0.122	2170	-0.008	0.122	1107	-0.003
0.127	4221	-0.014	0.127	2179	-0.008	0.127	1116	-0.003
0.132	4272	-0.014	0.132	2190	-0.008	0.132	1122	-0.003
0.137	4299	-0.014	0.137	2197	-0.008	0.137	1125	-0.003
0.142	4345	-0.015	0.142	2203	-0.008	0.142	1127	-0.004
0.147	4356	-0.015	0.147	2204	-0.008	0.147	1129	-0.004
0.152	4449	-0.015	0.152	2201	-0.009	0.152	1126	-0.004
0.157	4479	-0.015	0.157	2193	-0.009	0.157	1131	-0.004
0.162	4570	-0.015	0.162	2190	-0.009	0.162	1133	-0.004
0.167	4586	-0.015	0.167	2193	-0.009	0.167	1133	-0.004
0.172	4513	-0.016	0.172	2197	-0.009	0.172	1134	-0.004
0.177	4538	-0.016	0.177	2200	-0.009	0.177	1132	-0.004
0.182	4532	-0.016	0.182	2202	-0.009	0.182	1126	-0.005
0.187	4560	-0.016	0.187	2206	-0.010	0.187	1120	-0.005
0.192	4582	-0.017	0.192	2206	-0.010	0.192	1121	-0.005
0.197	4605	-0.017	0.197	2210	-0.010	0.197	1121	-0.005
0.202	4629	-0.017	0.202	2213	-0.010	0.202	1123	-0.005
0.207	4657	-0.017	0.207	2214	-0.010	0.207	1127	-0.005
0.212	4676	-0.017	0.212	2216	-0.010	0.212	1132	-0.005
0.217	4697	-0.018	0.217	2219	-0.010	0.217	1136	-0.005
0.222	4685	-0.018	0.222	2222	-0.010	0.222	1140	-0.005
0.227	4683	-0.019	0.227	2221	-0.010	0.227	1142	-0.005
0.232	4667	-0.019	0.232	2221	-0.010	0.232	1145	-0.006
0.237	4664	-0.019	0.237	2220	-0.010	0.237	1147	-0.006
0.242	4690	-0.019	0.242	2223	-0.011	0.242	1151	-0.006
0.247	4690	-0.019	0.247	2224	-0.011	0.247	1153	-0.006
0.252	4725	-0.019	0.252	2224	-0.011	0.252	1156	-0.006
0.257	4807	-0.019	0.257	2227	-0.011	0.257	1158	-0.007
0.262	4845	-0.020	0.262	2230	-0.011	0.262	1160	-0.007
0.267	4854	-0.020	0.267	2231	-0.011	0.267	1162	-0.007
0.272	4849	-0.020	0.272	2229	-0.011	0.272	1163	-0.007
0.277	4833	-0.020	0.277	2227	-0.011	0.277	1166	-0.007
0.282	4858	-0.020	0.282	2226	-0.011	0.282	1167	-0.007
0.287	4845	-0.021	0.287	2228	-0.012	0.287	1168	-0.007
0.292	4778	-0.021	0.292	2228	-0.012	0.292	1169	-0.007
0.297	4793	-0.021	0.297	2223	-0.012	0.297	1171	-0.007
0.301	4839	-0.021	0.302	2226	-0.012	0.302	1174	-0.007

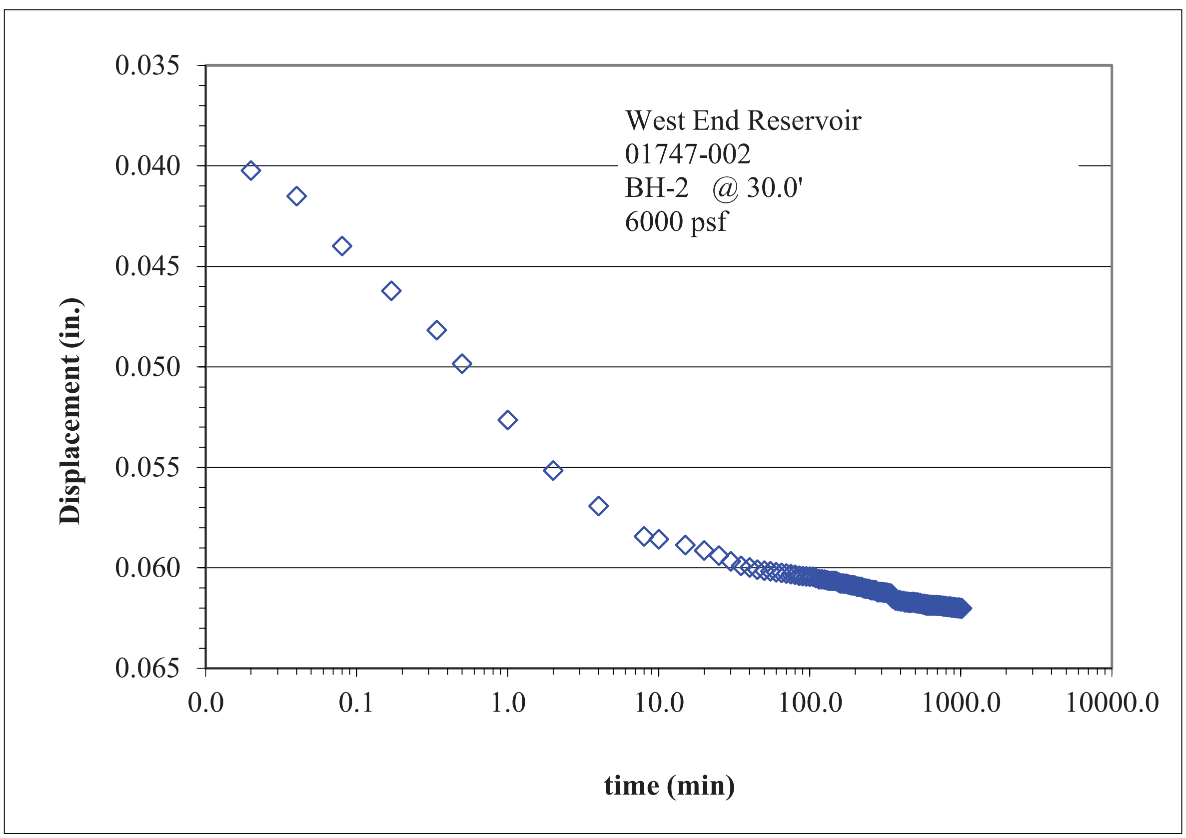
Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah

Boring No.: BH-2
Sample:
Depth: 30.0'





Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/13/2017
By: JDF

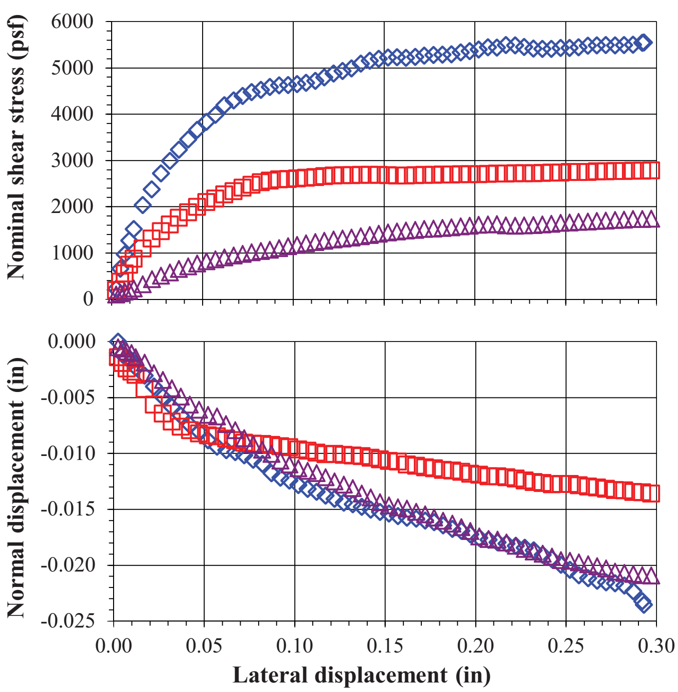
Boring No.: BH-5
Sample:
Depth: 36.0'
Sample Description: Brown clay
Sample type: Undisturbed-trimmed from ring

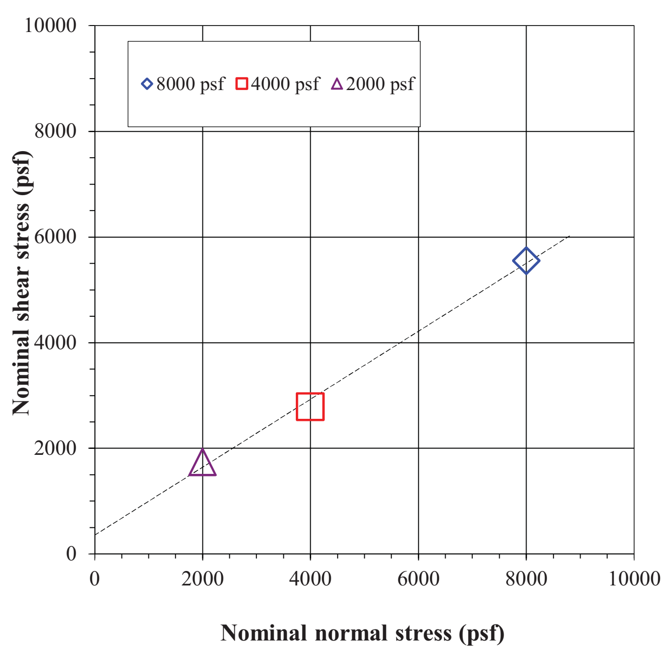
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0009
Specific gravity, Gs: 2.70 Assumed

	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	8000		4000		2000	
Peak shear stress (psf)	5552		2783		1739	
Lateral displacement at peak (in)	0.293		0.297		0.297	
Load Duration (min)	1161		1183		1164	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9295	1.0000	0.9513	1.0000	0.9590
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	196.77	193.40	200.03	197.45	194.76	195.13
Wt. rings (g)	44.13	44.13	45.63	45.63	45.29	45.29
Wet soil + tare (g)	275.92		275.92		275.92	
Dry soil + tare (g)	249.25		249.25		249.25	
Tare (g)	122.09		122.09		122.09	
Water content (%)	21.0	18.3	21.0	19.0	21.0	21.3
Dry unit weight (pcf)	104.8	112.8	106.1	111.4	102.7	107.0
Void ratio, e, for assumed Gs	0.61	0.49	0.59	0.51	0.64	0.57
Saturation (%)*	93.2	100.0	96.1	100.0	88.3	100.0

φ' (deg)	33	Average of 3 samples	Initial	Pre-shear
c' (psf)	354	Water content (%)	21.0	19.5
		Dry unit weight (pcf)	104.5	110.4

*Pre-shear saturation set to 100% for phase calculations





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[DS_GCv4.xlsm]2

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

IGES

Project: West End Reservoir **Boring No.:** BH-5
No: 01747-002 **Sample:**
Location: South Weber, Utah **Depth:** 36.0'

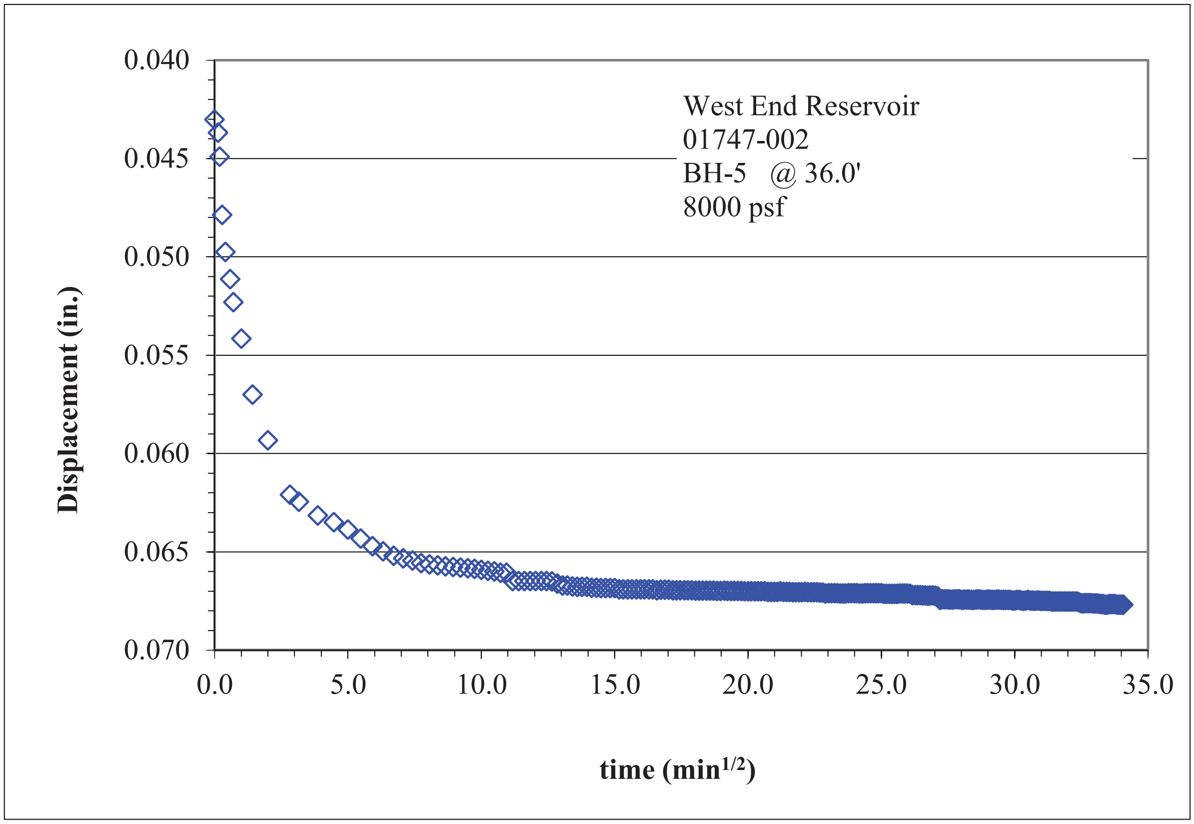
Nominal normal stress = 8000 psf			Nominal normal stress = 4000 psf			Nominal normal stress = 2000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.002	221	0.000	0.002	196	-0.001	0.002	98	-0.001
0.005	660	-0.001	0.005	377	-0.002	0.005	128	-0.001
0.007	967	-0.001	0.007	554	-0.002	0.007	164	-0.001
0.010	1270	-0.002	0.010	742	-0.003	0.010	184	-0.001
0.012	1517	-0.002	0.012	877	-0.003	0.012	231	-0.001
0.017	2033	-0.003	0.017	1095	-0.004	0.017	322	-0.002
0.022	2377	-0.004	0.022	1312	-0.006	0.022	430	-0.003
0.027	2723	-0.005	0.027	1469	-0.006	0.027	504	-0.003
0.032	2991	-0.006	0.032	1613	-0.007	0.032	578	-0.004
0.037	3231	-0.007	0.037	1758	-0.008	0.037	653	-0.005
0.042	3452	-0.007	0.042	1874	-0.008	0.042	710	-0.006
0.047	3661	-0.008	0.047	1992	-0.008	0.047	768	-0.006
0.052	3833	-0.009	0.052	2095	-0.008	0.052	817	-0.007
0.057	3985	-0.009	0.057	2177	-0.008	0.057	858	-0.007
0.062	4192	-0.010	0.062	2265	-0.009	0.062	900	-0.007
0.067	4301	-0.010	0.067	2334	-0.009	0.067	942	-0.008
0.072	4393	-0.010	0.072	2407	-0.009	0.072	977	-0.009
0.077	4475	-0.011	0.077	2469	-0.009	0.077	1009	-0.009
0.082	4529	-0.011	0.082	2526	-0.009	0.082	1043	-0.010
0.087	4587	-0.012	0.087	2564	-0.009	0.087	1069	-0.010
0.092	4622	-0.012	0.092	2586	-0.009	0.092	1105	-0.011
0.097	4631	-0.012	0.097	2597	-0.009	0.097	1140	-0.011
0.102	4651	-0.013	0.102	2607	-0.010	0.102	1173	-0.011
0.107	4676	-0.013	0.107	2623	-0.010	0.107	1205	-0.012
0.112	4718	-0.013	0.112	2639	-0.010	0.112	1234	-0.012
0.117	4793	-0.014	0.117	2661	-0.010	0.117	1262	-0.012
0.122	4877	-0.014	0.122	2670	-0.010	0.122	1287	-0.013
0.127	4938	-0.014	0.127	2679	-0.010	0.127	1307	-0.013
0.132	4990	-0.015	0.132	2681	-0.010	0.132	1329	-0.013
0.137	5091	-0.015	0.137	2686	-0.010	0.137	1358	-0.014
0.142	5155	-0.015	0.142	2685	-0.010	0.142	1386	-0.014
0.147	5195	-0.015	0.147	2683	-0.011	0.147	1415	-0.014
0.152	5226	-0.015	0.152	2679	-0.011	0.152	1439	-0.015
0.157	5230	-0.016	0.157	2675	-0.011	0.157	1461	-0.015
0.162	5215	-0.016	0.162	2672	-0.011	0.162	1481	-0.015
0.167	5236	-0.016	0.167	2677	-0.011	0.167	1496	-0.015
0.172	5266	-0.016	0.172	2684	-0.011	0.172	1514	-0.015
0.177	5281	-0.016	0.177	2688	-0.011	0.177	1526	-0.016
0.182	5288	-0.016	0.182	2693	-0.011	0.182	1537	-0.016
0.187	5297	-0.017	0.187	2694	-0.012	0.187	1552	-0.016
0.192	5333	-0.017	0.192	2699	-0.012	0.192	1569	-0.017
0.197	5366	-0.017	0.197	2700	-0.012	0.197	1589	-0.017
0.202	5401	-0.018	0.202	2701	-0.012	0.202	1606	-0.017
0.207	5446	-0.018	0.207	2707	-0.012	0.207	1617	-0.018
0.212	5437	-0.018	0.212	2711	-0.012	0.212	1618	-0.018
0.217	5495	-0.018	0.217	2713	-0.012	0.217	1594	-0.018
0.222	5485	-0.018	0.222	2718	-0.012	0.222	1587	-0.018
0.227	5456	-0.018	0.227	2724	-0.012	0.227	1593	-0.019
0.232	5420	-0.019	0.232	2724	-0.013	0.232	1603	-0.019
0.237	5414	-0.019	0.237	2730	-0.013	0.237	1617	-0.019
0.242	5415	-0.019	0.242	2734	-0.013	0.242	1630	-0.019
0.247	5433	-0.020	0.247	2737	-0.013	0.247	1645	-0.020
0.252	5435	-0.020	0.252	2745	-0.013	0.252	1657	-0.020
0.257	5447	-0.021	0.257	2749	-0.013	0.257	1669	-0.020
0.262	5479	-0.021	0.262	2751	-0.013	0.262	1679	-0.020
0.267	5488	-0.021	0.267	2759	-0.013	0.267	1688	-0.020
0.272	5497	-0.022	0.272	2764	-0.013	0.272	1698	-0.020
0.277	5491	-0.022	0.277	2769	-0.013	0.277	1709	-0.021
0.282	5498	-0.022	0.282	2770	-0.013	0.282	1720	-0.021
0.287	5501	-0.022	0.287	2774	-0.013	0.287	1728	-0.021
0.292	5546	-0.023	0.292	2779	-0.014	0.292	1733	-0.021
0.293	5552	-0.024	0.297	2783	-0.014	0.297	1739	-0.021
			0.300	2783	-0.014	0.301	1739	-0.021

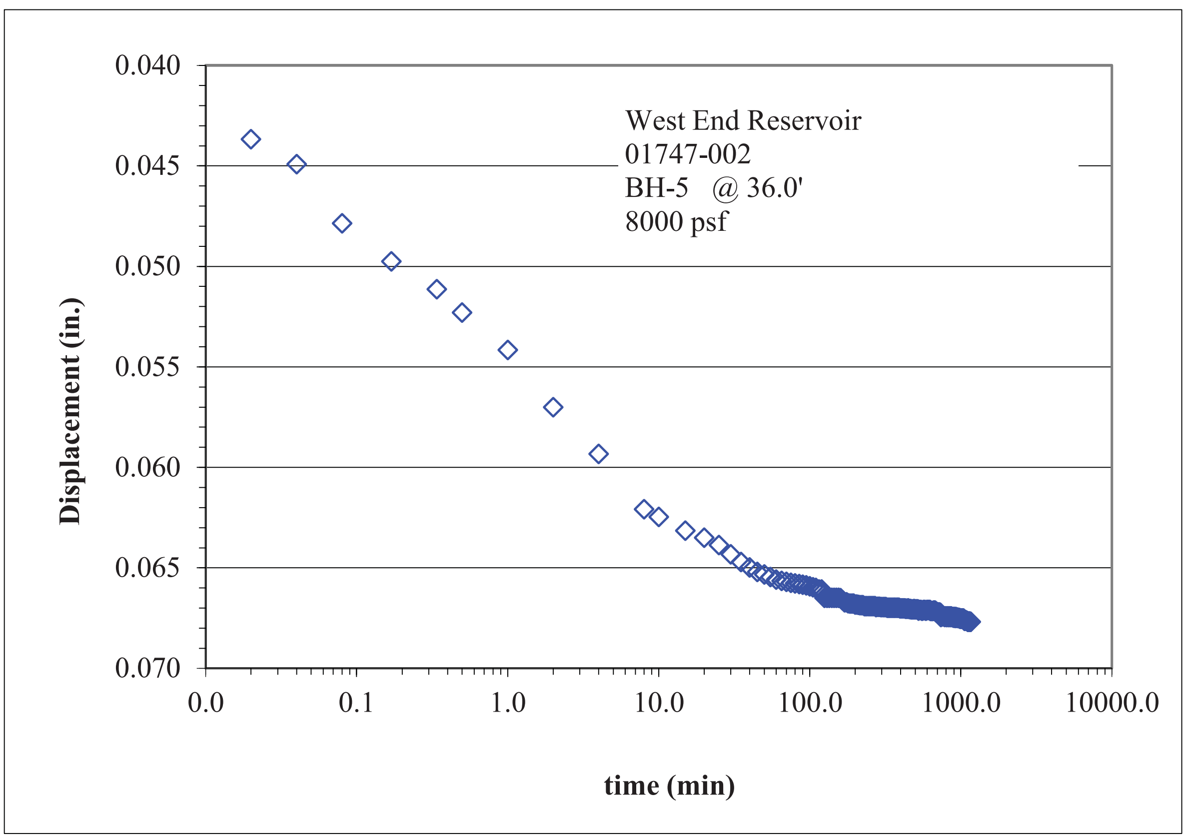
Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah

Boring No.: BH-5
Sample:
Depth: 36.0'





APPENDIX C

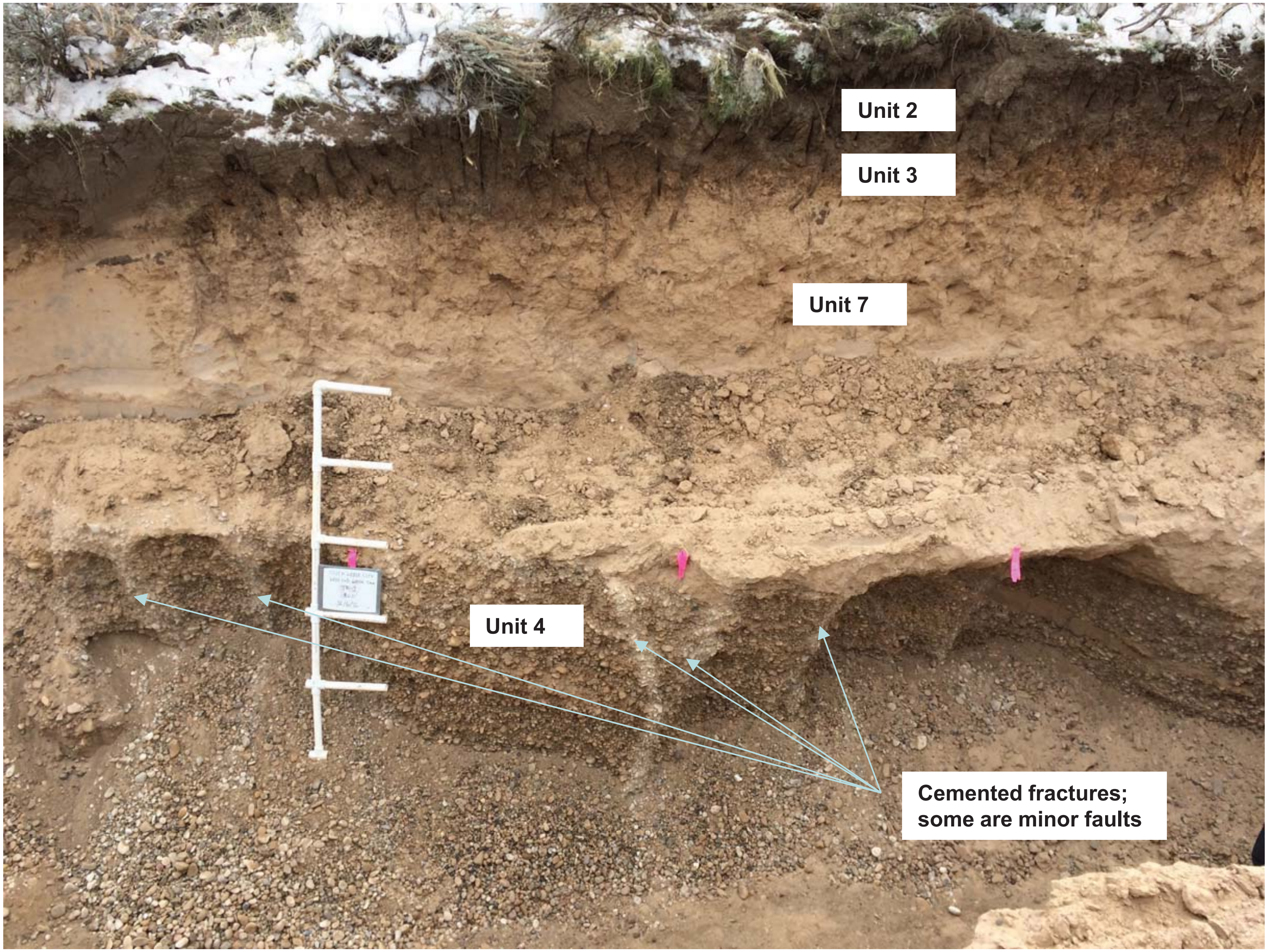


Figure C-1	Westside Reservoir Site Photos Trench 1 Project Number: 01747-002	**Overview of lithologic units in TR-1. Placard and scale at Station 80.**

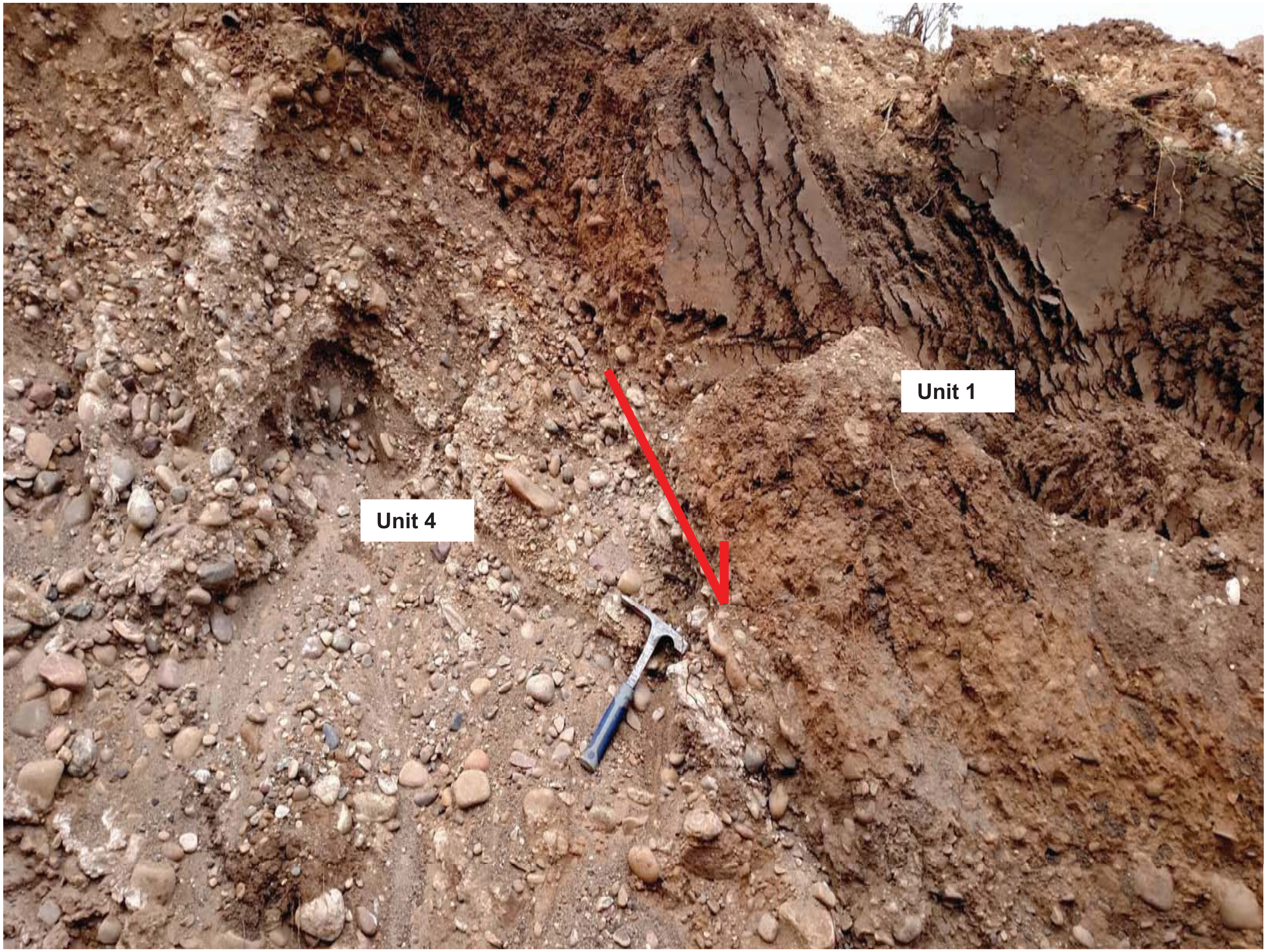


Figure C-2

Westside Reservoir
Site Photos
Trench 1
Project Number: 01747-002

Active scarp in TR-1, west wall of trench at Station 20. Red arrow is along the slide plane, indicating direction of movement downslope to the north.

IGES

Figure C-3

Westside Reservoir
Site Photos
Trench 1
Project Number: 01747-002

Bedded clay of Unit 5 at a depth of approximately 18 feet at Station 18.

IGES

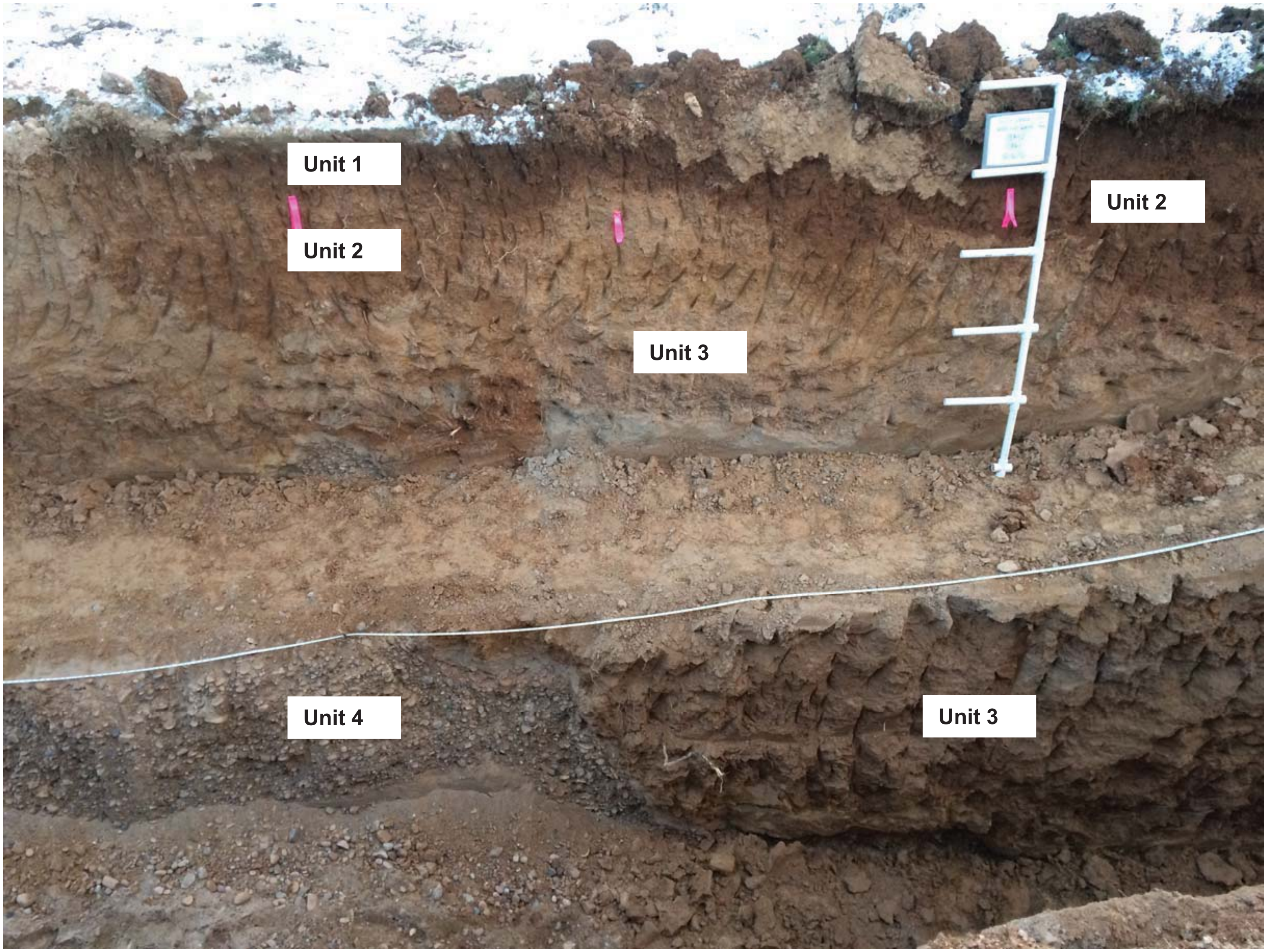


Figure C-4

Westside Reservoir
Site Photos
Trench 2
Project Number: 01747-002

Overview of lithologic units in TR-2. Placard and scale at Station 60.

IGES

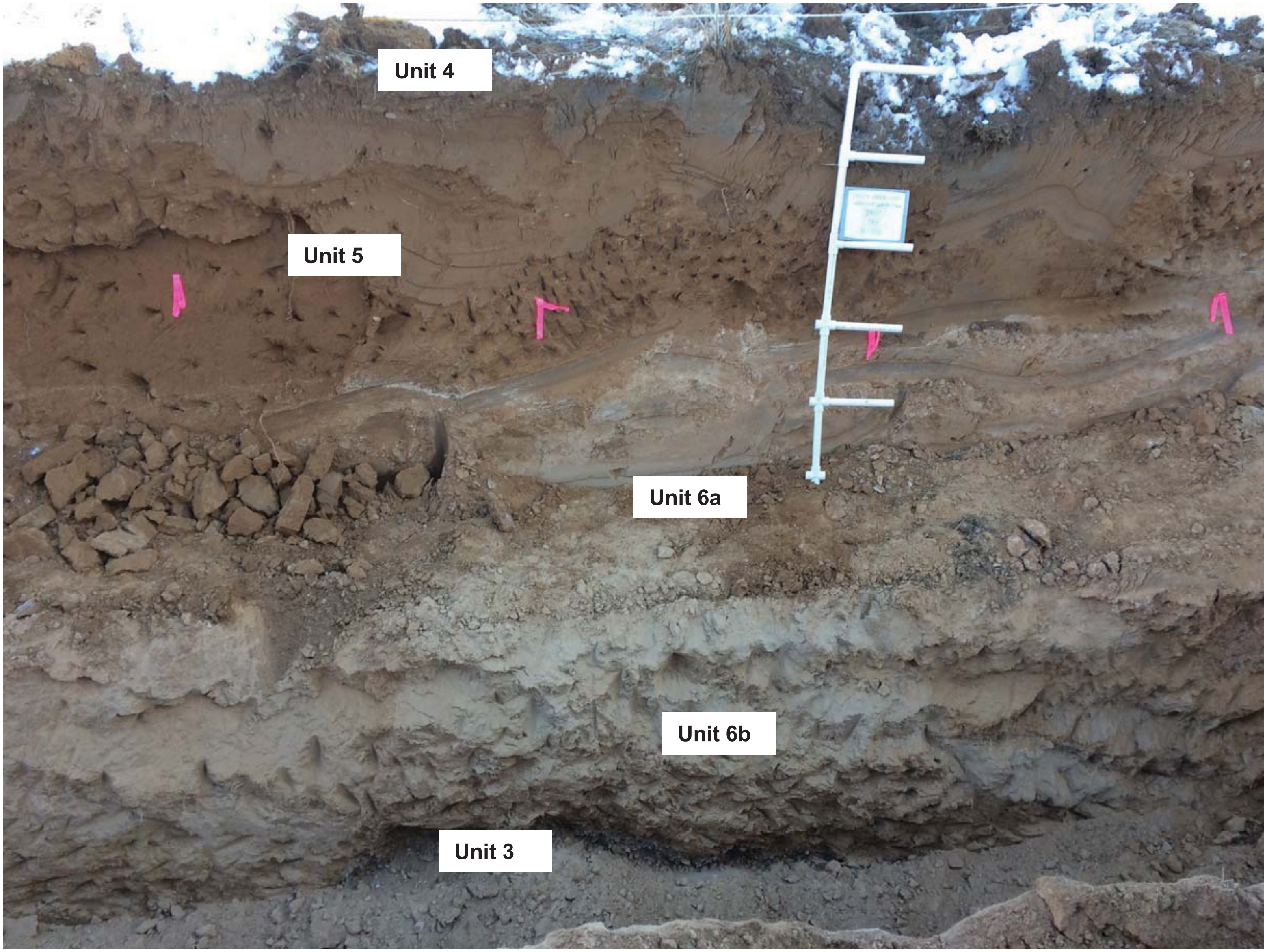


Figure C-5

Westside Reservoir
Site Photos
Trench 3
Project Number: 01747-002

Overview of lithologic units in TR-2. Placard and scale at Station 50.

IGES

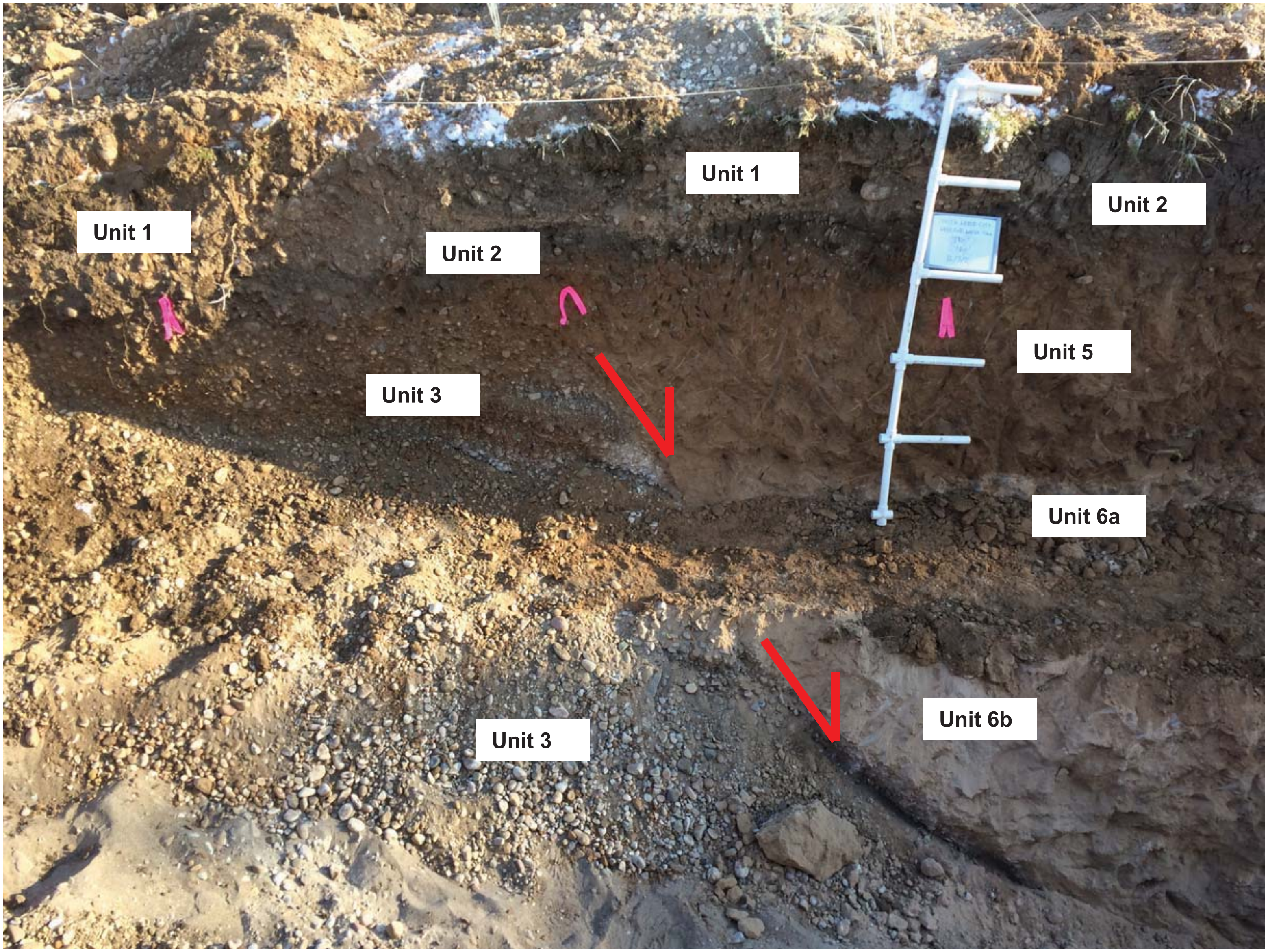


Figure C-6

Westside Reservoir
Site Photos
Trench 3
Project Number: 01747-002

Subsurface slide plane in TR-3. Scale and placard are at Station 20. Red arrows are along the slide plane, indicating direction of movement upslope to the south.

IGES

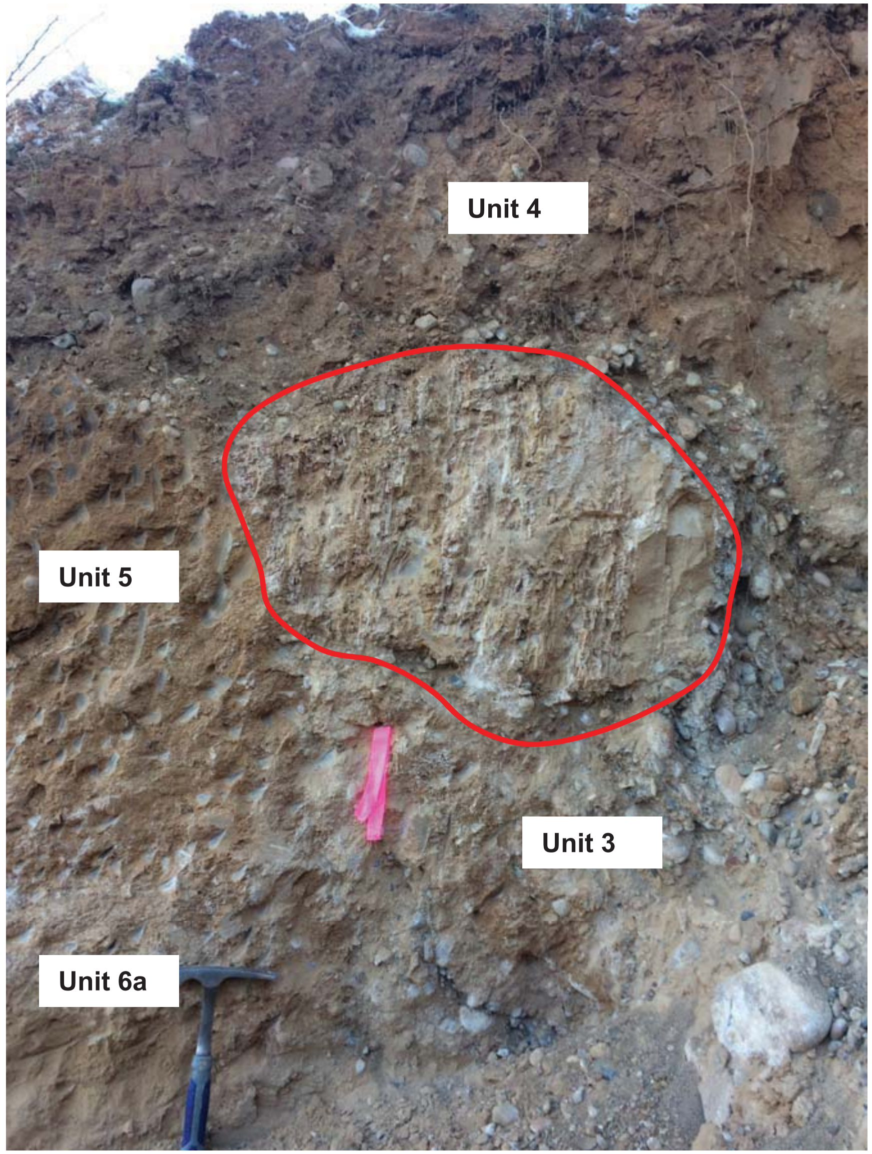


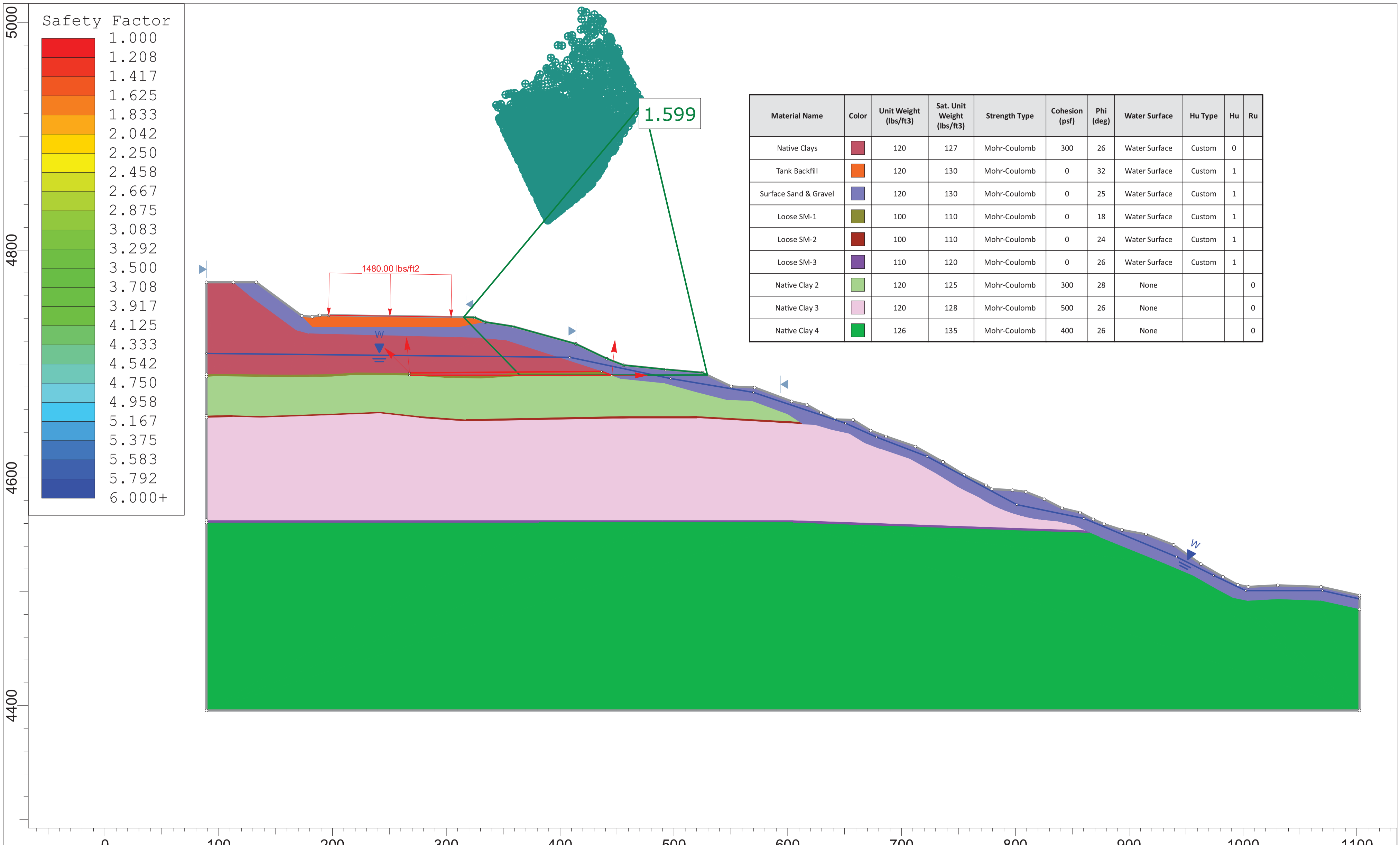
Figure C-7

Westside Reservoir
Site Photos
Trench 3
Project Number: 01747-002

Anomalous block of tilted clay in TR-3 within Unit 3, outlined in red. Pink flag is Station 75. Note vertical bedding within block. Block likely landslide-related.

IGES

APPENDIX D

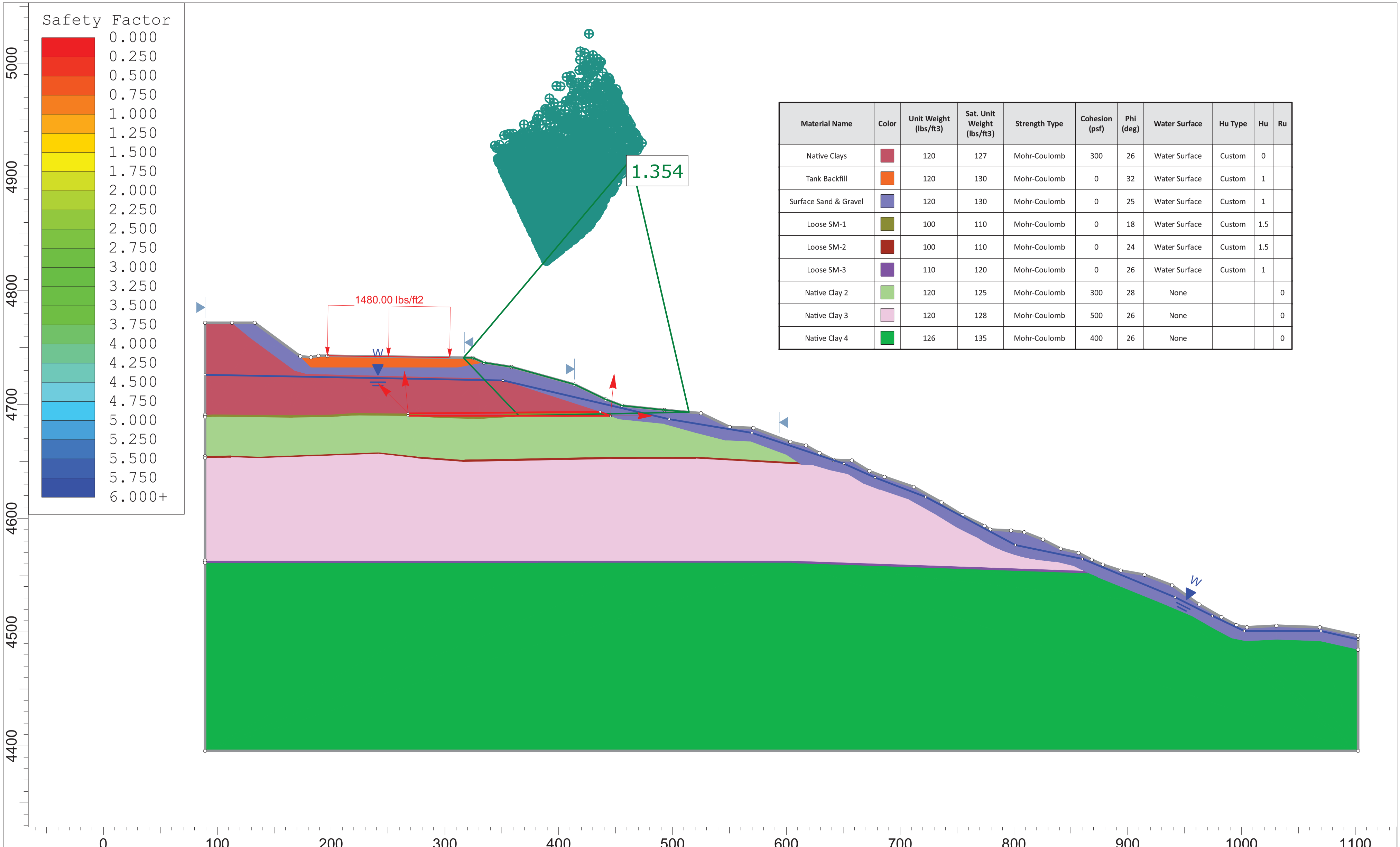


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	0	18	Water Surface	Custom	1	
Loose SM-2		100	110	Mohr-Coulomb	0	24	Water Surface	Custom	1	
Loose SM-3		110	120	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Global Stability (Existing Conditions)		
Drawn By JAH	*Scale* 1:1400	*Filename*	Global Stability.slim
Date	1/24/2017, 9:17:26 AM	*Figure*	D-1

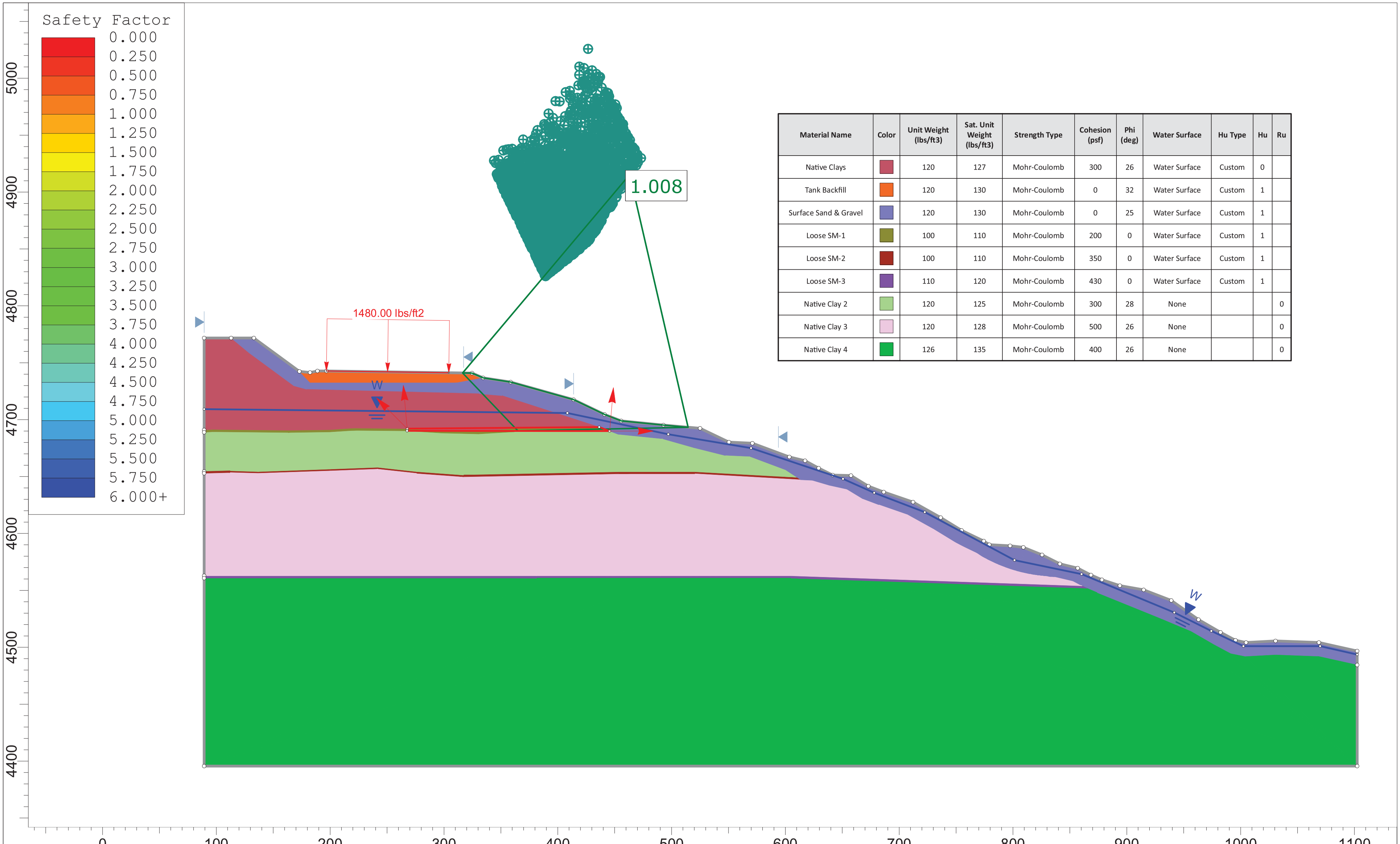


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	0	18	Water Surface	Custom	1.5	
Loose SM-2		100	110	Mohr-Coulomb	0	24	Water Surface	Custom	1.5	
Loose SM-3		110	120	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Global Stability (Increased Water)		
Drawn By JAH	*Scale* 1:1400	*Filename*	Global Stability (increased water).slim
Date	1/24/2017, 9:17:26 AM	*Figure*	D-2

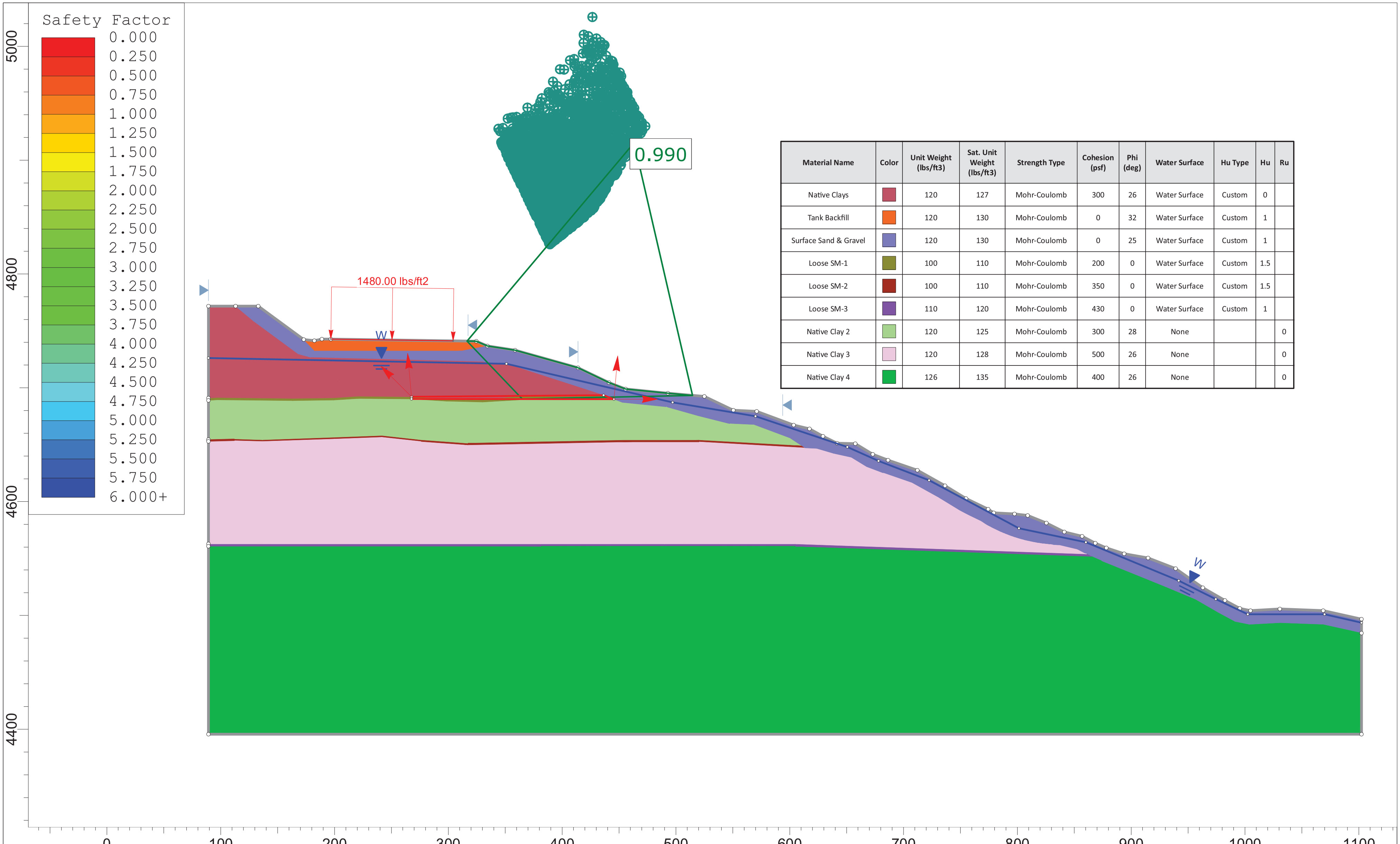


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	200	0	Water Surface	Custom	1	
Loose SM-2		100	110	Mohr-Coulomb	350	0	Water Surface	Custom	1	
Loose SM-3		110	120	Mohr-Coulomb	430	0	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Global Stability (Pseudo-static)		
Drawn By JAH	*Scale* 1:1400	*Filename*	Global Stability (post-seismic).slim
Date	1/24/2017, 9:17:26 AM	*Figure*	D-3



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	200	0	Water Surface	Custom	1.5	
Loose SM-2		100	110	Mohr-Coulomb	350	0	Water Surface	Custom	1.5	
Loose SM-3		110	120	Mohr-Coulomb	430	0	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

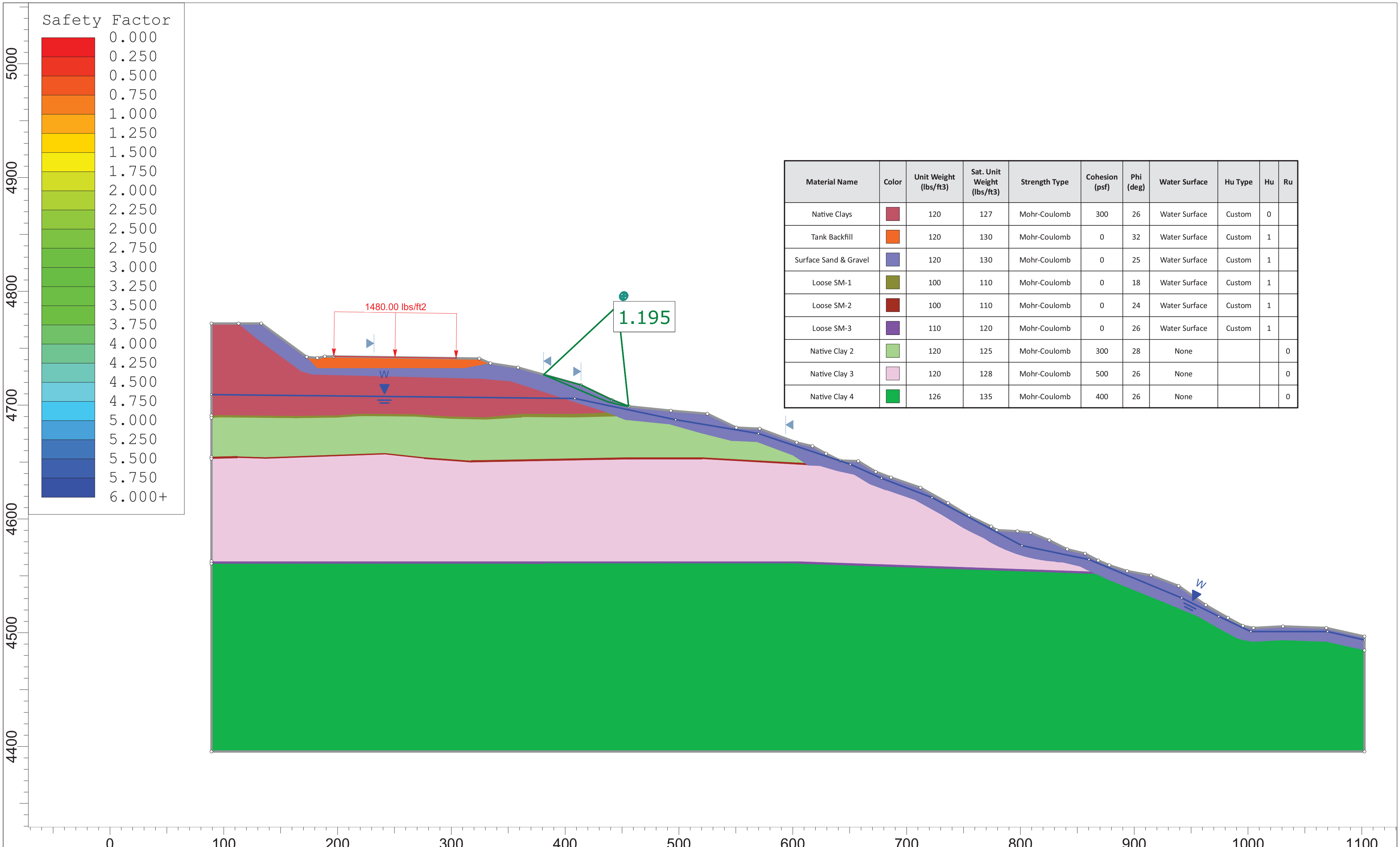
SLIDEINTERPRET 7.022

Project Westside Reservoir - South Weber, Utah

Analysis Description Global Stability (Pseudo-static - Increased Water)

Drawn By JAH | *Scale* 1:1400 | *Filename* Global Stability (increased water-post seismic).slim

Date 1/24/2017, 9:17:26 AM | *Figure* D-4

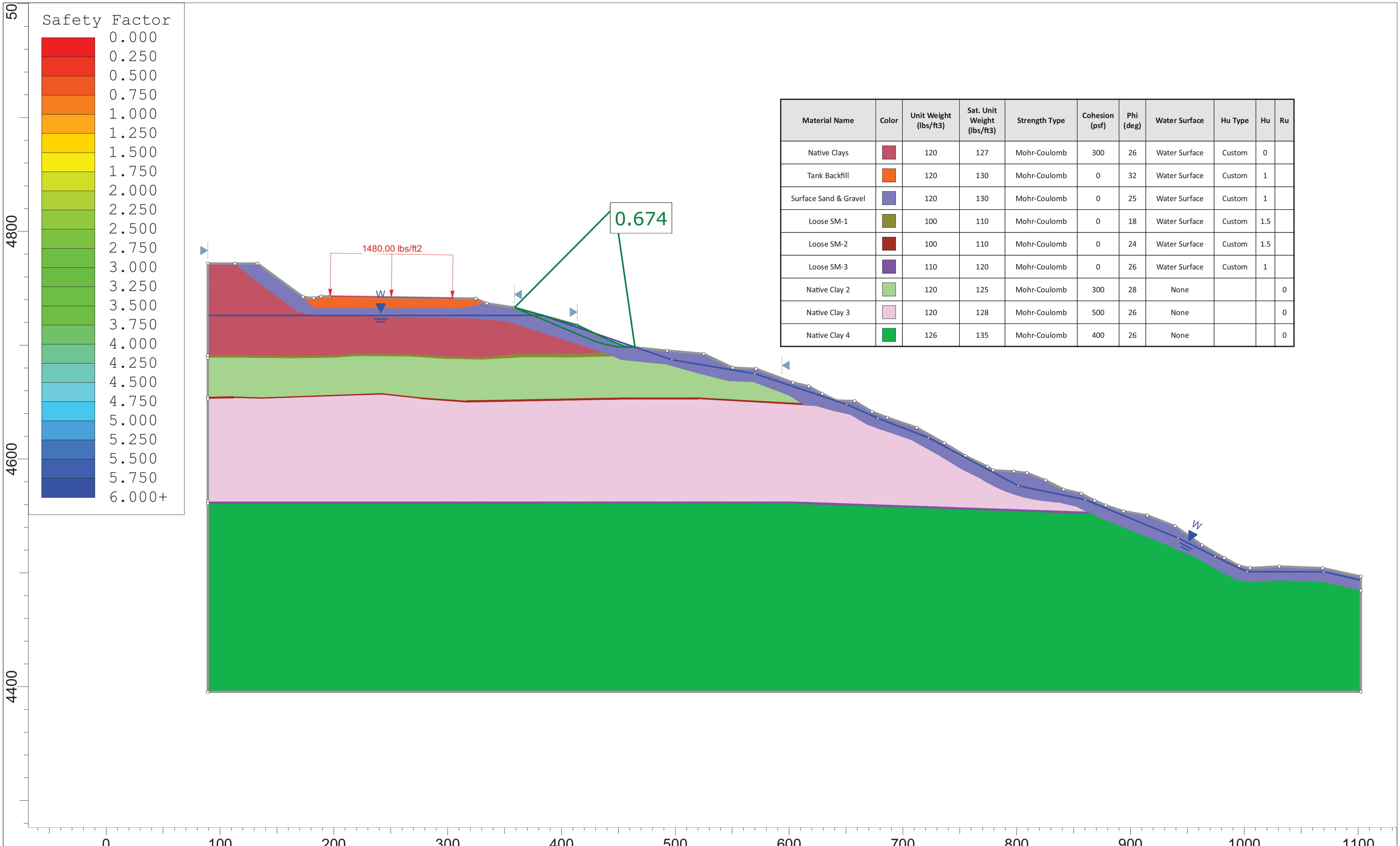


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	0	18	Water Surface	Custom	1	
Loose SM-2		100	110	Mohr-Coulomb	0	24	Water Surface	Custom	1	
Loose SM-3		110	120	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Shallow Failure (Existing)		
Drawn By JAH	*Scale* 1:1400	*Filename*	Global Stability (Shallow).slim
Date	1/24/2017, 9:17:26 AM	*Figure*	D-5



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	0	18	Water Surface	Custom	1.5	
Loose SM-2		100	110	Mohr-Coulomb	0	24	Water Surface	Custom	1.5	
Loose SM-3		110	120	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Shallow Failure (Increased Water)		
Drawn By JAH	*Scale* 1:1400	*Filename* Global Stability (Shallow increased water).slim	
Date 1/24/2017, 9:17:26 AM		*Figure* D-6	

ATTACHMENT B

ARW INVESTIGATION LETTER (2011)

November 29, 2010

Mark Larsen
Public Works Director
South Weber City
1600 East South Weber Drive
South Weber City, UT

Re: South Weber 1MG Water Tank Investigation
ARW Job # 10318

Mr. Larsen:

Per your request, ARW Engineers has performed a limited investigation of the above-referenced concrete water tank. The purpose was to look at cracks in the base slab, which have resulted in some leaking. It is our understanding that the City wants our opinion regarding the cracking, and whether or not there are structural concerns with the tank.

The following information was provided (verbally) by you:

- The water tank in question is a 1 million gallon capacity tank,
- there are no existing drawings,
- the date of construction is not known, however you believe that the tank is at least 20+ years old.

You indicated that the tank floor slab had been given a coat of Xypex coating about a year ago due to some leakâge concerns that were evident from seepage through the hill on the east side of the tank.

The cracking in question was located in the floor slab near the slab to wall interface along the south west portion of the tank. At the time of the visit, the crack was not visible because a new coating of Xypex had just been installed over it the day before. You indicated that the crack was about ¼" wide prior to patching. Also, at the exterior side of the tank there was a visible depression in the soil where water had apparently been seeping out. This leads to the reasonable conclusion that the water was leaking through the crack in the slab and running out beneath the slab through the soil.

Without existing structural drawings of the tank, it is hard to tell how the tank was constructed. Typical construction of a concrete tank such as this would have a thickened slab footing under the perimeter wall. Alternatively, the footing may be below the wall, with a thinner floor slab poured over the top. In either of these cases, cracks are possible at the slab to footing interface. The cracking would be exacerbated for a number of reasons, including poorly compacted soil or a discontinuity in reinforcing steel.

During our investigation of the inside perimeter of the tank, we found what appeared to be a visible crack in the slab just about 6" off of the wall near the east side. If it was a crack, it was not very wide. It was very hard to determine if it was actually a crack due to the possibility of it being some type of seam from previous water proofing membranes etc. If it was a crack it could possibly be due to the same reasons as stated above. We also noted during our investigation that there are numerous cracks throughout the slab that have been filled in with some type of joint filler material.

You also stated your concern about the condition of the soils below the tank, due to the fact that perhaps the seeping water could be washing away some of the soil. This is a very real possibility, and based on the visible soil depression on the exterior where you have already seen the water leaking, it is probable

that some soil has been removed. If any significant amount of soil gets washed away from beneath the tank slab and wall footing, there could be further cracking and other problems with the tank.
Because we don't know anything about the reinforcing of this tank structure, we cannot comment on what capacity the tank might have to bridge over some "soft spots" in the subgrade.

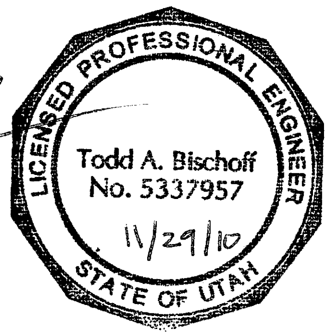
Based on our review of the situation, particularly noting that the walls do not seem to be leaking / cracking, it is our opinion that the issues at the slab are related in some way either to inadequate reinforcing and/or thickness of the slab/footing, or problems with the supporting soils.

We recommend that the city engage the services of a qualified, licensed geotechnical engineer to provide qualified recommendations regarding the subgrade soils. If it is determined that there are issues with the supporting subgrade, then the geotechnical engineer should have recommendations for possible remedial actions. If the walls need additional support, helical piers or micropiles may be an option. If the slab needs additional support, polymer injections into the subgrade may be an option.

Obviously, the City should continue to monitor this situation in two ways. One, the tank should be monitored to see if there are any signs of settlement / movement over time, or if there are any more signs of seepage as previously observed. Second, it would probably be good to monitor the amount of water that is leaking i.e. perform a leak test occasionally to see what the rate of water loss is when the tank is at operating capacity.

Please feel free to contact us with any questions or concerns.

Sincerely,



Todd Bischoff, PE

/10318_South Weber City Water Tank Inv Letter_112910.doc

ATTACHMENT C

GEOSTRATA ASSESSMENT (2011)

JONES & ASSOCIATES IGES ARW ENGINEERS structural consultants

GeoStrata
Engineering & Geosciences
781 West 14600 South, Bluffdale, Utah 84065
Phone (801) 501-0583 | Fax (801) 501-0584

Water Tank Assessment for the City of South Weber
South Weber, Utah

GeoStrata Job No. 683-002

March 15, 2011

Prepared for:

Jones & Associates
1716 East 5600 South
South Ogden, UT 84403

GeoStrata Engineering & Geosciences
T: (801) 501-0583 ~ F: (801) 501-0584
781 West 14600 South, Bluffdale, Utah 84065

Prepared for:

Jones & Associates
Attention: Mr. Brandon Jones, P.E.
1716 East 5600 South
South Ogden, UT 84403

Water Tank Assessment for the City of South Weber
South Weber, Utah
GeoStrata Job No. 683-002

Prepared by:

Mike Vorkink.
Project Geologist

Reviewed by:

REGISTERED PROFESSIONAL ENGINEER
03/11/11
HIRAM
ALBA
175774
STATE OF UTAH

Hiram Alba P.E., P.G.
Principal

GeoStrata, LLC
781 West 14600 South
Bluffdale, UT 84065
(801) 501-0583

March 11, 2011

TABLE OF CONTENTS

APPENDICES

1.0 EXECUTIVE SUMMARY

The purpose of this investigation and report are to assess the presence of voids within and below the concrete base of the water tank located on the banks of the Weber River valley in the city of South Weber (Plate A-1) To asses these issues GPR data, Manometer studies, and coring of the concrete base were performed at the subject site.

GeoStrata conducted GPR surveys along the base of the water tank using a Mala 2.6 Ghz system. Plate A-2 shows the locations of the different survey lines performed at the site. Plates A-5- through A-7 show the results of the GPR surveys.

Plate A-4 shows the results of the Manometer survey of the tank floor. 268 relative elevation points were acquired across the base of the water tank. Data points were contoured in ArcGIS using the Kriging contouring algorithm in the 3D analyst plug-in. The contour values are normalized from the drain elevation in the northern part of the tank.

GeoStrata extracted four 2.5 inch cores from the concrete base of the water tank. Plate A-2 shows the locations of the 4 cores. The cores range from 6-13 inches in length.

The GPR data while noisy indicates that there are numerous “anomalies” at the base of the concrete slab (Plate A-5). The noise in the GPR data is likely a result of water at the surface, water within the concrete and possibly water beneath the concrete slab. The presence of water as apposed to air in the void spaces diminishes the contrast in dielectric constants giving a weakened signal response.

Overall the tank bottom topography shows the base sloping towards the drain area. There is over 8-inches of relief from the drain to the highest elevations in the southeast part of the tank. There is approximately a 2-inch elevation difference between the northwest and southeast sides of the tank bottom.

The results of the coring verify that at least one of the GPR “anomalies” at the base of the concrete was indeed a ~1 inch void space beneath the concrete slab. The fact that all of the cores (Plate A-2) had ~ 1 inch of void space beneath the concrete slab suggests void spaces might be more wide spread.

To minimize the potential for additional leaks and to aid in supporting the tank floor we recommend that consideration be given to grouting under the tank floor. This can be accomplished by hiring a specialized contractor to perform the work. The grouting should be completed through a series of core holes strategically placed around the bottom of the tank.

NOTICE: This executive summary is not intended to replace the report of which it is part and should not be used separately from the report. The executive summary is provided solely for purposes of overview. The executive summary omits a number of details, any one of which could be crucial to the proper application of this report.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

The purpose of this investigation and report is to assess the conditions of the concrete base of the water tank located on the banks of the Weber River valley in the city of South Weber (Plate A-1). It is our understanding that the tank has been leaking and that several attempts have been made to minimize the leakage through the use of a Xypex sealing system. Flows have been noted emanating from the bottom of the tank and concerns about undermining of the tank floor were made to us. In an effort to asses the presence of void spaces within and below the concrete slab our scope of work included performing a GPR survey, a manometer survey, a site reconnaissance of the surrounding land area and coring from the concrete base. This scope was developed in discussions with Brandon Jones of Jones and Associates and Hiram Alba (GeoStrata).

The recommendations contained in this report are subject to the limitations presented in the "Limitations" section of this report.

2.2 GEOLOGIC SETTING

The site is located at an elevation of approximately 4745 feet in South Weber, Utah. The site is located adjacent to terraces of the Weber River valley within a broad sediment filled valley associated with basin and range style uplift characterized by sediments deposited in the past 30,000 years, mostly by Pleistocene Lake Bonneville (Scott and others, 1983; Hintze, 1993; Machette, 1992). Lake Bonneville deposits represent a variety of materials ranging from poorly graded beach sands and alluvial gravels to deeper water sands, silts, and clays. The area directly beneath the site is mapped as Quaternary landslide deposits (Qms2), the exact age of which is unavailable. The landslide deposit is characterized by unsorted, unstratified deposits of sand, silt and clay re-deposited by single to multiple slides, slumps and flows. The thickness of these deposits is uncertain (Yonkee and Lowe, 2004). Several other slides are mapped near the project site area and the general vicinity is known to be susceptible to landsliding activities. Plate A-3 presents a geologic map of the subject site and the surrounding site vicinity.

3.0 METHOD OF STUDY

3.1 GPR DATA

Ground Penetrating Radar (GPR) is a geophysical method which uses electromagnetic energy to image the subsurface. A GPR unit consists of a transmitter and antenna, the frequency of the antenna used depends on the type of study. Higher frequency antennas are typically used to resolve shallow small features while low frequency antennas are used for larger deeper features. Pulses of electromagnetic radiation are emitted from the transmitter of the GPR unit into the subsurface. When the electromagnetic energy encounters changes in the subsurface materials such as voids, the electromagnetic energy reflects off of the boundary and is received by the antenna.

GeoStrata used a MALA CX concrete imaging system with a 2.6 Ghz antenna to conduct field investigations at the subject site. This system is designed to image small features in the shallow subsurface. Raw GPR data was imported and processed in IXPGR software.

3.2 MANOMETER

GeoStrata conducted a monometer survey of the floor of the interior of the water tank. Manometers work on the principle that water equalizes to the same elevation on both sides of a water-filled tube. The manometer consists of a water reservoir connected to a stadia rod via plastic tubing. Relative elevation measurements are read by observing the water level on the graduated cylinder connected to the stadia rod. 268 relative elevation points were recorded across the base of the water tank. Manometer data was recorded on a map of the base of the water tank and data points were then contoured using the Kriging algorithm in the 3D analyst plug-in of ArcGIS. Plate A-4 shows the results of the contouring. It should be noted that data point distribution across the tank bottom is not equal. The data point density is greater in the southern half of the tank and data is sparser in the northern half of the tank. It is possible that the data density may impact on the contouring presented on the plate.

3.3 CORING

GeoStrata extracted four cores from the concrete base of the water tank. Plate A-2 shows the locations of the 4 cores. The cores are 2.5-in diameter and range from 6- to 13-inches in length. Core locations were chosen based on results of GPR surveys and locations of surface fractures. It was noted that water was emanating from the concrete cores when removed from the tank floor indicating that the void spaces in the concrete were saturated.

4.0 FIELD WORK RESULTS

4.1 GROUND PENETRATING RADAR

GeoStrata conducted GPR surveys along the base of the water tank using a Mala 2.6 Ghz system. Plate A-2 shows the locations of the different survey lines performed at the site. Plates A-5- through A-7 show the results of the GPR surveys. The GPR data shown in the profiles have been filtered to try and remove as much noise as possible and minimize the returns off of the rebar. Most of the small parabolic shapes in the upper 8 inches of the profiles are from rebar. The noise in the GPR data is a result of water at the surface, water within the concrete and possibly water beneath the concrete. The presence of water as apposed to air in the void spaces diminishes the contrast in dielectric constants giving a weakened signal response. Line 1 (Plate A-5) shows several examples of returns at or near the base of the concrete slab (see Plate A-2 for line location). The anomalies are subtle but suggest a small 1- to 2-inch feature at the base of the concrete slab. This was one of the more distinct features visible from the GPR data and we later cored near these features.

4.2 MANOMETER SURVEY

Plate A-4 shows the results of the Manometer survey of the tank floor. Data points were collected and these points were contoured in ArcGIS using the Kriging contouring algorithm in the 3D analyst plug-in. The contour values are normalized from the drain elevation in the northern part of the tank.

Overall the tank bottom topography shows the base sloping towards the drain area. There is over 8-inches of relief from the drain to the highest elevations in the southeast part of the tank. There is approximately a 2-inch elevation difference between the northwest and southeast sides of the tank bottom. There also appear to be small scale undulations of the bottom as seen by the contour lines. A slope towards the drain should be anticipated; in discussing typical slopes with tank designers it is not uncommon to have a 1% slope to a drain. The subject tank has a diameter of 105 feet with a maximum differential elevation of 8 inches (0.7 ft) as noted. This lies within the general design limits.

4.3 CORING

Cores were extracted at four locations concentrated near the southern part of the water tank. The cores ranged from 6 to 12 inches in length. The field technicians noted that once the cores were extracted water was seeping out of the cores through the visible voids. To test for void space beneath the concrete a wire was placed into the hole which was used to probe several inches around the base of the core. Probing in each of the 4 core holes indicated that there was approximately 1-inch of space between the base of the concrete and underlying soils.

4.4 FIELD STUDIES

In conjunction with conducting GPR studies inside the water tank, a qualified engineering geologist from Geostrata reviewed the geology of the area in the vicinity of the water tank. The area underlying the water tank is mapped as landslide deposit by Yonkee (2004). At the time of our visit, to the water tank site, the ground was covered with snow making the local geomorphology difficult to assess. A review of stereographic aerial photographs of the subject site resulted in the identification of several features. Stereographic aerial photographs were downloaded from the AGRC (http://agrc.its.state.ut.us/) website. Approximately 270 feet north and east of the water tank there appears to be a head scarp of a landslide. The landslide is approximately 500 feet in width and 270 ft long as mapped by Yonkee et al., 2004 (Plate A-2). The pronounced head scarp and other goemorphological features, visible on the stereographic aerial photographs, suggest that this landslide might still be active. The topographic slope around the water tank is shallower than the topography in the area of the active landslide area to the north.

There is a topographic depression approximately 70 feet southwest of the water tank. There was water visible in the depression at the time of our visit. The water in the topographic depression is likely fed by the runoff from the water tank when it is leaking. These types of depressions or sag ponds are often found in active landslides areas. Sag ponds will generally develop at the bottom of a landslide scarp and at the head of the slope mass. No particular scarp was noted in the area of the sag pond at the time of our site visit.

Plate A-8 is presents a photograph of the water tank where water has been observed by city officials to flow in a small stream to the south. Small mounds of soils can be seen collecting at the edge of the tank.

Plate A-9 and A-10 show photographs taken from the inside of the water tank. Cracks that have been sealed can be seen in the vicinity of the pillars. The diamond-shaped pattern of fractures around the pillar may be the result of settlement. Most of the pillars have this type of fracturing around the base.

5.0 DISCUSSION OF RESULTS

GeoStrata conducted field studies at the subject site including a GPR survey, Manometer studies, coring, and field observations. The GPR data while noisy indicates that there are numerous “anomalies” at the base of the concrete slab. The GPR data also shows there are 2 layers of rebar in the concrete base. The GPR signal from rebar produces a narrow parabola. Strong GPR signals like those produced from rebar often produce multiples. Multiples are similar to an echo where similar size and shaped features are repeated at depth multiple times. The GPR signals from rebar in this study have multiples and it is difficult to differentiate whether all small parabolas seen in the upper 8 inches are related to rebar. It is possible that some of these might reflect actual “anomalies” within the concrete. Additional field studies would have to be conducted to investigate these phenomena.

The results of the coring verify that at least one of the GPR “anomalies” at the base of the concrete was indeed a ~1 inch void space beneath the concrete slab. The fact that all of the cores (Plate A-2) had approximately 1-inch of void space beneath the concrete slab suggests this issue might be more wide spread.

It should be noted that both water tanks are built in an area of mapped landslides (Yonkee et al. 2004). There are active landslide features in close proximity to the water tanks. Adding excess water into the subsurface in an already landslide susceptible area may increase the probability of a slope failure. Due to the topographic slope in the area of the water tank being shallow GeoStrata does not believe that the leaking and or cracking observed is a result of landslide movement.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

As previously indicated, concerns about the undermining of the floor slab areas have been noted by City personnel. Based on the results of our study, the anomalies noted in the GPR survey which we attribute to be voids are generally small and localized. The coring substantiated that voids do exist beneath the slabs and that the voids are likely a combination of settlement and washing out of material from the tank leaks.

Several of the photographs indicate that some settlement of the tank has been occurring. It's unclear if the settlement is occurring in the column spread footings or in the floor slab. Based on a review of localized contouring, it seems evident that the settlement may be occurring in the floor slab. The contouring indicated a low in the middle of the slab between columns. We recommend that tank floor surveys be completed periodically to check movement that the tank may be experiencing.

6.2 RECOMMENDATIONS

To minimize the potential for additional leaks and to aid in supporting the tank floor we recommend that consideration be given to grouting under the tank floor. This can be accomplished by hiring a specialized contractor to perform the work. The grouting should be completed through a series of core holes strategically placed around the bottom of the tank. The grout should be slightly pressurized to allow the grout to flow beneath the tank floor and fill any existing voids. The grouting plan should be developed in conjunction with GeoStrata personnel and should include monitoring techniques to measure the lateral flow, volume and pressures of the grout. GeoStrata can aid in identifying a competent grouting contractor.

7.0 LIMITATIONS

The recommendations contained in this report are based on limited field exploration and our understanding of the purpose of the subject site. The subsurface data used in the preparation of this report were obtained from the geophysical studies and cores across the subject site. It is possible that variations in the soil and groundwater conditions might exist. The nature and extent of variations may not be evident without additional subsurface exploration. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the purpose of the subject site changes from that described in this report, our firm should also be notified.

This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, expressed or implied, is made.

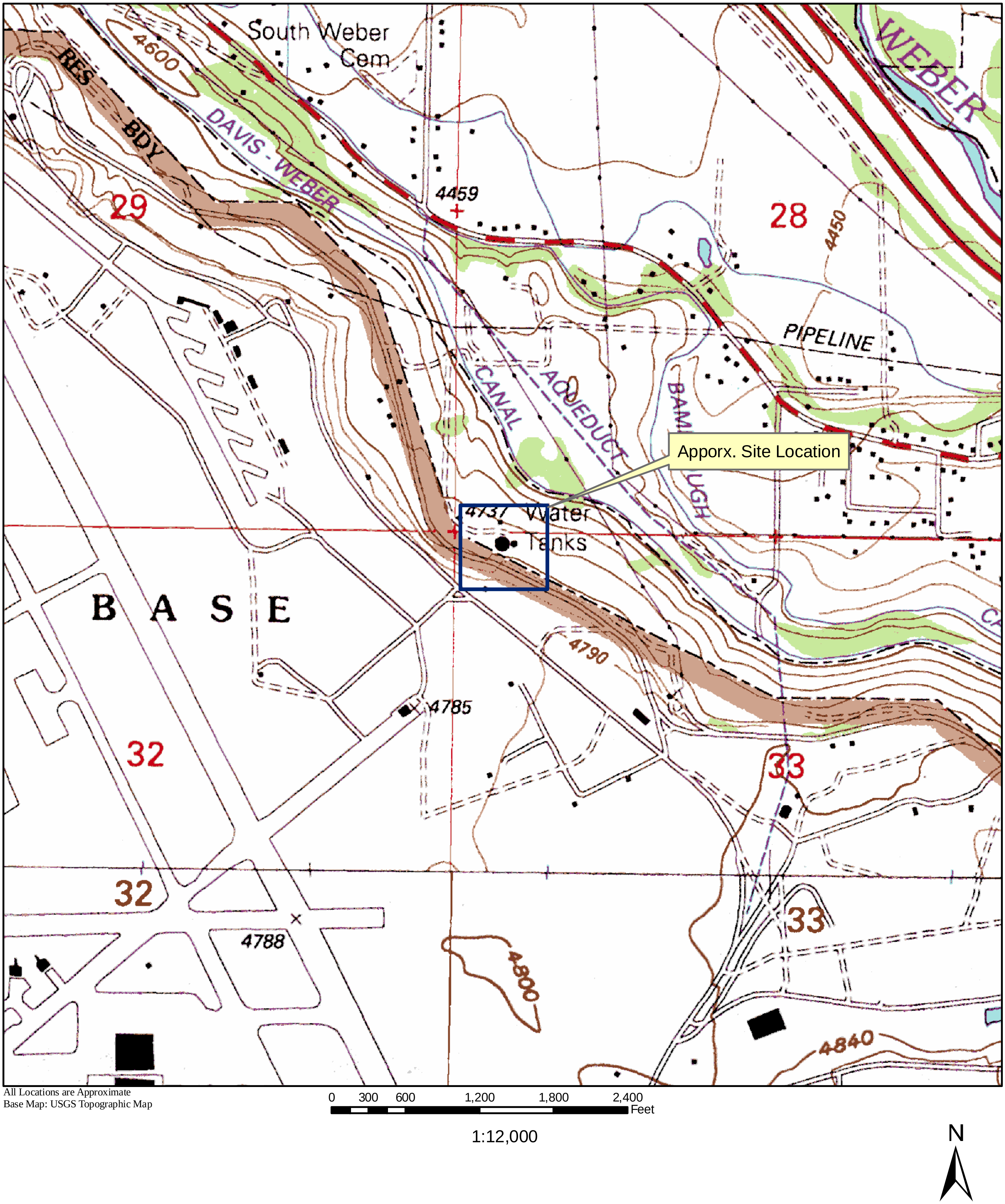
It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

8.0 REFERENCES CITED

Hintze, L.F. (1993). “Geologic History of Utah” Brigham Young University Studies, Special Publication 7, 202p.

Machette, M. 1992, Surficial geologic map of the Wasatch Fault Zone, Eastern Part of Utah Valley Utah County and Parts of Salt Lake and Juab Counties, Utah, 1:50,000, 1992 United States Geological Survey, I-2095.

Yonkee, Adolph, and Lowe, Mike, 2004, Geologic map of the Ogden 7.5’ quadrangle, Weber and Davis Counties, Utah. Utah Geological Survey, scale 1: 24000.

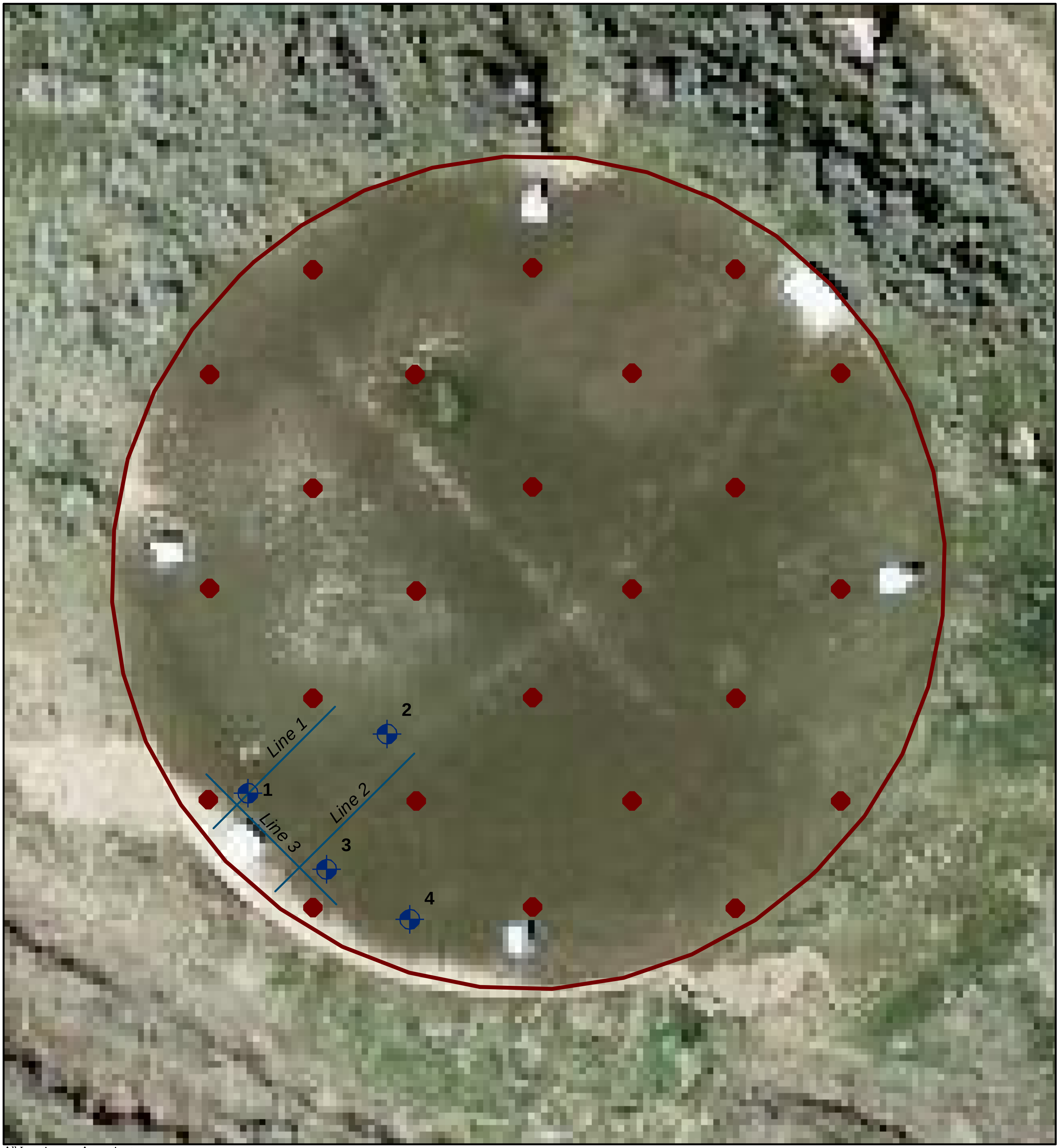


All Locations are Approximate
Base Map: USGS Topographic Map

South Weber Water Tank Leak Investigation
Jones and Associates
South Weber, Utah
Project Number: 683-002

Site Vicinity Map

Plate A-1



All Locations are Approximate
Base Map: 1 Foot NAIP 2009 Orthophotography

0 5 10 20 30 40 Feet

1:200

N

Legend

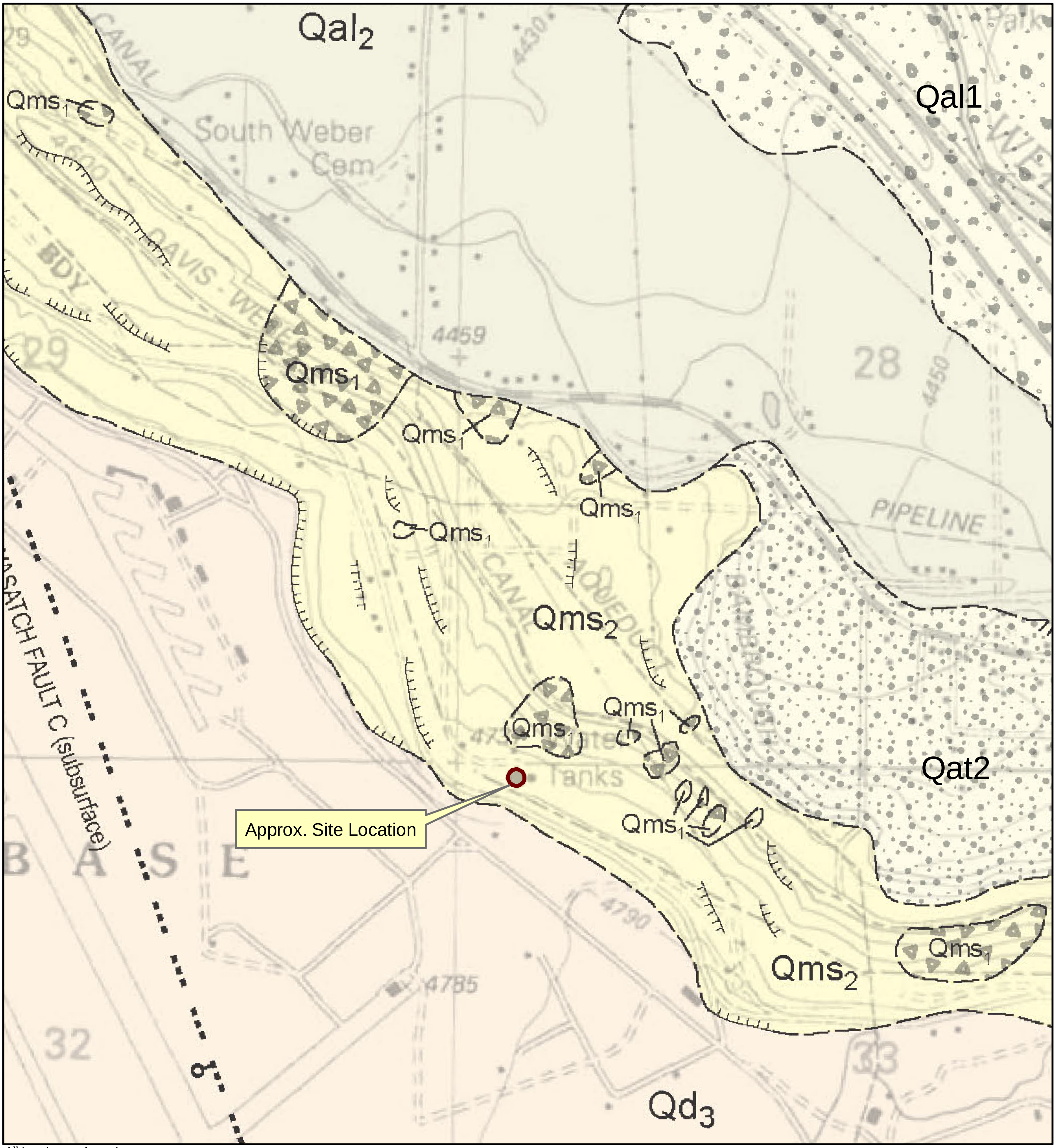
- Coring Location
- GPR Line
- Pillar

GeoStrata

South Weber Water Tank Leak Investigation
Jones and Associates
South Weber, Utah
Project Number: 683-002

Site Exploration Map

Plate A-2



All Locations are Approximate
Base Map: Geologic Map of the Ogden 7.5' Quadrangle

0 250 500 1,000 1,500 2,000 Feet

1:10,000

N

Qd_3 – Deltaic Deposits

Qms_1 – Younger Landslide Deposits

Qms_2 – Older Landslide Deposits

Qat_2 – Older Alluvial Terrace Deposits

Qal_1 – Younger Stream Alluvium

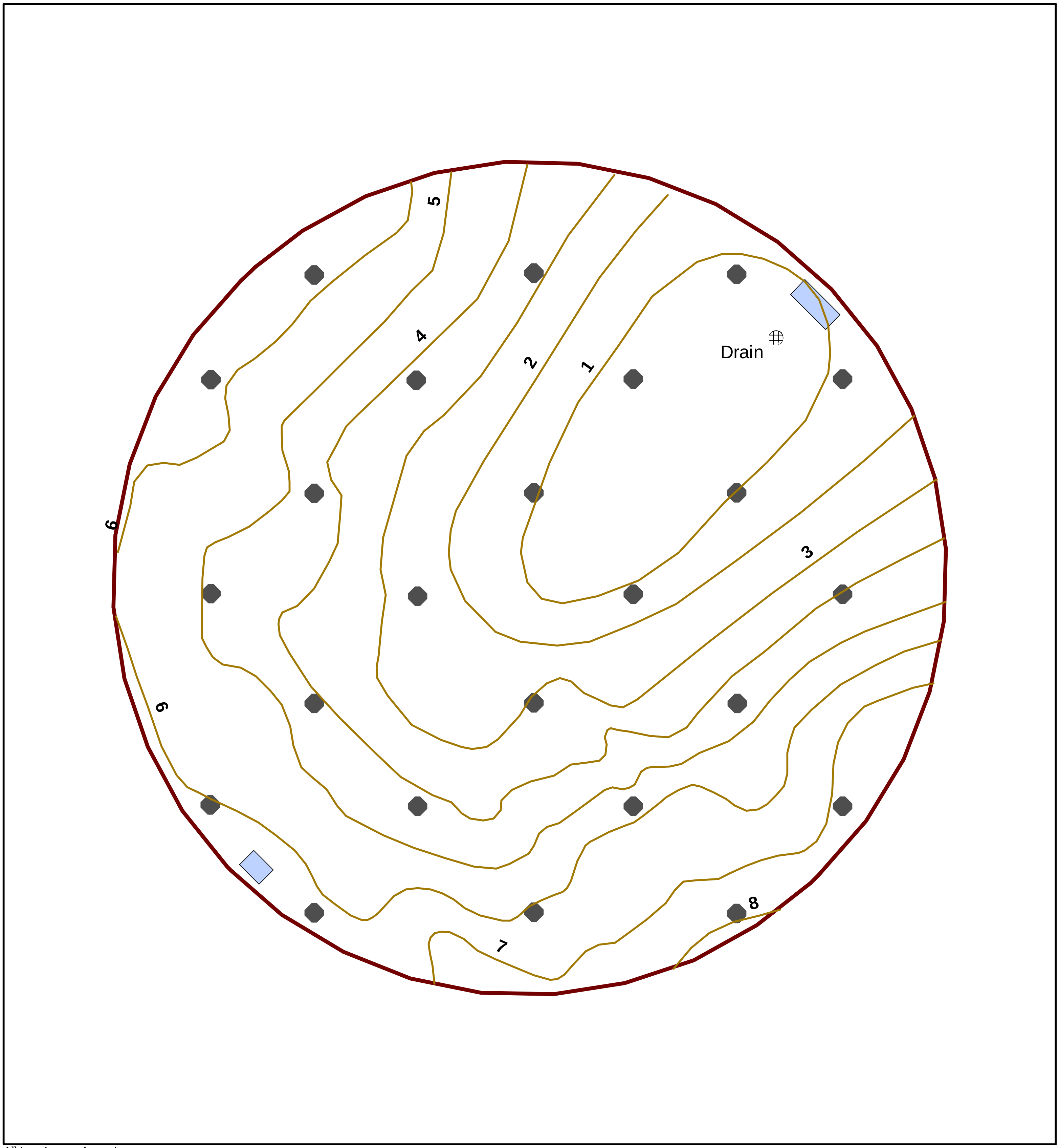
Qal_2 – Older Stream Alluvium

GeoStrata

South Weber Water Tank Leak Investigation
Jones and Associates
South Weber, Utah
Project Number: 683-002

Surfical Geologic Map

Plate A-3



All Locations are Approximate

0 5 10 20 30 40 Feet

1:200

N

Legend

Contour (in.)

Pillar

Roof Access

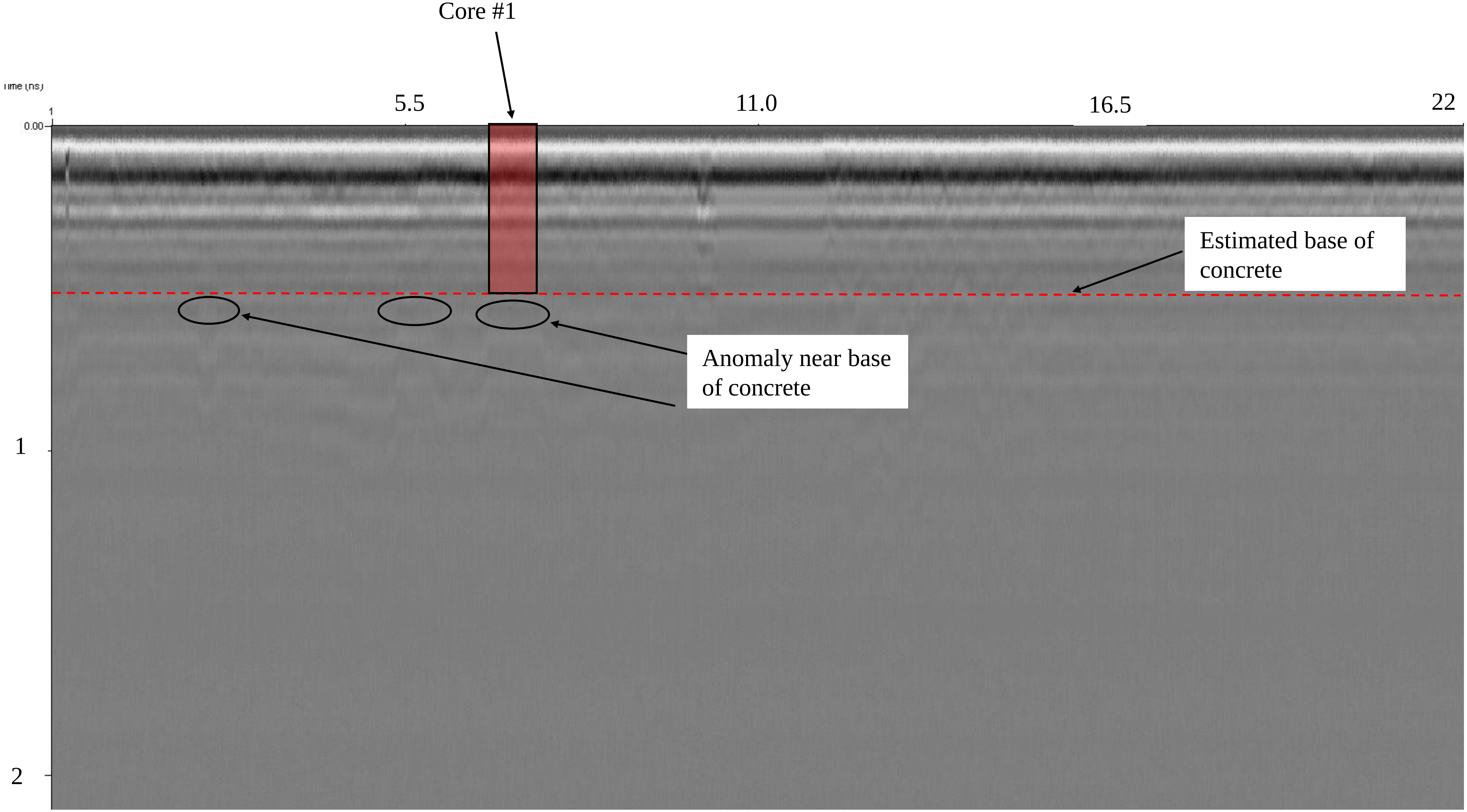
GeoStrata

South Weber Water Tank Leak Investigation
City of South Weber
South Weber, Utah
Project Number: 683-002

Tank Floor Topography

Plate A-4

Line 1



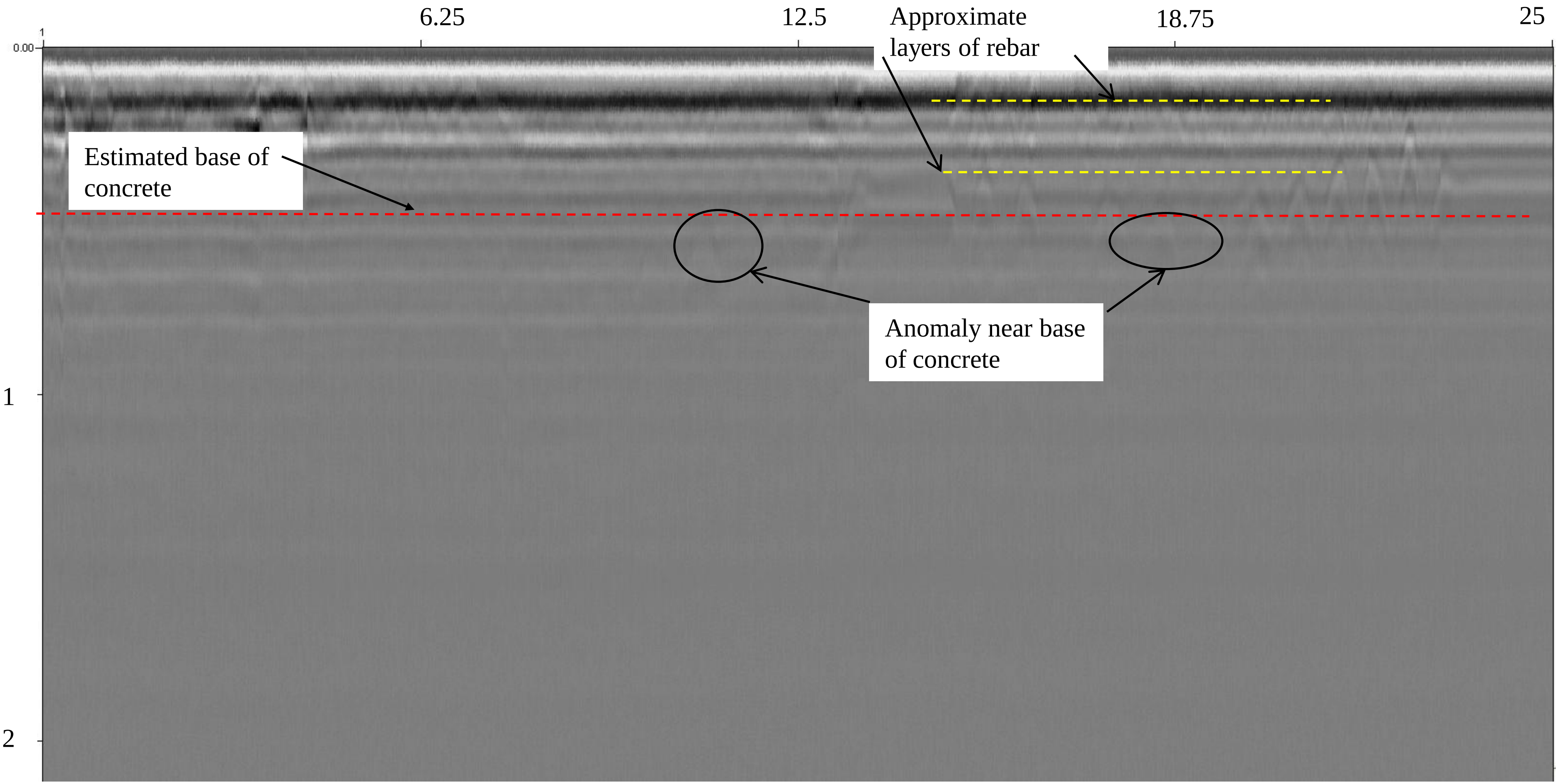
GeoStrata

South Weber Water Tank Leak Investigation

Jones and Associates
South weber, UT
Project Number 683-002

Plate A-5

Line 2

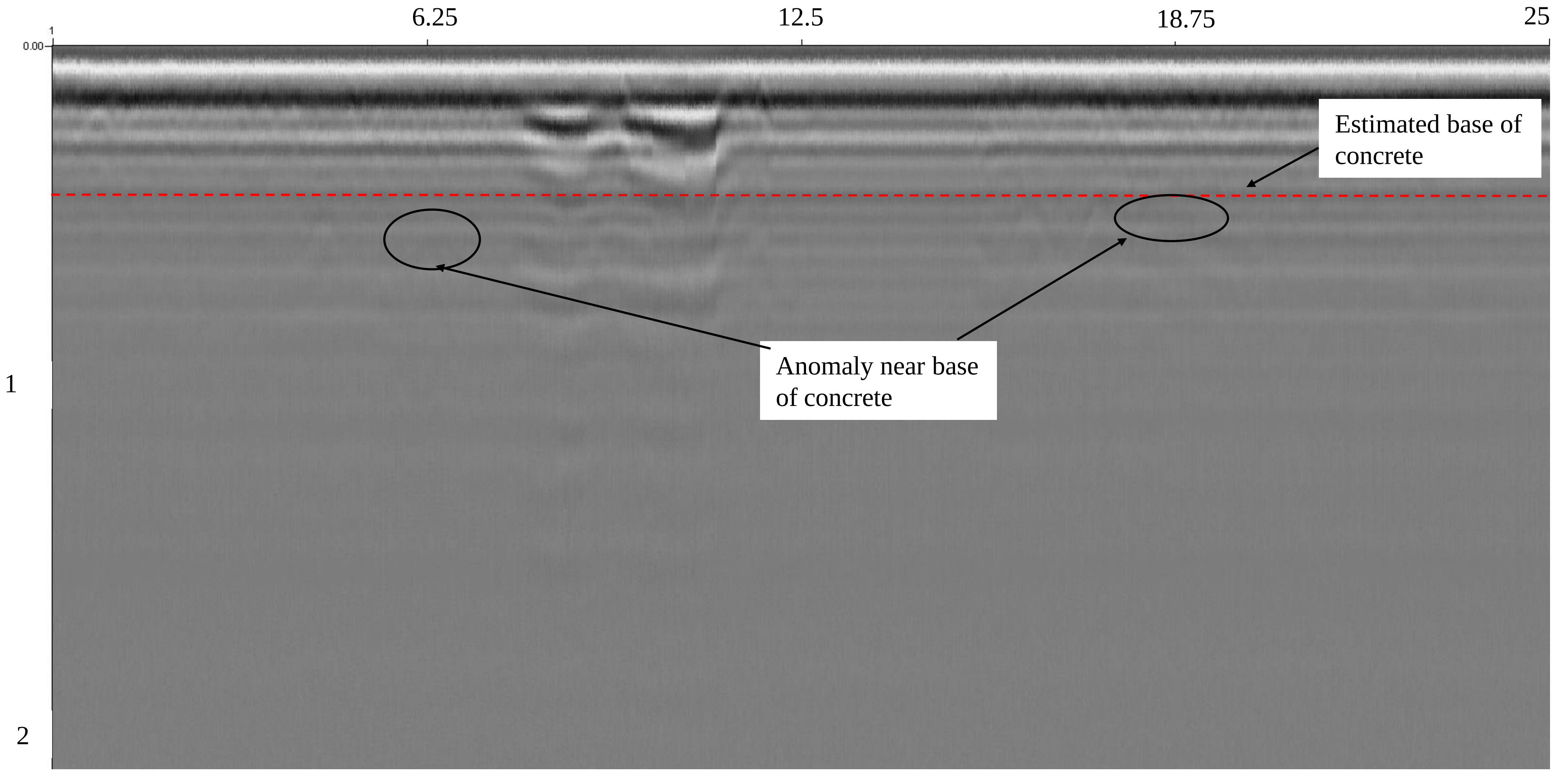


Copyright GeoStrata LLC 2011

South Weber Water Tank Leak Investigation
Jones and Associates
South weber, UT
Project Number 683-002

Plate A-6

Line 3



GeoStrata

South Weber Water Tank Leak Investigation **Jones and Associates** **South weber, UT** **Project Number 683-002**	**Plate A-7**

GeoStrata

South Weber Water Tank Leak Investigation

Jones and Associates
South weber, UT
Project Number 683-002

Plate A-8

GeoStrata

South Weber Water Tank Leak Investigation

Jones and Associates
South weber, UT
Project Number 683-002

Plate A-9

GeoStrata

South Weber Water Tank Leak Investigation

Jones and Associates
South weber, UT
Project Number 683-002

Plate
A-10

ATTACHMENT D

CONCEPT PLANS

JONES & ASSOCIATES IGES ARW ENGINEERS structural consultants

JA CONSULTING ENGINEERS
JONES & ASSOCIATES

1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

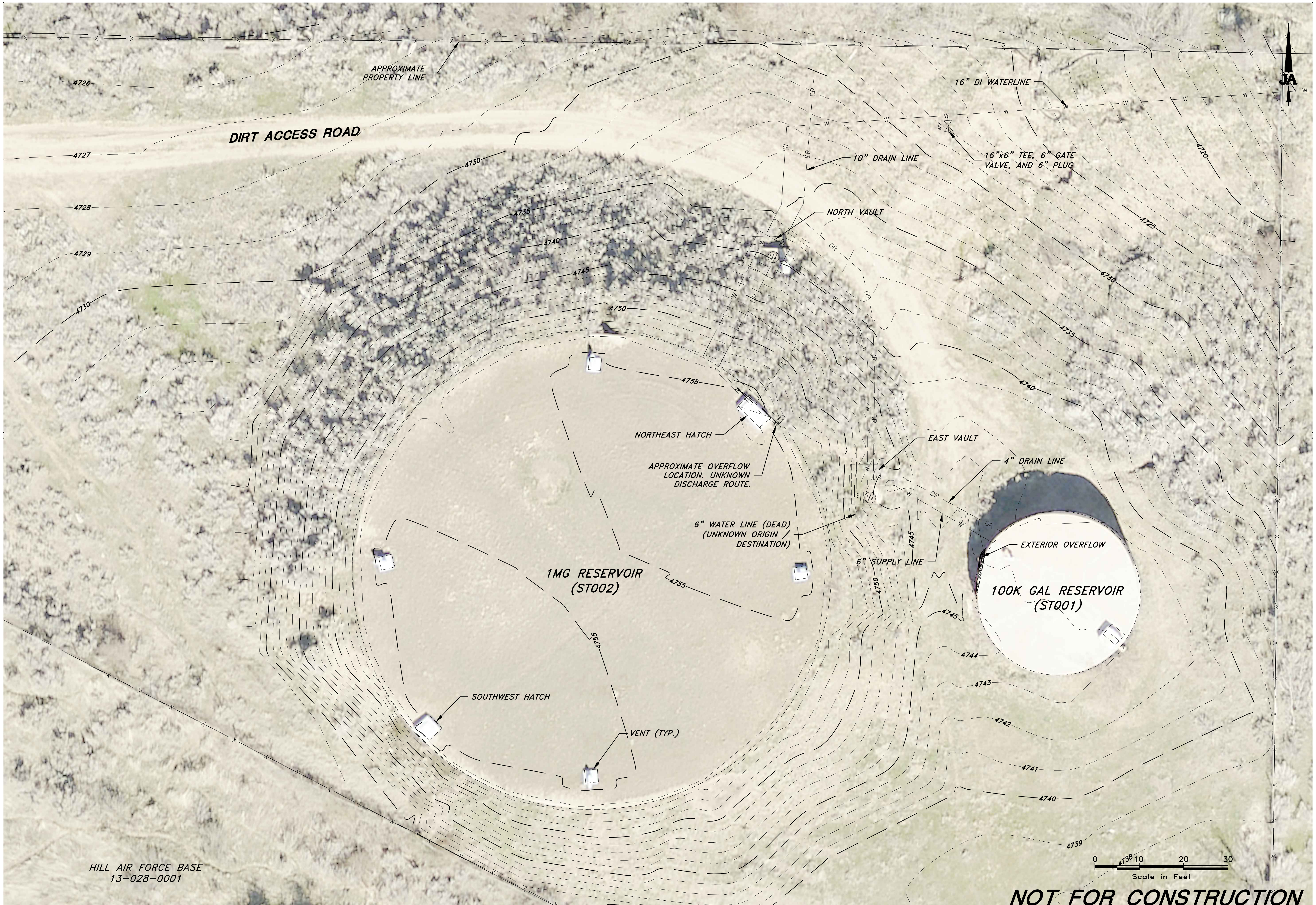
LOCATION AND PARCEL MAP

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=120'
11"x17" H:1"=240'

SHEET: 1
OF 1 SHEETS



JA JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

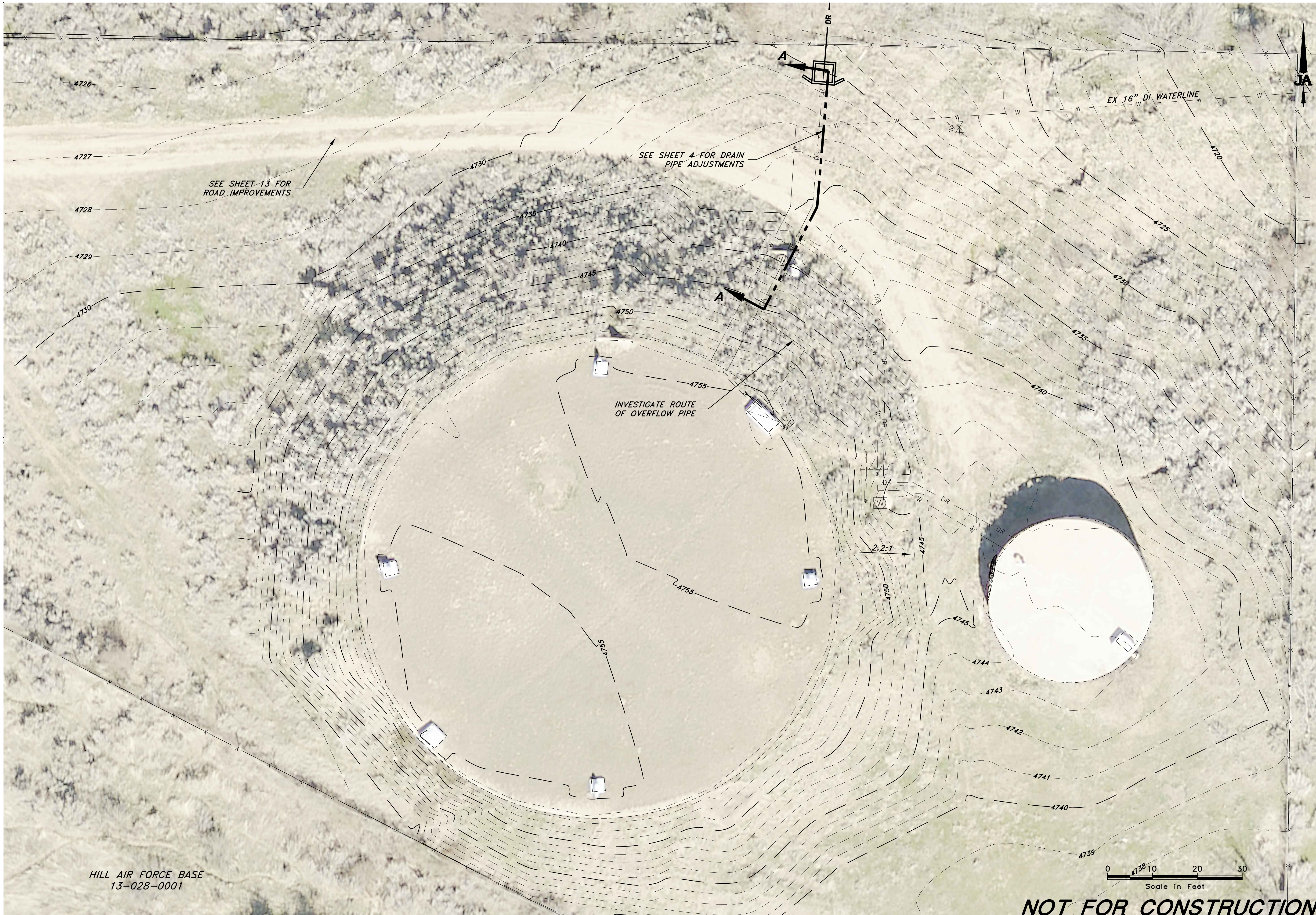
EXISTING SITE PLAN

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=10'
11"x17" H:1"=20'

SHEET: 2
OF 1 SHEETS



NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION

WESTSIDE RESERVOIR PROJECT

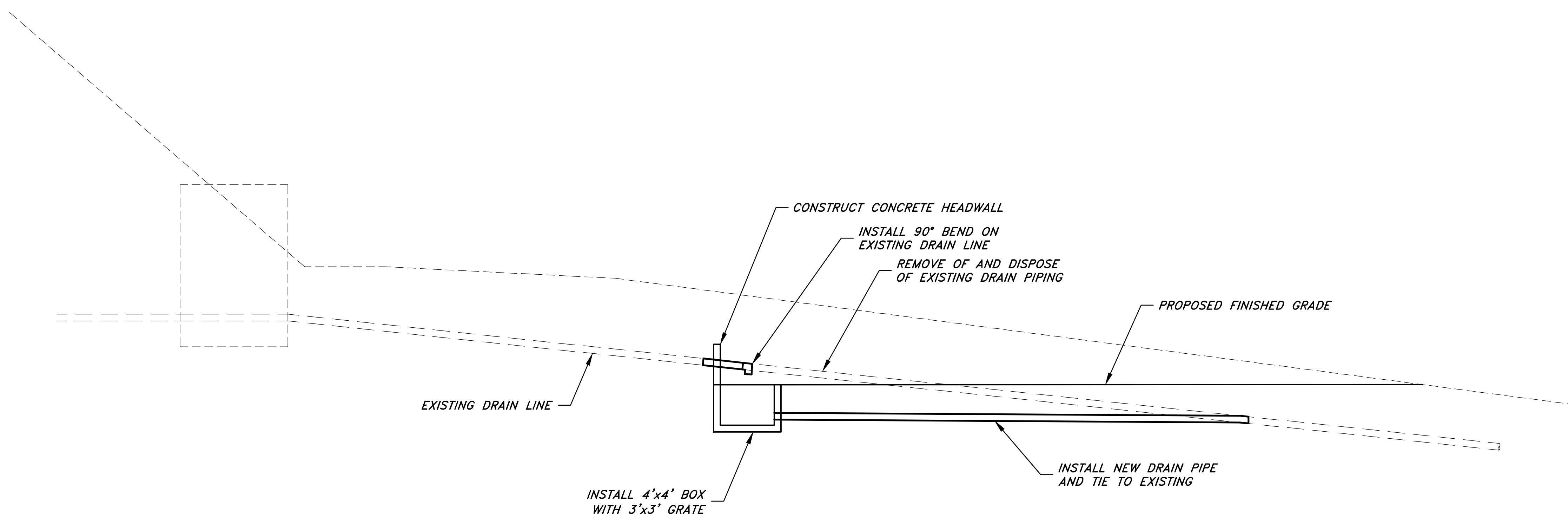
YARD PIPING IMPROVEMENTS

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=10' 11"x17" H:1"=20'

SHEET: 3 OF 1 SHEETS



SECTION A-A WITH AIR GAP STRUCTURE

0 5 10 15
Scale in Feet

NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

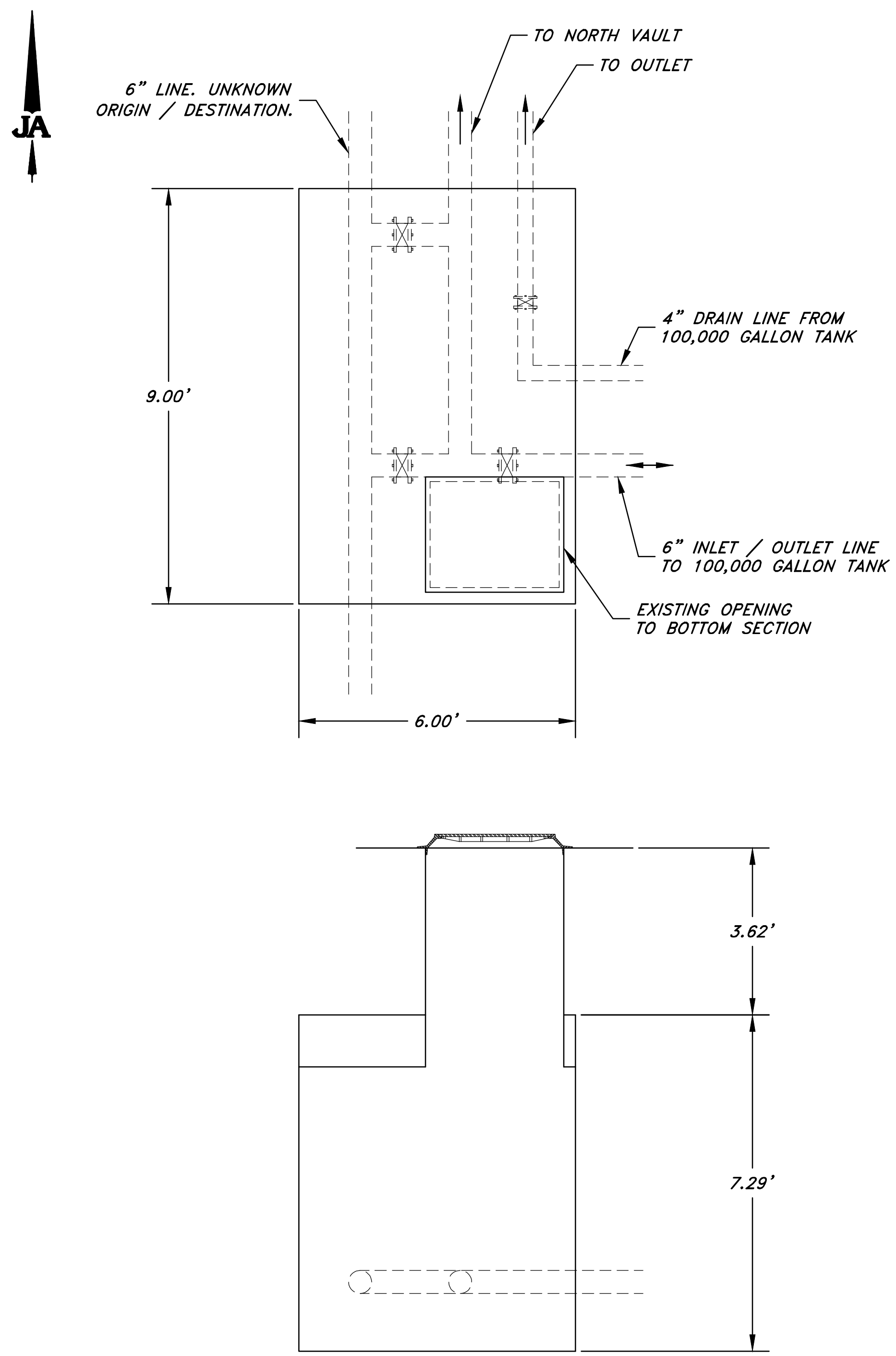
AIR GAP STRUCTURE

REV.	DATE	APPR.

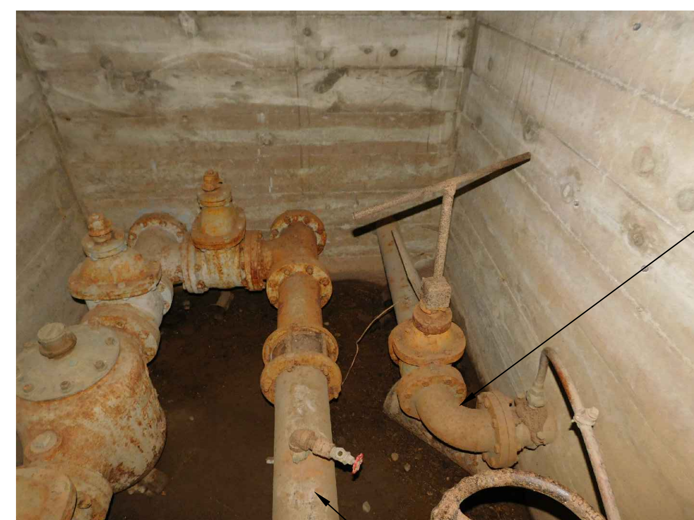
DQS DESIGNED
TWE DRAWN
DQS CHECKED

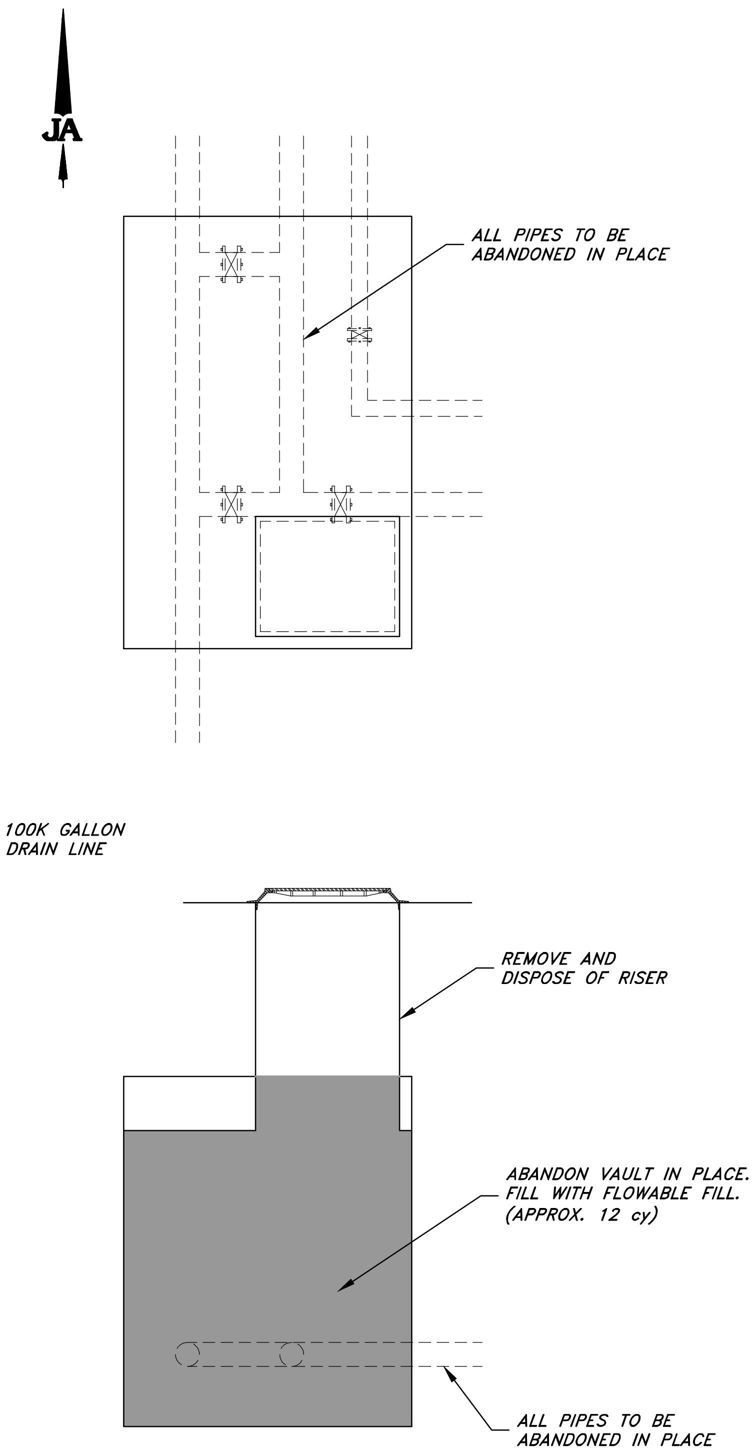
SCALE: 24"x36" H:1"=5'
11"x17" H:1"=10'

SHEET: 4
OF 1 SHEETS



EXISTING EAST VAULT





POPOOSED EAST VAULT

0 2 4 6
Scale in Feet

NOT FOR CONSTRUCTION

JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

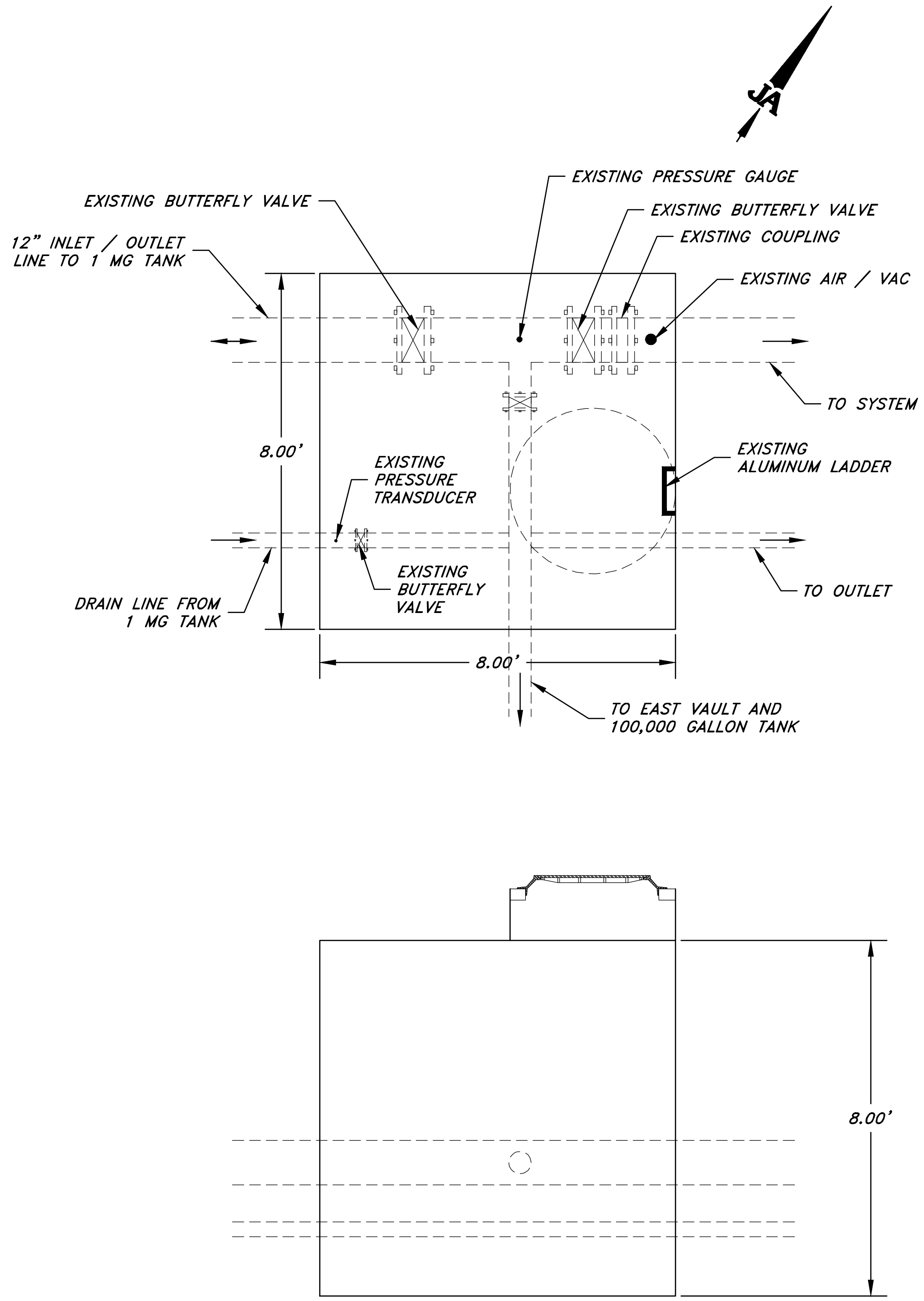
EAST VAULT

REV.	DATE	APPR.

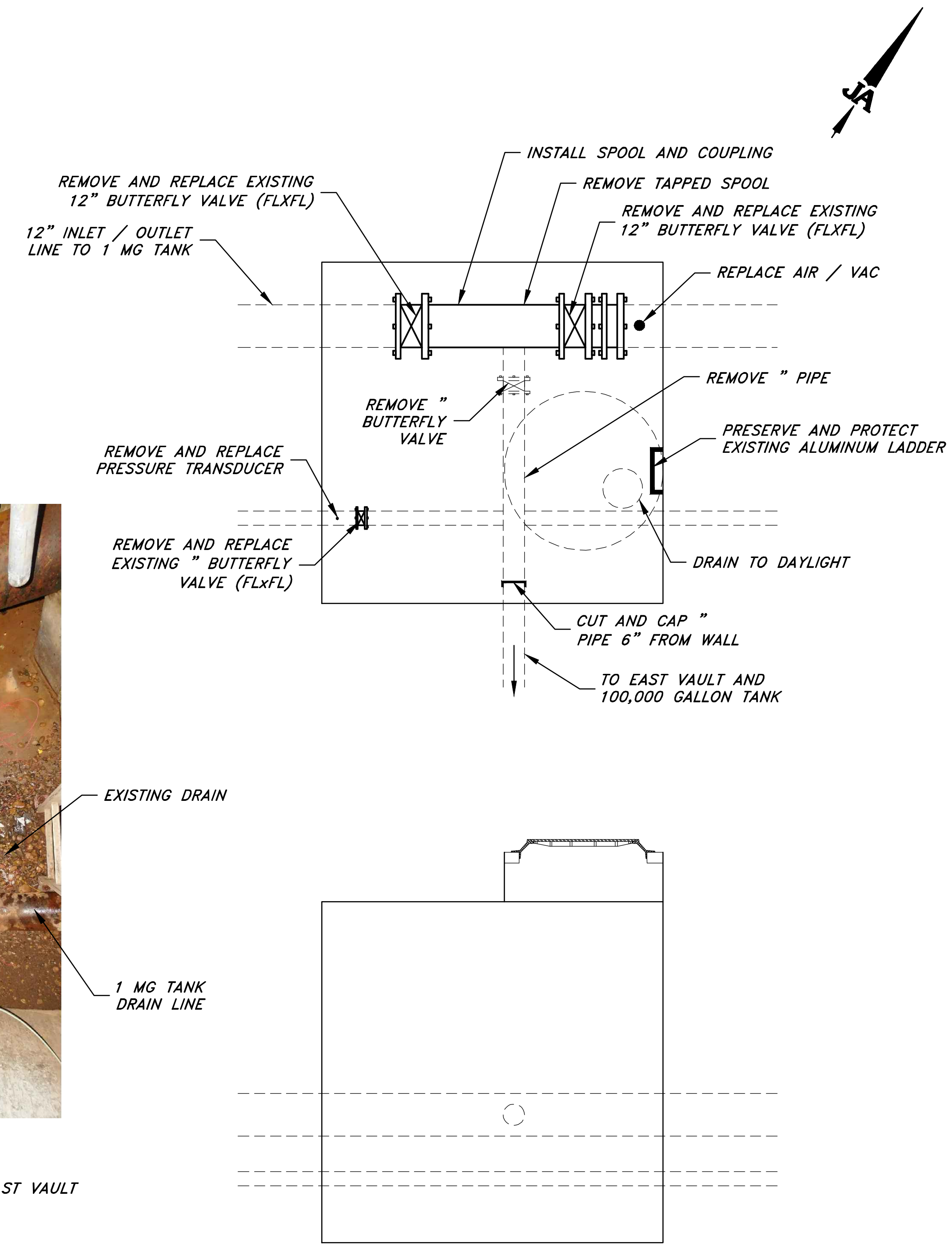
DQS DESIGNED | TWE DRAWN | DQS CHECKED

SCALE: 24"x36" H:1"=2' | 11"x17" H:1"=4'

SHEET: 5
OF 1 SHEETS



EXISTING NORTH VAULT



PROPOSED NORTH VAULT

NOTE:
CONTRACTOR TO FIELD VERIFY ALL MEASUREMENTS PRIOR TO FABRICATION OF CUSTOM APPURTENANCES.

0 2 4 6
Scale in Feet

NOT FOR CONSTRUCTION

JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

NORTH VAULT

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=2' 11"x17" H:1"=4'

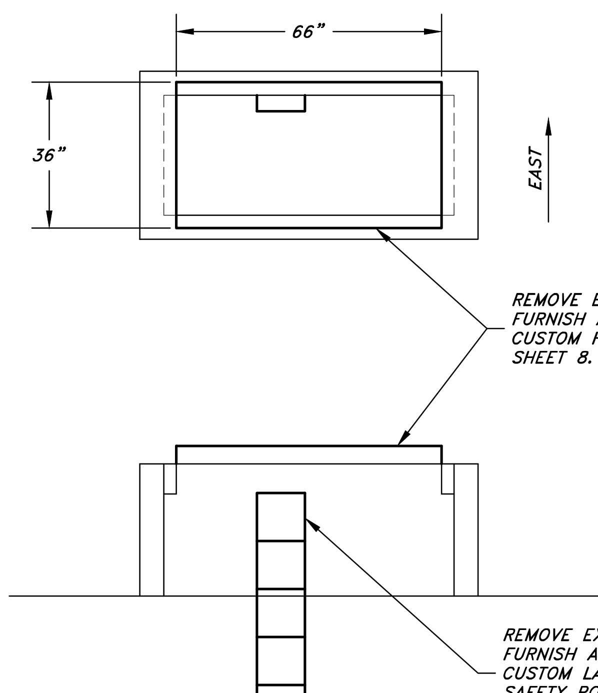
SHEET: 6
OF 1 SHEETS

REMOVE EXISTING HATCH. FURNISH AND INSTALL CUSTOM HATCH. SEE SHEET 8.

REMOVE EXISTING HATCH. FURNISH AND INSTALL CUSTOM HATCH. SEE SHEET 8.

REMOVE EXISTING LADDER. FURNISH AND INSTALL CUSTOM LADDER. SEE SHEET 8.

REMOVE EXISTING LADDER. FURNISH AND INSTALL CUSTOM LADDER. SEE SHEET 8.

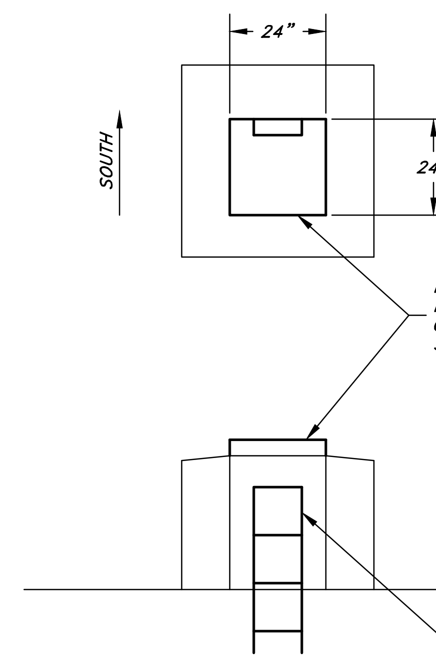


REMOVE EXISTING HATCH. FURNISH AND INSTALL CUSTOM HATCH. SEE SHEET 8.

REMOVE EXISTING LADDER. FURNISH AND INSTALL CUSTOM LADDER WITH SAFETY POST. SEE SHEET 8.

NORTHEAST HATCH

NOTE:
CONTRACTOR TO FIELD VERIFY ALL MEASUREMENTS PRIOR TO FABRICATION OF CUSTOM APPURTENANCES.



REMOVE EXISTING HATCH. FURNISH AND INSTALL CUSTOM HATCH. SEE SHEET 8.

REMOVE EXISTING LADDER. FURNISH AND INSTALL CUSTOM LADDER WITH SAFETY POST. SEE SHEET 8.

SOUTHWEST HATCH

0 2 4 6
Scale in Feet

NOT FOR CONSTRUCTION

JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

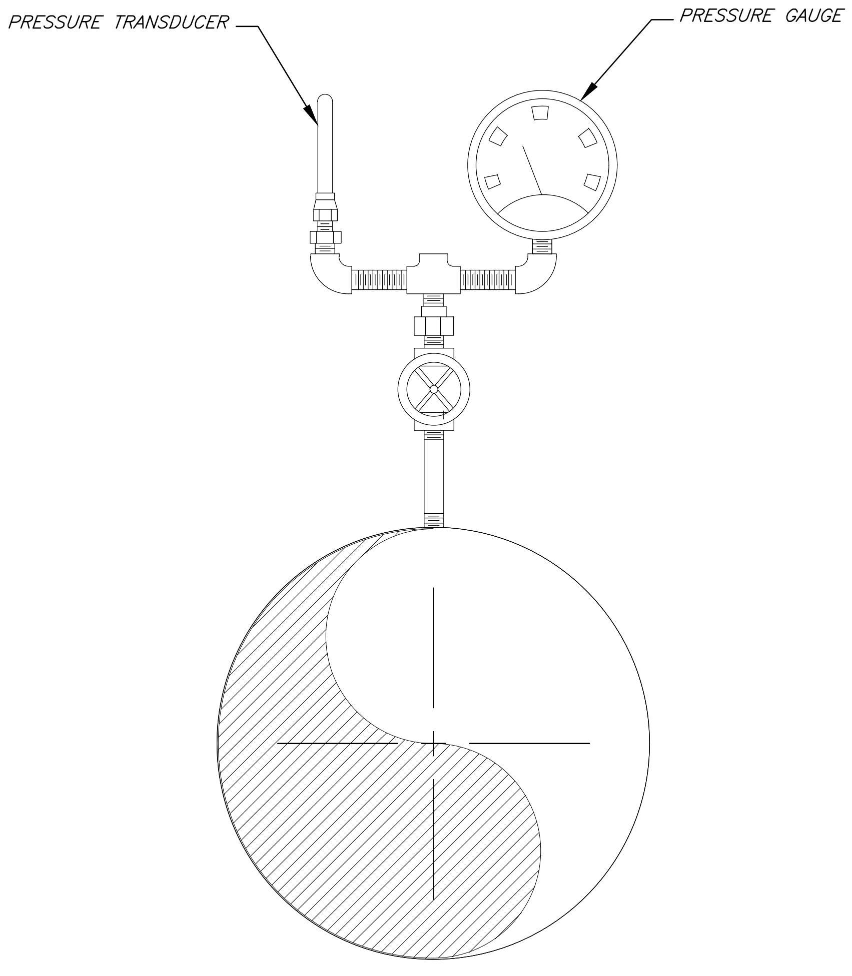
SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

HATCHES

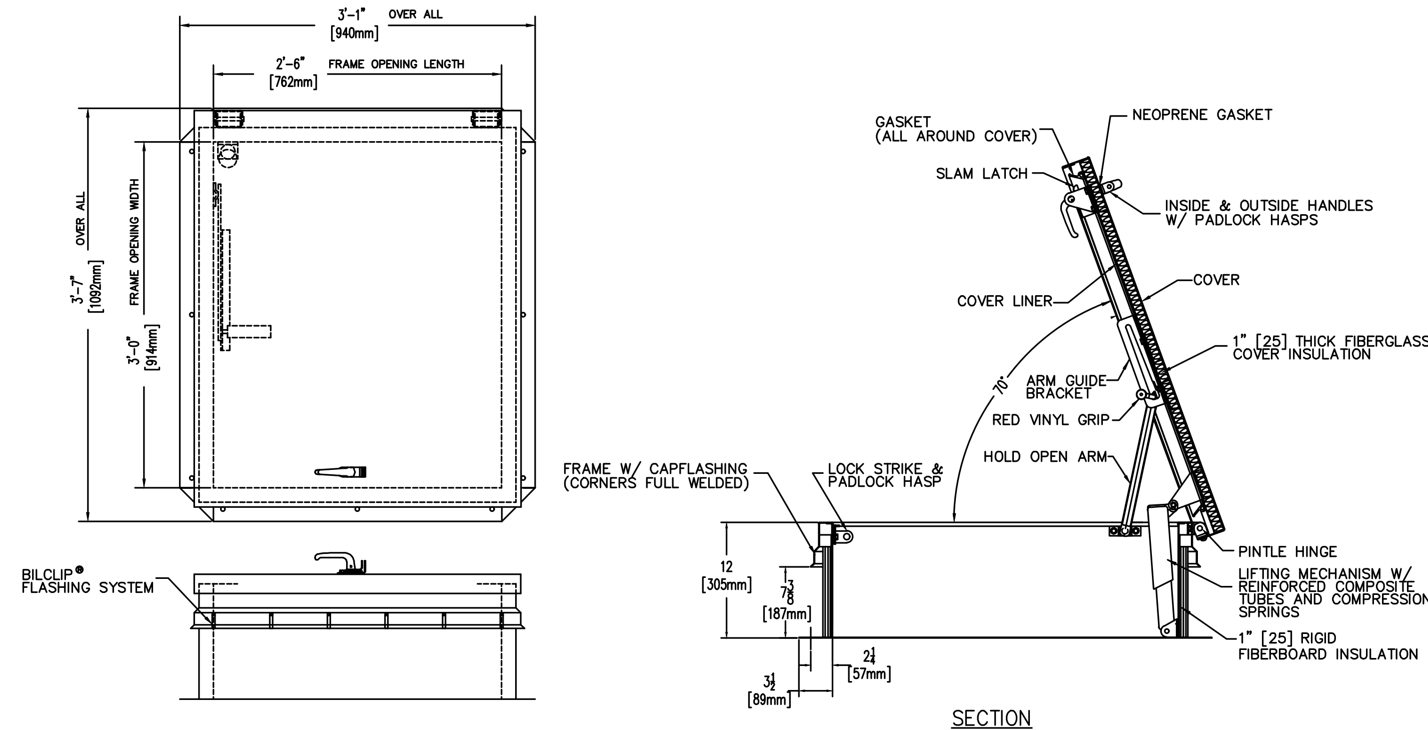
REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=2' 11"x17" H:1"=4'

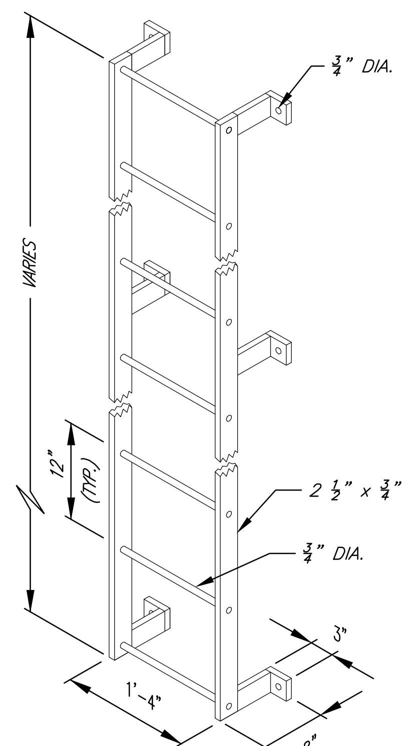


PRESSURE GAUGE AND TRANSDUCER DETAIL



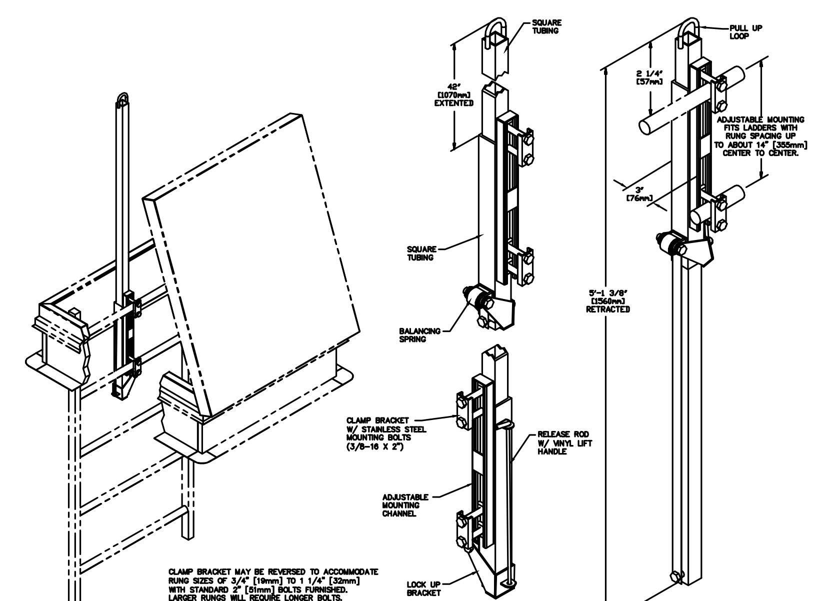
BILCO TYPE S ROOF SCUTTLE

(OR APPROVED EQUAL)



LADDER DETAIL

HOT DIP GALVANIZE AFTER FABRICATION



BILCO
LADDER UP SAFETY POST

BILCO LADDER UP SAFETY POST

(OR APPROVED EQUAL)

NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

MISCELLANEOUS DETAILS

REV.	DATE	APPR.

DESIGNED: DQS
DRAWN: TWE
CHECKED: DQS

SCALE: 24"x36" H:1"=2'; 11"x17" H:1"=4'

SHEET: 8
OF 1 SHEETS

NOT FOR CONSTRUCTION

JA JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

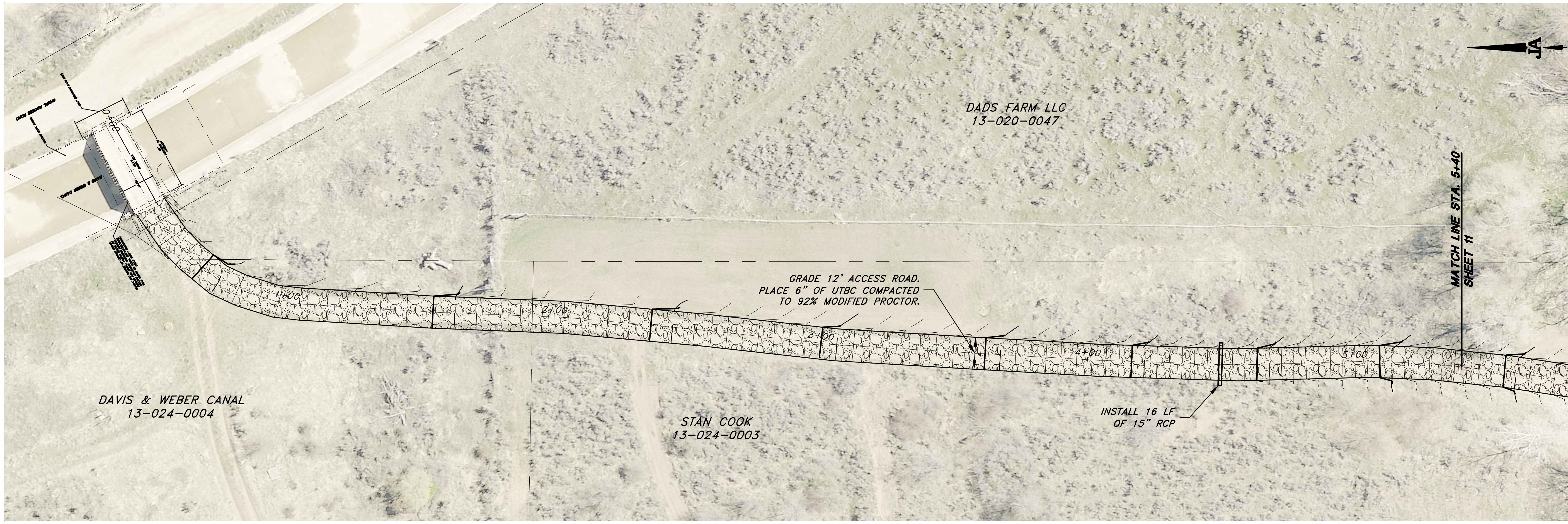
EXISTING ACCESS ROAD

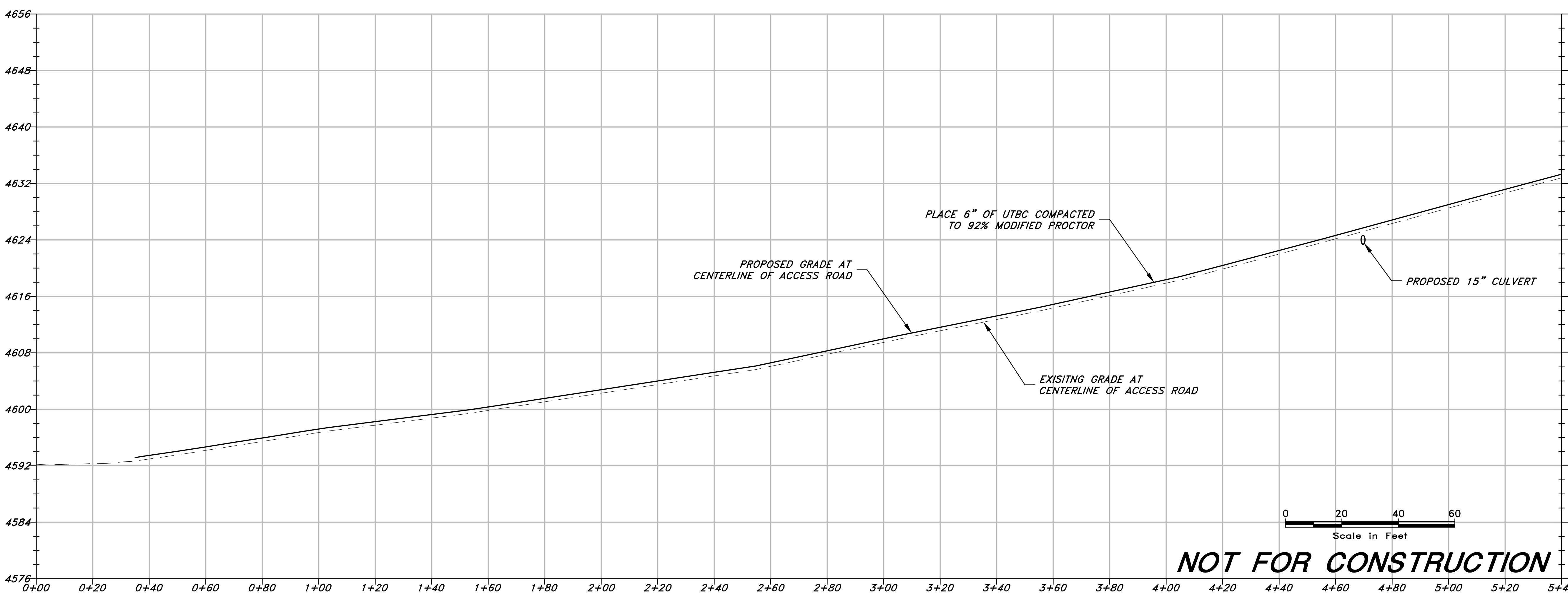
REV.	DATE	APPR.

DESIGNED: DOS
DRAWN: TWE
CHECKED: DOS

SCALE:
24"x36" H:1"=60'
11"x17" H:1"=120'

SHEET: 9
OF 1 SHEETS





NOT FOR CONSTRUCTION

JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

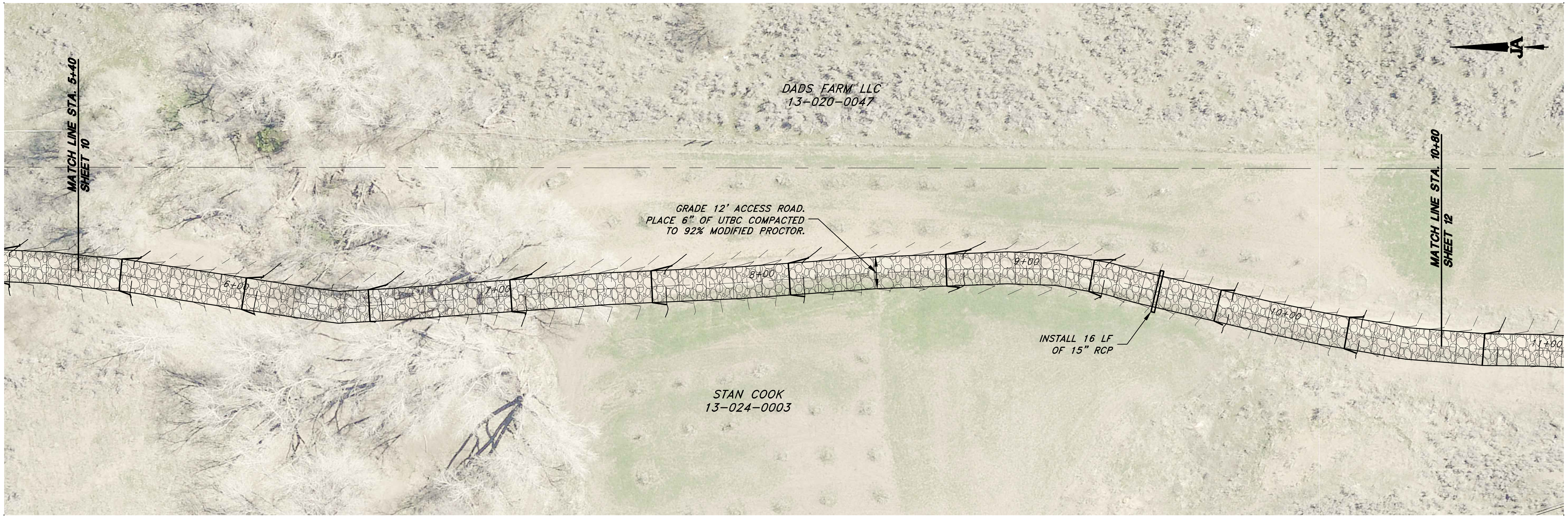
EXISTING ACCESS ROAD IMPROVEMENTS PLAN AND PROFILE STA. 0+00 5+40

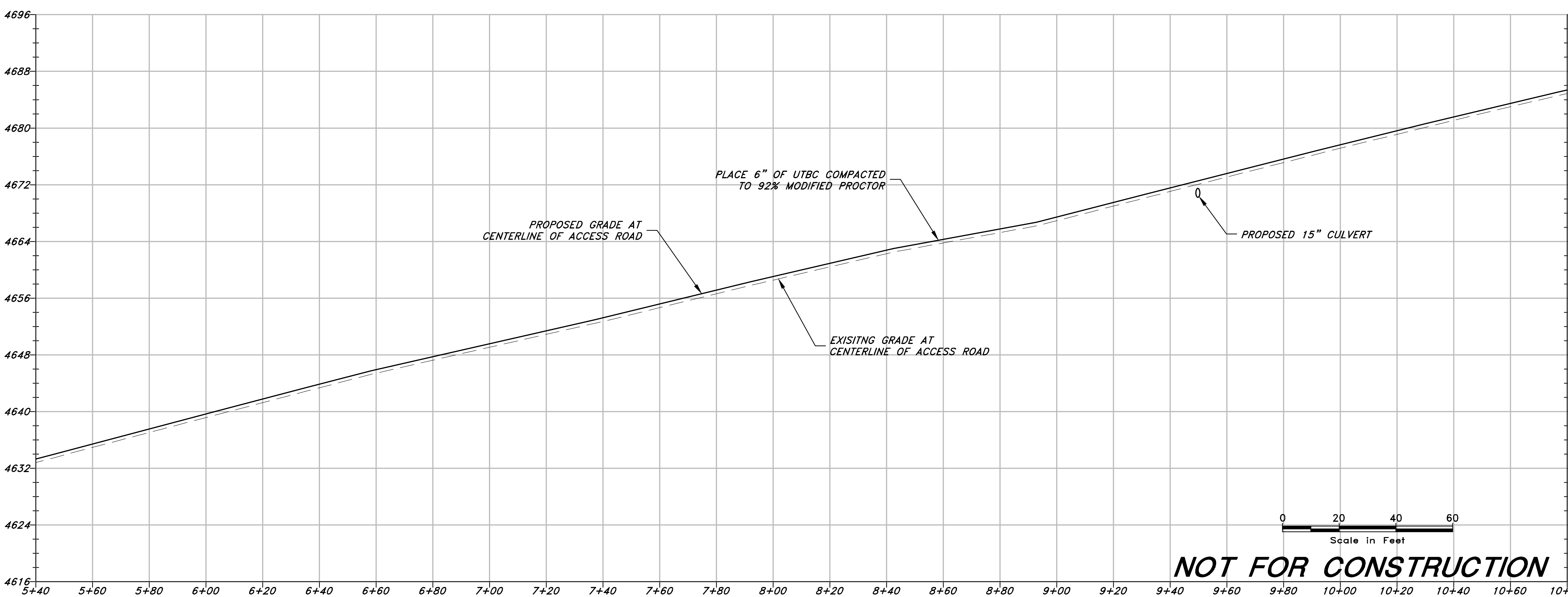
REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE:
24"x36" H:1"=20' V:1"=8'
11"x17" H:1"=40' V:1"=16'

SHEET:
10
OF 1 SHEETS





NOT FOR CONSTRUCTION

JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801) 476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

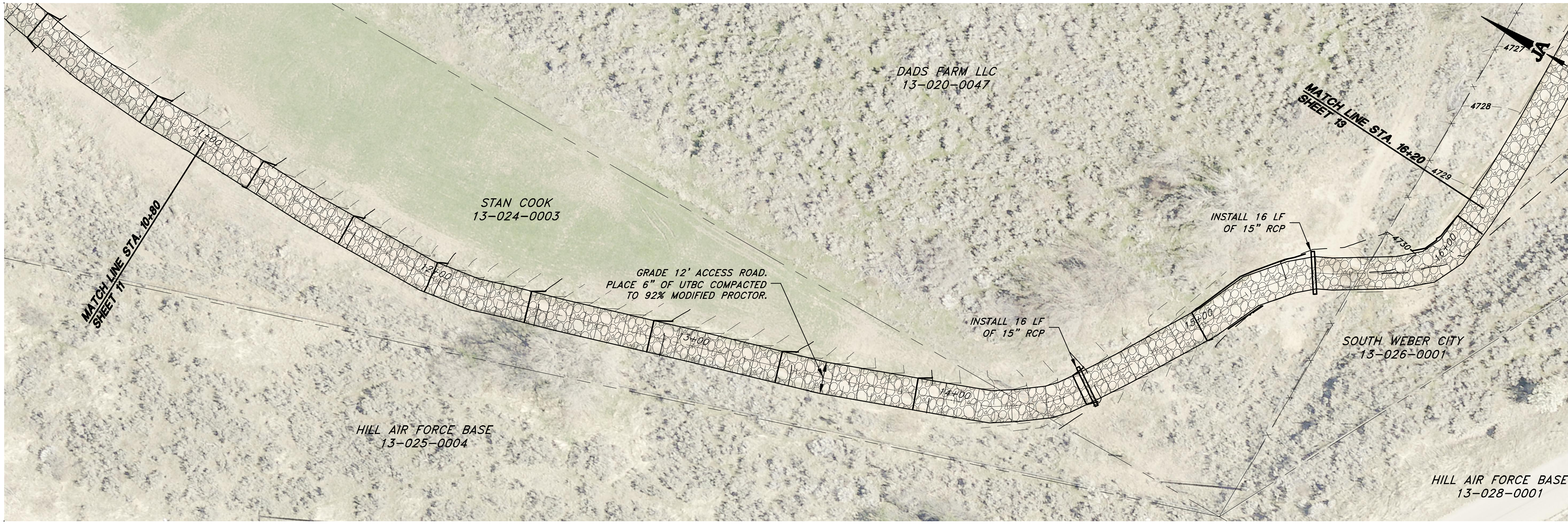
EXISTING ACCESS ROAD IMPROVEMENTS
PLAN AND PROFILE STA. 5+40 10+80

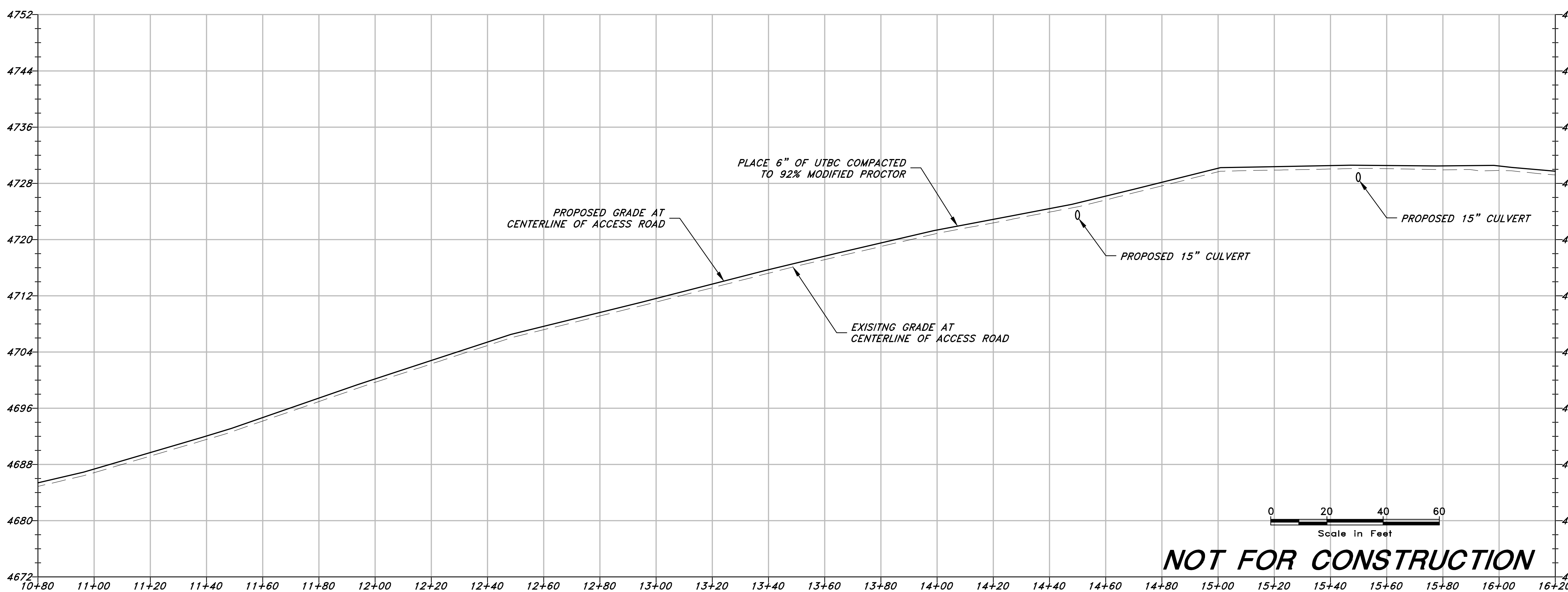
REV.	DATE	APPR.

DESIGNED: DQS
DRAWN: TWE
CHECKED: DQS

SCALE: 24"x36" H:1"=20' V:1"=8'
11"x17" H:1"=40' V:1"=16'

SHEET: 11
OF 1 SHEETS





NOT FOR CONSTRUCTION

JA JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

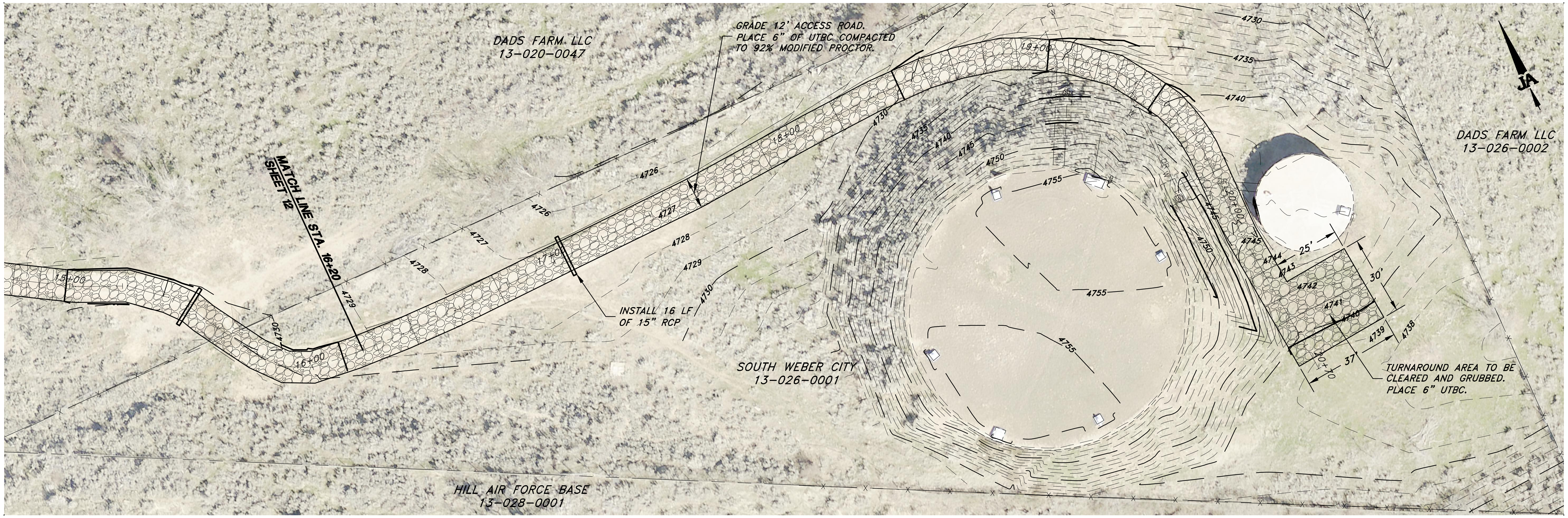
EXISTING ACCESS ROAD IMPROVEMENTS PLAN AND PROFILE STA. 10+80 16+20

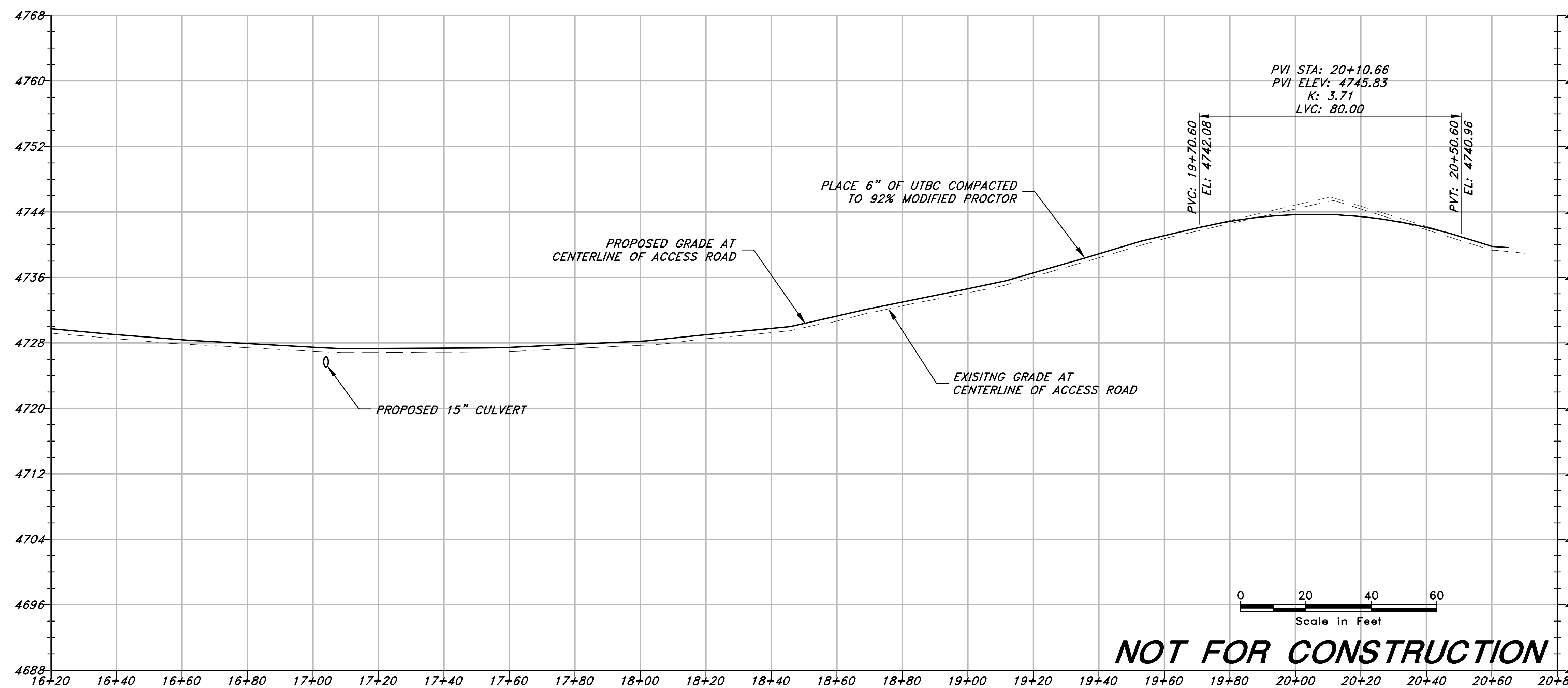
REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE:
24"x36" H:1"=20' V:1"=8'
11"x17" H:1"=40' V:1"=16'

SHEET: 12
OF 1 SHEETS





NOT FOR CONSTRUCTION

JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

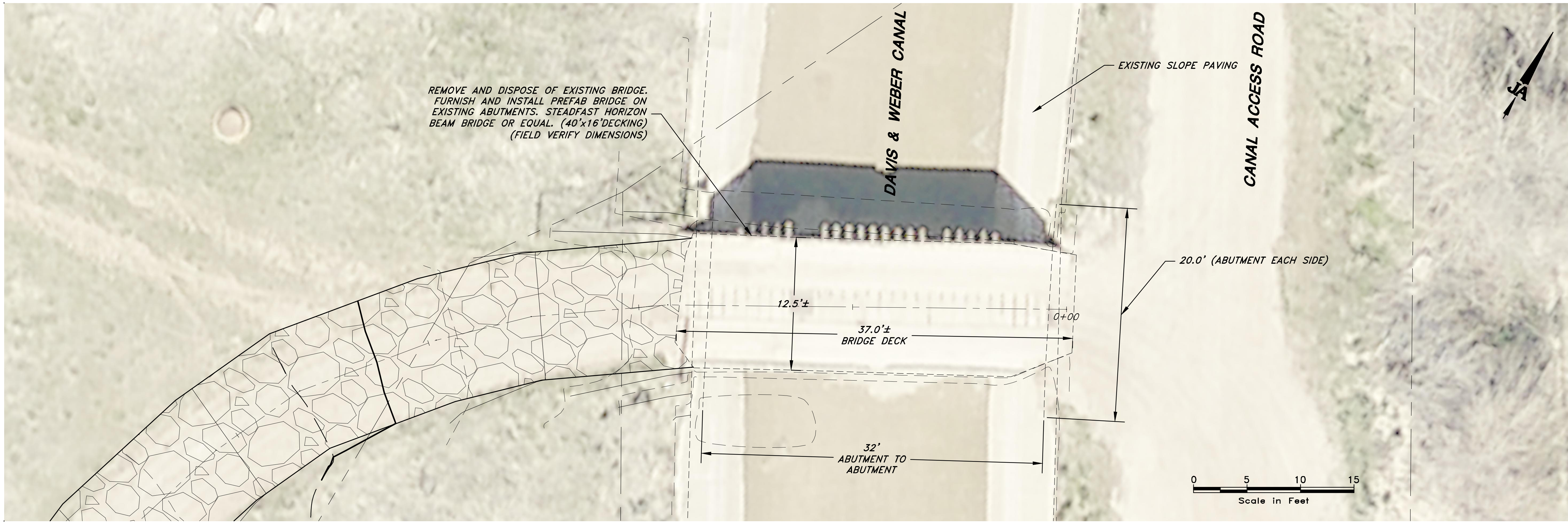
EXISTING ACCESS ROAD IMPROVEMENTS PLAN AND PROFILE STA. 16+20 20+80

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE:
24"x36" H:1"=20' V:1"=8'
11"x17" H:1"=40' V:1"=16'

SHEET:
13
OF 1 SHEETS



NOT FOR CONSTRUCTION

JA JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

BRIDGE IMPROVEMENTS

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE:
24"x36" H:1"=5'
11"x17" H:1"=10'

SHEET: 14
OF 1 SHEETS

ATTACHMENT E

BUDGETARY ESTIMATE

South Weber City
Westside Water Reservoir Project, Phase 2
Budgetary Estimate

No.	Description		Quantity		Unit Cost	Total Cost	Item Subtotal
1	1 MG Tank Interior						$ 156,600
	1.1	Pressure grout under floor	1	ls	$ 80,000	$ 80,000	
	1.2	Blast interior and rout out cracks	1	ls	20,000	20,000	
	1.3	Crack seal	600	lf	6.00	3,600	
	1.4	Coat interior surface (floor and walls)	15,000	sf	3.00	45,000	
	1.5	Blast and paint piping	1	ls	2,000	2,000	
	1.6	Replace ladders	2	ea	3,000	6,000	
2	Site Improvements (on-site)						$ 41,660
	2.1	Grading	75	cy	$ 20	$ 1,500	
	2.2	6" UTBC	130	cy	50	6,500	
	2.3	15" RCP culvert	16	lf	25	400	
	2.4	Repair fencing and gate	1	ls	2,000	2,000	
	2.5	Air gap for 1 MG drain/overflow	1	ls	8,500	8,500	
	2.6	Inclinometers (install and monitor)	1	ls	22,760	22,760	
3	SCADA						$ 12,000
	3.1	Upgrade controls	1	ls	$ 12,000	$ 12,000	
4	North Vault						$ 10,500
	4.1	Revise piping	1	ls	$ 6,000	$ 6,000	
	4.2	Replace air/vac	1	ls	2,500	2,500	
	4.3	Add drain to daylight	1	ls	2,000	2,000	
5	East Vault						$ 1,000
	5.1	Abandon in place	1	ls	$ 1,000	$ 1,000	
6	1 MG Tank Exterior						$ 4,200
	6.1	Replace northeast hatch (65"x36")	1	ea	$ 3,000	$ 3,000	
	6.2	Replace southwest hatch (24"x24")	1	ea	1,200	1,200	
7	Bridge						$ 73,500
	7.1	Remove and dispose of existing bridge	1	ls	$ 9,500	$ 9,500	
	7.2	Furnish and install new 40x16 bridge	640	sf	100	64,000	
8	Access Improvements (off-site)						$ 20,600
	8.1	Grading	100	cy	$ 20	$ 2,000	
	8.2	6" UTBC	340	cy	50	17,000	
	8.3	15" RCP culvert	64	lf	25	1,600	
						Subtotal	$ 320,060
						25% Engineering and Contingencies	80,015
						TOTAL	**$ 400,075**

SOUTH WEBER city

Technical Memorandum

July 19, 2017

To: Mayor, Council Members, and City Staff
South Weber City

From: Dana Q. Shuler, P.E.
Jones & Associates

PROFESSIONAL ENGINEER 7/20/17 No. 6578621 DANA Q. SHULER STATE OF UTAH

Re: Westside Water Reservoir Project
Phases 2 and 4 – Remediation Design (Existing Reservoir) and Alternative Site Selection (Replacement Reservoir Siting)

Jones & Associates, along with their subconsultants, IGES and ARW Engineers, has been hired by South Weber City for the Westside Water Reservoir Project. Following the completion of Phase 1 of this project which included assessing the existing reservoir, the scopes of proposed Phases 2 and 4 were revised and authorized. Phases 2 and 4 include the remediation design recommendations for the reservoir and an alternative site selection of a replacement reservoir, respectively. Deliverables include this technical memorandum, geotechnical/geological report, cost estimates, and preliminary design drawings.

1. Property and Access Assessment

The one-million gallon (1 MG) reservoir is situated on a 1.5585 acre parcel owned by South Weber City. It shares the site with a 100,000 gallon above-ground reservoir. The property was conveyed via warranty deed from Luella H Byram on March 23, 1976. Abutting properties are Hill Air Force Base and Dad's Farm LLC (Darrell Byram).

Beginning at South Weber Drive, access to the site is obtained via a private road (7150 S) and dirt driveway. Although no formal survey was performed, parcels traversed may include:

1. 13-020-0002 – Mountain Fuel
2. 13-020-0051 – Goates, Jeffrey & Kim C
3. 13-020-0052 – Cook, Scott S & Savannah H – Trustees
4. 13-246-0002 – Cook, Ryan J & Stephanie A
5. 13-246-0001 – Cook, Scott S & Savannah H
6. 13-020-0025 – Bigler, Barrey J – Trustee
7. 13-020-0026 – Coy, Lynn T & Judy M – Trustees
8. 13-020-0028 – East South Weber LLC

9. 13-020-0053 – Cook , Scott S & Savannah H – Trustees
10. 13-024-0004 – Davis & Weber Counties Canal Company
11. 13-024-0005 – Davis & Weber Counties Canal Company
12. 13-024-0003 – Cook, Stanley R & Bonnie B
13. 13-020-0047 – Dad's Farm LLC, c/o J Darrell Byram, Indian Springs LLC

Based on conversations with Mark Larsen (Public Works Director) and Mr. Byram (adjacent property owner), no access easements or agreements are known to exist. Additionally, the drain line from the tanks leaves the City's property and heads due-north through Mr. Byram's property down to the canal. According to Mr. Byram, no easement was obtained for the drain line.

In-depth deed research was not included in this task.

1.1. Property and Access Recommendations

It is recommended that the City have the area formally surveyed to determine where property lines lie, and therefore which properties are affected. Then, the City should obtain access easements from the affected property owners. Recording these easements will ensure the City's access rights if and when parcels are sold and/or developed. On the south side of the Davis and Weber Counties Canal Company (DWCCC) canal, the City may be able to trade road and bridge improvements for no-cost easements.

2. Geotechnical Investigation

2.1. Investigation

Under this task, IGES performed a subsurface investigation to assess the geologic and geotechnical conditions in the area of the 1MG tank. The physical investigation included three (3) geologic trenches and five (5) soil borings. Engineering analysis consisted of performing slope stability modeling of the hillside north of the tank under existing conditions. Both static and pseudo-static (seismic) loading conditions were evaluated. Consideration was also given to possible fluctuations in soil moisture content as a result of tank seepage or seasonal climatic variations.

2.2. Findings

IGES' conclusions are as follows:

1. Based on observations, testing and modeling, the hillside will be globally stable under existing conditions.
2. Smaller ancillary slides or local stability failures may occur.
3. Increased soil moisture will elevate the risk for local and global slope failures.
4. The seismic performance of the existing hillside under observed conditions is considered acceptable, but is not acceptable if saturated moisture conditions or buildup of excess pore pressure coincide with a seismic event.

For further information, please see IGES' full report contained in Attachment A.

2.3. Geotechnical Recommendations

IGES' recommendations are as follows:

1. Provide adequate surface drainage to manage storm water at the site, limiting infiltration of surface water into the near surface soils downhill of the tank.
2. Repair tank leaks to prevent infiltration of moisture from the tank into the soil.
3. Monitor the slope for future movement. Monitoring should include observations and surveying to document any surficial mass movements.
4. Install an inclinometer to monitor potential movement at greater depth. The exact location of inclinometer casing can be somewhat flexible, however it should be located on the slope between the existing landslide headscarp and the tank.

3. Reservoir Remediation Investigation (Leak Investigation)

3.1. Previous Studies

In 2010, South Weber City retained ARW Engineers to perform a limited investigation of the leaking reservoir. With no drawings of the tank or known construction methods, ARW could not evaluate the structural integrity of the tank. Based on their findings, they concluded that the tank was most likely leaking through cracks in the floor or the floor-wall joint possibly caused by unstable subsoils or poor structural design. ARW recommended hiring a geotechnical engineer to investigate the subsurface soils. They also stated that "polymer injections into the subgrade might be an option" if the slab needed additional support. Attachment B contains the letter with their findings.

Subsequently, in 2011, South Weber City contracted with GeoStrata Engineering and Geosciences to investigate the floor of the 1 MG reservoir. GeoStrata used a combination of ground penetrating radar (GPR), a manometer survey, and floor cores to evaluate the reservoir's floor. Overall, they found:

1. Numerous "anomalies" under the floor slab, indicative of voids filled with water or air;
2. The floor slab had 8-inches of elevation difference from the high side to the drain; and
3. Four (4) 6- to 13-inch long cores of the floor revealed a 1-inch void under the slab.

Additionally, GeoStrata investigated the general geology of the area. While noting that the tank is built upon an old landslide, and a new landslide scarp is evident nearby, they do not believe this to be affecting the tank. GeoStrata recommended pressure grouting under the floor for stabilization. The full assessment can be found in Attachment C.

3.2. Previous Remedies

Following that investigation, the City opted to seal the cracks in the floor and approximately one (1) foot either side of the wall-floor joint. At that time, it was assumed that the reservoir would be replaced, so expenditures were kept to a minimum. The leak rate subsided temporarily, but then increased over time, likely due to floor movement/settling.

Based on the information contained in the aforementioned reports and provided by City personnel, previous remedies for the leak have included sealing floor cracks and sealing the floor slab.

3.3. Leak Remediation Recommendations

Based on our observations and current and past investigations, we recommend the following in order to best control leaking of the tank:

1. Pressure grout under floor slab to fill voids under the floor and stabilize the floor slab. Without this stabilization measure, sealing cracks is futile because the floor will continue to settle.
2. Remove, via sandblasting, existing deteriorated coatings. Rout out and seal cracks and joints with new joint sealer.
3. While the tank is offline, it would be prudent to apply sealant to the entire floor and walls (to 1' below lid).

4. Criticality Assessment

Asset criticality is the relative risk of a high cost arising from failure of that asset. A criticality assessment prioritizes which assets are most important to monitor and maintain. Components of criticality include:[1]

1. Modes of Asset Failure – physical (deterioration, structural); capacity/utilization; level of service; obsolescence; cost or economic impact
2. Cost of Failure – cost of replacement; cost from loss of service; cost from legal liability
3. Risk of Asset Failure – design life; maintenance program; operations; external factors
   - ✓ "Risk equals Cost of Failure times Probability of Failure."[1]
4. Relative Importance – for which assets is it most important to avoid failure?

Evaluating the criticality of the 1 MG reservoir using the above components:

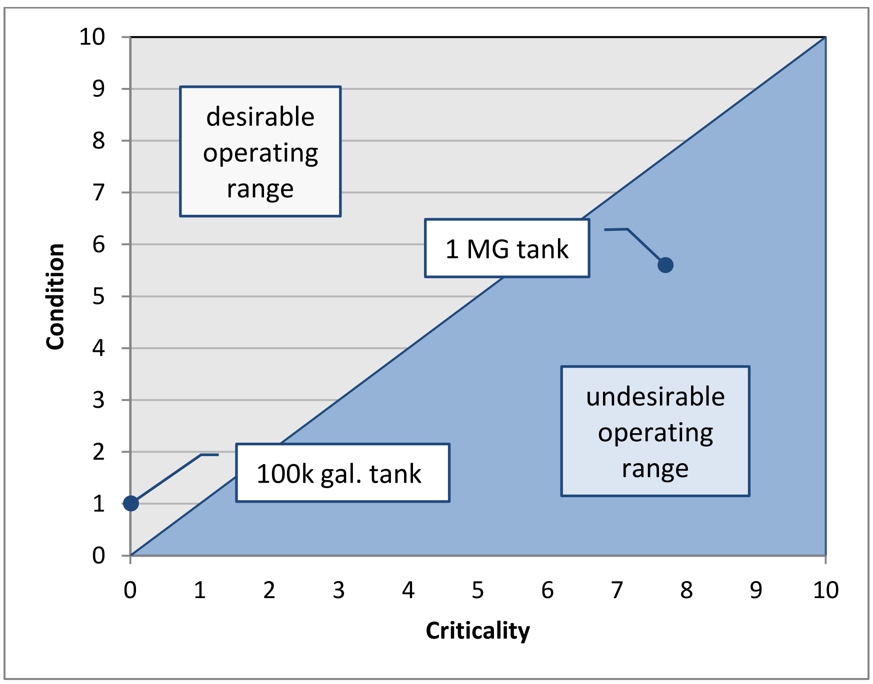
1. Modes of Asset Failure – The reservoir is in average physical condition with capacity that contributes to the City's ability to provide a level of service meeting the Division of Drinking Water regulations. The tank is not obsolete in its use.
2. Cost of Failure – Should the tank catastrophically fail, significant costs are associated with replacement and loss of service, as the water system would operate very inefficiently during such time. Some costs from legal liability may occur, although small. Should development occur downhill of the tank, this liability will increase.
3. Risk of Asset Failure – With an unknown design and erection date, it is difficult to identify the probability of failure. Recent inspections find the reservoir to be in average condition, but it is unknown if the structure was designed to withstand seismic events. Operation and

[1] Trilogics Technologies, Inc. (2005, November 30). *Criticality: A Key Idea in Asset Management.* Retrieved April 2017, from International City/County Management Association: www.icma.org

maintenance costs of the asset are relatively low. External factors that may contribute to failure include natural or manmade disasters, such as earthquake or sabotage.

4. Relative Importance – Relative to the overall operation of the water system, this reservoir is of medium-high importance, meaning, while the water system can continue to operate without this tank, it will do so ineffectively and with a decline in the customers' level of service.

Smaller towns and cities typically do not have unnecessary redundancy built in to their water systems. Most of the infrastructure components are of medium-to-high importance to the overall workings of the system, and therefore must be kept in good working order. Deterioration occurs rapidly once a component is neglected or out of use. The more critical the structure to the workings of a system, the better condition it needs to be kept. This is pictorially shown in the following figure.



Currently, the 1MG reservoir is medium-to-high on the criticality scale and in average condition. As shown in the figure, this puts the asset in the undesirable operating range. Additionally, if one of the other reservoirs should go offline for maintenance or an emergency problem, this reservoir's criticality would increase, pushing its current evaluation even further into the undesirable operating range. Therefore, it would be beneficial to increase the condition of the tank in order to stay in the desirable operating range.

Also shown is the 100k gallon reservoir. This reservoir is not needed for the operation of the water system and is in poor condition, therefore falling in the lower left portion of the graph.

5. Remediation Design Recommendations

After assessing the site and reservoir using past and current data, the following remediation measures are recommended in order of priority:

1. 1 MG Reservoir
    a. See previous section (leak remediation)
    b. Replace ladders with new; add ladder-ups (safety device)
    c. Blast and paint interior pipes
2. Site Improvements. The following site improvements are based on safety and security:
    a. Grading for drainage around and away from reservoirs
    b. Grade and add base course for parking
    c. Replace gate with new 16' wide gate
    d. As funds allow, add intruder resistance (barbed wire)
3. Upgrade SCADA
    a. Ultrasonic sensors (pressure transducers)
    b. Hatch alarms
    c. Coordination with Weber Basin Water Conservancy District well (meter and valve status readability)
4. North Vault
    a. Revise piping
    b. New gauge and transducer
    c. Replace air/vacuum valve
    d. Add drain piping
5. East Vault
    a. Abandon in place
6. 1 MG Tank Exterior
    a. Replace both hatches with new spring-assisted lids
7. Bridge across canal
    a. Replace with pre-fabricated bridge
    b. Enter in agreement with DWCCC, possibly landowners
8. Access Improvements. This 1 MG reservoir should be considered a critical facility for the City. Therefore, safe access to/from the site should be traversable in all weather conditions.
    a. Grade and add base course to access road for all-weather surface
    b. Add drainage improvements

Concept plans showing these recommendations are included in Attachment D.

6. Budgetary Estimates

Budgetary estimates have been developed for each of the above eight (8) items. Engineering and contingencies have been figured based on the total of all the items. The estimated grand total for the rehabilitation of this tank is $400,000. Details of this cost estimate can be found in Attachment E. Additionally, preparation and obtainment of easements is estimated at $90,000.

For comparison, a budgetary estimate was developed for a replacement reservoir, assuming that the location would be adjacent to the existing site. This is estimated at $1.6M and includes the same off-site improvements as the rehabilitation estimate, as well as the demolition of the 100,000 gallon reservoir and new site work and piping. $240,000 is estimated to be the cost of the land and easements. Please note that the costs for components included in a new tank can fluctuate drastically depending on the economy; therefore, this estimate should only be used as a reference for future budgeting proposes.

7. Cost/Benefit Analysis

Below is a summary table comparing the rehabilitation and replacement options.

Rehabilitation	Replacement
$400,000 – Engineering and Construction $90,000 – Survey and Easement Acquisition 15-20 year design life • $32,700/year capital cost	$1,600,000 – Engineering and Construction $240,000 – Survey, Easement and Property Acquisition 50-60 year design life • $36,800/year capital cost
Unknown design and construction standards	Up-to-date design and construction standards • Structural/seismic • Geotechnical/geological
Safety upgrades	Safety considerations incorporated
No additional land needed (utilize existing site)	Additional land needed
Access and utility easements needed	Access and utility easements needed
Off-site improvements recommended • Can also be used for future replacement reservoir	Off-site improvements needed
-	May keep 1MG reservoir for emergency purposes

8. Alternative Site Evaluation

8.1. Geologic/Geotechnical Reconnaissance

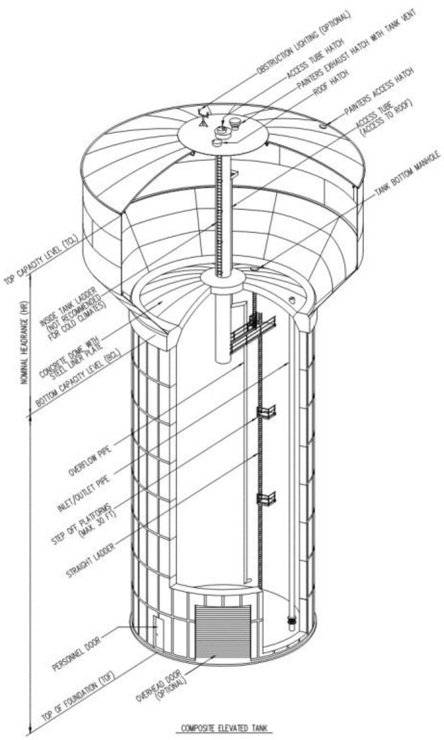
Based on the geologic map[2] for the South Weber area, all of hillside in the vicinity of the reservoir is landslide deposit (geologic unit Q_{ms}, either older or younger), scattered with scarps. Some scarps are visible to the naked eye. South Weber Drive generally follows the boundary of two geological units: Q_{ms} and Q_{al}. (Q_{al} is stream alluvium.)

8.2. Property Search (Elevation/Proximity/Accessibility)

The site of a replacement buried or ground reservoir would need to approximately match the ground elevation of the existing reservoir. The elevation contour of the current tank only traverses private property in the immediate vicinity of the existing reservoir; otherwise, that elevation falls within Hill Air Force Base boundaries and/or property.

8.3. Alternative Configuration

An alternative to replacing the existing ground storage tank with another ground storage tank would be to construct an elevated tank, likely located near South Weber Drive. While not prevalent in Utah, elevated storage tanks are common across the United States. They vary in volume from tens of thousands to many million gallons. The most common sizes are 200,000 to 2,000,000 gallons. The figure to the right shows a cross-section of composite elevated water tank.[3]



Benefits of an elevated storage tank include a small footprint and flexible location due to height variability. Drawbacks include slightly higher maintenance costs and the unfamiliarity of operation and maintenance personnel. Elevations would have to be more closely examined, but an elevated tank may be considered.

8.4. Recommendations

For the purposes of this report, we have assumed that the City favors ground storage over elevated storage. Since no other suitable property exists, we recommend obtaining property, about 1.5 acres, on land adjacent (east-south) of the existing site.

a. Site will have access to existing transmission line and drain line.
b. Demolishing the existing 100,000 gallon reservoir will provide additional area.

[2] Yonkee and Lowe (2004). Geologic Map of the Ogden 7.5' Quadrangle, Weber and Davis Counties, Utah. Utah Geological Survey.
[3] ©CB&I (2017). www.cbi.com

c. Assuming access and utility easements for the existing reservoir are obtained, no additional easements would be needed.
d. While this location won't improve the pressure or flows at west end of town, development with looped water lines will help improve service.

9. Overall Recommendations – Summary

9.1. Property and Access

a. Obtain easements/agreements for legal access and existing pipelines

9.2. Geotechnical

a. Install and monitor piezometers
b. Other recommendations incorporated into Section 9.3 – Improvements below

9.3. Improvements, in order of priority

a. 1 MG tank interior improvements (pressure grout under floor; crack seal; surface sealant)
b. Site Improvements (grade for positive drainage, driveway, 1 MG drain air gap)
c. SCADA upgrades
d. North vault improvements
e. East vault abandonment
f. 1 MG tank exterior improvements (hatches)
g. Bridge replacement
h. Access improvements (off-site)

9.4. Alternate Site Evaluation

a. Consider purchasing land adjacent to existing site for future replacement reservoir (about 1.5 acres)

Attachments

A – IGES Report (2017)
B – ARW Investigation Letter (2010)
C – GeoStrata Assessment (2011)
D – Concept Plans
E – Budgetary Estimate

ATTACHMENT A

IGES REPORT (2017)

ATTACHMENT B

ARW INVESTIGATION LETTER (2011)

ATTACHMENT C

GEOSTRATA ASSESSMENT (2011)

ATTACHMENT D

CONCEPT PLANS

ATTACHMENT E

BUDGETARY ESTIMATE

4153 Commerce Drive
Salt Lake City, UT 84107
Ph: 801.270.9400
Fx: 801.270-9401

Geologic/Geotechnical Evaluation for:

Westside Reservoir, South Weber, Utah

IGES Job No. 01747-002

February 21, 2017

Prepared for:

Jones & Associates

c/o Dana Shuler, P.E.

THIS DOCUMENT WAS PREPARED FOR USE ONLY BY THE CLIENT, ONLY FOR THE PURPOSES STATED, AND WITHIN A REASONABLE TIME FROM ITS ISSUANCE. PLEASE READ THE "LIMITATIONS" SECTION OF THIS REPORT.

Prepared for:

Jones & Associates
c/o Dana Shuler, P.E. | Senior Engineer
1716 East 5600 South,
South Ogden, UT 84403.

Geologic/Geotechnical Evaluation for:

Westside Reservoir
South Weber, Utah
IGES Job No. 01747-002

Prepared by:

Jared A. Hawes, P.E.
Senior Engineer

Peter E. Doumit, P.G., C.P.G.
Senior Geologist

IGES, Inc.
4153 South 300 West
Salt Lake City, Utah 84107
(801) 270-9400

February 21, 2017

TABLE OF CONTENTS

APPENDIX

1.0 EXECUTIVE SUMMARY

This report presents the results of a subsurface geologic/geotechnical investigation conducted to support evaluation of the existing Westside Reservoir (Water Tank) located in South Weber, Utah. The tank is located in the northwest quarter of Section 33, Township 5 North, Range 1 West, S.L.B.M (USGS, 2014) in an area that has been mapped as being underlain by Holocene-aged landslide deposits (Yonkee & Lowe, 2004). The purposes of this investigation were to assess the geologic and geotechnical conditions in the area of the tank and to assist Jones & Associates (JA) in understanding how these conditions could impact slope stability and the tank itself. In particular, field investigation, laboratory testing and slope stability modeling were performed to: 1) evaluate the possible origins of the geomorphological features mapped as landslides; 2) assess the nature, age, and current stability of the mapped landslide mass; and 3) determine the potential for future movement of the mass.

A preliminary geologic hazards assessment, including site reconnaissance and surface mapping of landslide evidence was completed by IGES in September of 2016. Subsurface investigation of the site was performed by IGES between December 5 and 13, 2016. Exploration of the subsurface soil conditions was accomplished by excavating three near-surface trenches and advancing five soil borings at select locations surrounding the tank. Trenches were completed with the aid of a Hitachi Zaxis 160 LC tracked excavator. They varied in length from 79 to 167 feet and depth from 12 to 18 feet. Approximate trench locations are shown on the Site/Exploration Location Map (Plate A-3). The five borings were completed to depths of 46.5 to 51.5 feet below the existing site grade and are also shown on the Site/Exploration Location Map. Drilling was accomplished with a Geoprobe 7822 DT track-mounted drill-rig equipped with percussion hammer and 7-inch hollow-stem augers for continuous and conventional geotechnical sampling, respectively.

Our engineering analysis consisted of performing slope stability modeling of the hillside north of the existing tank under existing conditions. Both static and pseudo-static (seismic) loading conditions were evaluated. Consideration was also given to possible fluctuations in soil moisture content as a result of tank seepage or seasonal climatic variations.

Our conclusions and recommendations are summarized below:

- Based on our observations, testing and modeling we assert that the hillside will be globally stable under existing conditions.
- Smaller ancillary slides or local stability failures may occur.
- Increased soil moisture will elevate the risk for local and global slope failures.
- The seismic performance of the existing hillside under observed conditions is considered acceptable, but is not acceptable if saturated moisture conditions or buildup of excess pore pressure coincide with a seismic event.
- Repair of tank leaks is recommended to prevent infiltration of moisture from the tank into the soil.
- We recommend adequate surficial drainage be provided to manage storm water at the site, limiting infiltration of surface water into the near surface soils downhill of the tank.
- If the tank is to remain in service, we anticipate that leak repairs and other structural upgrades will be made.
- We recommend that the slope be monitored for future movement. Monitoring should include observations and surveying to document any surficial mass movements.
- We also recommend that an inclinometer be installed to monitor potential movement at greater depth.
- Inclinometer casing is usually installed in a borehole. The exact location of inclinometer casing can be somewhat flexible, but it should be located on the slope between the existing headscarp and the tank.

NOTICE: The scope of services provided within this report are limited to the assessment of the subsurface conditions for the proposed residential development. This executive summary is not intended to replace the

report of which it is part and should not be used separately from the report. The executive summary is provided solely for purposes of overview. The executive summary omits a number of details, any one of which could be crucial to the proper application of this report.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

This report presents the results of a subsurface geologic/geotechnical investigation conducted to support evaluation of the existing Westside Reservoir located in South Weber, Utah. The tank is located in the northwest quarter of Section 33, Township 5 North, Range 1 West, S.L.B.M (USGS, 2014) in an area that has been mapped as being underlain by Holocene-aged landslide deposits (Yonkee & Lowe, 2004). The purposes of this investigation were to assess the geologic and geotechnical conditions in the area of the tank and to assist Jones & Associates (JA) in understanding how these conditions could potentially impact slope stability surrounding the tank. In particular, field investigation, laboratory testing and slope stability modeling were performed to: 1) evaluate the possible origins of the geomorphological features mapped as landslides; 2) assess the nature, age, and current stability of the mapped landslide mass; and 3) determine the potential for future movement of the mass.

This report documents the follow-up subsurface investigation to a preliminary geologic hazard assessment conducted for the property in September of 2016 (IGES, 2016). The scope of work completed for this study included subsurface exploration, soil sampling, laboratory testing, engineering analyses, and preparation of this report. Our services were performed in accordance with our proposals and signed authorizations, dated November 2, 2016. The recommendations contained in this report are subject to the limitations presented in the "Limitations" section of this report.

2.2 PROJECT DESCRIPTION

It is believed that the Westside Reservoir water tank was originally constructed sometime in the 1950's by the federal government for use by Hill Air Force Base, but was purchased by South Weber City and has been used as part of the City water system ever since. The tank is known to leak and South Weber is currently evaluating it for continued use or possible replacement.

The tank sits on a natural slope above the Weber River floodplain. Geologic mapping of the area shows the entire slope to be comprised of Quaternary-aged landslide deposits. Young landslides (Holocene) are mapped at several locations along the hillside east and west of the tank site, with one slide being located immediately downslope of the tanks. Slope failure in the vicinity of the tank could cause not only damage to the tank and the water supply, but to the Davis-Weber Canal and other homes located downhill of the tank.

3.0 METHOD OF STUDY

3.1 PREVIOUS INVESTIGATION

In Phase I of our investigation an engineering geologist investigated the geologic conditions within the area of the tank. Geologic research consisted of reviewing existing aerial photographs, previous geologic reports of the area, and other available geologic literature pertinent to the site. A field geologic reconnaissance was conducted to observe existing geologic conditions and site geomorphology. Detailed findings of the preliminary geologic investigation were presented in a letter report (IGES, 2016) and additional details from this work are summarized in Sections 4.0 and 5.0 of this report.

3.2 SUBSURFACE INVESTIGATION

Based on the previous mapping and site observations, three locations were selected for near-surface investigation using trenching and five locations were selected for deeper investigation with soil borings. The subsurface exploration locations are shown on Figure A-1 in Appendix A.

3.2.1 Trenches

Between December 6 and December 7, 2016, three exploration trenches were excavated at representative locations across the property, where potential landslide hazards had been identified during the site reconnaissance and field mapping. The trenches were excavated to depths ranging between 12 and 18 feet below existing grade and 79 and 167 feet long with the aid of a Hitachi Zaxis 160 LC tracked excavator. Detailed hand logs for each of the trenches are displayed in Figures A-2 through A-4 in Appendix A, and a discussion of the findings from each of the trenches is presented in Section 5.0. In general, the subsurface profile consisted of distinct A and B topsoil horizons forming upon several different Lake Bonneville deposits (both shoreline sands and gravels, as well as deeper water silts and clays) that have been modified by mass-movement processes. Groundwater was not encountered in any of the trenches.

3.1.2 Soil Borings

IGES conducted deeper subsurface investigation of the site on December 12 and 13, 2016. Exploration of the subsurface soil conditions was accomplished by advancing five soil borings at select locations near the existing tank and hillside north of the tank. The approximate locations of the borings are also shown on Figure A-1. The borings were completed to depths of 40 to 55 feet below the existing site grade. Drilling was accomplished with a GeoProbe 7822 DT track-mounted drill-rig equipped with both percussion hammer for continuous sampling and 7-inch hollow-stem augers which were utilized to collect conventional disturbed and relatively undisturbed geotechnical soil samples.

The materials encountered during drilling were observed and logged by our field engineer and are presented on the Boring Logs in Appendix A (Figures A-5 to A-9). A key to Soil Symbols and Terms is located on Plate A-10.

3.3 LABORATORY INVESTIGATION

Representative soil samples were tested in the laboratory to evaluate pertinent physical and engineering properties. Laboratory soil tests consisted of moisture, density, gradation analyses and Atterberg limits tests, to aid in characterizing the soils encountered. Consolidated undrained direct shear tests were performed to assess the strength characteristics of the soils. The results of all laboratory tests are presented on the Boring Logs in Appendix A, and in the Summary of Laboratory Test Results Table (Figure B-1) and lab results data sheets in Appendix B.

3.4 ENGINEERING ANALYSIS

Global slope stability analyses were performed to assess stability concerns for the slope adjacent to the tank. Within the global modeling scenario, additional models were developed to potential conditions such as groundwater fluctuations, and performance under seismic or pseudodynamic loading conditions. The software Slide version 7.0 (by Rocscience), which expresses the stability in terms of a factor of safety against sliding, was used to model the global and local stability concerns for the existing hillside. Considering the favorable results of preliminary tank structural assessment, we have not accounted for any potential changes to the tank or the grading surrounding the tank. If any changes to site grading are proposed, IGES should be notified so that we can assess potential impacts on slope stability.

Soil parameters used in the existing and proposed analyses were derived from the in situ sampling and laboratory testing completed for this investigation. Topographic and stratigraphic parameters for the existing landslide mass were generated from maps of the surrounding topography, field observations, and sampling and testing of soils encountered within the trench and boring explorations.

4.0 GEOLOGIC CONDITIONS

4.1 PREVIOUS STUDIES

A detailed discussion of local geology was provided during Phase I, Geologic Hazards Assessment of this project (IGES, 2016). Previous work included a thorough review of geologic literature, historical aerial photography and site reconnaissance to assess and document the general geologic conditions present across the property, with specific interest in those areas identified by literature and aerial imagery reviews as potential geologic hazard areas. Our 2016 report can be reviewed for detailed assessment of faults, debris-flows, rockfall hazard and liquefaction potential. The intent of this report is to provide greater detail on potential landslides/mass-movement hazard associated with this property.

4.1 LANDSLIDES/MASS MOVEMENT

Landslides and mass movement hazards pose the most risk to the tanks located on the property. The property is entirely within an area previously mapped as landslide deposits (Yonkee and Lowe, 2004; Coogan and King, 2016), aerial imagery indicated hummocky topography and associated scarps, and the site reconnaissance observed hummocky topography, several landslide scarps (including fresh scarps), and buried modern topsoil. The project area and associated water tanks are located within the Washington Terrace Landslide Complex. Additionally, multiple historic landslide events have occurred within ½ mile of the property and the aerial imagery review and site reconnaissance documented evidence of ongoing upslope propagation of an active landslide headscarp located approximately 300 feet to the northeast of the larger water tank.

4.2 SURFACE-FAULT RUPTURE AND EARTHQUAKE-RELATED HAZARDS

No faults are known to be present on or projecting towards the property, and the closest active fault to the property is the Weber Segment of the Wasatch Fault Zone, located approximately 3.1 miles to the west of the property (USGS and UGS, 2006). Given this information, the risk associated with surface-fault-rupture on the property is considered low.

The entire property and associated water tanks are subject to earthquake-related ground shaking from a large earthquake generated along the active Wasatch Fault. Given that the tanks are situated upon already marginally stable landslide deposits, seismic energy from an earthquake is likely to induce movement of these deposits. This could result in significant damage to the tanks. Therefore, the risk associated with earthquake-related ground shaking is considered high. The expected maximum ground acceleration from a large earthquake at the subject site with a two (2) percent probability of exceedance in 50 years is 0.56g. Based on our field investigation, it is our opinion the subsurface stratum and soils at this site are representative of a "stiff soil" profile having an average shear-wave velocity of $600 \leq \bar{\upsilon}_S \leq 1{,}200$ (ft/sec) in the top 100 feet, best represented by IBC Site Class D, having Site Coefficients of F_a= 1.0 and F_v=1.51.

5.0 GENERALIZED SITE CONDITIONS

5.1 SURFACE CONDITIONS

The hillside surrounding the tank property consists of a gradual northeast trending slope vegetated with brush and grasses. More substantial tree growth is sparse. The head of the mapped landslide is located in a north, northeast-facing “U” shaped scarp. The head wall of this scarp has the general appearance of a steep slope vegetated with native brush, grass and scrub oak. The surface of the landslide mass is not as steep as the “U” shaped scarp, and is similarly vegetated with native grasses and brush. Similar vegetation is present near the existing tanks.

5.2 SUBSURFACE CONDITIONS

As previously mentioned, the subsurface soil conditions were explored on the landslide during two phases of investigation. During the first phase three relatively shallow trenches were excavated and logged. Five relatively deep borings were completed in the second phase. The subsurface soil conditions encountered were logged at the time of trenching and drilling and are included in Appendix A (Figures A-2 to A-9). The soil and moisture conditions encountered during our investigation are discussed below.

5.2.1 Soils

Near-surface soils were sampled at selected locations within the trench excavation as well as in the five borings advanced for this investigation. Soil depth was observed to the maximum depth of boring excavation (55 feet in Boring B-4), and bedrock was not encountered in any of the trench or boring investigations performed for this project. The soils encountered in these exploration locations consisted of Lean CLAY (CL), GRAVEL (GM, GP-GM) and SAND (SP, SM). These soils may consist of both locally-derived sediments and layers of Lake Bonneville deposits.

Near-surface conditions encountered during trenching are described in the following sections.

5.2.1.1 Trench 1

TR-1 was the longest (167 feet) and deepest (up to 18 feet) of the three trenches excavated. The trench was spotted north of the City tank property, with the southern end of the trench located approximately 140 feet north of the Westside Reservoir (see Figure A-1). The trench cut through the active landslide headscarp that was observed north of the property during the site reconnaissance, and extended upslope to near the base of the older landslide headscarp found immediately north of the northern margin of the property.

As many as 11 distinct lithologic units were identified within the trench, representing facies[1] changes from shoreline sands and gravels to near-shore, shallow-water sands to off-shore, deeper-water silts and clays (Figure A-2). Evidence of landsliding was prevalent throughout the trench. Near the northern (downslope) margin of the trench, the active landslide headscarp was observed to have a conspicuous slide plane striking at N50°W and dipping at approximately 60-65°NE. The slide plane appeared to be listric[2], exhibiting a shallower dip angle with depth, and was observed to pass through individual lithologic units as opposed to along the contact between them. In large part due to the presence of granular materials, slickensides[3] and other evidence of shear were not observed along the slide plane. Vertical offset of subsurface units along the slide plane was approximately 3 feet.

Unit 4, denoted as Bonneville Sand and Gravel 1, was the most prevalent unit within the trench, and displayed several characteristics indicative of mass-movement. The top and bottom contacts were very sharp, but highly undulatory and irregular. Bedding was found to have a wide variety of orientations, with apparent dips ranging from steeply dipping downslope to the north to subhorizontal to gently dipping upslope to the south. Several small unit-confined faults with as much as 3 feet of offset and abundant other fractures with calcium carbonate cement were

---

[1] Facies: The aspect, appearance, and characteristics of a rock unit, usually reflecting the conditions of its origin; esp. as differentiating the unit from adjacent or associated units. (AGI, 2005)

[2] Listric fault: A curved downward-flattening fault, generally concave upward. (AGI, 2005)

[3] Slickenside: Originally, a polished fault surface formed by frictional wear during sliding, but now used to denote any of several types of lineated fault surfaces. (AGI, 2005)

observed within the unit, suggestive of continual minor adjustments being made within the unit to accommodate slow downslope movement.

The southern end of the trench exhibited a highly irregular assemblage of lithologic units, showing undulatory, unorthodox contacts and chaotic bedding orientations that was interpreted to be indicative of a discrete episode of shallow landsliding (Unit 10). However, a distinct slide plane was not observed, despite the southern end of the trench being located near an older, inactive headscarp.

5.2.1.2 Trench 2

TR-2 was spotted in the southeastern corner of the City property, approximately 80 feet southeast of the Westside Reservoir (see Figure A-1). The trench was 87 feet long, and was excavated to a maximum depth of 13 feet below existing grade.

Four distinct lithologic units were identified within the trench, including a thin topsoil (Unit 1) forming upon a fill unit (Unit 2) that was likely local material utilized to level the ground surface preceding the emplacement of the existing water tanks at the site (Figure A-2). Distinct evidence of landsliding was not observed within the trench, though a highly irregular contact between a sandy silt deposit (Unit 3) and an underlying sand and gravel deposit (Unit 4) was observed. Bedding within Unit 3 was found to be horizontal to subhorizontal.

5.2.1.3 Trench 3

TR-3 was the shortest (79 feet) and shallowest (up to 12 feet) of the three trenches excavated. The trench was spotted in the central portion of the Weber City property, approximately 75 feet northwest of the Westside Reservoir. The southern end of the trench located approximately 140 feet southwest of the Westside Reservoir (see Figure A-1).

Six distinct lithologic units were identified within the trench, with the characteristics of the lithologic units more consistent with TR-1 than TR-2 (Figure A-2). Like TR-1, evidence of landsliding was prevalent throughout the trench. Two slide planes were observed at opposite ends of the trench, and dipping in opposite directions. The northern slide plane was much more conspicuous, having abundant associated calcite cement/infilling and a stony trace, and was found to be striking at S80°E and dipping listrically at 70°SW (upslope). The southern slide plane had an apparent dip of 64°N. Similar to as seen in TR-1, these slide planes were observed to pass through individual lithologic units as opposed to along the contact between them, and no slickensides or evidence of shear were observed. The amount of vertical offset associated with these slide planes was unable to be determined, though bedding observed in Unit 6b was entirely dipping to the south. This suggests the slide planes are connected as part of a generally shallow rotational slump plane, and that the material between the two slide planes has been back-rotated.

Most of the trench was encompassed by silty sand deposits (Units 5 and 6), though the basal contact of these deposits with underlying sand and gravel deposits (Unit 3) was highly irregular. In the southern end of the trench, an isolated block of silty clay was found within a package of sand and gravel, and the block had been rotated such that the bedding was vertical. South of the southern slide plane, multiple Unit 3 sand and gravel packages were found to be in anomalous contact with the silty sands of Units 6a and 6b.

5.2.1.4 Deep Soils

To explore beneath the safe limits of trench exploration, five additional borings were completed. The approximate location of these explorations is also shown on Figure A-1.

Beneath the soils described in the previous trench sections, explorations typically encountered fine-grained soils. Lean CLAY (CL) with occasional to frequent seams of fine sand (SP) and silty-sand (SM) were encountered throughout the depth of each exploration. Bedding of sediments appeared to be horizontal to subhorizontal. Most sand seams were dry and relatively thin (<1/4 inch). However, less-frequent, moist and loose sand seams up to 3 feet in thickness were encountered in some of the explorations. Boring logs with detailed descriptions of the conditions encountered are included as Figures A-5 to A-9. The stratification lines shown on the boring logs represent the approximate boundary between soil types. The actual in-situ transition may be gradual. Due to the nature and depositional characteristics of the landslide deposits, care should be taken in interpolating subsurface conditions between and beyond the exploration locations.

5.2.2 Bedrock

Bedrock was not observed to outcrop in the area of the tank property, and was not encountered in any of the trench or boring explorations.

5.2.3 Groundwater/Moisture Content Conditions

The soil moisture content ranged from a low of 2.8% to a high of 28.8%. Seasonal fluctuations in precipitation, surface runoff, or other on or offsite sources may also increase moisture conditions within the soils. Groundwater was not encountered near the surface in any of the open trench excavations; however, perched water was confined in some sand and clayey sand seams located at greater depth within the hillside clay deposits. Based on discussions with South Weber City personnel, water has been encountered in near-surface excavations at various locations and depths along the hillside below the tank. We anticipate that moisture levels within the near-surface sands and gravel will fluctuate seasonally with precipitation and snowmelt.

6.0 ENGINEERING ANALYSIS AND CONCLUSIONS

6.1 GENERAL CONCLUSIONS

Our engineering analysis consisted of performing slope stability modeling of the hillside under existing conditions and loads. Additional modeling was performed in an effort to understand potential impacts of seismic activity and variations in moisture to stability. As with other large slides, smaller ancillary landslides are often present within the larger slide complex. Our slope stability modeling considered the presence of smaller and shallower slides within the slide complex. To assess movement of any type both around and within the slide, an engineering geologist visually inspected the area, including an active internal scarp located downslope of the water tank for signs of recent distress and/or movement. The active scarp was observed to be stepped upslope with fresh soil exposures, indicating ongoing upslope propagation of the scarp. However, mature vegetation including large scrub oak was present in these areas, indicating that no recent large-scale movement has occurred.

6.2 SLOPE STABILITY

6.2.1 Topography

The existing topography of the terrace slope was approximated from site topographic maps and Google Earth Pro. Some topography data was provided by Jones & Associates, but the topography of the entire slope was not generated from a site survey performed specifically for this study.

A two-dimensional slope section was generated from this estimated surface topography, taking into account the steepest portions of the slope and the locations of the existing tank and observed internal scarp north/downhill of the tank. This section was then modeled using Slide 7.0 by Rocscience, a two-dimensional geotechnical software application which compares slope geometry, stratigraphy and soil strengths to evaluate slope stability.

6.2.2 Soil Strength Parameters

Soil strength parameters for the static stability evaluations are based on laboratory analysis and in-situ testing of the soil samples taken during both phases of our field investigation. Additionally, published strength data values were utilized for similarly classified soil types. Several soil types were used in the slope stability models. The soil parameters used in the slope stability assessment are listed below.

Model Soil Type	Total Unit Wt (pcf)	Saturated Unit Wt. (pcf)	Cohesion (psf)	Friction Angle (deg)
Surface Sand & Gravel	120	130	0	25
Tank Backfill	120	130	0	32
Native Clay	120	127	300	32
Loose Silty Sand	100	110	0	18
Native Clay 2	120	125	300	32
Loose Sand 2	100	110	0	24
Native Clay 3	120	128	500	32
Loose Sand 3	110	120	0	26
Native Clay 4	126	135	400	32

As described in section *5.2.1 Soils* and shown Appendix A, a wide range of soil types were encountered in relatively shallow excavations. Determination of the engineering properties for each soil type identified on site is beyond the scope of this investigation. Given the observed variability of soils, the limited exploration of the site conducted for this investigation may not accurately predict all geomechanical behavior to be expected at the site.

6.2.3 Stratigraphy

In creating a geologic section for use in the global slope stability model it was necessary to make assumptions regarding the deeper subsurface stratigraphy between the exploratory borings.

Because soils are deposited by natural, uncontrolled processes, extrapolation of our observations is not likely to produce an exact representation of the deeper stratigraphy.

Based on our observations, the soils that comprise the majority of the terrace deposit are fine-grained in nature with occasional seams of moist to wet sand and silt. Sand seams of varying thickness were noted in continuous sampling, but despite repeated attempts, we were not able to collect suitable "undisturbed" samples for laboratory strength analysis from auger borings. Given the variation in depth and thickness, we cannot be certain that these lenses/layers are continuous, but have modeled them as such. We observed near horizontal bedding of fine-grained clay deposits and that the sandier zones were typically wet/moist relative to the clay. We conservatively modeled the entire slope utilizing the strength parameters obtained for the soils observed, confining the water to a few discrete, relatively horizontal sand seams, assuming that they would be the most likely to move in static and seismic conditions.

The soil strength parameters are also listed in the Slope Stability Analysis in Appendix D (Plates D-1 to D-6). The laboratory test results are presented in Appendix B.

6.2.4 Stability Analysis

The majority of the hillside surrounding the Westside Reservoir has been mapped as landslide deposits (Yonkee & Lowe, 2004). The purpose of our investigation was to assess the condition of the landslide under current static and anticipated seismic conditions, and provide an opinion as to whether the site is suitable to support the existing water tank.

6.2.4.1 Static Stability

Global stability of the existing slope was modeled using the surface topography directly downhill of the larger tank according to contour maps. In the model, groundwater was intentionally confined within the sandy seams to reflect the conditions observed. Given the generally horizontal bedding observed within the deeper clay deposits, we do not believe that a previous deep circular-type mass movement event has occurred in the soils beneath, or immediately downhill of the tank. It is our opinion that the saturated sand and silty sand zones represent the most likely failure plane along which a future deep slide could occur. Based on our exploration, we cannot be certain if these layers are continuous; however, given the relatively high moisture content within these zones we assume they are, as they must be connected to transmit moisture from locations uphill. The safety factor against sliding along the uppermost sand seam has been evaluated to be between 1.5 and 1.7. Typically a safety factor of at least 1.5 is desired for slopes under static loading conditions. Given the reports by South Weber personnel of water encountered in near surface excavations, IGES also performed sensitivity analysis by modeling the global stability under increased moisture conditions. In these cases, moisture was still confined to the sandy zones, but a reduction to effective stress was manually created in those areas. Under these modified static loading conditions, the slope was shown to be slightly less stable (safety factor 1.3-1.4). Considering that our investigation was performed at the end of a relatively dry season, the potential impacts of increased moisture should be considered. Water from a leaking tank, or increased precipitation could adversely impact the slope stability. Graphical representations of the static stability modeling results are shown in Appendix D, Figures D-1 to D-2.

6.2.4.2 Pseudo-Static Slope Stability

Pseudo-static slope stability analyses were also performed for the existing hillside under dynamic conditions, induced by seismic ground motion.

A key difference in seismic stability analysis compared to static analysis is that undrained strength parameters are typically used for the strength of saturated soils subjected to cyclic loading because of the relatively rapid rate of earthquake loading. The behavior of cohesive soils (clay) can be much different than for cohesionless soils (silt, sand and gravel). Some research indicates that there is little reason to reduce shear strength of low to intermediate sensitivity cohesive soils. Based on our observation that moisture is largely confined to a few discrete sandy layers, we have not reduced strength properties for clay soils in our pseudo-static analyses.

For saturated cohesionless soils, even relative modest cyclic shear stresses can lead to pore pressure rise and a significant loss of undrained strength. Direct evaluation of the potential for shear strength reduction in saturated or nearly saturated cohesionless soils subjected to cyclic loading would require sophisticated cyclic laboratory testing. We were not able to collect appropriate samples for such testing of these soils. As an alternative, residual strength values for sandy soils were assigned based on in situ test results (SPT) using methods outlined by Idriss & Boulanger (2007) and Olson & Johnson (2008).

The results from this analysis indicate the existing slope will be subject to deformation and possible mass movement during or just after a seismic event. These results are found in Appendix D (Figure D-3 and D-4). Reductions in shear strength anticipated as a result of seismic loading under existing and increased moisture conditions resulted in factors of safety less than 1.0 for global mass stability models. Therefore, there is significant risk of slope movement resulting from a seismic event.

6.2.4.3 Near-surface Stability

While we did not observe evidence of "deep" movement along the hillside in the immediate vicinity of the tank, trenching exploration showed evidence of near-surface mass movements adjacent to and down slope of the existing tanks (see Sections 5.2.1.1 and 5.2.1.3).

IGES performed additional static stability modeling under observed and potentially increased saturation levels which allowed for failure of near-surface sands and gravels. Resulting safety factors of less than 1.5 under observed moisture conditions, and less than 1.0 with increased moisture indicate that the upper soils are marginally stable at best. It is possible that continued shallow failures will occur, particularly if soil moisture increases as a result of tank seepage, or during wet climatic periods.

Table 6.2.4 presents a brief summary of each model condition, calculated safety factors and our interpretation of the results. Graphical representations of each modeled condition, including soil strength parameters, are presented in Appendix D (Plates D-1 to D-16). Pseudo static models utilize the same residual strength parameters.

Table 6.2.4 – Slope Stability Modeling Results

Plate	Category	Static/ Pseudo-static	Safety Factor	Interpretation of Stability
D-1	Global (Existing)	Static	1.5-1.7	Acceptable
D-2	Global (Increased Water)	Static	1.3-1.4	Poor
D-3	Global (Existing)	Pseudo-static	1.0-1.1	Acceptable
D-4	Global (Increased Water)	Pseudo-static	0.9-1.0	Unacceptable
D-5	Shallow (Existing)	Static	1.1-1.2	Poor
D-6	Shallow (Increased Water)	Static	0.6-0.7	Unacceptable

6.3 CONCLUSIONS

Based on our observations, testing and modeling we assert that the hillside will be globally stable under existing conditions. However, smaller ancillary slides or local stability failures may occur, likely beginning near the existing active internal scarp and propagating uphill toward the tank. Additionally, increased soil moisture will elevate the risk for local and global slope failures, as indicated by our modeling. The seismic performance of the hillside under observed conditions is considered marginally acceptable, but is not acceptable if saturated moisture conditions or excess pore pressure buildup coincide with a seismic event. Additional modeling of shallow failures under seismic loading was not performed as it is already considered poor during static loading.

Under the relatively dry conditions encountered at the time of our investigation, stability modeling has shown that the site will be stable both locally and globally under static loading conditions. However, previous excavations performed by South Weber personnel indicate that near-surface soils on the hillside have been at least partially saturated in the past. It is imperative to take precaution to prevent excessive infiltration of moisture from the tank into the soil. We recommend adequate drainage also be provided to manage storm water at the tank site, limiting run-off and infiltration of surface water into the near-surface soils.

If the tank is to remain in service at its' current location, we anticipate that leak repairs and other structural upgrades are likely. In addition to review and improvements to the site drainage, we recommend that the slope be monitored for future movement. Monitoring should include surficial observations and surveying to document any mass movements. We also recommend that an inclinometer be installed to monitor potential movement at greater depth. The following table indicates the minimum recommended frequency and duration of monitoring, the need and frequency of continued monitoring should be reevaluated at the end of the initial monitoring period.

Table 6.3 – Slope Stability Monitoring Recommendations

Type	Minimum Frequency	Minimum Duration
Survey	Annual	Twice (Begin/end of year)
Observation	Quarterly	18 months
Inclinometer	Monthly	18 months

Inclinometers are used to monitor subsurface movements and deformations; they also assist in establishing whether movement is constant or accelerating, and how the movement may be impacted by fluctuations in moisture. An inclinometer system has two components: (1) inclinometer casing and (2) an inclinometer measurement system. Inclinometer casing provides access for subsurface measurements. Grooves inside the casing control the orientation of the inclinometer sensor and provide a uniform surface for measurements. Inclinometer casing is usually installed in a borehole. The exact location of inclinometer casing can be somewhat flexible, but it should be located on the slope between the existing active internal scarp and the tank. This could mean securing an easement for installation and monitoring of the slope from the property owner. Options for data collection vary. Traditionally, the measurements were taken manually at specific intervals. Newer technologies exist that can allow for continuous monitoring and reporting to better understand the slope and its' response to changing conditions.

In-place inclinometer sensors could also provide early warning of changing conditions and potential slope failure.

7.0 CLOSURE

7.1 LIMITATIONS

The recommendations contained in this report are based on limited field exploration, laboratory testing, and our understanding of site conditions. The subsurface data used in the preparation of this report were obtained from the explorations made for this investigation. It is possible that variations in the soil and groundwater conditions exist between and beyond the points explored. The nature and extent of variations may not be evident unless additional earthwork/excavation occurs. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the scope of the proposed tank upgrades changes from that described in this report, our firm should also be notified.

The concept of risk is a significant consideration of geotechnical analyses. The analytical means and methods used in performing geotechnical analyses and development of resulting recommendations do not constitute an exact science. Analytical tools used by geotechnical engineers are based on limited data, empirical correlations, engineering judgment and experience. As such the solutions and resulting recommendations presented in this report cannot be considered risk-free, but do constitute IGES's best professional opinions and recommendations based on the available data and other design information available at the time they were developed. IGES has developed the preceding analyses, recommendations and designs, at a minimum, in accordance with generally accepted professional geotechnical engineering practices and care being exercised in the project area at the time our services were performed. No warrantees, guarantees or other representations are made.

It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

7.2 ADDITIONAL SERVICES

IGES can assist in determining an acceptable solution for instrumentation and monitoring of the slope. We can also assist in installation, measurement, documentation and interpretation and data collected on the slope. We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please do not hesitate to contact us at your convenience at (801) 270-9400.

8.0 REFERENCES CITED

American Geological Institute (AGI), 2005, Glossary of Geology, Fifth Edition, revised, Neuendorf, K.K.E., Mehl, Jr. J.P., and Jackson, J.A., editors: American Geological Institute, Alexandria, Virginia, 783 p.

Blake, T.F., Hollingsworth, R.A., Stewart, J.P., 2002, Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Landslide Hazards in California, Southern California Earthquake Center, 132 p.

Coogan, J.C., and King, J.K., 2016, Interim Geologic Map of the Ogden 30’ x 60’ Quadrangle, Box Elder, Cache, Davis, Morgan, Rich, and Summit Counties, Utah, and Uinta County, Wyoming: Utah Geological Survey Open-File Report 653DM, 1 Plate, 151 p., Scale 1:62,500.

Federal Emergency Management Agency [FEMA], 2007, Flood Insurance Rate Map, Davis County, Utah: Map Number 49011C0089E, Effective June 18, 2007.

Idriss, I.M. and Boulanger, R.W. (2007) “SPT and CPT-based relationships for the residual shear strength of liquefied soils.” Earthquake Geotechnical Engineering, 4th International Conference on Earthquake Geotechnical Engineering – Invited Lectures, K.D. Pitilakis, ed., Springer, The Netherlands, 1-22.

IGES, 2016, Reconnaissance-Level (Phase I) Geologic Hazards Assessment, South Weber Westside Reservoir, South Weber, Utah: Unpublished consultant report dated September 26, 2016, submitted to Jones & Associates; IGES Project No. 01747-002.

Lund, W.R., 1984, Inspection of landslides adjacent to Hill Air Force Base in Davis County: Utah Geological Survey Applied Geology, Job No. 84-009, 2 p., accessed from https://geodata.geology.utah.gov/

Olson, S.M. and Johnson, C.I (2008) "Analyzing Liquefaction-Induced Lateral Spreads Using Strength Ratios," J. Geotech. And Geoenvir. Engrg. Volume 134, Issue 8, pp. 1035-1049

Stark, T.D., Hisham, T.E., 1994, Drained Residual Strength of Cohesive Soils, Journal of Geotechnical Engineering, Vol. 120, No. 5.

U.S. Department of Transportation – Federal Highway Administration, 2012, "LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations," Publication No. FHWA-NHI-11-032, Reference Manual: NHI Course No. 130094, Geotechnical Engineering Circular No. 3

U.S. Geological Survey, 2014, Topographic Map of the Ogden Quadrangle, Ogden, Utah: Scale 1:24,000.

U.S. Geological Survey and Utah Geological Survey, 2006, Quaternary fault and fold database for the United States, accessed 8-26-16, from the USGS website: http://earthquakes.usgs.gov/regional/qfaults

Yonkee, A., and Lowe, M., 2004, Geologic Map of the Ogden 7.5' Quadrangle, Weber and Davis Counties, Utah: Utah Geological Survey Map 200, 2 Plates, 42 p., Scale 1:24,000.

AERIAL PHOTOGRAPHS

Data Set	Date	Flight	Photographs	Scale
1937 AAJ-AAK	September 26, 1937	2	14, 15, 16	1:20,000

*https://geodata.geology.utah.gov/imagery/

APPENDIX A

LEGEND

TRENCH TRACE

BOREHOLE LOCATION

SOUTH WEBER CITY PROPERTY

LANDSLIDE SCARP (OLDER)

LANDSLIDE SCARP (ACTIVE)

BASE IMAGE FROM GOOGLE EARTH
DATED 7/8/2016

N

0 50 100
FEET

FIGURE A-1

EXCAVATION LOCATION MAP

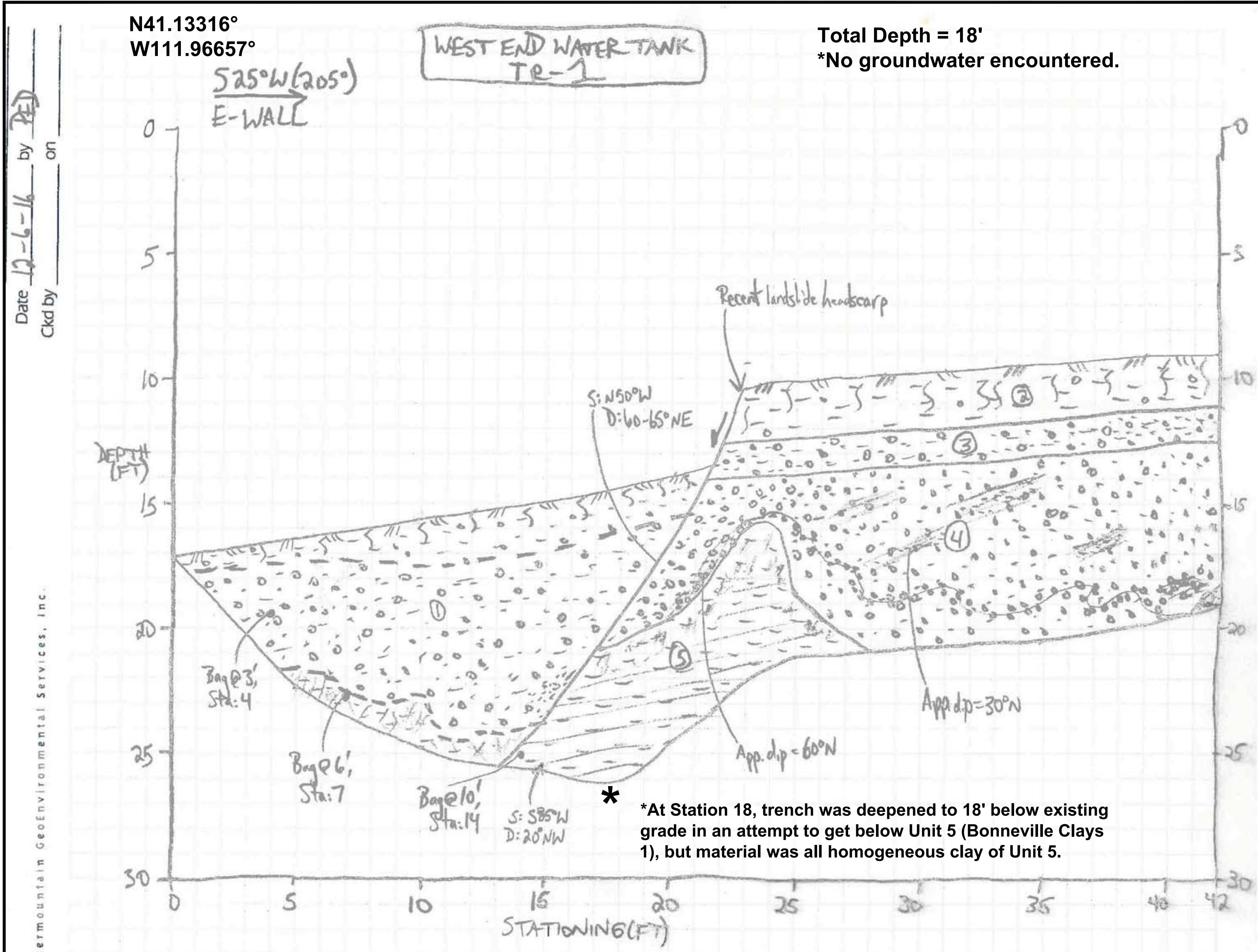
WESTSIDE RESERVOIR

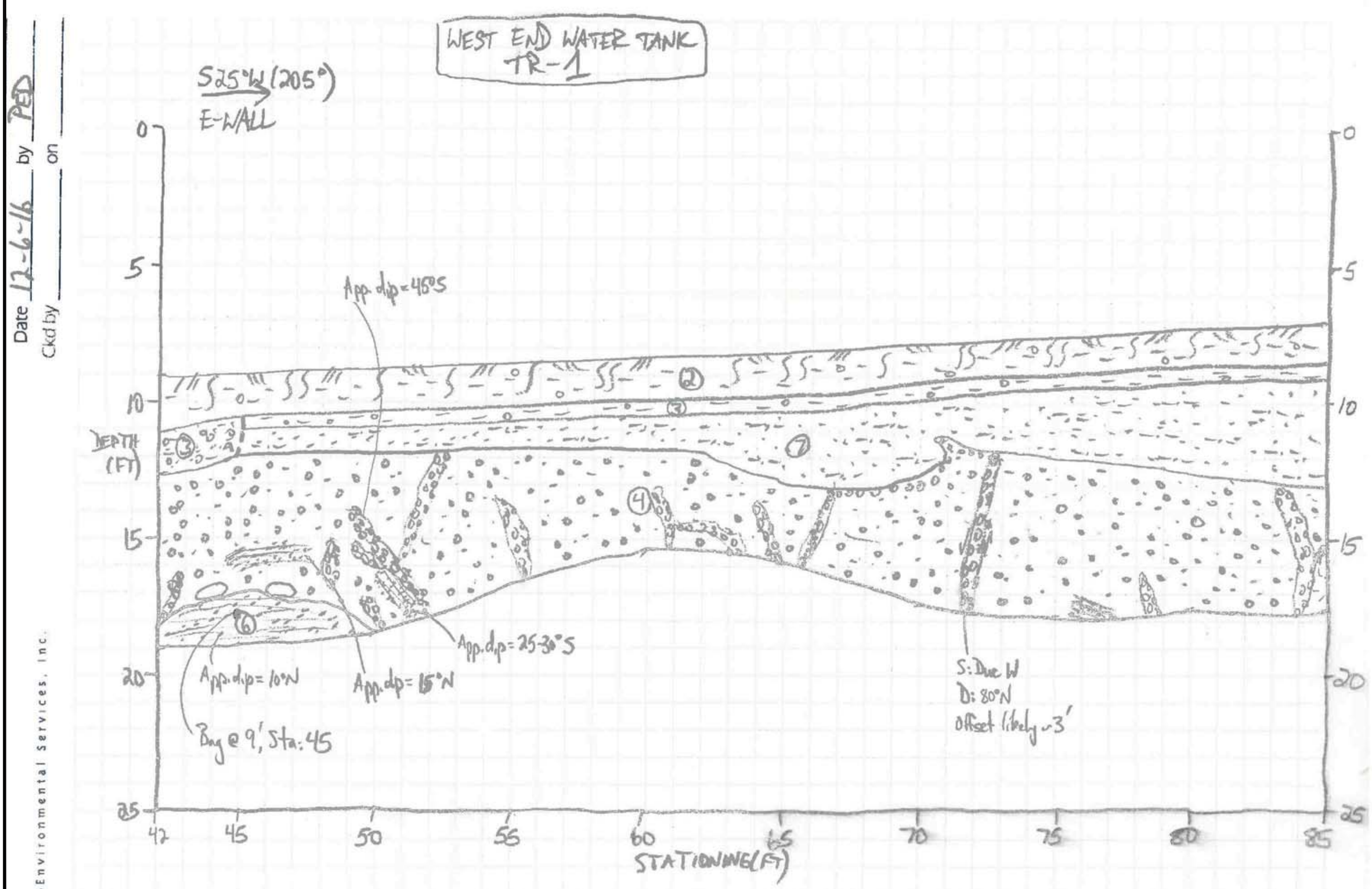
GEOTECHNICAL AND GEOLOGIC HAZARD ASSESSMENT

SOUTH WEBER CITY, UTAH

DATE: 01/24/2017
FILE: 01747-002
SCALE: 1"=100'

IGES



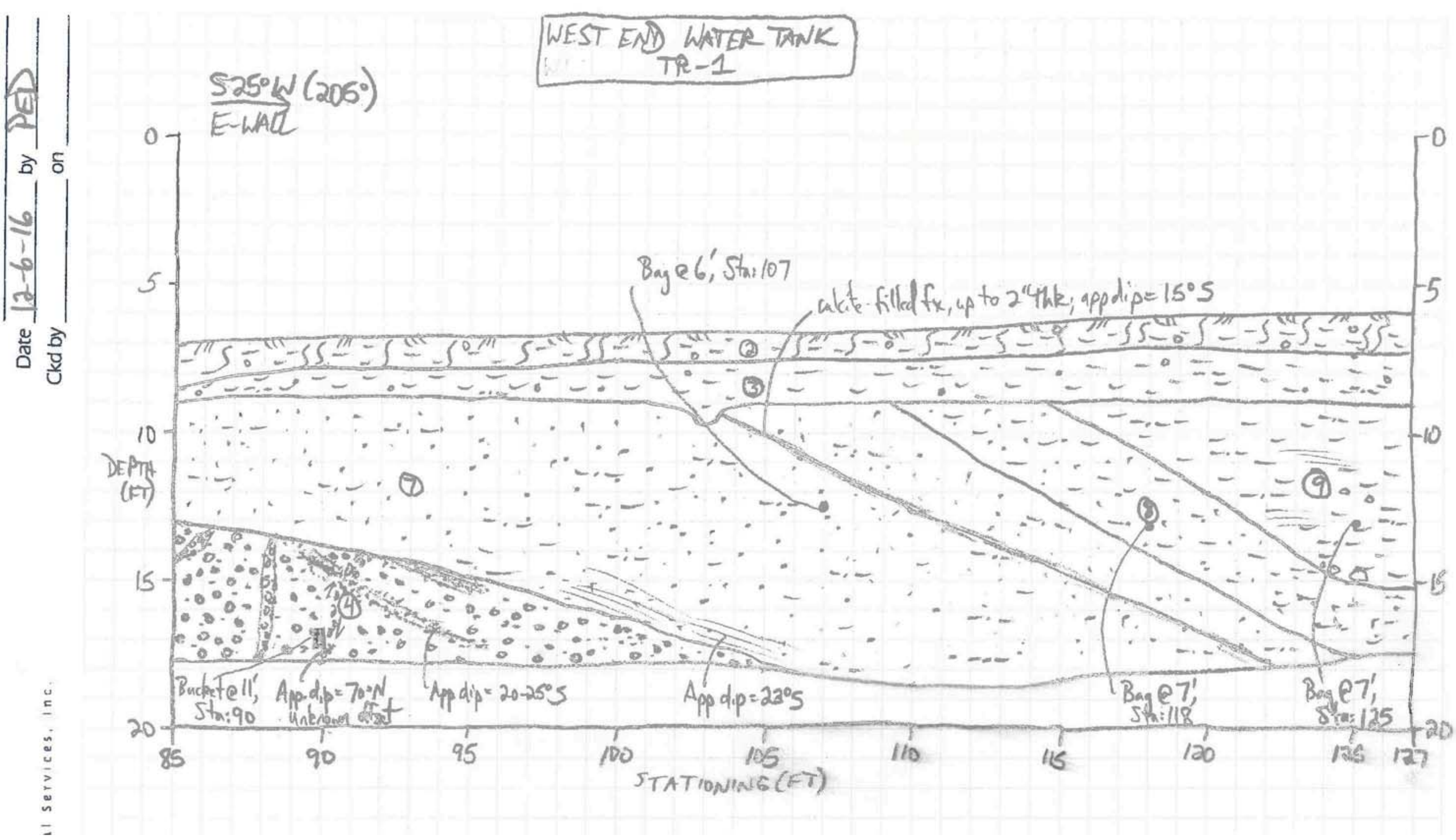


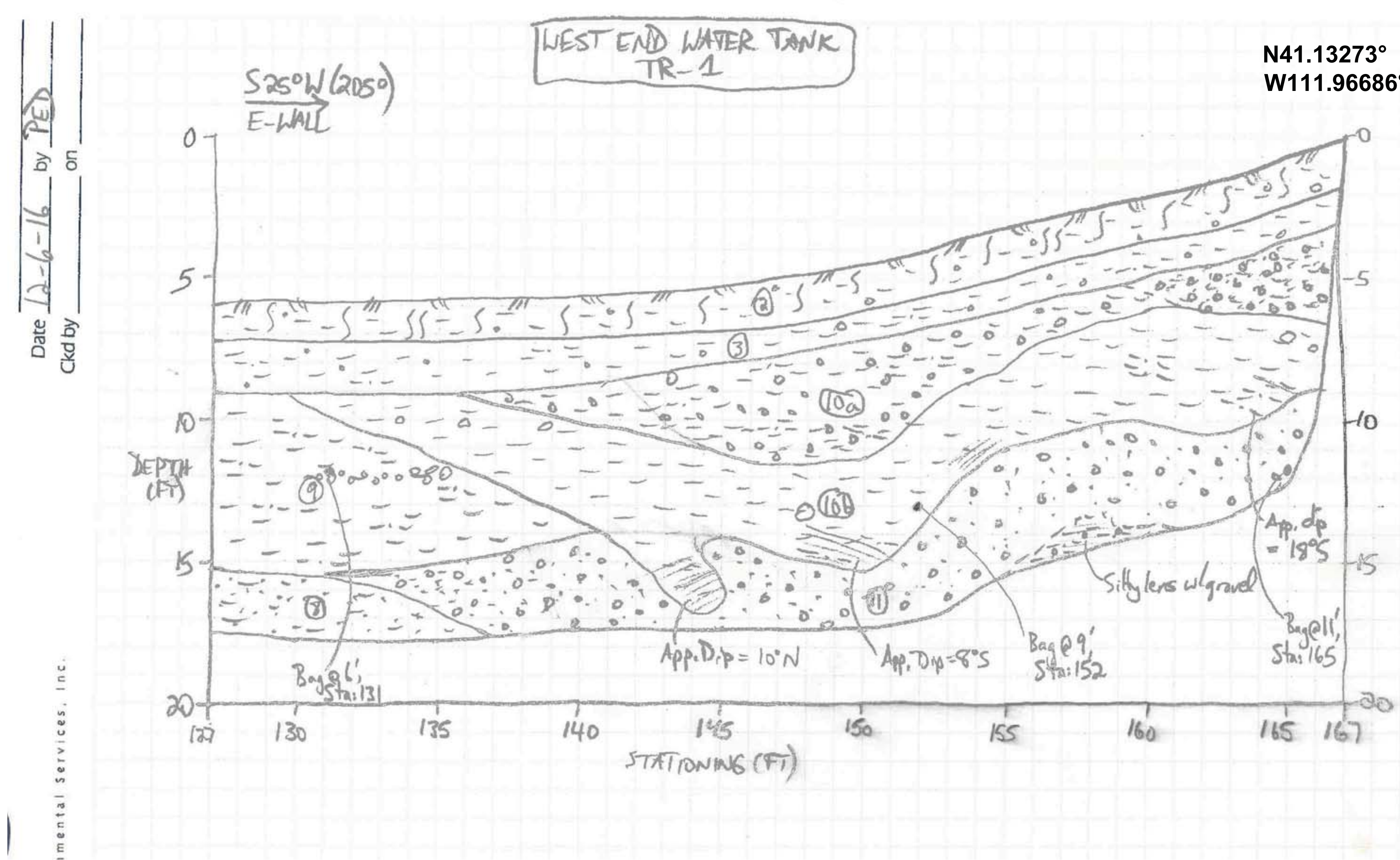
LITHOLOGIC UNIT DESCRIPTIONS ON FIGURE A-2c

WESTSIDE RESERVOIR
SOUTH WEBER CITY
GEOLOGIC HAZARD ASSESSMENT

FIGURE A-2a
TRENCH-1 LOG

DATE: 01/23/2017
PROJECT: 01747-002
SCALE: 1"=5'
IGES





N41.13273°
W111.96686°

Total Depth = 18'
***No groundwater encountered.**

LITHOLOGIC UNIT DESCRIPTIONS ON FIGURE A-2c	WESTSIDE RESERVOIR SOUTH WEBER CITY GEOLOGIC HAZARD ASSESSMENT	FIGURE A-2b TRENCH-1 LOG DATE: 01/23/2017 PROJECT: 01747-002 SCALE: 1"=5' IGES

LITHOLOGIC UNIT DESCRIPTIONS:

1. Landslide 1: >8' thick; varicolored, because comprised of a mix of A/B soil horizons (Units 2 and 3), Bonneville Sand and Gravel 1 (Unit 4), and Bonneville Clays 1 (Unit 5); unit is jumbled mix of these units, with A/B soil horizons containing a higher proportion of clasts (~10-15%) than seen elsewhere in trench, sand and gravel containing topsoil mixed in, and clays entirely highly broken and with a distinct calcium carbonate coating/infilling absent to the south of the scarp; more common plant and tree roots than elsewhere in trench; very stiff to loose, slightly moist, chaotic structure; definite high-angle scarp noted on both sides of trench, though no shear/slickensides present due to highly granular nature of soil materials.

2. A-Horizon: ~1-1.5' thick; brownish black (5YR 2/1) lean CLAY with gravel (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise ~5-10% of unit; clasts are medium gray (N5) rounded to subrounded quartzite and granodiorite up to 1.5" in diameter, though mode size ~1/2"; abundant plant and tree roots; abundant large worm holes; gradational, irregular basal contact.

3. B-Horizon: ~1-1.5' thick; grayish brown (5Y 3/2) to dark yellowish brown (10YR 4/2) to moderate yellowish brown (10YR 5/4) lean CLAY with gravel (CL), stiff, moist, low plasticity, massive, though blocky texture; gravel and larger sized clasts comprise <5% of unit; clasts are medium gray (N5) rounded to subrounded quartzite and granodiorite up to 1" in diameter; common pinhole voids (1 mm diameter); occasional to common plant and tree roots; lightens in color with depth; sharp, irregular basal contact.

4. Bonneville Sand and Gravel 1: ~6' thick; mottled in appearance, due to abundant varicolored gravel; matrix is medium gray (N5) to dark yellowish brown (10YR 4/2); Lake Bonneville well-graded sandy GRAVEL (GW), loose to medium-dense, slightly moist, massive to finely bedded; gravel and larger sized clasts comprise ~70-80% of unit; clasts all rounded to subrounded medium gray (N5) quartzite and granodiorite up to 6" in diameter, though mode size ~1"; matrix is medium to coarse-grained sand; occasional sand lenses, which are finely bedded; weak calcite cement; poorly sorted; common white partially cemented subvertical unit-controlled faults; occasional plant and tree roots; sharp, highly undulatory basal contact.

5. Bonneville Clays 1: >10' thick; brownish gray (5YR 4/1) to moderate reddish brown (10R 4/6) Lake Bonneville lean CLAY (CL), very stiff, dry to slightly moist, low to moderate plasticity, finely to medium-bedded and varved; devoid of clasts; blocky jointing; uppermost ~2-3' of unit is highly broken and appears to have been severely stressed; common dark yellowish orange (10YR 6/6) silt interbands up to 1 cm thick; occasional fine-grained sand lenses.

6. Bonneville Sand 1: >2' thick; light brown (5YR 6/4) to pale yellowish orange (10YR 8/6) Lake Bonneville sandy SILT (ML), medium-dense to dense, dry to slightly moist, finely bedded; sand is very fine-grained and gradational to silt; devoid of clasts; common small subvertical fractures with calcite infilling; found at the bottom of the trench in the northern 1/3 of the trench.

7. Bonneville Sand 2: ~6' thick; medium light gray (N6) to light gray (N7) Lake Bonneville silty SAND (SM), medium-dense, dry to slightly moist, massive to finely bedded; clayey/silty in part, and pinholed (1-2 mm diameter) where fines component present; devoid of clasts; weak calcite cement; occasional white calcite-filled fractures; sand if fine to very fine-grained; small-scale cross-bedding seen at base of unit; few plant and tree roots; sharp, wavy basal contact.

8. Transitional 1: ~2-2.5' thick; dark yellowish brown (10YR 4/2) lean CLAY with sand (CL), medium-stiff, moist, low plasticity, massive; largely devoid of clasts, though rare quartzite clasts up to 1" diameter; common pinhole voids throughout (1-2 mm diameter); sharp, curvilinear basal contact.

9. Transitional 2: ~2' thick; light brown (5YR 6/4) to moderate yellowish brown (10YR 5/4) silty CLAY with gravel (CL-ML), very stiff, slightly moist, low plasticity, discontinuously thinly bedded; unit appears as a combination of both subunits of Landslide 1 (Unit 10), as it is finely bedded, though bedding is commonly disrupted by mottling as seen in Unit 10, and the unit contains occasional gravel clasts; gravel and larger sized clasts comprise ~5% of unit; clasts all quartzite as above, up to 4" in diameter; common pinhole voids (1-2 mm diameter); gravel common near base of unit; occasional to few small plant roots; sharp, wavy basal contact.

10. Landslide 2: Up to 8' thick; light brownish gray (5YR 6/1) to brownish gray (5YR 4/1) to dark yellowish orange (10YR 6/6); contains 2 subunits:

10a. Bonneville Sand and Gravel 2: >6' thick; medium light gray (N6) to light brown (5YR 6/4) Lake Bonneville well-graded gravelly SAND (SW), loose, slightly moist, massive to weakly finely bedded; poorly sorted sand, largely medium-grained, but some fine-grained and coarse-grained; very weak silica cement; sand grains angular to subrounded, with ~75% quartz, with common quartzite and granodiorite grains; gravel and larger sized clasts comprise ~40-50% of the unit; clasts are rounded to subrounded quartzite and granodiorite up to 4" in diameter, though mode size ~1/2-1"; contains some very fine-grained sand and silt lenses; sharp, irregular basal contact.

10b. Bonneville Clays 2: ~3' thick; brownish gray (5YR 4/1) Lake Bonneville lean CLAY (CL), very stiff, slightly moist, low plasticity, finely laminated, though contorted bedding; occasional to common pinhole voids throughout (1 mm diameter); devoid of clasts; occasional small plant roots, largely along bedding planes; common dark yellowish orange (10YR 6/6) silt interbands up to 1 cm thick; contains several several loose gravel lenses that appear like underlying unit and are cemented with a clay matrix; chaotic appearance; sharp, wavy basal contact.

11. Bonneville Sand and Gravel 3: >6' thick; light brown (5YR 6/4) to moderate yellowish brown (10YR 5/4) well-graded sandy GRAVEL (GW), loose to medium-dense, slightly moist, massive to finely bedded; gravel and larger sized clasts comprise ~50% of unit; clasts are rounded to subrounded medium gray (N5) to purple to pale yellowish orange (10YR 8/6) granodiorite and quartzite up to 5" in diameter, though mode size ~1"; finely bedded silt lens in base of trench.

FIGURE A-2c

IGES®

WESTSIDE RESERVOIR
SOUTH WEBER CITY
GEOLOGIC HAZARD ASSESSMENT

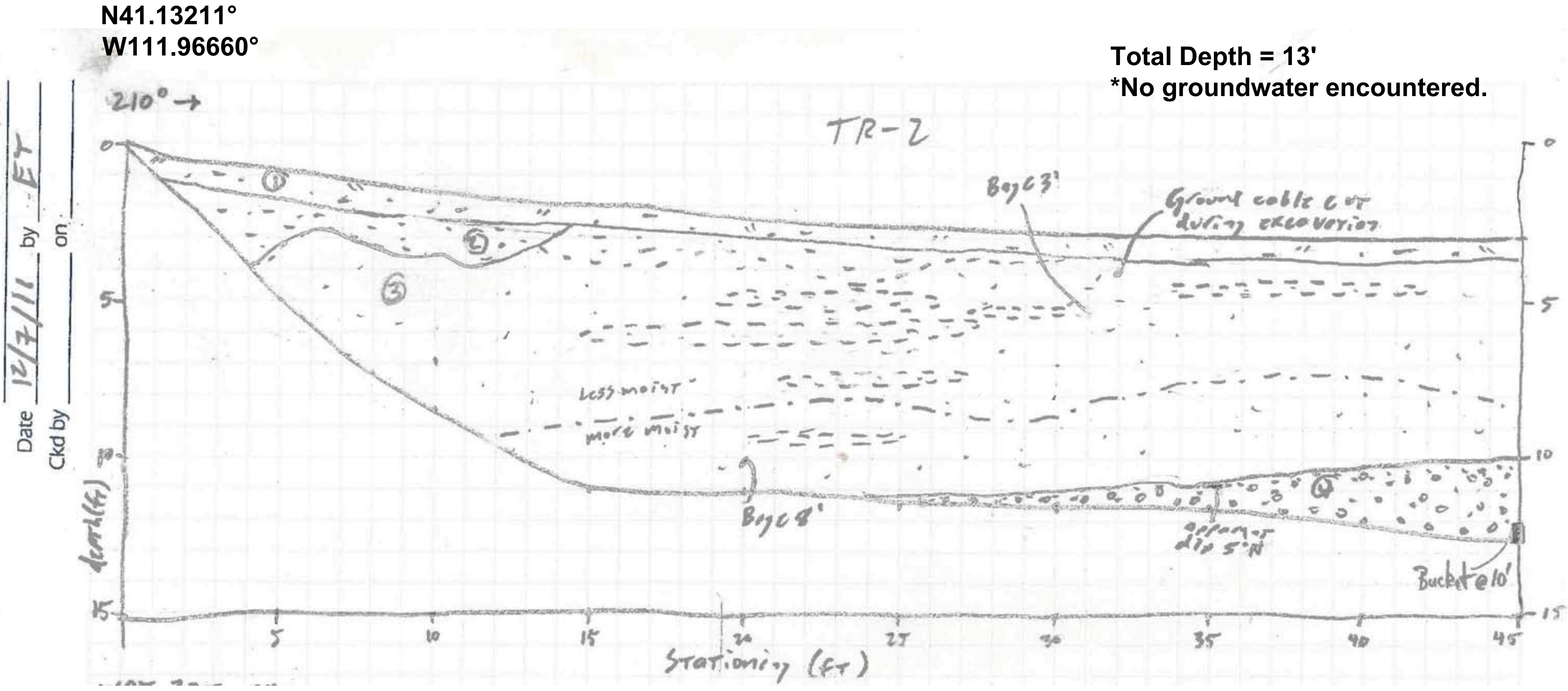
TRENCH-1 LOG

PROJECT NO: 01747-002

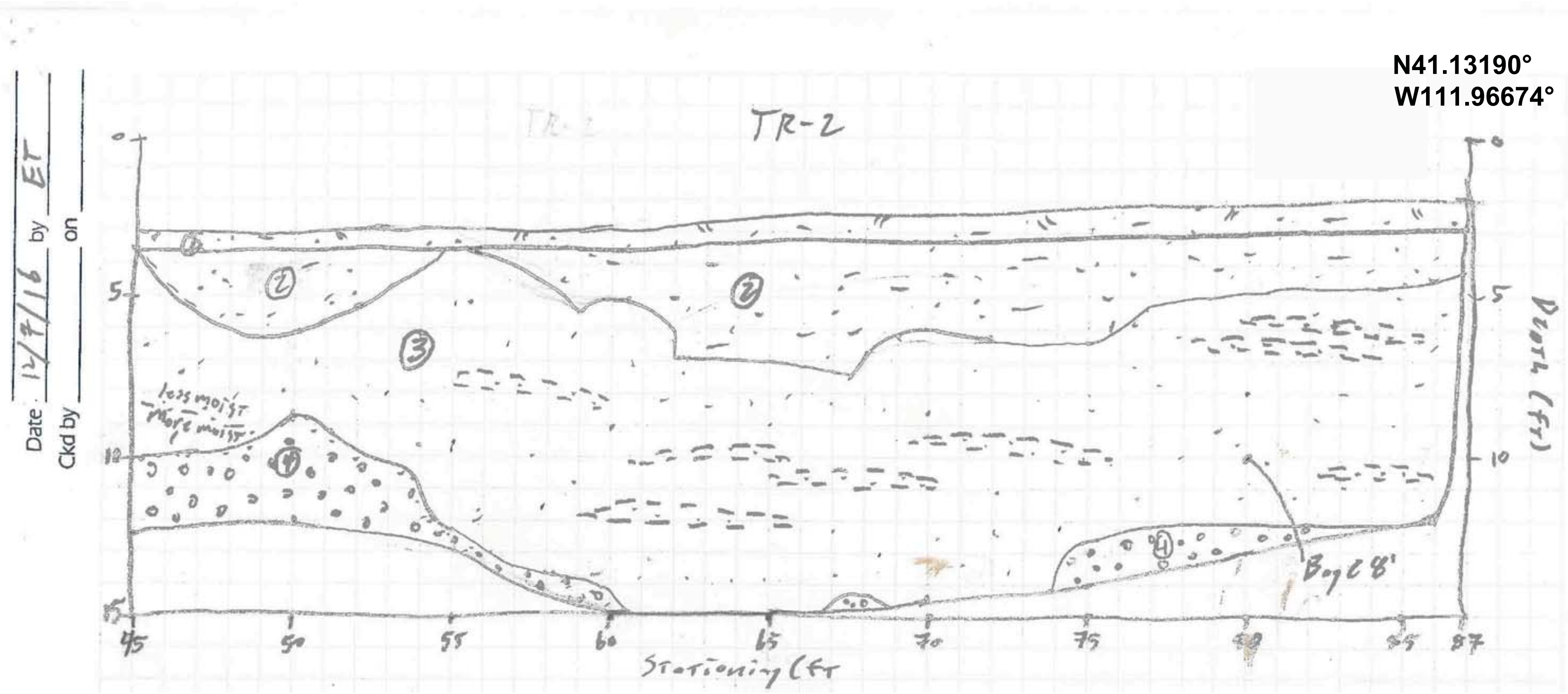
DATE: 01/23/2017
PROJECT:01747-002
SCALE: 1"=5'
IGES®

N41.13211°
W111.96660°

Total Depth = 13'
*No groundwater encountered.



N41.13190°
W111.96674°



LITHOLOGIC UNIT DESCRIPTIONS:

1. A/B Soil Horizon: ~1/2-1' thick topsoil; dark yellowish brown (10YR 4/2) to brownish black (5YR 2/1) sandy lean CLAY (CL), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise <5% of unit; clasts entirely subrounded quartzite up to 1" in diameter; A and B horizons distinguishable throughout most of unit; unit thins away from north end of trench; occasional plant and tree roots; sharp, largely planar basal contact.

2. Fill: ~1-4' thick, though highly variable; dark yellowish brown (10YR 4/2) to moderate yellowish brown (10YR 5/4) sandy lean CLAY (CL), medium stiff, moist, low plasticity, massive; gravel and larger sized clasts comprise <3% of unit; clasts entirely subrounded quartzite up to 1.5" in diameter; lateral extents of unit highly variable, likely local material used as fill to level ground preceding tank emplacement; sharp, highly irregular basal contact.

3. Bonneville Silt and Sand: ~5-8' thick; light brown (5YR 6/4) Lake Bonneville sandy SILT (ML) gradational to silty SAND (SM), medium stiff, slightly moist but becomes moist with depth, low plasticity, faint bedding possible throughout unit; contains no visible gravel clasts; contains lenticular sandy lean clay lenses throughout unit with a blocky texture; calcium carbonate flour found to be concentrated around clay lenses; sharp increase in moisture content near the base of the unit between stations 10 and 48; sharp, irregular basal contact.

4. Bonneville Sand and Gravel: >3' thick; light gray (N7) Lake Bonneville well-graded sandy GRAVEL (GW), loose, slightly moist, massive, though occasional subhorizontal sand lenses; gravel and larger sized clasts comprise ~65% of unit; clasts all well rounded to subrounded medium gray (N5) quartzite up to 4" in diameter, though mode size ~1"; at upper contact is ~3-4" sand lens with a fine sand similar to the sandy matrix of this unit and contains subhorizontal laminae and trough cross-stratification.

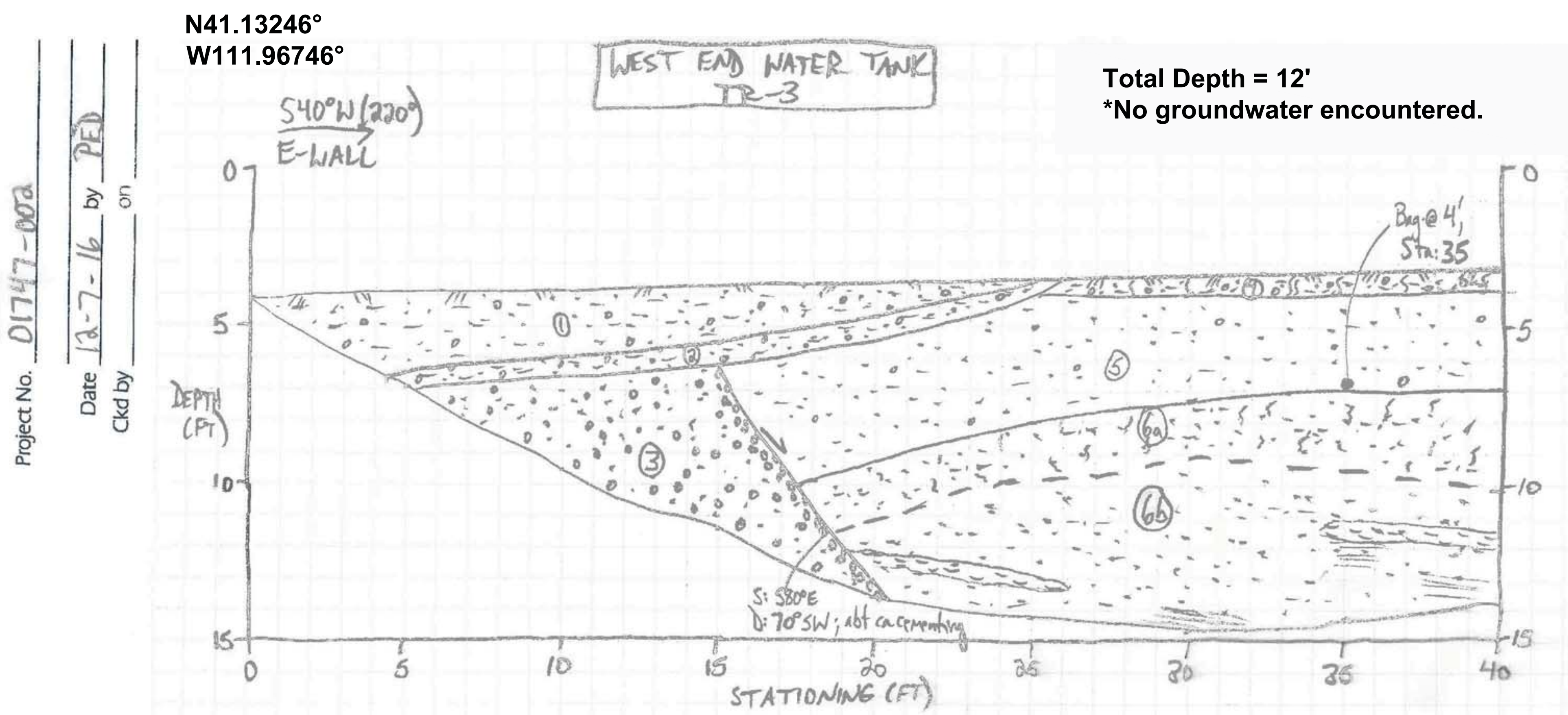
IGES®

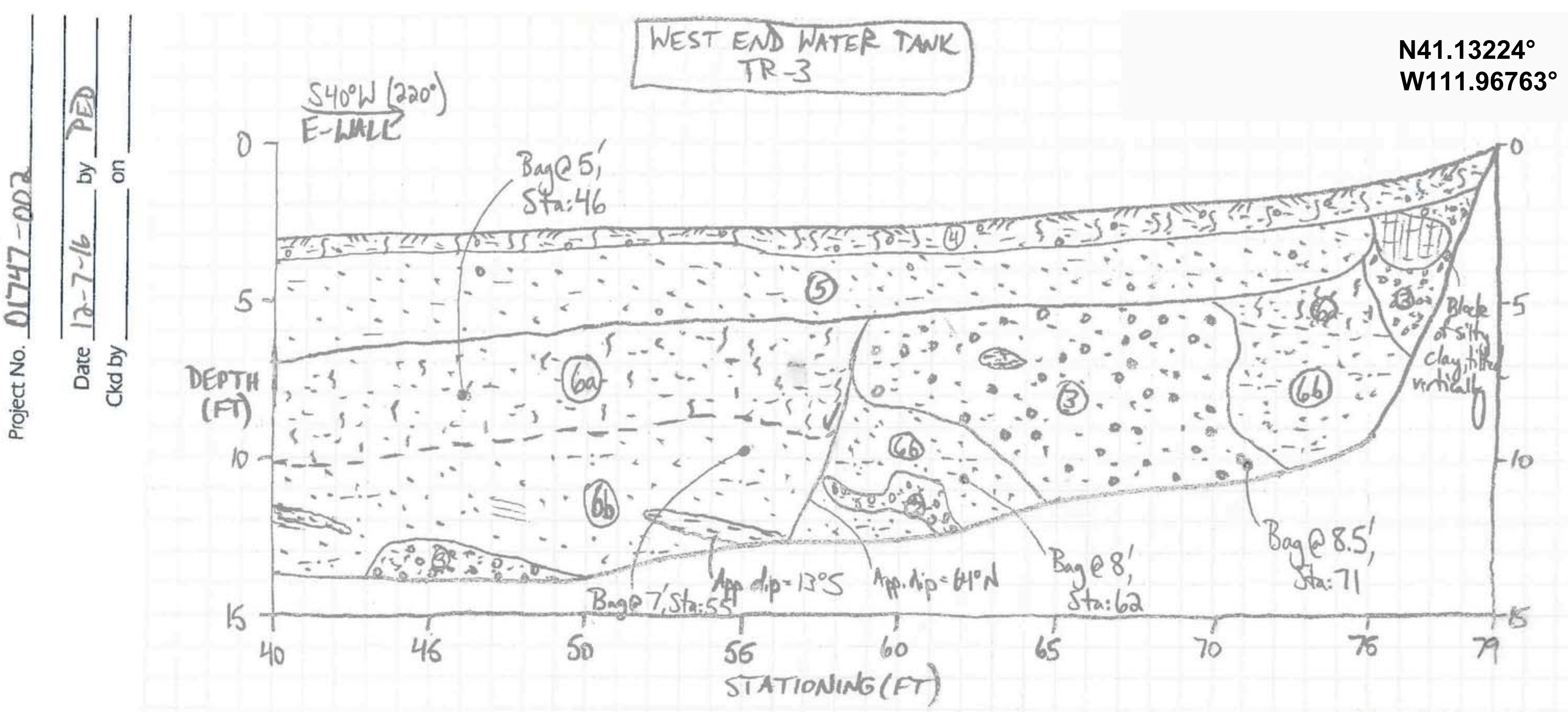
PROJECT NO: 01747-002

WESTSIDE RESERVOIR
SOUTH WEBER CITY
GEOLOGIC HAZARD ASSESSMENT

FIGURE A-3
TRENCH-2 LOG

DATE: 01/24/2017
PROJECT: 01747-002
SCALE: 1"=5'





LITHOLOGIC UNIT DESCRIPTIONS:

1. Fill: >2' thick; dark yellowish brown (10YR 4/2) clayey SAND with gravel (SC), medium-dense to loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~15-20% of unit; clasts entirely medium gray (N5) to pale yellowish orange (10YR 8/6) rounded to subrounded quartzite up to 5" in diameter, though mode size ~1"; likely derived from native materials; abundant plant and tree roots in uppermost ~3", otherwise occasional; unit thickens downslope; sharp, planar basal contact.

2. Buried Topsoil: ~6" thick, buried by fill; brownish black (5YR 2/1) clayey SAND with gravel (SC), medium-dense, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10-15% of unit; clasts all quartzite as above up to 2" in diameter; occasional plant and tree roots; becomes more gravelly downslope to northwest; sharp, largely planar basal contact.

3. Bonneville Sand and Gravel: >6' thick; moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2) matrix, though mottled due to varicolored clasts; Lake Bonneville sandy GRAVEL (GW) gradational to gravelly SAND (SW), loose to medium-dense, except dense where calcium carbonate present, slightly moist, massive to faintly bedded; gravel and larger sized clasts comprise ~50-75% of unit; clasts consist of roughly equal proportions of pale yellowish orange (10YR 8/6) to medium gray (N5) granodiorite and quartzite up to 3" in diameter, though mode size ~1/2"; sandy matrix is medium to coarse-grained, as seen in TR-1; occasional calcium carbonate cement; occasional plant and tree roots.

4. A/B Soil Horizon: ~3-6" thick; dark yellowish brown (10YR 4/2) to brownish black (5YR 2/1) clayey SAND with gravel (SC), loose, slightly moist, low plasticity, massive; gravel and larger sized clasts comprise ~10% of unit; clasts entirely granodiorite and quartzite as above up to 1" in diameter; abundant plant and tree roots; gradational, planar basal contact.

5. Bonneville Sand: ~4' thick; dark yellowish brown (10YR 4/2) Lake Bonneville silty SAND (SM),medium-dense, moist, low plasticity, massive; gravel and larger sized clasts comprise ~2% of unit; clasts are granodiorite and quartzite as above up to 2" in diameter, though mode size ~1/2"; reversely graded; common pinhole voids (1 mm diameter); occasional to common plant and tree roots; sharp, irregular basal contact.

6. Bonneville Silt and Sand: >8' thick; Lake Bonneville silt and sand deposits; north side of trench displays dark yellowish orange (10YR 6/6) oxidation due to recent groundwater flow, though no groundwater present at time of logging; consists of 2 subunits:

6a: ~2-3' thick; moderate yellowish brown (10YR 5/4) to dark yellowish brown (10YR 4/2) silty SAND (SM),dense to very dense due to abundant calcium carbonate fill and stringers, slightly moist to moist, low plasticity, massive to finely bedded; fine-grained to very fine-grained sand gradational to silt; devoid of clasts.

6b: >6' thick; light gray (N7) to moderate yellowish brown (10YR 5/4) silty, clayey SAND (SW-SC), medium-dense to loose, slightly moist to moist, low plasticity, massive to finely bedded; devoid of clasts; occasional clay lenses with calcium carbonate infilling up to 5" thick; few plant and tree roots.

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO:
BH-1
Sheet 1 of 2

LOCATION
NORTHING 3,572,524.09 EASTING 1,511,796.36 ELEVATION 4,688 feet
Lower Road - west of trench 1

DEPTH METERS	DEPTH FEET	SAMPLES	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit – Moisture Content – Liquid Limit) 10 20 30 40 50 60 70 80 90
0	0			CL	Lean CLAY - medium stiff, moist, brown.								
				SP	Poorly-graded SAND - medium dense, dry, light brown								
1													
	5			SP	Poorly-graded SAND with gravel - loose-medium dense, dry, light yellowish-brown; rounded-subrounded gravel≤3/4-in diam.								
2													
3	10												
4													
	15				- gravel in tip, NO RECOVERY								
5													
6											31	13	
	20			CL	Varved lean CLAY - soft-medium stiff, moist, reddish brown; occasionally wet and sandy								
7				SC	Clayey-SAND - loose, wet, reddish brown								
				CL	Sandy Lean CLAY - medium stiff, moist, brown; sandy seams every 1-1.5-in. (≤1/4-in thick)								
	25												
8													

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 5a

LOG OF BORING (A-FIG) CAL&SHBY 01747-002_III.GPJ IGES.GDT 2/9/17

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO:
BH-1
Sheet 2 of 2

LOCATION
NORTHING 3,572,524.09 EASTING 1,511,796.36 ELEVATION 4,688 feet
Lower Road - west of trench 1

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (10 20 30 40 50 60 70 80 90)

DEPTH METERS	DEPTH FEET	SAMPLES	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
9				CL								
	30			SP-SM	Poorly-graded SAND with silt - loose (flowing), wet, brown							
				CLS	Sandy lean CLAY - medium stiff, moist, brown; occasional sand seams ≤1/4-in thick.							
10										0		
	35											
11				SP-SM	Poorly-graded SAND with silt - loose (flowing), wet, brown					51		
12	40				Sandy lean CLAY - medium stiff, moist, brown; occasional sand seams ≤1/4-in thick.							
13				CL	Sandy lean CLAY - medium stiff, moist, brown; occasional sand seams ≤1/4-in thick.							
14	45											
15	50				Bottom of Boring @ 50 Feet							
16												
17	55											

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 5b

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 6-in HSA

BORING NO:
BH-2
Sheet 1 of 2

LOCATION
NORTHING 3,572,418.01 EASTING 1,511,952.39 ELEVATION 4,700 feet
Lower Road - east of trench 1

DEPTH METERS	DEPTH FEET	SAMPLES	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit, Moisture Content, Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0												
1													
	5			CL	Lean CLAY - stiff, dry, light brown								
2													
				SP	Poorly-graded SAND with gravel - loose, dry, tan								
3	10	Modified California Sampler			- no recovery	11 11 12							
4					-rounded gravel≤2-in diam in cuttings								
	15	Modified California Sampler			- no recovery	4 8 19							
5													
6	20	Modified California Sampler		SP	Poorly-graded SAND with gravel - medium dense, dry, brown	14 23 21		126.2	3				●
7													
	25												
8													

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. "U" Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure
A - 6a

DATE			
STARTED:	12/12/16		
COMPLETED:	12/12/16		
BACKFILLED:	12/12/16		

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 6-in HSA

BORING NO:
BH-2

LOCATION
NORTHING 3,572,418.01 EASTING 1,511,952.39 ELEVATION 4,700 feet
Lower Road - east of trench 1

DEPTH (METERS)	DEPTH (FEET)	SAMPLES	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
9	30	▲	▨	CL	Varved lean CLAY - medium stiff, moist, brown; near horizontal bedding of altenating clay and sand seams.	5 7 7		103.8	22	84	41	21
10	35	▲	▨	CL		4 5 8		94.4	29		36	17
11, 12, 13	40		▨									
14	45	▲	▨	CL	Lean CLAY - med. stiff-stiff, moist, brown; occiasional fine sand seams, clay is frequently wet/soft near seams.	5 7 9		100.8	24		37	20
					Bottom of Boring @ 46.5 Feet							
15, 16, 17	50, 55											

Moisture Content and Atterberg Limits
Plastic Limit ├ Moisture Content ● Liquid Limit ┤
10 20 30 40 50 60 70 80 90

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- ⊠ - 2" O.D./1.38" I.D. Split Spoon Sampler
- ◪ - 3.25" O.D./2.42" I.D. "U" Sampler
- ▱ - 3" O.D. Thin-Walled Shelby Sampler
- ▯ - Grab Sample
- ◢ - Modified California Sampler
- ☐ - Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 6b

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir Landslide Evaluation

South Weber, Utah

Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO: **BH-3**

Sheet 1 of 2

LOCATION
NORTHING 3,572,168.60 EASTING 1,511,818.39 ELEVATION 4,739 feet
south of small tank, west of trench 2

DEPTH METERS	DEPTH FEET	SAMPLES	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index	Moisture Content and Atterberg Limits (Plastic Limit / Moisture Content / Liquid Limit; 10 20 30 40 50 60 70 80 90)
0	0				Topsoil (~6-in)								
				GP	Poorly-graded GRAVEL - medium dense, moist, gray								
				CL	Lean CLAY - medium stiff, dry, tan; powder								
1													
	5												
2													
3	10			SP									
				SP	Poorly-graded SAND with gravel - medium dense, dry, tan; pebble gravel only in sampler (≤1-in diam)								
4													
	15			SP	<3' recovery								
5													
6	20			SP									
7													
	25												
8													
				CL	Lean CLAY - stiff, moist, reddish brown; occasional sand seams 1/4 - 2 in thick					84	38	21	

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 7a

LOG OF BORING (A-FIG) CAL&SHBY 01747-002_III.GPJ IGES.GDT 2/9/17

DATE	
STARTED:	12/12/16
COMPLETED:	12/12/16
BACKFILLED:	12/12/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO:
BH-3
Sheet 2 of 2

LOCATION
NORTHING 3,572,168.60 EASTING 1,511,818.39 ELEVATION 4,739 feet
south of small tank, west of trench 2

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

DEPTH METERS	DEPTH FEET	SAMPLES	GRAPHICAL LOG	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
9	30				- lost 30-32' sample							
10										71		
11	35			CL	Lean CLAY with sand seams - stiff-hard, moist, brown							
12					-sample liner compressing in stiff clay, expanding in casing and unable to retrieve.							
	40				Bottom of Boring @ 40 Feet							
13												
14	45											
15	50											
16												
17	55											

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 7b

DATE	
STARTED:	12/13/16
COMPLETED:	12/13/16
BACKFILLED:	12/13/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO:
BH-4
Sheet 1 of 2

LOCATION
NORTHING 3,572,340.81 EASTING 1,511,737.20 ELEVATION 4,729 feet
north of large tank

Depth (meters)	Depth (feet)	Unified Soil Classification	Material Description	N	Water Level	Dry Density (pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0–4.7	0–15.5	SP	Poorly-graded SAND with gravel - loose-medium dense, dry, light brown -sampling in upper 15 feet is not accurate for depth, attempted to over puxh and pack sampler in order to keep loose/dry sand from falling into casing.					75	28	11
		CL	Lean CLAY - hard, dry, reddish brown							
			sand seam							
		CL								
		SM	Silty SAND - loose-medium dense, moist, reddish brown.							
	20	CL	Lean CLAY with frequent sand seams - stiff, moist, reddish brown							
		SM	Silty SAND - medium dense, moist, reddish brown							
		CL						38	NP	NP

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (10 20 30 40 50 60 70 80 90)

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:
abandonned hole at 40 ft, liner continuing to break and get stuck in casing

WATER LEVEL
▼- MEASURED ▽- ESTIMATED

Figure
A - 8a

DATE	
STARTED:	12/13/16
COMPLETED:	12/13/16
BACKFILLED:	12/13/16

Westside Reservoir
Landslide Evaluation

South Weber, Utah
Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 1.5-in DP

BORING NO:
BH-4
Sheet 2 of 2

LOCATION
NORTHING 3,572,340.81 EASTING 1,511,737.20 ELEVATION 4,729 feet
north of large tank

Depth scale: METERS 9, 10, 11, 12, 13, 14, 15, 16, 17; FEET 30, 35, 40, 45, 50, 55

UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
SM	Silty SAND - loose, wet (flowing), reddish brown							
CL	Lean CLAY with sand seams - medium stiff, moist, reddish brown; sand seams≤1/4-in thick							
	clay transition to grayish-brown color							
SM	Silty SAND - loose, wet, reddish brown;							
	Silty SAND with clay lenses							
CL	Lean CLAY - stiff, moist, alternating brown & reddish brown seams; some fine sand seams					93	35	16
CL	Sandy Lean CLAY							
CL	Lean CLAY - medium stiff, moist, brown with black staining; frequent sand seams≤1/8-in thick							
	Lean CLAY - soft-medium stiff, moist; alternating brown/reddish-brown and black seams 1/8-3/8-in thick							
	loose, wet silty SAND seam							
CL	Lean CLAY medium stiff-stiff, moist, alternating red/black/brown clay seams with frequent moist sand seams							
	Bottom of Boring @ 55 Feet							

Moisture Content and Atterberg Limits
Plastic Limit — Moisture Content — Liquid Limit
10 20 30 40 50 60 70 80 90

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3" O.D./2.42" I.D. California Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample

BORING LOG

NOTES:
abandonned hole at 40 ft, liner continuing to break and get stuck in casing

WATER LEVEL
▼- MEASURED ▽- ESTIMATED

Figure
A - 8b

DATE		
STARTED:	12/13/16	
COMPLETED:	12/13/16	
BACKFILLED:	12/13/16	

Westside Reservoir Landslide Evaluation

South Weber, Utah

Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 6-in HSA

BORING NO: **BH-5**

Sheet 1 of 2

LOCATION

NORTHING 3,572,313.83 EASTING 1,511,578.85 ELEVATION 4,728 feet

west of large tank and Trench 3

Depth (Meters)	Depth (Feet)	Samples	Unified Soil Classification	Material Description	N	Water Level	Dry Density (pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0	0		CL-ML	Silty lean CLAY with sand - medium stiff, dry, reddish brown							
1	5			-frequent sand seams							
3	10	Modified California Sampler	CL	Lean CLAY with sand seams - stiff, dry, reddish brown	9, 10, 20		106.3	11			
			SM	Silty SAND - medium dense, dry, reddish brown							
4–5	15	Split Spoon Sampler	CL	Lean CLAY with sand seams - soft-medium stiff, moist, brown-reddish brown	1, 2, 4						
6	20	Modified California Sampler	CL	Varved lean CLAY - stiff, moist, reddish brown; some sand seams (1/2 - 3/4-in thick) are wet	5, 9, 6		27.1				
7–8	25	Modified California Sampler	CL	Lean CLAY - soft-medium stiff, moist, brown-grayish brown	3, 4, 4		26.2				

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (scale 10 20 30 40 50 60 70 80 90)

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. "U" Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 9a

DATE	
STARTED:	12/13/16
COMPLETED:	12/13/16
BACKFILLED:	12/13/16

Westside Reservoir Landslide Evaluation

South Weber, Utah

Project Number: 01747-002

IGES Rep: JAH
Rig Type: GP 7822 DT
Boring Type: 6-in HSA

BORING NO: **BH-5**

LOCATION
NORTHING 3,572,313.83 EASTING 1,511,578.85 ELEVATION 4,728 feet
west of large tank and Trench 3

Depth (Meters)	Depth (Feet)	Samples	Unified Soil Classification	Material Description	N	Water Level	Dry Density (pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
9	30	Split Spoon	CL	Lean CLAY - medium stiff, moist, alternating brown/reddish-brown/black seams with occasional seams of fine sand (≤1/4-in thick)	2 4 6					41	22
10–11	35	Modified California	CL		2 4 8		104.5	21			
12	40	Split Spoon	CL	alternating seams of red/black/brown/gray CLAY and fine SAND (1/8-3/8-in thick)	3 3 6						
13–14	45	Modified California		- soft-medium stiff	1 4 4		23.7				
15	50	Modified California		- sand seams ≤1/2-in thick	7 12 11		27.9				
	51.5			Bottom of Boring @ 51.5 Feet							

Moisture Content and Atterberg Limits: Plastic Limit — Moisture Content — Liquid Limit (scale 10 20 30 40 50 60 70 80 90)

N - OBSERVED UNCORRECTED BLOW COUNT

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. "U" Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 9b

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (More than half of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid limit less than 50)		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

LOG KEY SYMBOLS

BORING SAMPLE LOCATION	TEST-PIT SAMPLE LOCATION
WATER LEVEL (level after completion)	WATER LEVEL (level where first encountered)

CEMENTATION

DESCRIPTION	DESCRIPTION
WEAKLY	CRUMBLES OR BREAKS WITH HANDLING OR SLIGHT FINGER PRESSURE
MODERATELY	CRUMBLES OR BREAKS WITH CONSIDERABLE FINGER PRESSURE
STRONGLY	WILL NOT CRUMBLE OR BREAK WITH FINGER PRESSURE

OTHER TESTS KEY

C	CONSOLIDATION	SA	SIEVE ANALYSIS
AL	ATTERBURG LIMITS	DS	DIRECT SHEAR
UC	UNCONFINED COMPRESSION	T	TRIAXIAL
S	SOLUBILITY	R	RESISTIVITY
O	ORGANIC CONTENT	RV	R-VALUE
CBR	CALIFORNIA BEARING RATIO	SU	SOLUBLE SULFATES
COMP	MOISTURE/DENSITY RELATIONSHIP	PM	PERMEABILITY
CI	CALIFORNIA IMPACT	-200	% FINER THAN #200
COL	COLLAPSE POTENTIAL	Gs	SPECIFIC GRAVITY
SS	SHRINK SWELL	SL	SWELL LOAD

MODIFIERS

DESCRIPTION	%
TRACE	<5
SOME	5 - 12
WITH	>12

MOISTURE CONTENT

DESCRIPTION	FIELD TEST
DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL BELOW WATER TABLE

GENERAL NOTES

1. Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
2. No warranty is provided as to the continuity of soil conditions between individual sample locations.
3. Logs represent general soil conditions observed at the point of exploration on the date indicated.
4. In general, Unified Soil Classification designations presented on the logs were evaluated by visual methods only. Therefore, actual designations (based on laboratory tests) may vary.

STRATIFICATION

DESCRIPTION	THICKNESS
SEAM	1/16 - 1/2"
LAYER	1/2 - 12"

DESCRIPTION	THICKNESS
OCCASIONAL	ONE OR LESS PER FOOT OF THICKNESS
FREQUENT	MORE THAN ONE PER FOOT OF THICKNESS

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPT (blows/ft)	MODIFIED CA. SAMPLER (blows/ft)	CALIFORNIA SAMPLER (blows/ft)	RELATIVE DENSITY (%)	FIELD TEST
VERY LOOSE	<4	<4	<5	0 - 15	EASILY PENETRATED WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
LOOSE	4 - 10	5 - 12	5 - 15	15 - 35	DIFFICULT TO PENETRATE WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
MEDIUM DENSE	10 - 30	12 - 35	15 - 40	35 - 65	EASILY PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
DENSE	30 - 50	35 - 60	40 - 70	65 - 85	DIFFICULT TO PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
VERY DENSE	>50	>60	>70	85 - 100	PENETRATED ONLY A FEW INCHES WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER

CONSISTENCY - FINE-GRAINED SOIL

CONSISTENCY	SPT (blows/ft)	TORVANE UNTRAINED SHEAR STRENGTH (tsf)	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH (tsf)	FIELD TEST
VERY SOFT	<2	<0.125	<0.25	EASILY PENETRATED SEVERAL INCHES BY THUMB. EXUDES BETWEEN THUMB AND FINGERS WHEN SQUEEZED BY HAND.
SOFT	2 - 4	0.125 - 0.25	0.25 - 0.5	EASILY PENETRATED ONE INCH BY THUMB. MOLDED BY LIGHT FINGER PRESSURE.
MEDIUM STIFF	4 - 8	0.25 - 0.5	0.5 - 1.0	PENETRATED OVER 1/2 INCH BY THUMB WITH MODERATE EFFORT. MOLDED BY STRONG FINGER PRESSURE.
STIFF	8 - 15	0.5 - 1.0	1.0 - 2.0	INDENTED ABOUT 1/2 INCH BY THUMB BUT PENETRATED ONLY WITH GREAT EFFORT.
VERY STIFF	15 - 30	1.0 - 2.0	2.0 - 4.0	READILY INDENTED BY THUMBNAIL.
HARD	>30	>2.0	>4.0	INDENTED WITH DIFFICULTY BY THUMBNAIL.

IGES

Project Number 01747-002

Figure A-10

APPENDIX B

SUMMARY OF LABORATORY TEST RESULTS TABLE

West Side Reservoir - Landslide Evaluation (South Weber, UT) Project Number: 01747-002

Sample Location ID	Station (ft)	Depth (ft)	Dry Density (pcf)	Water Content (%)	% Gravel >#4 & <3"	% Sand >#200 & <#4	% Fines <#200	Liquid Limit	PI	Direct Shear (c) (psf)	Direct Shear ϕ' (degrees)
BH-1		19.5						31	13		
BH-1		30			0	99.6	0.4				
BH-1		37			0	49.1	50.9				
BH-2		20	126.2	2.8							
BH-2		30	103.8	22			84.0	41	21	0	39
BH-2		35						36	17		
BH-2		36	94.4	28.8							
BH-2		46	100.8	24				37	20		
BH-3		27		20.6			84.4	38	21		
BH-3		33.5		17.52			70.5				
BH-4		15		15.8			74.6	28	11		
BH-4		27.5		22.0			37.9	NP	NP		
BH-4		43		22.29			92.6	35	16		
BH-5		10	106.3	10.7							
BH-5		21		27.1							
BH-5		26		26.2							
BH-5		30						41	22		
BH-5		36	104.5	21						354	33
BH-5		46		23.7							
BH-5		51		27.9							
TR-1	4	3			52.1	38.3	9.6				
TR-1	7	6			0	3.7	96.3				
TR-1	14	9						46	25		
TR-1	45	9			0.2	29.9	69.9				
TR-1	90	11			63.9	33.9	2.2				
TR-1	107	6			0	65.8	34.2				
TR-1	118	7			0	21.7	78.3	29	13		
TR-1	125	7					71.0				
TR-1	131	6						33	14		
TR-1	165	11			49.6	48.7	1.7				
TR-2	20	8			0.5	13.6	85.9				
TR-2	45	10			64.6	33.2	2.2				
TR-2	80	8			0.5	7.4	92.1				
TR-3	35	4			2.3	61.6	36.1				
TR-3	46	5			0	58.3	41.7				
TR-3	62	8			67.8	29.6	2.6				
TR-3	71	8.5			7.1	89.7	3.2				

Water Content and Unit Weight of Soil

(In General Accordance with ASTM D7263 Method B and D2216)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 12/29/2016
By: BSS

Sample Info.	Boring No.	BH-2	BH-2	BH-5	BH-5	BH-5	BH-5	BH-5	BH-2
	Sample:								
	Depth:	36.0'	46.0'	10.0'	21.0'	26.0'	46.0'	51.0'	20.0'
Unit Weight Info.	Sample height, H (in)	6.000	5.000	6.000	5.000	5.000	5.000	5.000	5.150
	Sample diameter, D (in)	2.416	2.416	2.416	2.416	2.416	2.416	2.416	2.416
	Sample volume, V (ft^3)	0.0159	0.0133	0.0159	0.0133	0.0133	0.0133	0.0133	0.0137
	Mass rings + wet soil (g)	1142.30	974.13	1114.32	960.43	966.50	955.88	962.75	1764.82
	Mass rings/tare (g)	264.30	222.09	264.63	218.25	224.35	221.14	217.81	960.90
	Moist soil, Ws (g)	878.00	752.04	849.69	742.18	742.15	734.74	744.94	803.92
	Moist unit wt., γ_m (pcf)	121.60	124.99	117.68	123.35	123.34	122.11	123.81	129.72
Water Content	Wet soil + tare (g)	627.87	505.03	478.81	480.08	498.39	474.33	486.94	1024.53
	Dry soil + tare (g)	516.04	432.10	444.54	403.39	415.80	407.91	408.00	1003.15
	Tare (g)	128.00	127.87	123.30	120.89	123.44	127.08	124.77	227.27
	Water Content, w (%)	**28.8**	**24.0**	**10.7**	**27.1**	**28.2**	**23.7**	**27.9**	**2.8**
	Dry Unit Wt., γ_d (pcf)	**94.4**	**100.8**	**106.3**	**97.0**	**96.2**	**98.8**	**96.8**	**126.2**

Comments:

Specimen changed from DSCD to M&D

Entered by:___________

Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: DKS

Boring No.: BH-1
Station:
Depth: 19.5'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

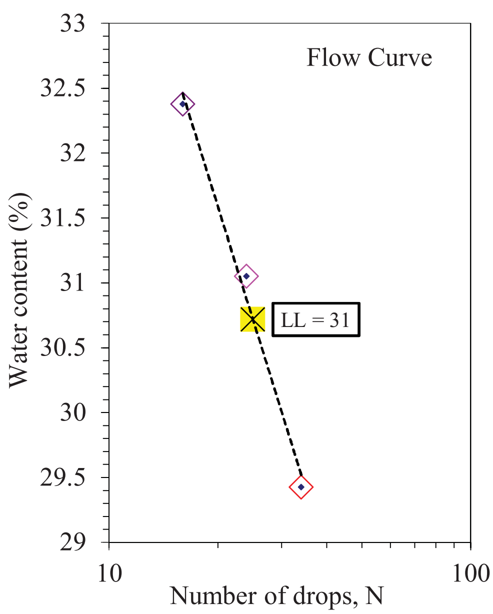
Plastic Limit

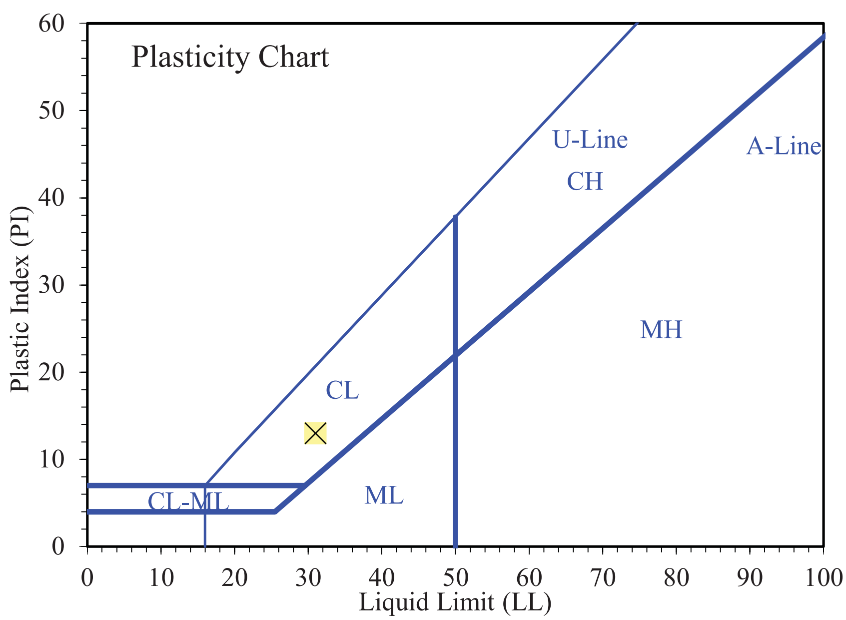
Determination No	1	2				
Wet Soil + Tare (g)	32.78	33.07				
Dry Soil + Tare (g)	31.09	31.37				
Water Loss (g)	1.69	1.70				
Tare (g)	21.81	21.95				
Dry Soil (g)	9.28	9.42				
Water Content, w (%)	18.21	18.05				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	24	16			
Wet Soil + Tare (g)	32.45	32.81	32.88			
Dry Soil + Tare (g)	29.94	30.27	30.17			
Water Loss (g)	2.51	2.54	2.71			
Tare (g)	21.41	22.09	21.80			
Dry Soil (g)	8.53	8.18	8.37			
Water Content, w (%)	29.43	31.05	32.38			
One-Point LL (%)		31				

Liquid Limit, LL (%)	**31**
Plastic Limit, PL (%)	**18**
Plasticity Index, PI (%)	**13**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]1

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

© IGES 2004, 2017

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 12/30/2016
By: DKS

Boring No.: BH-2
Station:
Depth: 30.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

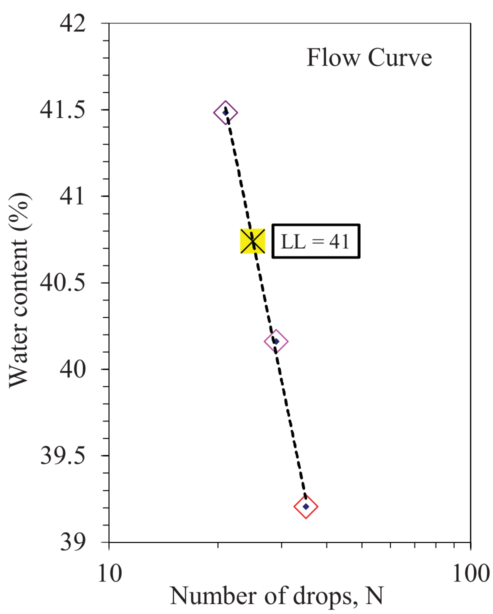
Plastic Limit

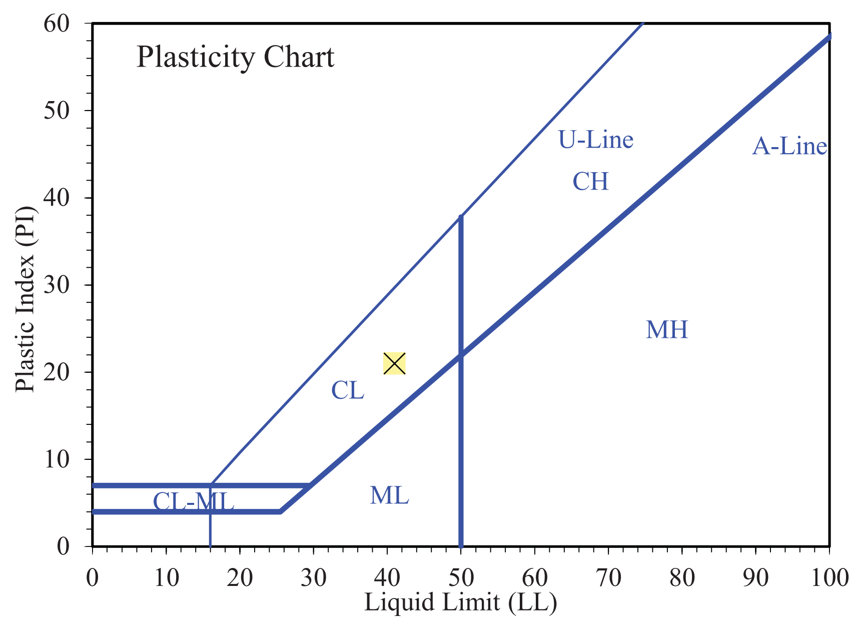
Determination No	1	2				
Wet Soil + Tare (g)	31.43	33.69				
Dry Soil + Tare (g)	29.75	31.79				
Water Loss (g)	1.68	1.90				
Tare (g)	21.28	22.07				
Dry Soil (g)	8.47	9.72				
Water Content, w (%)	19.83	19.55				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	29	21			
Wet Soil + Tare (g)	30.83	32.45	32.35			
Dry Soil + Tare (g)	28.36	29.45	29.33			
Water Loss (g)	2.47	3.00	3.02			
Tare (g)	22.06	21.98	22.05			
Dry Soil (g)	6.30	7.47	7.28			
Water Content, w (%)	39.21	40.16	41.48			
One-Point LL (%)		41	41			

Liquid Limit, LL (%)	**41**
Plastic Limit, PL (%)	**20**
Plasticity Index, PI (%)	**21**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]2

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 12/30/2016
By: DKS

Boring No.: BH-2
Station:
Depth: 35.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

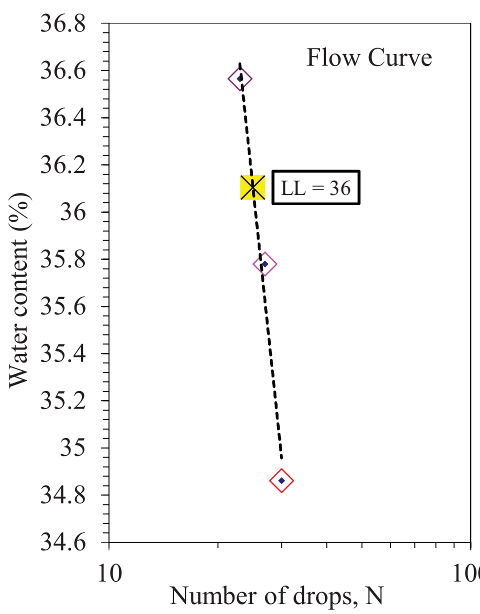
Plastic Limit

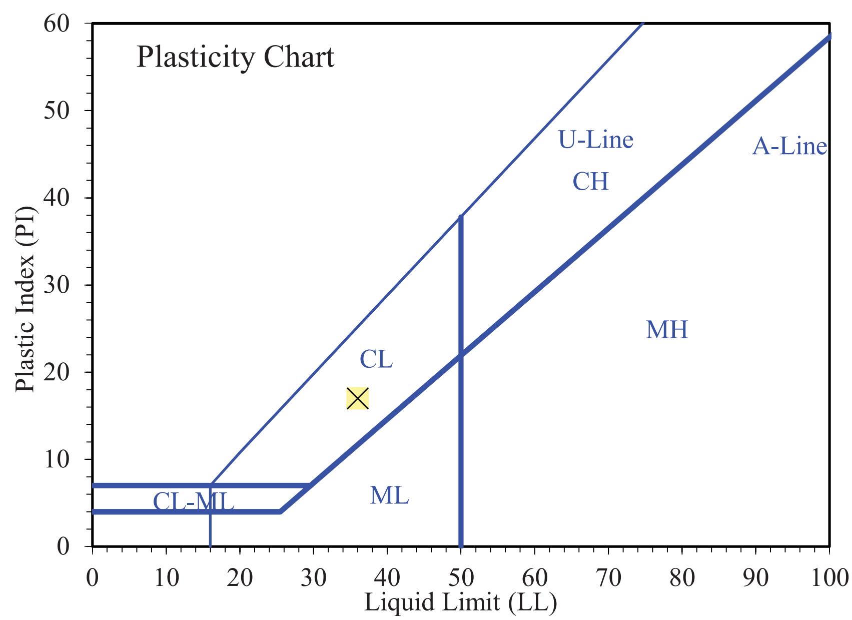
Determination No	1	2				
Wet Soil + Tare (g)	31.56	34.33				
Dry Soil + Tare (g)	29.94	32.30				
Water Loss (g)	1.62	2.03				
Tare (g)	21.52	21.78				
Dry Soil (g)	8.42	10.52				
Water Content, w (%)	19.24	19.30				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	30	27	23			
Wet Soil + Tare (g)	33.28	32.22	33.67			
Dry Soil + Tare (g)	30.39	29.49	30.54			
Water Loss (g)	2.89	2.73	3.13			
Tare (g)	22.10	21.86	21.98			
Dry Soil (g)	8.29	7.63	8.56			
Water Content, w (%)	34.86	35.78	36.57			
One-Point LL (%)	36	36	36			

Liquid Limit, LL (%)	**36**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**17**





Entered by:___________
Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/6/2017
By: BRR

Boring No.: BH-2
Station:
Depth: 46.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

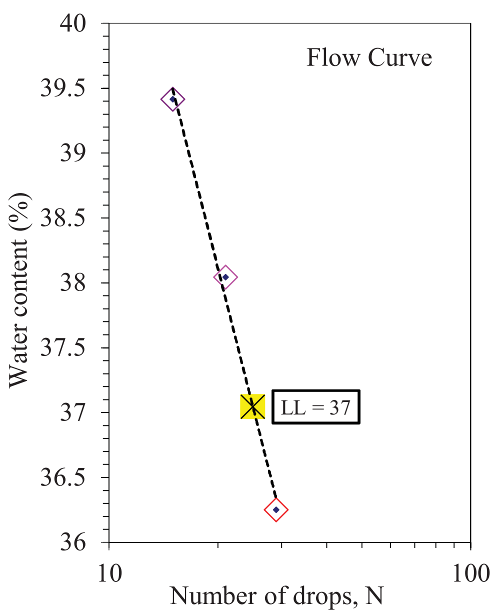
Plastic Limit

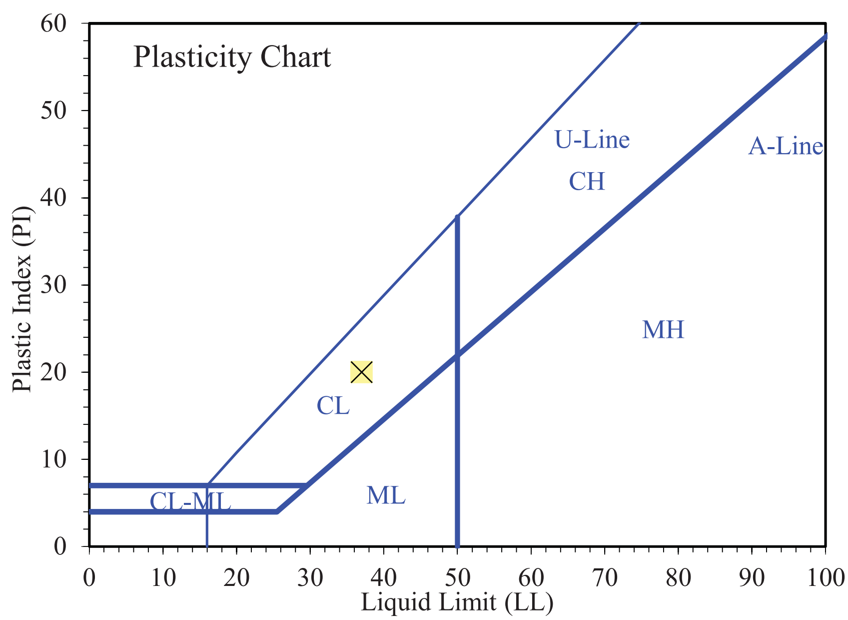
Determination No	1	2				
Wet Soil + Tare (g)	27.80	28.03				
Dry Soil + Tare (g)	26.92	27.13				
Water Loss (g)	0.88	0.90				
Tare (g)	21.60	21.83				
Dry Soil (g)	5.32	5.30				
Water Content, w (%)	16.54	16.98				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	29	21	15			
Wet Soil + Tare (g)	31.53	30.58	32.46			
Dry Soil + Tare (g)	28.92	28.13	29.50			
Water Loss (g)	2.61	2.45	2.96			
Tare (g)	21.72	21.69	21.99			
Dry Soil (g)	7.20	6.44	7.51			
Water Content, w (%)	36.25	38.04	39.41			
One-Point LL (%)	37	37				

Liquid Limit, LL (%)	**37**
Plastic Limit, PL (%)	**17**
Plasticity Index, PI (%)	**20**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]4

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/9/2017
By: BRR

Boring No.: BH-3
Station:
Depth: 27.0'
Description: Reddish brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

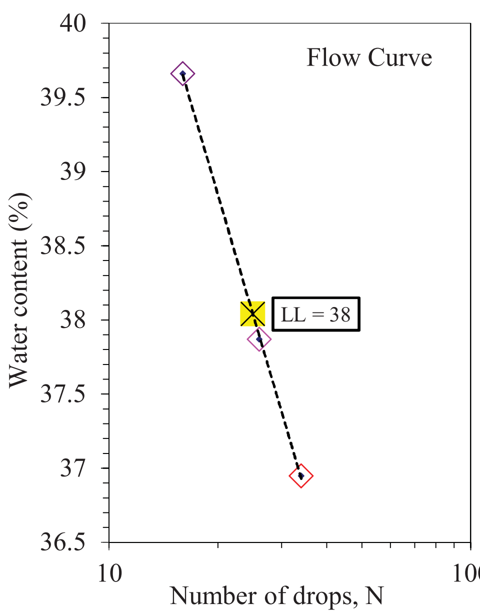
Plastic Limit

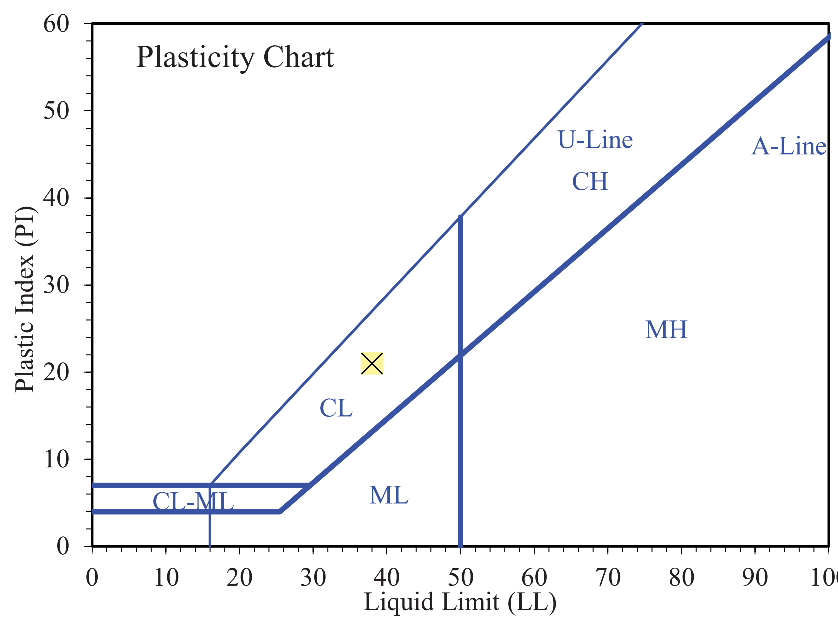
Determination No	1	2				
Wet Soil + Tare (g)	27.57	29.54				
Dry Soil + Tare (g)	26.66	28.41				
Water Loss (g)	0.91	1.13				
Tare (g)	21.43	21.84				
Dry Soil (g)	5.23	6.57				
Water Content, w (%)	17.40	17.20				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	26	16			
Wet Soil + Tare (g)	29.59	30.32	30.49			
Dry Soil + Tare (g)	27.58	28.01	28.15			
Water Loss (g)	2.01	2.31	2.34			
Tare (g)	22.14	21.91	22.25			
Dry Soil (g)	5.44	6.10	5.90			
Water Content, w (%)	36.95	37.87	39.66			
One-Point LL (%)		38				

Liquid Limit, LL (%)	**38**
Plastic Limit, PL (%)	**17**
Plasticity Index, PI (%)	**21**





Entered by:____________
Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/9/2017
By: BRR

Boring No.: BH-4
Station:
Depth: 15.0'
Description: Reddish brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

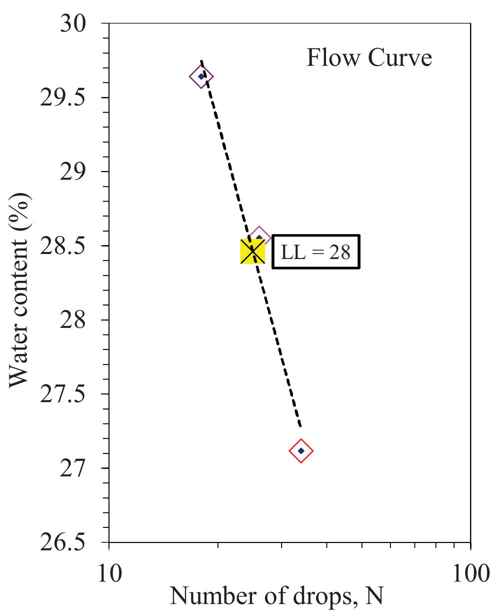
Plastic Limit

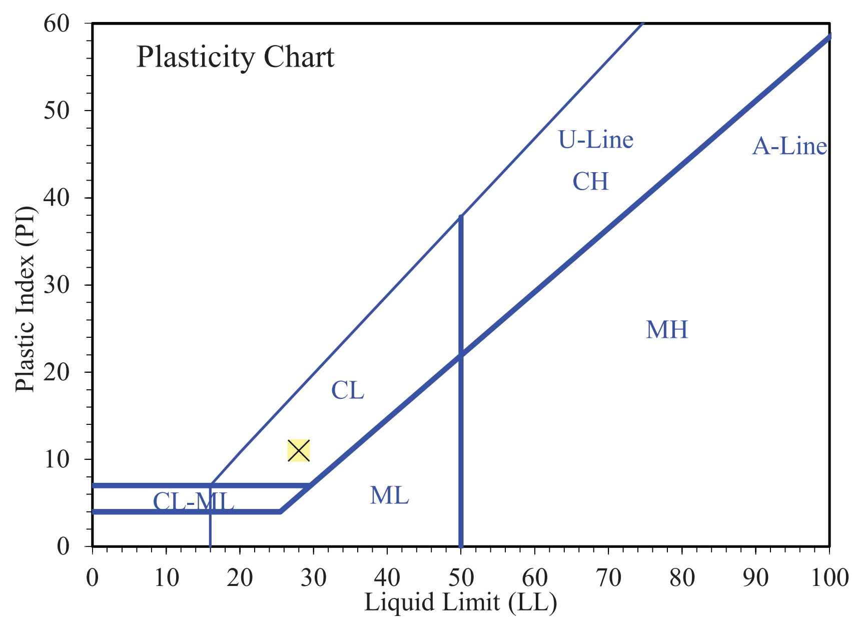
Determination No	1	2				
Wet Soil + Tare (g)	28.95	28.10				
Dry Soil + Tare (g)	27.91	27.18				
Water Loss (g)	1.04	0.92				
Tare (g)	21.77	21.71				
Dry Soil (g)	6.14	5.47				
Water Content, w (%)	16.94	16.82				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	26	18			
Wet Soil + Tare (g)	30.63	31.19	30.33			
Dry Soil + Tare (g)	28.74	29.14	28.43			
Water Loss (g)	1.89	2.05	1.90			
Tare (g)	21.77	21.96	22.02			
Dry Soil (g)	6.97	7.18	6.41			
Water Content, w (%)	27.12	28.55	29.64			
One-Point LL (%)		29				

Liquid Limit, LL (%)	**28**
Plastic Limit, PL (%)	**17**
Plasticity Index, PI (%)	**11**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]6

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: DKS

Boring No.: BH-4
Station:
Depth: 27.5'
Description: Brown silt

Preparation method: Wet
Liquid Limit: Could not be determined (N.P.)

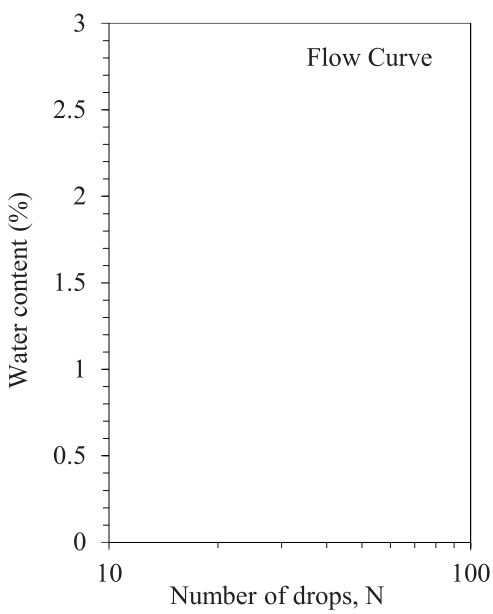
Plastic Limit

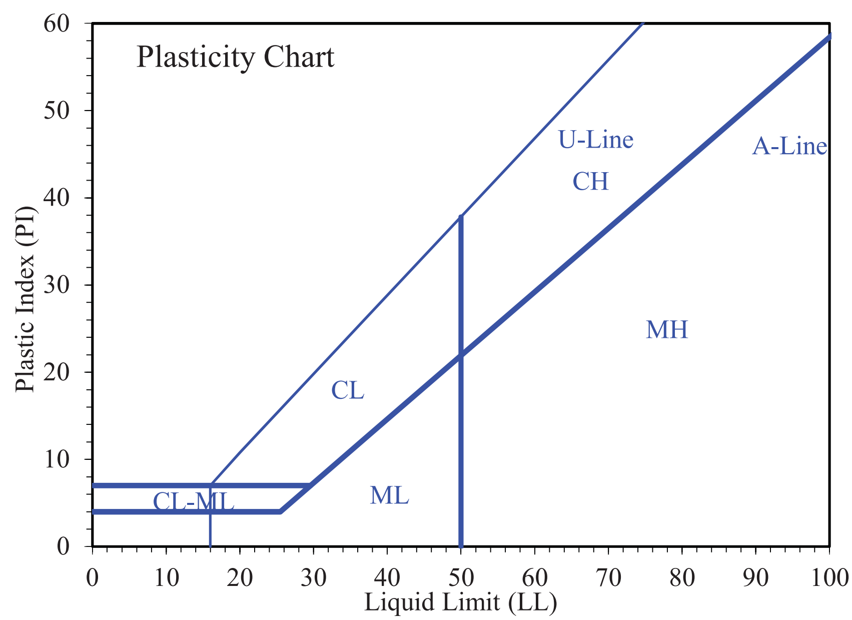
Determination No						
Wet Soil + Tare (g)						
Dry Soil + Tare (g)		Difficult to thread.				
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						

Liquid Limit: Could not be determined (N.P.)

Determination No						
Number of Drops, N						
Wet Soil + Tare (g)	Unable to obtain an adequate blow count.					
Dry Soil + Tare (g)						
Water Loss (g)						
Tare (g)						
Dry Soil (g)						
Water Content, w (%)						
One-Point LL (%)						

Liquid Limit, LL (%)	**Nonplastic (N.P.)**
Plastic Limit, PL (%)	
Plasticity Index, PI (%)	





Entered by:____________
Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

© IGES 2004, 2017

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: DKS

Boring No.: BH-4
Station:
Depth: 43.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

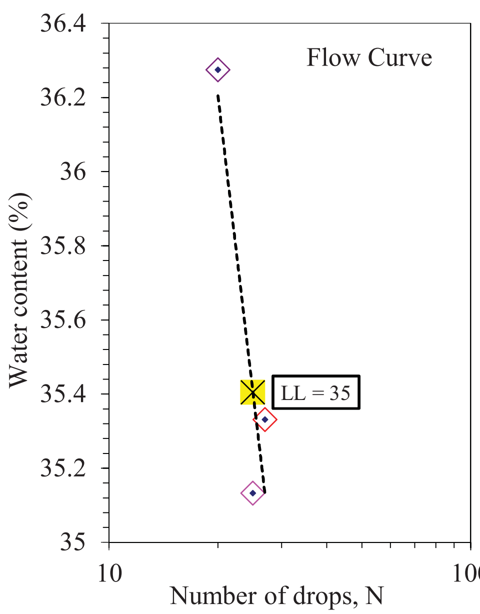
Plastic Limit

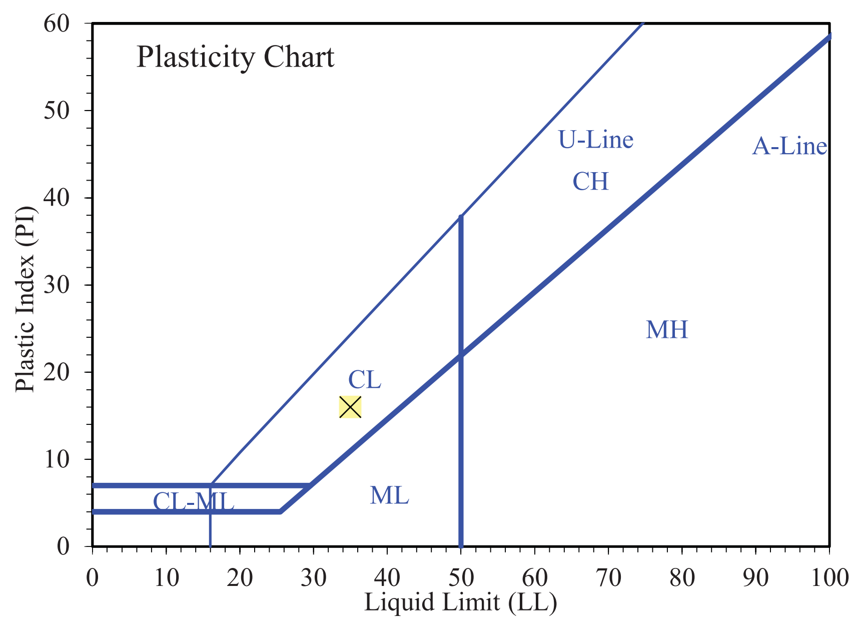
Determination No	1	2				
Wet Soil + Tare (g)	32.20	30.38				
Dry Soil + Tare (g)	30.60	28.97				
Water Loss (g)	1.60	1.41				
Tare (g)	22.05	21.45				
Dry Soil (g)	8.55	7.52				
Water Content, w (%)	18.71	18.75				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	27	25	20			
Wet Soil + Tare (g)	34.90	35.95	34.74			
Dry Soil + Tare (g)	31.54	32.37	31.41			
Water Loss (g)	3.36	3.58	3.33			
Tare (g)	22.03	22.18	22.23			
Dry Soil (g)	9.51	10.19	9.18			
Water Content, w (%)	35.33	35.13	36.27			
One-Point LL (%)	36	35	35			

Liquid Limit, LL (%)	**35**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**16**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]8

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/6/2017
By: BRR

Boring No.: BH-5
Station:
Depth: 30.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

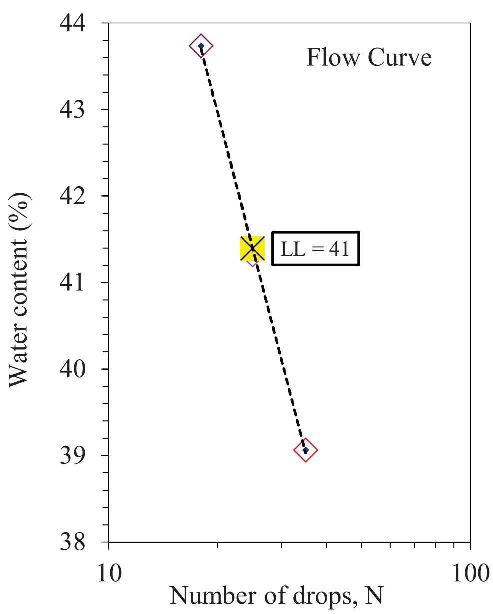
Plastic Limit

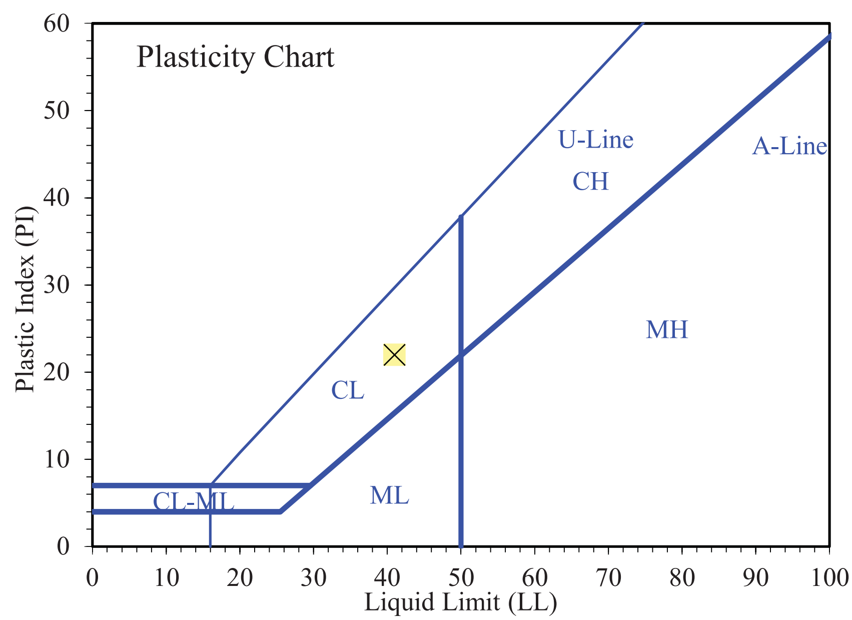
Determination No	1	2				
Wet Soil + Tare (g)	29.19	28.98				
Dry Soil + Tare (g)	28.06	27.79				
Water Loss (g)	1.13	1.19				
Tare (g)	22.11	21.58				
Dry Soil (g)	5.95	6.21				
Water Content, w (%)	18.99	19.16				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	35	25	18			
Wet Soil + Tare (g)	27.99	31.09	29.22			
Dry Soil + Tare (g)	26.15	28.40	27.02			
Water Loss (g)	1.84	2.69	2.20			
Tare (g)	21.44	21.89	21.99			
Dry Soil (g)	4.71	6.51	5.03			
Water Content, w (%)	39.07	41.32	43.74			
One-Point LL (%)		41				

Liquid Limit, LL (%)	**41**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**22**





Entered by:____________
Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: DKS

Boring No.: TR-1
Station: 131'
Depth: 6.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

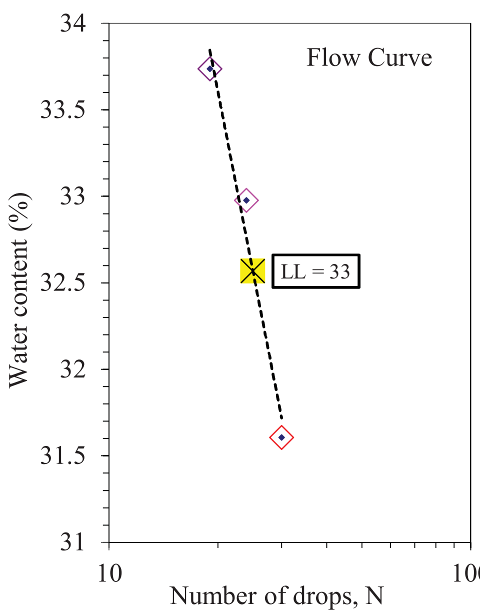
Plastic Limit

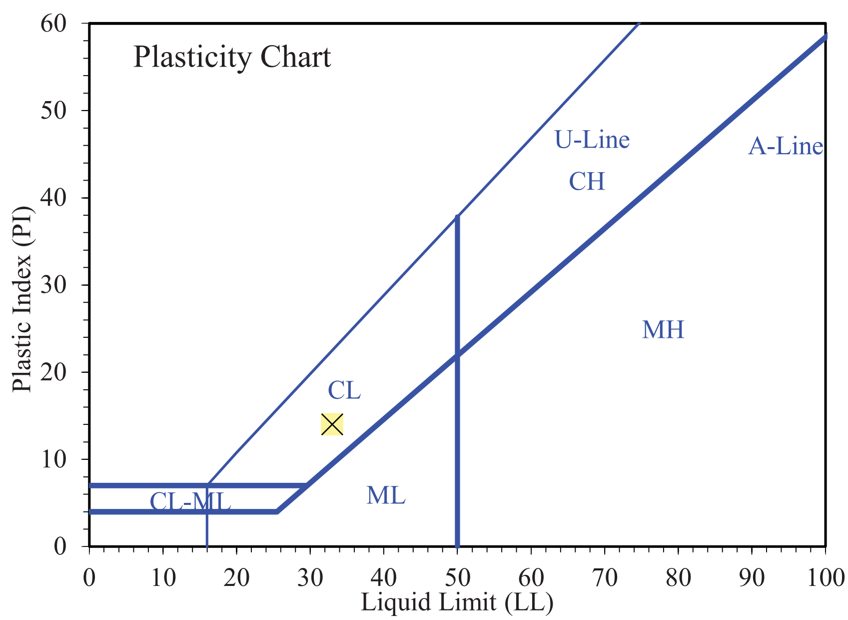
Determination No	1	2				
Wet Soil + Tare (g)	33.56	33.05				
Dry Soil + Tare (g)	31.74	31.20				
Water Loss (g)	1.82	1.85				
Tare (g)	21.97	21.15				
Dry Soil (g)	9.77	10.05				
Water Content, w (%)	18.63	18.41				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	30	24	19			
Wet Soil + Tare (g)	34.84	35.90	33.19			
Dry Soil + Tare (g)	31.79	32.50	30.41			
Water Loss (g)	3.05	3.40	2.78			
Tare (g)	22.14	22.19	22.17			
Dry Soil (g)	9.65	10.31	8.24			
Water Content, w (%)	31.61	32.98	33.74			
One-Point LL (%)	32	33				

Liquid Limit, LL (%)	**33**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**14**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]10

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: DKS

Boring No.: TR-1
Station: 118'
Depth: 7.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

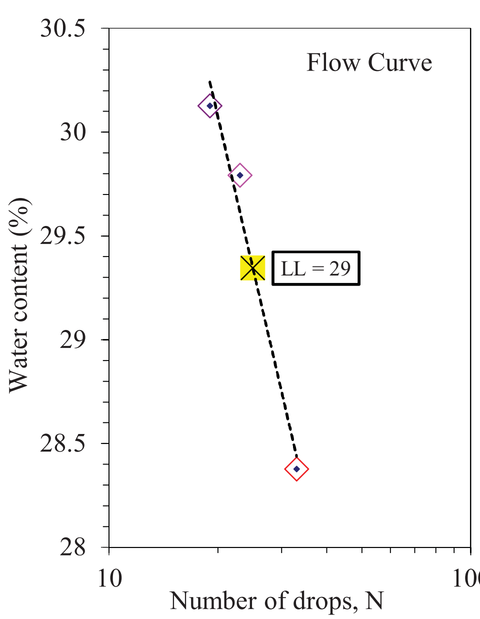
Plastic Limit

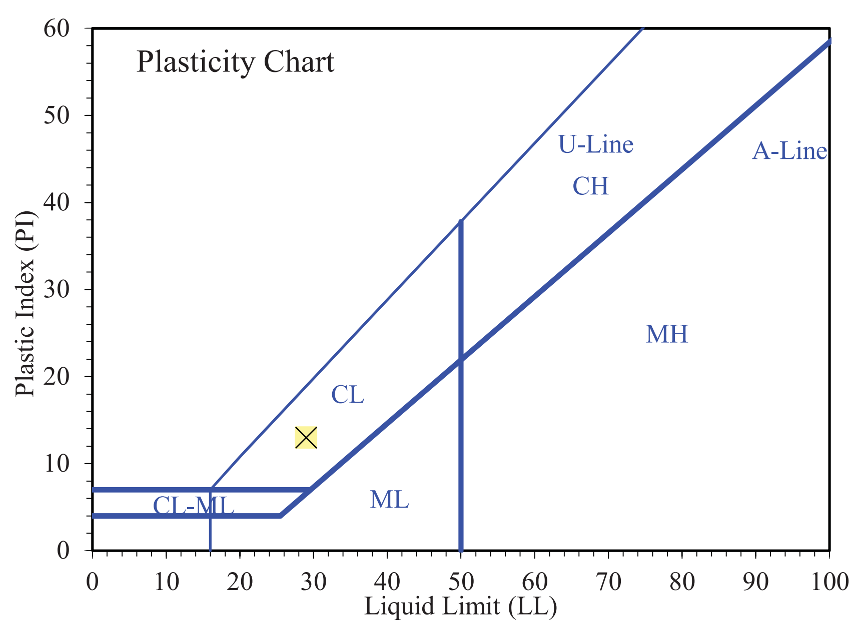
Determination No	1	2				
Wet Soil + Tare (g)	32.26	32.88				
Dry Soil + Tare (g)	30.80	31.35				
Water Loss (g)	1.46	1.53				
Tare (g)	21.71	21.78				
Dry Soil (g)	9.09	9.57				
Water Content, w (%)	16.06	15.99				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	33	23	19			
Wet Soil + Tare (g)	35.17	32.23	34.37			
Dry Soil + Tare (g)	32.25	29.79	31.52			
Water Loss (g)	2.92	2.44	2.85			
Tare (g)	21.96	21.60	22.06			
Dry Soil (g)	10.29	8.19	9.46			
Water Content, w (%)	28.38	29.79	30.13			
One-Point LL (%)		29				

Liquid Limit, LL (%)	**29**
Plastic Limit, PL (%)	**16**
Plasticity Index, PI (%)	**13**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]11

Liquid Limit, Plastic Limit, and Plasticity Index of Soils
(ASTM D4318)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/6/2017
By: DKS

Boring No.: TR-1
Station: 14'
Depth: 9.0'
Description: Brown lean clay

Preparation method: Wet
Liquid limit test method: Multipoint

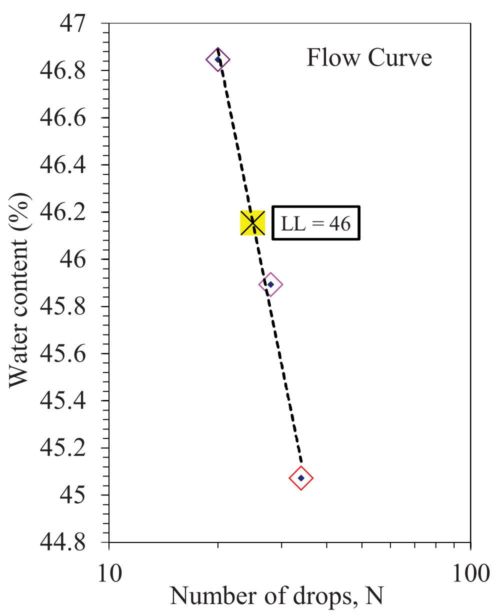
Plastic Limit

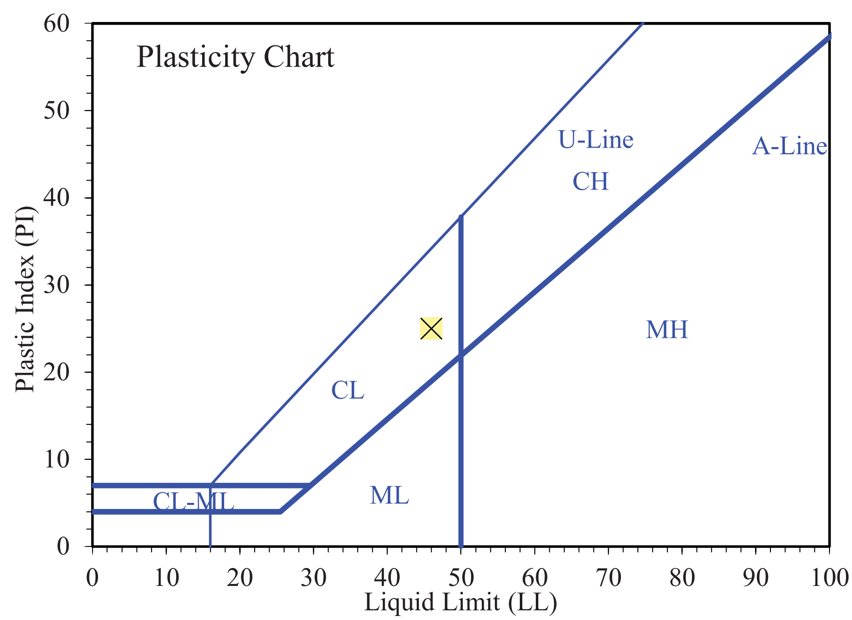
Determination No	1	2				
Wet Soil + Tare (g)	33.45	32.91				
Dry Soil + Tare (g)	31.37	31.06				
Water Loss (g)	2.08	1.85				
Tare (g)	21.43	22.29				
Dry Soil (g)	9.94	8.77				
Water Content, w (%)	20.93	21.09				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	34	28	20			
Wet Soil + Tare (g)	32.02	32.31	33.56			
Dry Soil + Tare (g)	28.91	29.07	29.92			
Water Loss (g)	3.11	3.24	3.64			
Tare (g)	22.01	22.01	22.15			
Dry Soil (g)	6.90	7.06	7.77			
Water Content, w (%)	45.07	45.89	46.85			
One-Point LL (%)		47	46			

Liquid Limit, LL (%)	**46**
Plastic Limit, PL (%)	**21**
Plasticity Index, PI (%)	**25**





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[ALv1.xlsm]12

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

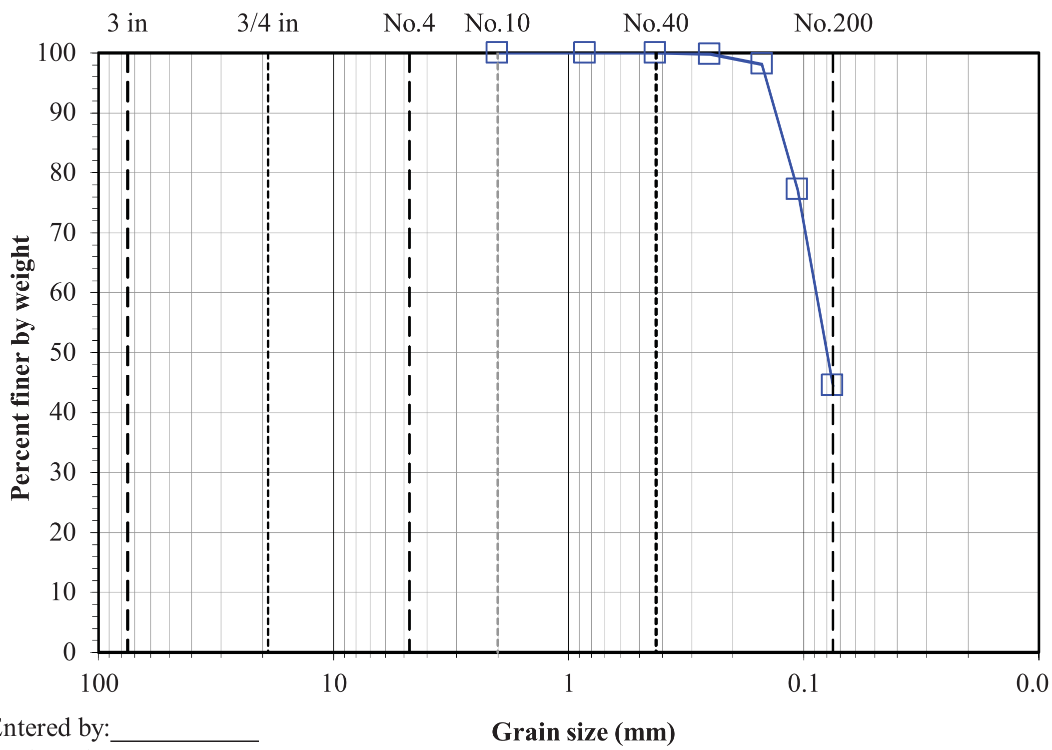
Boring No.: BH-1
Sample:
Depth: 30.0'
Description: Brown silty sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	161.94	142.30
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	435.18
Dry soil + tare (g):	-	415.54
Tare (g):	-	273.24
Water content (%):	0.0	13.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	-
No.10	-	2	100.0
No.20	0.02	0.85	100.0
No.40	0.04	0.425	100.0
No.60	0.34	0.25	99.8
No.100	2.68	0.15	98.1
No.140	32.53	0.106	77.1
No.200	78.96	0.075	44.5



Gravel (%): 0.0
Sand (%): 55.5
Fines (%): 44.5

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]1

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

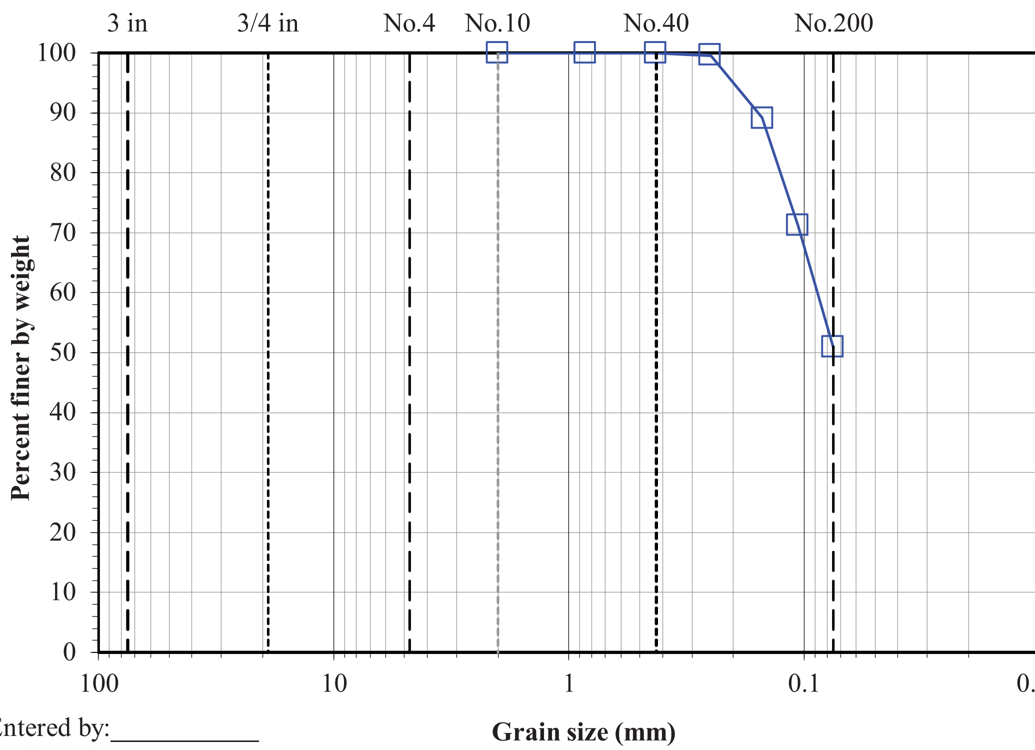
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: BH-1
Sample:
Depth: 37.0'
Description: Brown sandy silt

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	219.21	195.79
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	346.53
Dry soil + tare (g):	-	323.11
Tare (g):	-	127.32
Water content (%):	0.0	12.0

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	-
No.10	-	2	100.0
No.20	0.02	0.85	100.0
No.40	0.05	0.425	100.0
No.60	0.79	0.25	99.6
No.100	21.34	0.15	89.1
No.140	56.42	0.106	71.2
No.200	96.21	0.075	50.9



Gravel (%): 0.0
Sand (%): 49.1
Fines (%): 50.9

Entered by:___________
Reviewed:___________

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

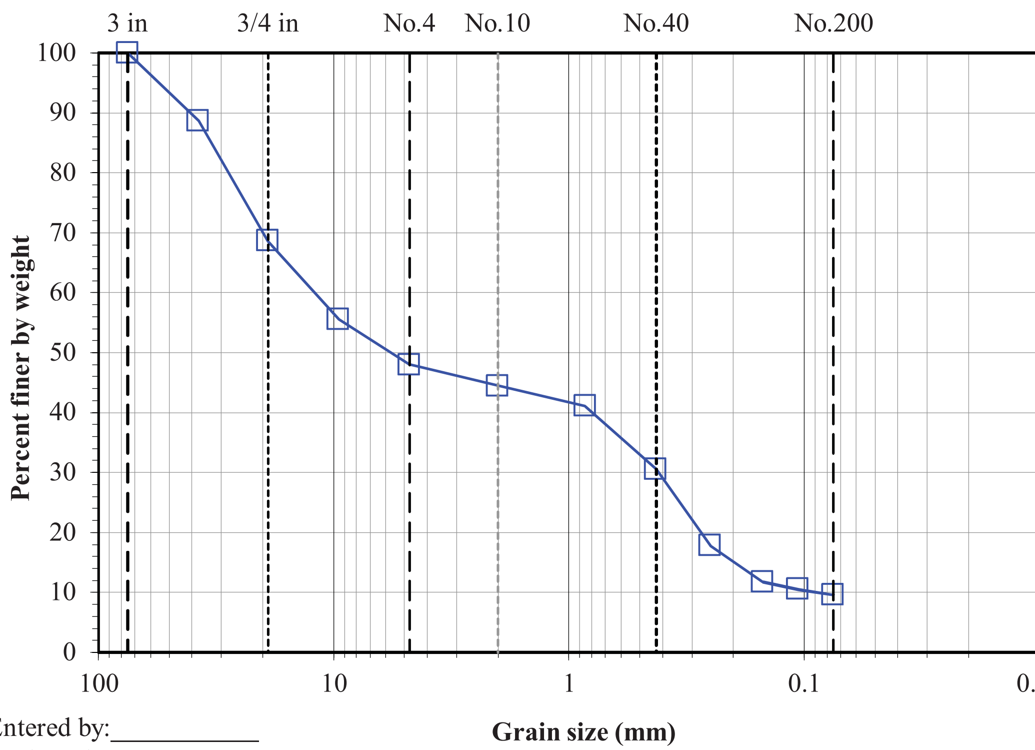
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-1
Station: 4'
Depth: 3.0'
Description: Brown gravel with silt and sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	3923.90	3746.15
+3/8" Coarse fraction (g):	1691.50	1666.88
-3/8" Split fraction (g):	264.74	246.58
Split fraction:	0.555	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	2100.05	486.76
Dry soil + tare (g):	2075.43	468.60
Tare (g):	408.55	222.02
Water content (%):	1.5	7.4

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	100.0
1.5"	424.53	37.5	88.7
3/4"	1175.14	19	68.6
3/8"	1666.88	9.5	55.5 ←Split
No.4	33.65	4.75	47.9
No.10	49.37	2	44.4
No.20	64.31	0.85	41.0
No.40	111.03	0.425	30.5
No.60	167.66	0.25	17.8
No.100	194.55	0.15	11.7
No.140	200.01	0.106	10.5
No.200	204.06	0.075	9.6



Gravel (%): 52.1
Sand (%): 38.4
Fines (%): 9.6

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]3

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

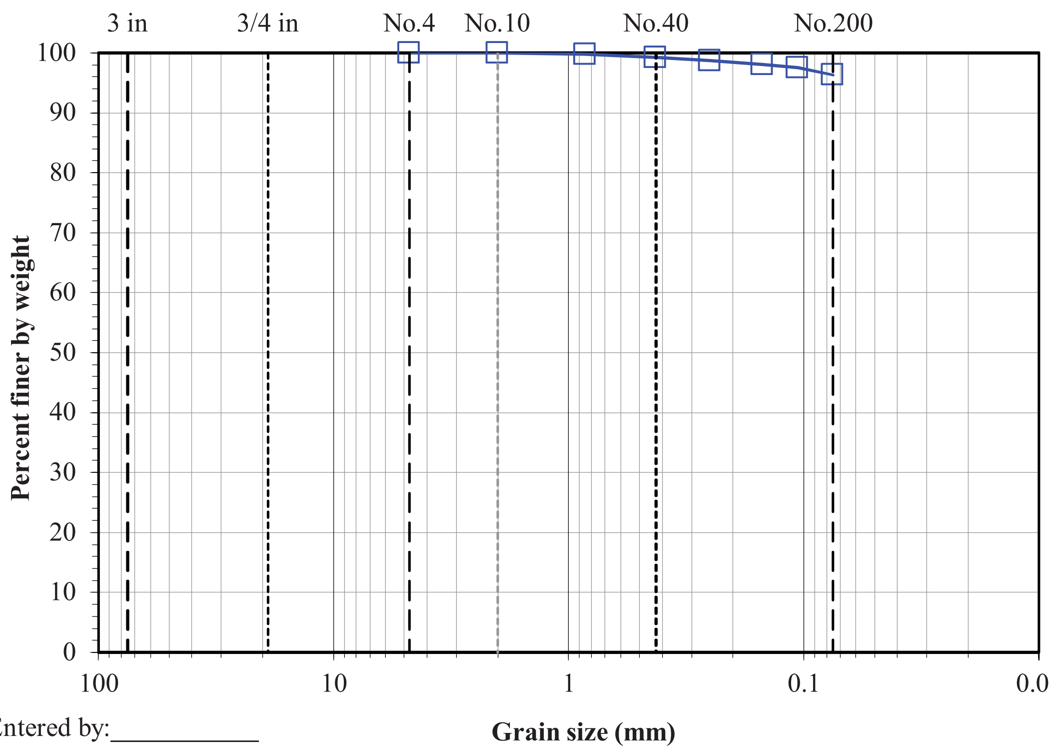
Boring No.: TR-1
Station: 7'
Depth: 6.0'
Description: Brown clay

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	279.33	251.05
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	501.58
Dry soil + tare (g):	-	473.30
Tare (g):	-	222.25
Water content (%):	0.0	11.3

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	100.0
No.10	0.13	2	99.9
No.20	0.66	0.85	99.7
No.40	1.90	0.425	99.2
No.60	3.24	0.25	98.7
No.100	4.83	0.15	98.1
No.140	6.21	0.106	97.5
No.200	9.33	0.075	96.3



Gravel (%): 0.0
Sand (%): 3.7
Fines (%): 96.3

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]4

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

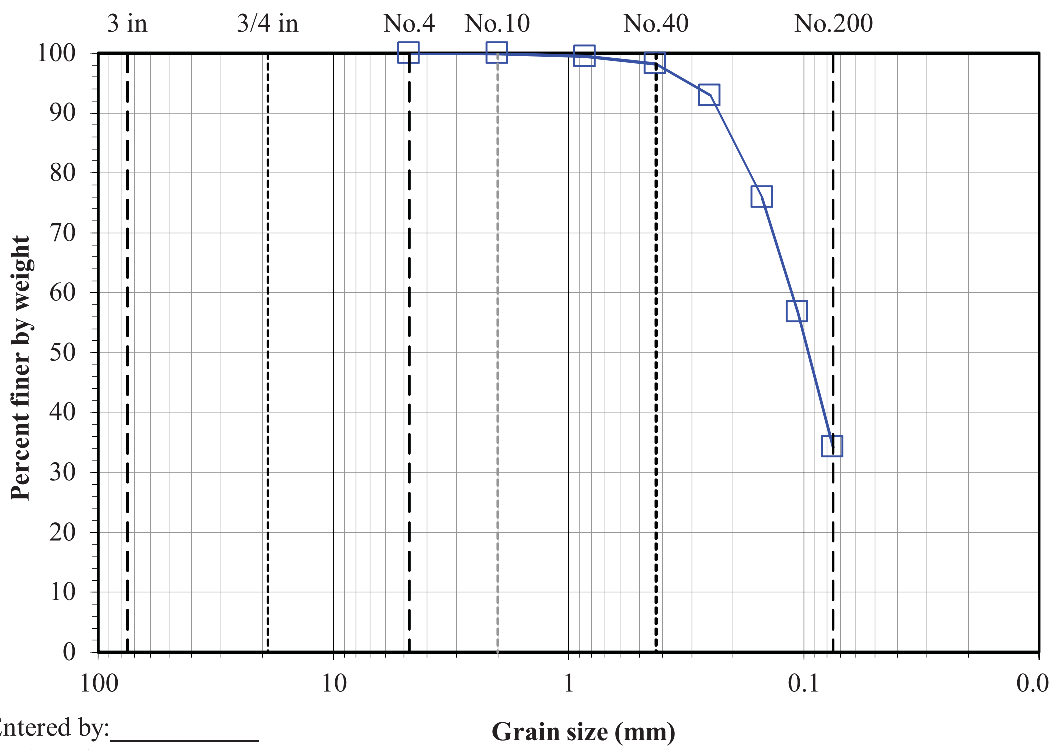
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-1
Station: 107'
Depth: 6.0'
Description: Light brown silty sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	276.65	268.59
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	492.01
Dry soil + tare (g):	-	483.95
Tare (g):	-	215.36
Water content (%):	0.0	3.0

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	100.0
No.10	0.28	2	99.9
No.20	1.49	0.85	99.4
No.40	4.78	0.425	98.2
No.60	18.95	0.25	92.9
No.100	64.76	0.15	75.9
No.140	116.16	0.106	56.8
No.200	176.63	0.075	34.2



Gravel (%): 0.0
Sand (%): 65.8
Fines (%): 34.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]5

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

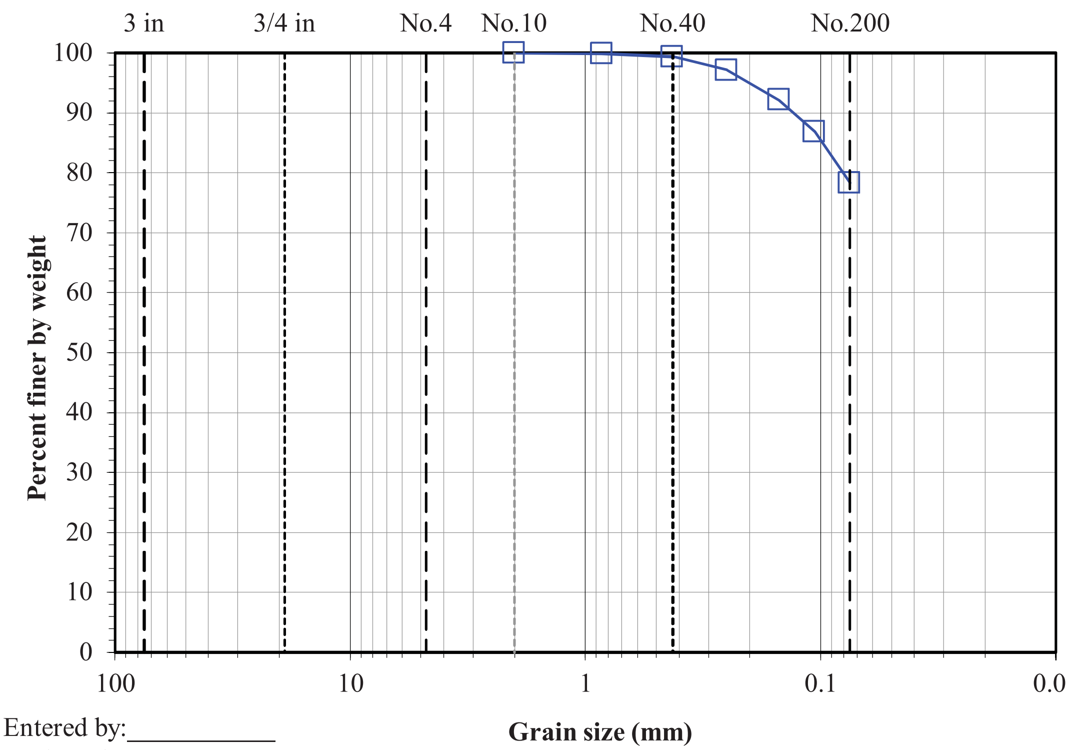
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-1
Station: 118'
Depth: 7.0'
Description: Light brown clay with sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	230.33	217.49
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	381.08
Dry soil + tare (g):	-	368.24
Tare (g):	-	150.75
Water content (%):	0.0	5.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	-
No.10	-	2	100.0
No.20	0.31	0.85	99.9
No.40	1.43	0.425	99.3
No.60	6.35	0.25	97.1
No.100	17.08	0.15	92.1
No.140	28.65	0.106	86.8
No.200	47.21	0.075	78.3



Gravel (%): 0.0
Sand (%): 21.7
Fines (%): 78.3

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]6

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

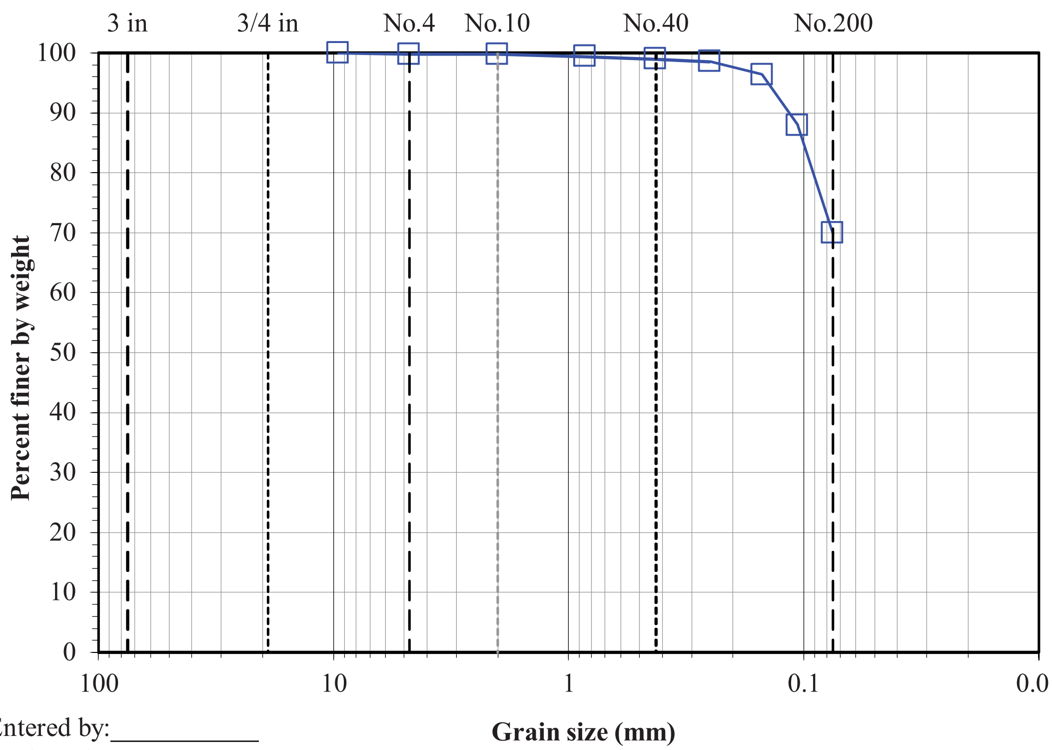
Boring No.: TR-1
Station: 45'
Depth: 9.0'
Description: Brown silt with sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	147.80	143.22
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	268.77
Dry soil + tare (g):	-	264.19
Tare (g):	-	120.97
Water content (%):	0.0	3.2

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	100.0
No.4	0.31	4.75	99.8
No.10	0.37	2	99.7
No.20	0.89	0.85	99.4
No.40	1.51	0.425	98.9
No.60	2.10	0.25	98.5
No.100	5.25	0.15	96.3
No.140	17.34	0.106	87.9
No.200	43.11	0.075	69.9



Gravel (%): 0.2
Sand (%): 29.9
Fines (%): 69.9

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]7

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

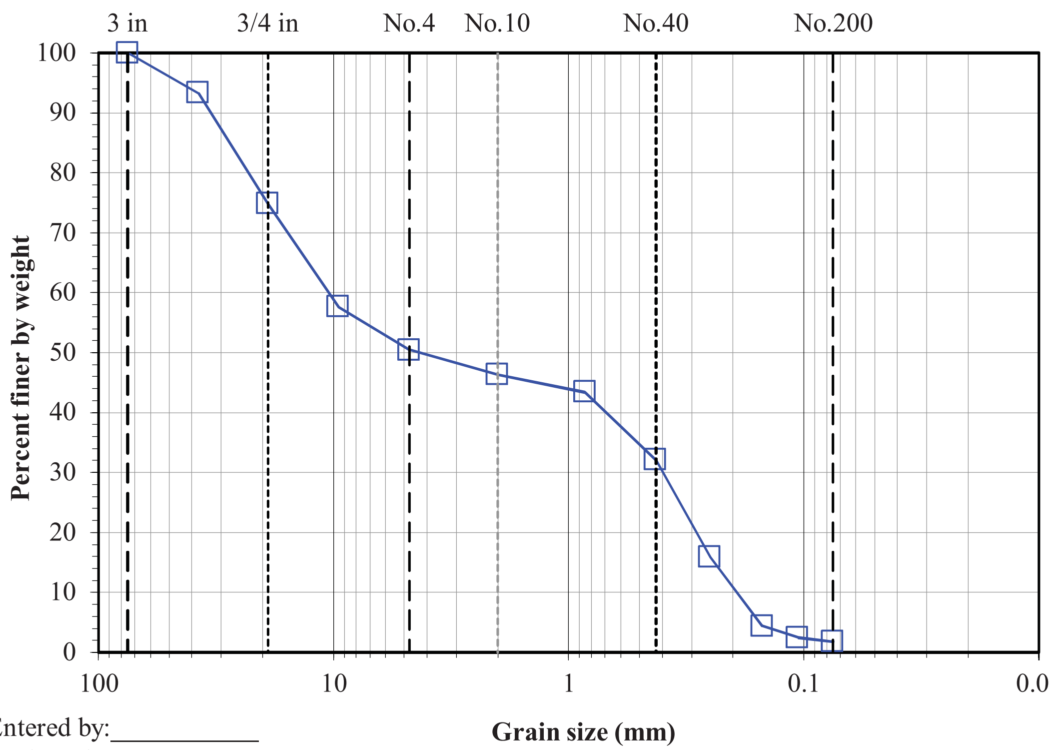
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/7/2017
By: BSS

Boring No.: TR-1
Station: 165'
Depth: 11.0'
Description: Brown gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	6289.41	6213.47
+3/8" Coarse fraction (g):	2654.01	2632.97
-3/8" Split fraction (g):	204.63	201.54
Split fraction:	0.576	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	3389.18	344.87
Dry soil + tare (g):	3368.14	341.78
Tare (g):	735.17	140.24
Water content (%):	0.8	1.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	415.08	37.5	93.3	
3/4"	1560.63	19	74.9	
3/8"	2632.97	9.5	57.6	←Split
No.4	25.34	4.75	50.4	
No.10	39.65	2	46.3	
No.20	49.70	0.85	43.4	
No.40	89.42	0.425	32.1	
No.60	146.22	0.25	15.8	
No.100	186.25	0.15	4.4	
No.140	193.07	0.106	2.4	
No.200	195.49	0.075	1.7	



Gravel (%): 49.6
Sand (%): 48.6
Fines (%): 1.7

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]8

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

© IGES 2004, 2017

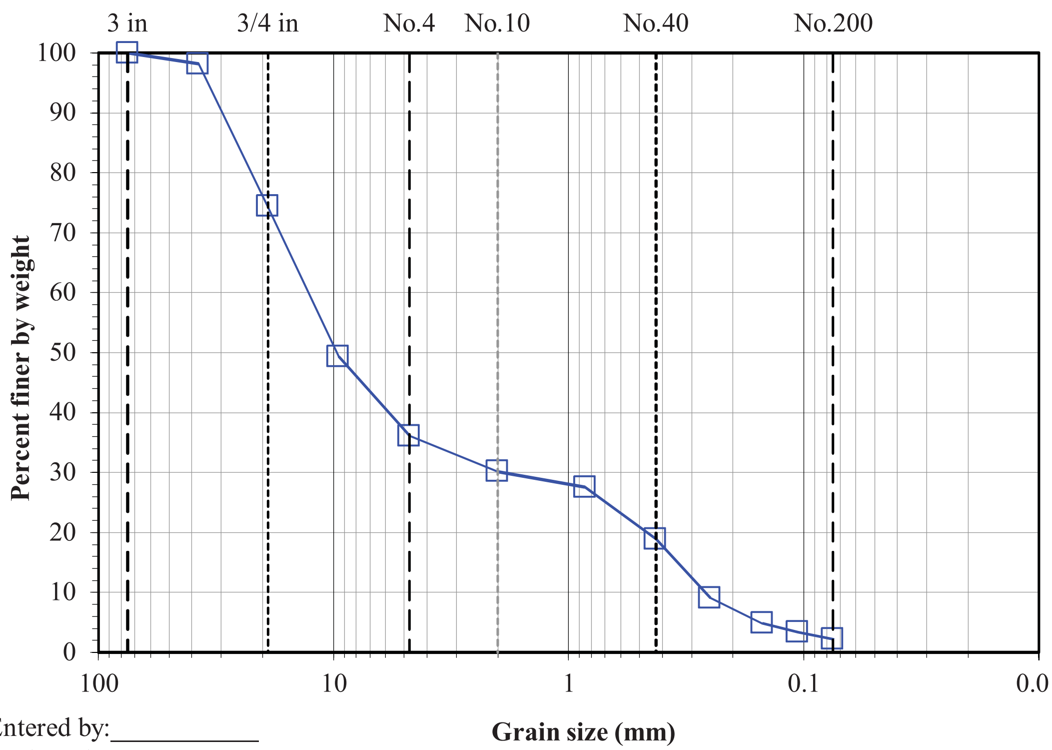
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/5/2017
By: BSS

Boring No.: TR-1
Station: 90'
Depth: 11.0'
Description: Brown gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	29970.50	29804.29
+3/8" Coarse fraction (g):	15157.30	15095.39
-3/8" Split fraction (g):	343.70	341.28
Split fraction:	0.494	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	4119.80	563.09
Dry soil + tare (g):	4105.88	560.67
Tare (g):	711.54	219.39
Water content (%):	0.4	0.7

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	546.66	37.5	98.2	
3/4"	7626.42	19	74.4	
3/8"	15095.39	9.5	49.4	←Split
No.4	91.67	4.75	36.1	
No.10	132.66	2	30.2	
No.20	150.69	0.85	27.6	
No.40	210.78	0.425	18.9	
No.60	278.85	0.25	9.0	
No.100	307.96	0.15	4.8	
No.140	318.26	0.106	3.3	
No.200	325.93	0.075	2.2	



Gravel (%): 63.9
Sand (%): 33.9
Fines (%): 2.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]9

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

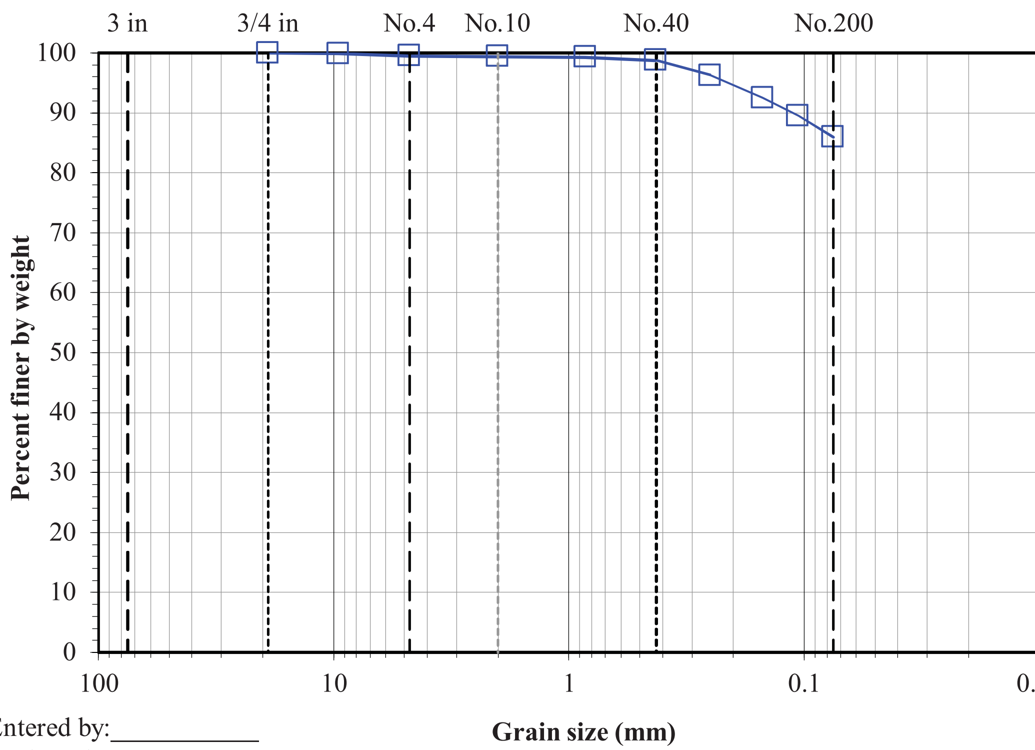
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-2
Station: 20'
Depth: 8.0'
Description: Brown silt

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	4102.61	3425.98
+3/8" Coarse fraction (g):	5.21	5.16
-3/8" Split fraction (g):	195.67	163.36
Split fraction:	0.998	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	133.44	322.50
Dry soil + tare (g):	133.39	290.19
Tare (g):	128.23	126.83
Water content (%):	1.0	19.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	-	
3/4"	-	19	100.0	
3/8"	5.16	9.5	99.8	←Split
No.4	0.56	4.75	99.5	
No.10	0.73	2	99.4	
No.20	0.97	0.85	99.3	
No.40	1.84	0.425	98.7	
No.60	5.92	0.25	96.2	
No.100	12.06	0.15	92.5	
No.140	16.97	0.106	89.5	
No.200	22.77	0.075	85.9	



Gravel (%): 0.5
Sand (%): 13.6
Fines (%): 85.9

Entered by:___________
Reviewed:___________

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

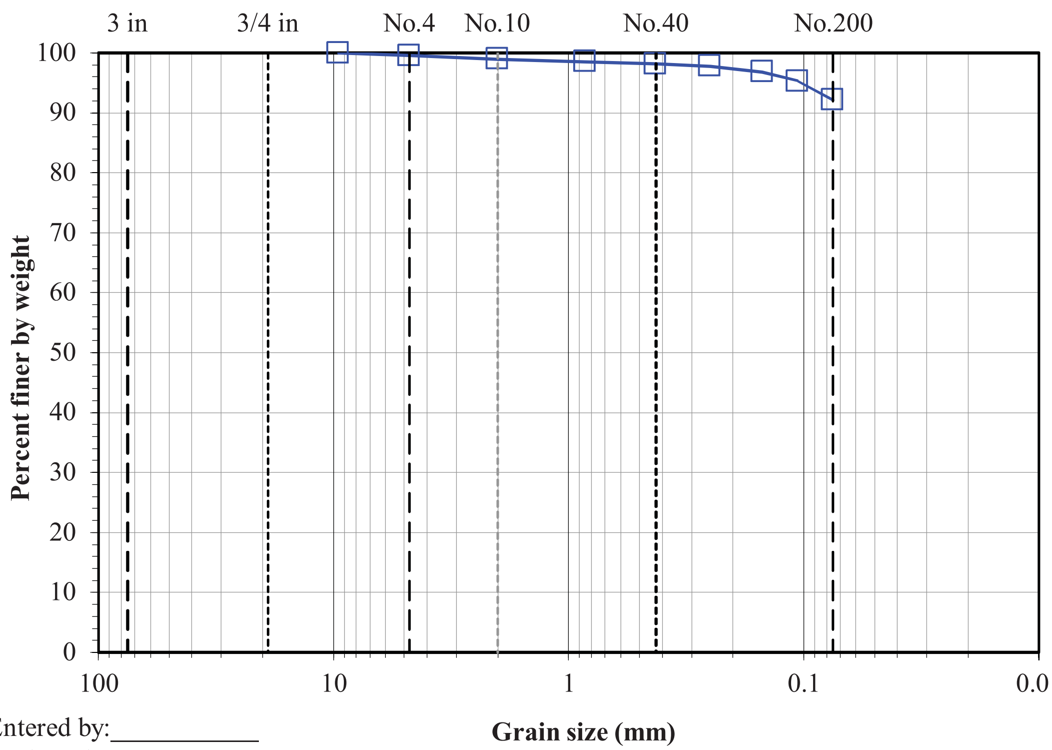
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-2
Station: 80'
Depth: 8.0'
Description: Light brown silt

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	199.84	190.57
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	321.55
Dry soil + tare (g):	-	312.28
Tare (g):	-	121.71
Water content (%):	0.0	4.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	100.0
No.4	0.86	4.75	99.5
No.10	2.01	2	98.9
No.20	2.82	0.85	98.5
No.40	3.49	0.425	98.2
No.60	4.24	0.25	97.8
No.100	6.04	0.15	96.8
No.140	9.00	0.106	95.3
No.200	15.03	0.075	92.1



Gravel (%): 0.5
Sand (%): 7.4
Fines (%): 92.1

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]11

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

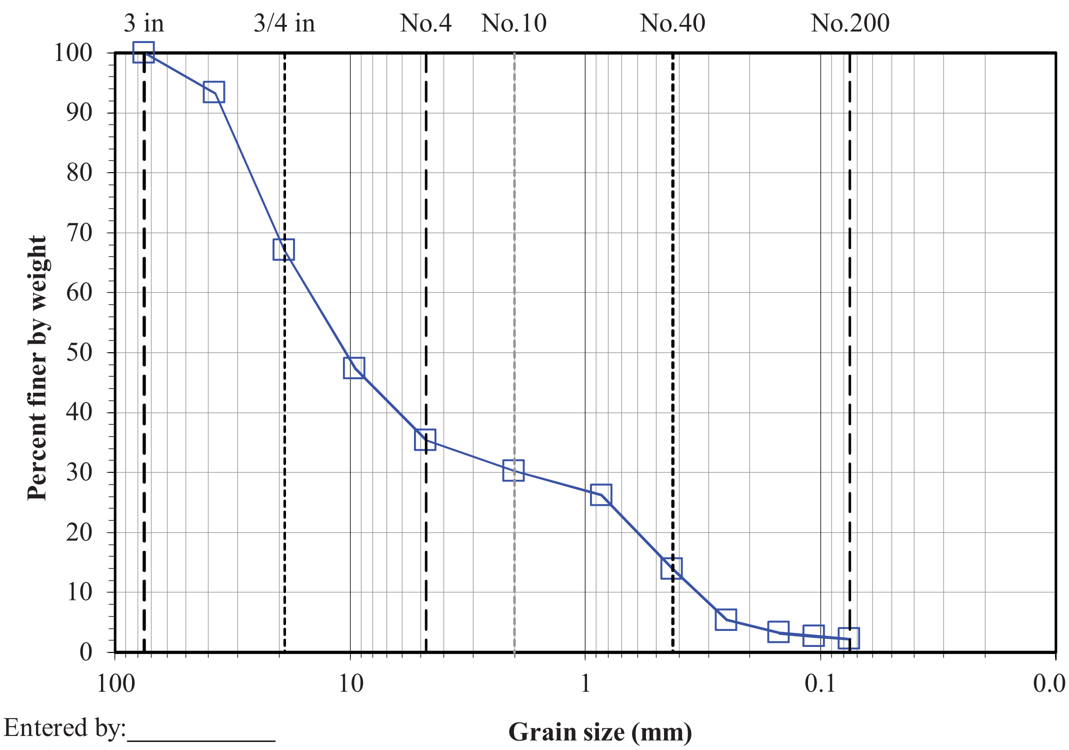
IGES

Project:	West End Reservoir	**Boring No.:**	TR-2
No:	01747-002	**Station:**	45'
Location:	South Weber, Utah	**Depth:**	10.0'
Date:	1/6/2017	Description:	Brown gravel with sand
By:	BSS		

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	31540.70	31056.09
+3/8" Coarse fraction (g):	16543.60	16361.47
-3/8" Split fraction (g):	336.16	329.38
Split fraction:	0.473	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	4181.34	551.54
Dry soil + tare (g):	4143.47	544.76
Tare (g):	741.48	215.38
Water content (%):	1.1	2.1

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	100.0	
1.5"	2081.33	37.5	93.3	
3/4"	10224.20	19	67.1	
3/8"	16361.47	9.5	47.3	←Split
No.4	83.23	4.75	35.4	
No.10	119.18	2	30.2	
No.20	147.31	0.85	26.2	
No.40	232.95	0.425	13.9	
No.60	292.51	0.25	5.3	
No.100	306.72	0.15	3.3	
No.140	311.13	0.106	2.6	
No.200	314.39	0.075	2.2	



Gravel (%): 64.6
Sand (%): 33.2
Fines (%): 2.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]12

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

IGES

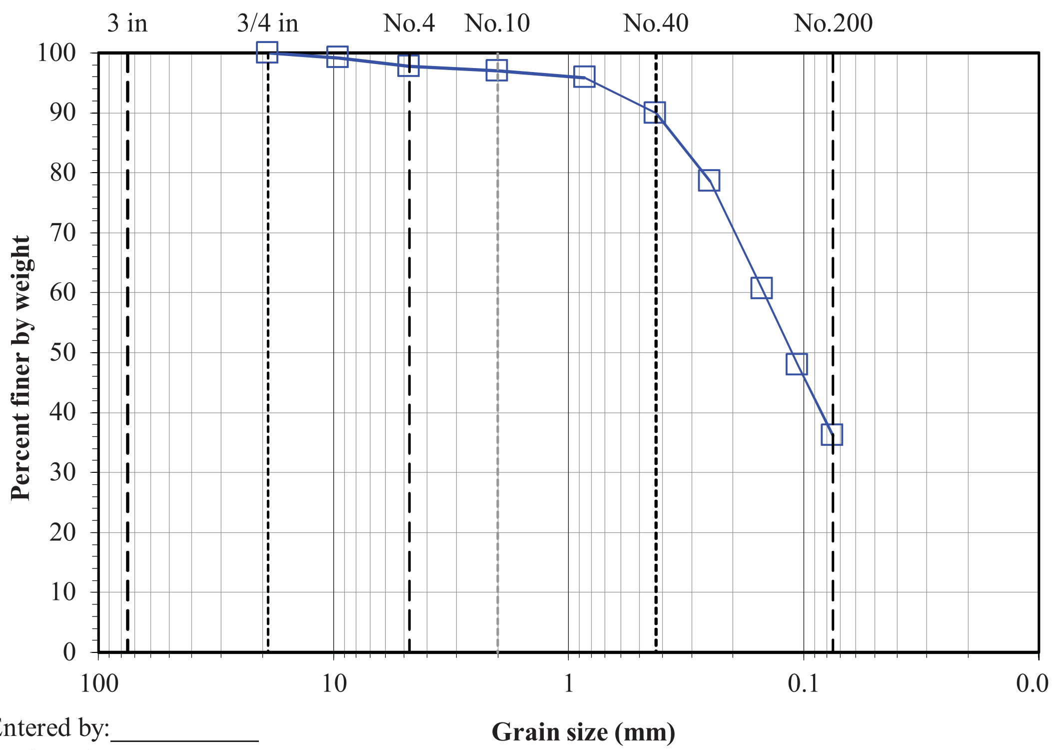
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-3
Station: 35'
Depth: 4.0'
Description: Brown silty sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	168.54	154.88
Split fraction:	1.000	

Water content data		
Moist soil + tare (g):	-	290.41
Dry soil + tare (g):	-	276.75
Tare (g):	-	121.87
Water content (%):	0.0	8.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	100.0
3/8"	1.31	9.5	99.2
No.4	3.53	4.75	97.7
No.10	4.65	2	97.0
No.20	6.43	0.85	95.8
No.40	15.57	0.425	89.9
No.60	33.25	0.25	78.5
No.100	61.01	0.15	60.6
No.140	80.69	0.106	47.9
No.200	98.94	0.075	36.1



Gravel (%): 2.3
Sand (%): 61.6
Fines (%): 36.1

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]13

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

© IGES 2004, 2017

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

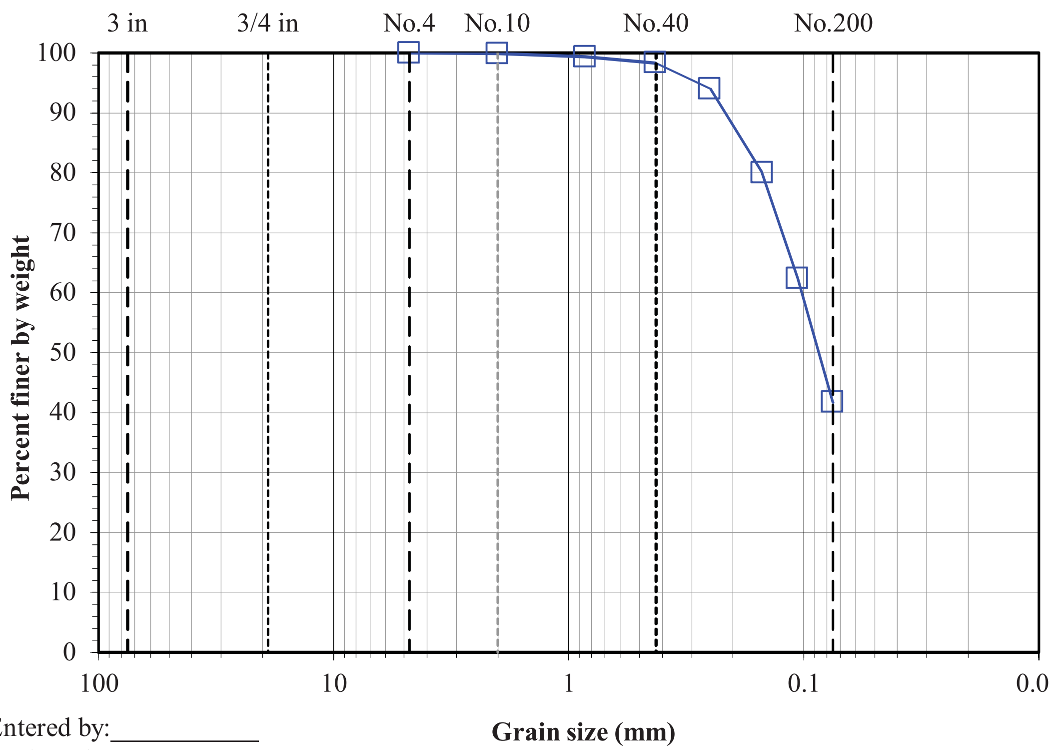
Boring No.: TR-3
Station: 46'
Depth: 5.0'
Description: Light brown silty sand

Split:	No	
	-	
	Moist	Dry
Total sample wt. (g):	99.44	96.07
Split fraction:	1.000	

Water content data

Moist soil + tare (g):	-	240.23
Dry soil + tare (g):	-	236.86
Tare (g):	-	140.79
Water content (%):	0.0	3.5

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer
8"	-	200	-
6"	-	150	-
4"	-	100	-
3"	-	75	-
1.5"	-	37.5	-
3/4"	-	19	-
3/8"	-	9.5	-
No.4	-	4.75	100.0
No.10	0.12	2	99.9
No.20	0.64	0.85	99.3
No.40	1.63	0.425	98.3
No.60	5.77	0.25	94.0
No.100	19.24	0.15	80.0
No.140	36.17	0.106	62.4
No.200	56.02	0.075	41.7



Gravel (%): 0.0
Sand (%): 58.3
Fines (%): 41.7

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]14

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

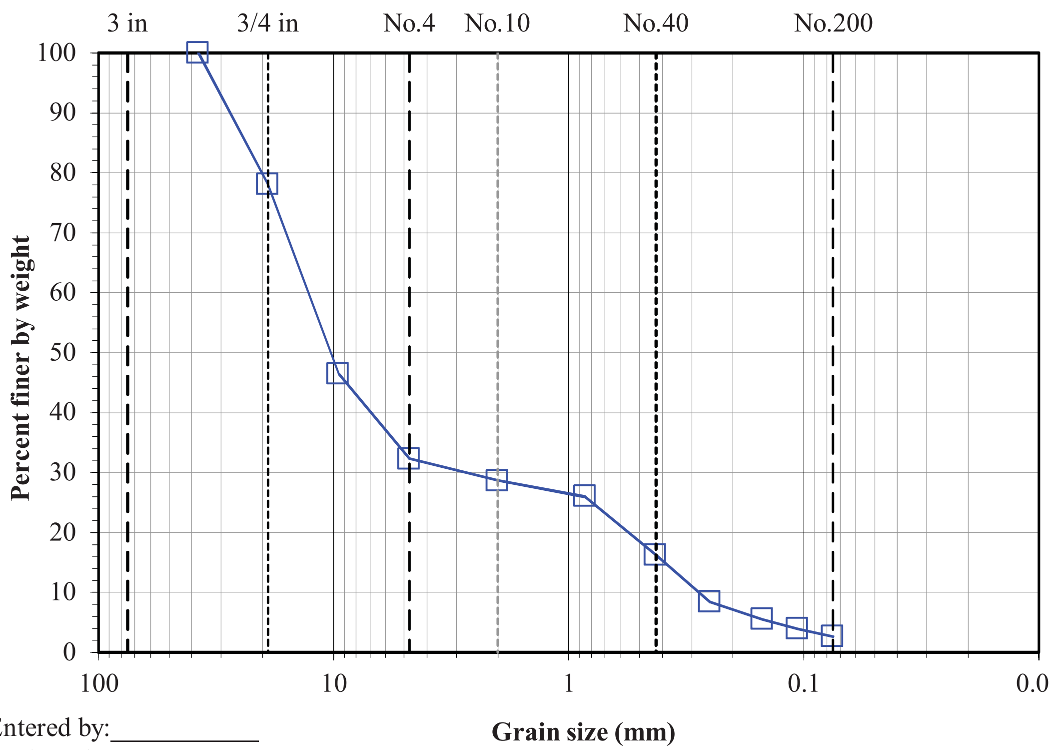
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-3
Station: 62'
Depth: 8.0'
Description: Light brown gravel with sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	5673.49	5599.34
+3/8" Coarse fraction (g):	3024.99	2997.48
-3/8" Split fraction (g):	339.55	333.57
Split fraction:	0.465	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	3766.51	466.33
Dry soil + tare (g):	3739.00	460.35
Tare (g):	741.52	126.78
Water content (%):	0.9	1.8

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	100.0	
3/4"	1229.02	19	78.1	
3/8"	2997.48	9.5	46.5	←Split
No.4	102.17	4.75	32.2	
No.10	128.13	2	28.6	
No.20	146.92	0.85	26.0	
No.40	217.35	0.425	16.2	
No.60	273.57	0.25	8.4	
No.100	294.16	0.15	5.5	
No.140	305.93	0.106	3.9	
No.200	314.82	0.075	2.6	



Gravel (%): 67.8
Sand (%): 29.6
Fines (%): 2.6

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]15

Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

(ASTM D6913)

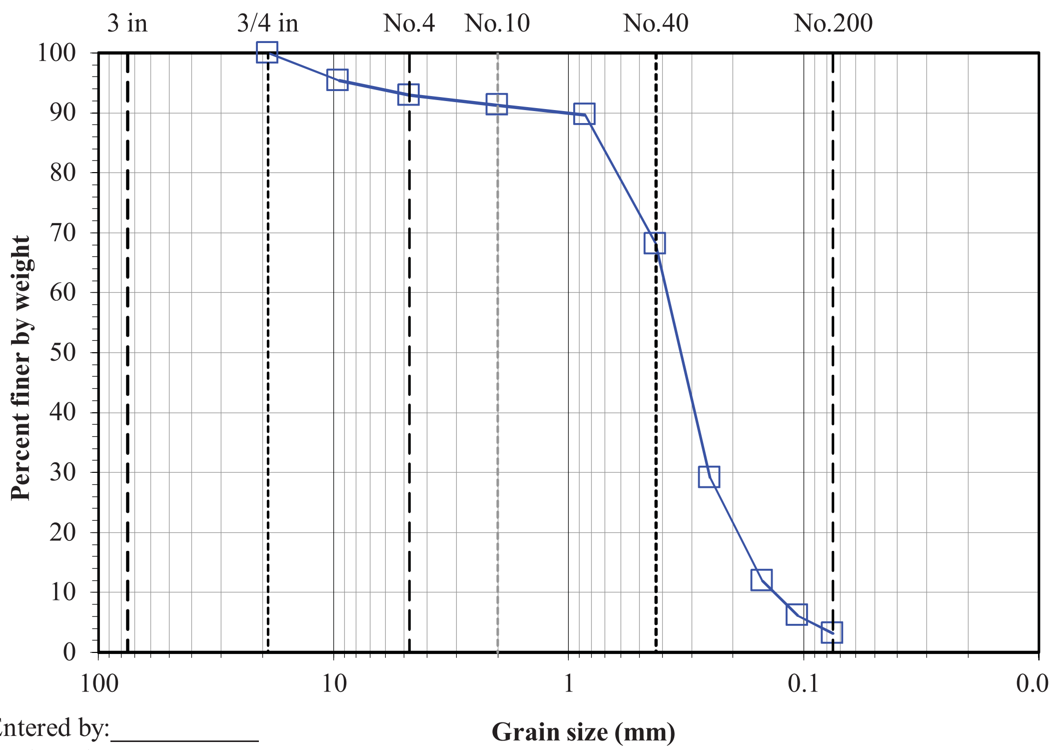
Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/3/2017
By: BSS

Boring No.: TR-3
Station: 71'
Depth: 8.5'
Description: Light brown sand

Split:	Yes	
Split sieve:	3/8"	
	Moist	Dry
Total sample wt. (g):	1404.78	1391.93
+3/8" Coarse fraction (g):	65.38	64.68
-3/8" Split fraction (g):	163.20	161.72
Split fraction:	0.954	

Water content data	C.F.(+3/8")	S.F.(-3/8")
Moist soil + tare (g):	188.94	289.80
Dry soil + tare (g):	188.24	288.32
Tare (g):	123.56	126.60
Water content (%):	1.1	0.9

Sieve	Accum. Wt. Ret. (g)	Grain Size (mm)	Percent Finer	
8"	-	200	-	
6"	-	150	-	
4"	-	100	-	
3"	-	75	-	
1.5"	-	37.5	-	
3/4"	-	19	100.0	
3/8"	64.68	9.5	95.4	←Split
No.4	4.16	4.75	92.9	
No.10	6.95	2	91.3	
No.20	9.68	0.85	89.6	
No.40	46.25	0.425	68.1	
No.60	112.35	0.25	29.1	
No.100	141.48	0.15	11.9	
No.140	151.39	0.106	6.1	
No.200	156.36	0.075	3.2	



Gravel (%): 7.1
Sand (%): 89.7
Fines (%): 3.2

Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[GSDv2.xlsx]16

Amount of Material in Soil Finer than the No. 200 (75µm) Sieve

(ASTM D1140)

Project: **West End Reservoir**
No: **01747-002**
Location: South Weber, Utah
Date: 12/30/2016
By: BSS

Sample Info.	Boring No.	BH-2	BH-3	BH-3	BH-4	BH-4	BH-4	TR-1	
	Station							125'	
	Depth	30.0'	27.0'	33.5'	15.0'	27.5	43.0'	7.0'	
	Split	No	No	No	No	No	No	No	
	Split Sieve*								
	Method	B	B	B	B	B	B	B	
	Specimen soak time (min)	120	190	260	260	290	300	330	
	Moist total sample wt. (g)	205.94	121.94	216.49	170.90	119.21	182.60	122.14	
	Moist coarse fraction (g)								
	Moist split fraction + tare (g)								
	Split fraction tare (g)								
	Dry split fraction (g)								
	Dry retained No. 200 + tare (g)	150.84	138.16	195.18	161.24	182.59	132.34	186.63	
	Wash tare (g)	124.51	122.36	140.86	123.75	121.87	121.29	152.71	
	No. 200 Dry wt. retained (g)	26.33	15.80	54.32	37.49	60.72	11.05	33.92	
	Split sieve* Dry wt. retained (g)								
	Dry total sample wt. (g)	164.23	101.10	184.21	147.57	97.71	149.32	116.94	
Coarse Fraction	Moist soil + tare (g)								
	Dry soil + tare (g)								
	Tare (g)								
	Water content (%)								
Split Fraction	Moist soil + tare (g)	330.45	244.30	357.35	294.65	241.08	303.89	274.85	
	Dry soil + tare (g)	288.74	223.46	325.07	271.32	219.58	270.61	269.65	
	Tare (g)	124.51	122.36	140.86	123.75	121.87	121.29	152.71	
	Water content (%)	25.40	20.61	17.52	15.81	22.00	22.29	4.45	
	Percent passing split sieve* (%)								
	Percent passing No. 200 sieve (%)	**84.0**	**84.4**	**70.5**	**74.6**	**37.9**	**92.6**	**71.0**	

Entered by:___________

Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

IGES

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/9/2017
By: JDF

Boring No.: BH-2
Sample:
Depth: 30.0'
Sample Description: Brown clay with sand
Sample type: Undisturbed-trimmed from ring

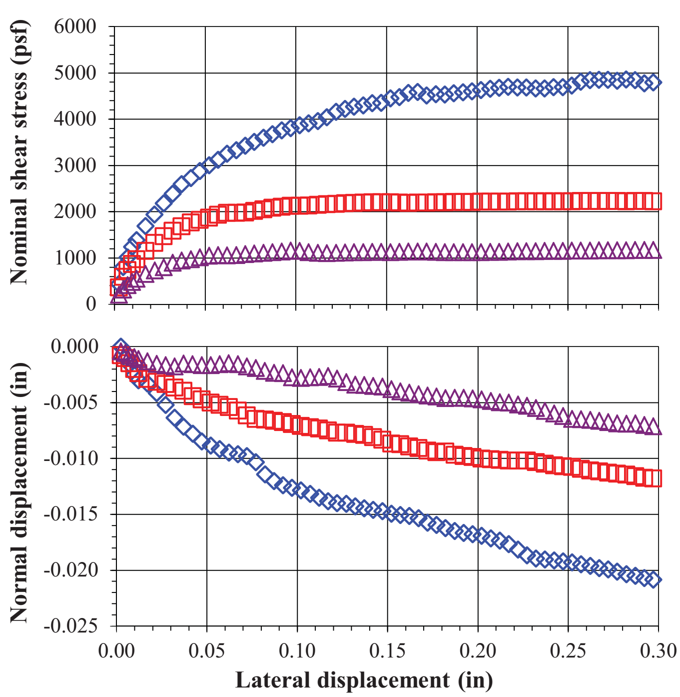
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0009
Specific gravity, Gs: 2.70 Assumed

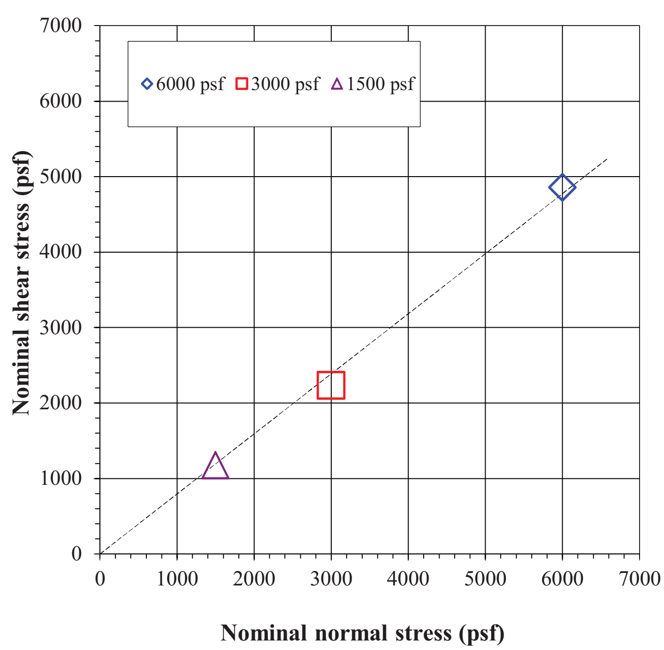
	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	6000		3000		1500	
Peak shear stress (psf)	4858		2231		1174	
Lateral displacement at peak (in)	0.282		0.267		0.302	
Load Duration (min)	1017		1035		1048	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9362	1.0000	0.9453	1.0000	0.9723
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	196.30	192.67	199.60	196.63	196.55	195.44
Wt. rings (g)	43.73	43.73	46.99	46.99	43.58	43.58
Wet soil + tare (g)	305.00		305.00		305.00	
Dry soil + tare (g)	277.15		277.15		277.15	
Tare (g)	151.72		151.72		151.72	
Water content (%)	22.2	19.3	22.2	19.8	22.2	21.3
Dry unit weight (pcf)	103.7	110.8	103.8	109.7	104.0	106.9
Void ratio, e, for assumed Gs	0.62	0.52	0.62	0.54	0.62	0.58
Saturation (%)*	96.0	100.0	96.0	100.0	96.6	100.0

φ' (deg)	39
c' (psf)	0

Average of 3 samples	Initial	Pre-shear
Water content (%)	22.2	20.1
Dry unit weight (pcf)	103.8	109.1

*Pre-shear saturation set to 100% for phase calculations





Entered by:___________
Reviewed:___________

Z:\PROJECTS\01747_Jones_Associates\002_West_End_Reservoir\[DS_GCv4.xlsm]1

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir **Boring No.:** BH-2
No: 01747-002 **Sample:**
Location: South Weber, Utah **Depth:** 30.0'

Nominal normal stress = 6000 psf			Nominal normal stress = 3000 psf			Nominal normal stress = 1500 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.002	440	0.000	0.002	364	-0.001	0.002	201	0.000
0.005	802	-0.001	0.005	589	-0.001	0.005	315	-0.001
0.007	1011	-0.002	0.007	735	-0.001	0.007	408	-0.001
0.010	1237	-0.003	0.010	866	-0.002	0.010	479	-0.001
0.012	1388	-0.003	0.012	971	-0.002	0.012	549	-0.001
0.017	1687	-0.003	0.017	1153	-0.003	0.017	651	-0.001
0.022	1938	-0.004	0.022	1322	-0.003	0.022	728	-0.002
0.027	2181	-0.005	0.027	1466	-0.003	0.027	798	-0.002
0.032	2390	-0.006	0.032	1587	-0.004	0.032	892	-0.002
0.037	2599	-0.007	0.037	1686	-0.004	0.037	942	-0.002
0.042	2725	-0.008	0.042	1764	-0.004	0.042	970	-0.002
0.047	2882	-0.008	0.047	1824	-0.005	0.047	1012	-0.002
0.052	3007	-0.009	0.052	1873	-0.005	0.052	1045	-0.002
0.057	3123	-0.009	0.057	1931	-0.005	0.057	1058	-0.002
0.062	3250	-0.009	0.062	1972	-0.005	0.062	1051	-0.001
0.067	3331	-0.010	0.067	1974	-0.006	0.067	1060	-0.002
0.072	3423	-0.010	0.072	1982	-0.006	0.072	1078	-0.002
0.077	3513	-0.010	0.077	2016	-0.006	0.077	1095	-0.002
0.082	3600	-0.011	0.082	2052	-0.007	0.082	1109	-0.002
0.087	3676	-0.012	0.087	2083	-0.007	0.087	1125	-0.002
0.092	3755	-0.012	0.092	2107	-0.007	0.092	1138	-0.002
0.097	3808	-0.013	0.097	2123	-0.007	0.097	1157	-0.003
0.102	3869	-0.013	0.102	2128	-0.007	0.102	1151	-0.003
0.107	3907	-0.013	0.107	2133	-0.007	0.107	1121	-0.003
0.112	3957	-0.014	0.112	2144	-0.007	0.112	1110	-0.003
0.117	4042	-0.014	0.117	2160	-0.008	0.117	1105	-0.003
0.122	4160	-0.014	0.122	2170	-0.008	0.122	1107	-0.003
0.127	4221	-0.014	0.127	2179	-0.008	0.127	1116	-0.003
0.132	4272	-0.014	0.132	2190	-0.008	0.132	1122	-0.003
0.137	4299	-0.014	0.137	2197	-0.008	0.137	1125	-0.003
0.142	4345	-0.015	0.142	2203	-0.008	0.142	1127	-0.004
0.147	4356	-0.015	0.147	2204	-0.008	0.147	1129	-0.004
0.152	4449	-0.015	0.152	2201	-0.009	0.152	1126	-0.004
0.157	4479	-0.015	0.157	2193	-0.009	0.157	1131	-0.004
0.162	4570	-0.015	0.162	2190	-0.009	0.162	1133	-0.004
0.167	4586	-0.015	0.167	2193	-0.009	0.167	1133	-0.004
0.172	4513	-0.016	0.172	2197	-0.009	0.172	1134	-0.004
0.177	4538	-0.016	0.177	2200	-0.009	0.177	1132	-0.004
0.182	4532	-0.016	0.182	2202	-0.009	0.182	1126	-0.005
0.187	4560	-0.016	0.187	2206	-0.010	0.187	1120	-0.005
0.192	4582	-0.017	0.192	2206	-0.010	0.192	1121	-0.005
0.197	4605	-0.017	0.197	2210	-0.010	0.197	1121	-0.005
0.202	4629	-0.017	0.202	2213	-0.010	0.202	1123	-0.005
0.207	4657	-0.017	0.207	2214	-0.010	0.207	1127	-0.005
0.212	4676	-0.017	0.212	2216	-0.010	0.212	1132	-0.005
0.217	4697	-0.018	0.217	2219	-0.010	0.217	1136	-0.005
0.222	4685	-0.018	0.222	2222	-0.010	0.222	1140	-0.005
0.227	4683	-0.019	0.227	2221	-0.010	0.227	1142	-0.005
0.232	4667	-0.019	0.232	2221	-0.010	0.232	1145	-0.006
0.237	4664	-0.019	0.237	2220	-0.010	0.237	1147	-0.006
0.242	4690	-0.019	0.242	2223	-0.011	0.242	1151	-0.006
0.247	4690	-0.019	0.247	2224	-0.011	0.247	1153	-0.006
0.252	4725	-0.019	0.252	2224	-0.011	0.252	1156	-0.006
0.257	4807	-0.019	0.257	2227	-0.011	0.257	1158	-0.007
0.262	4845	-0.020	0.262	2230	-0.011	0.262	1160	-0.007
0.267	4854	-0.020	0.267	2231	-0.011	0.267	1162	-0.007
0.272	4849	-0.020	0.272	2229	-0.011	0.272	1163	-0.007
0.277	4833	-0.020	0.277	2227	-0.011	0.277	1166	-0.007
0.282	4858	-0.020	0.282	2226	-0.011	0.282	1167	-0.007
0.287	4845	-0.021	0.287	2228	-0.012	0.287	1168	-0.007
0.292	4778	-0.021	0.292	2228	-0.012	0.292	1169	-0.007
0.297	4793	-0.021	0.297	2223	-0.012	0.297	1171	-0.007
0.301	4839	-0.021	0.302	2226	-0.012	0.302	1174	-0.007

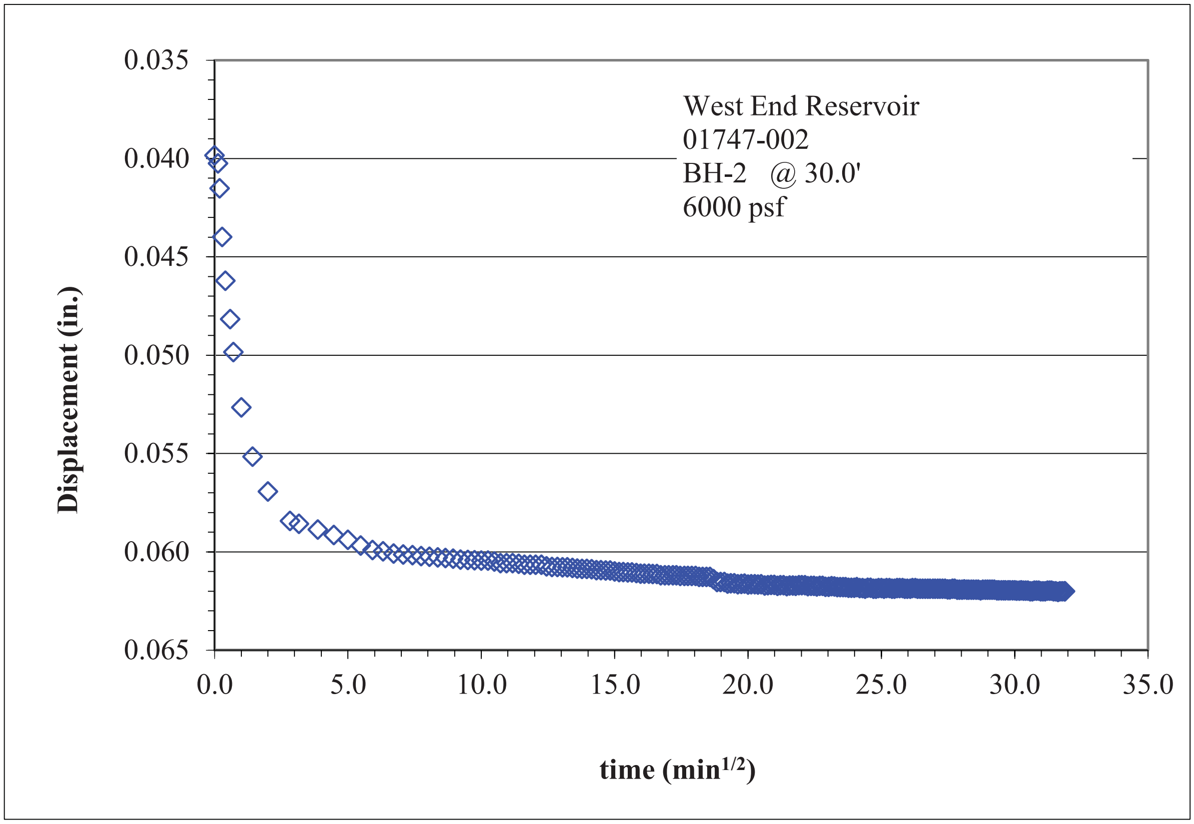
Direct Shear Test for Soils Under Drained Conditions

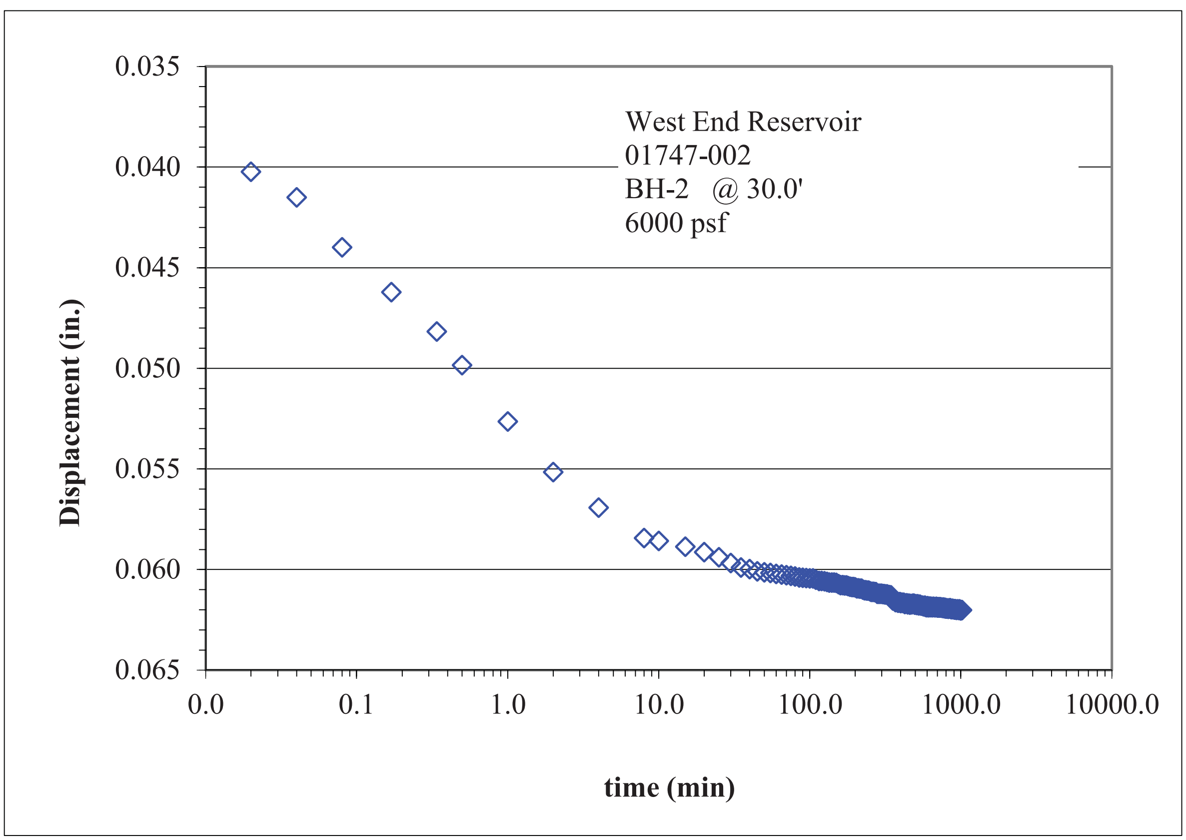
(ASTM D3080)

© IGES 2009, 2017

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah

Boring No.: BH-2
Sample:
Depth: 30.0'





Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah
Date: 1/13/2017
By: JDF

Boring No.: BH-5
Sample:
Depth: 36.0'
Sample Description: Brown clay
Sample type: Undisturbed-trimmed from ring

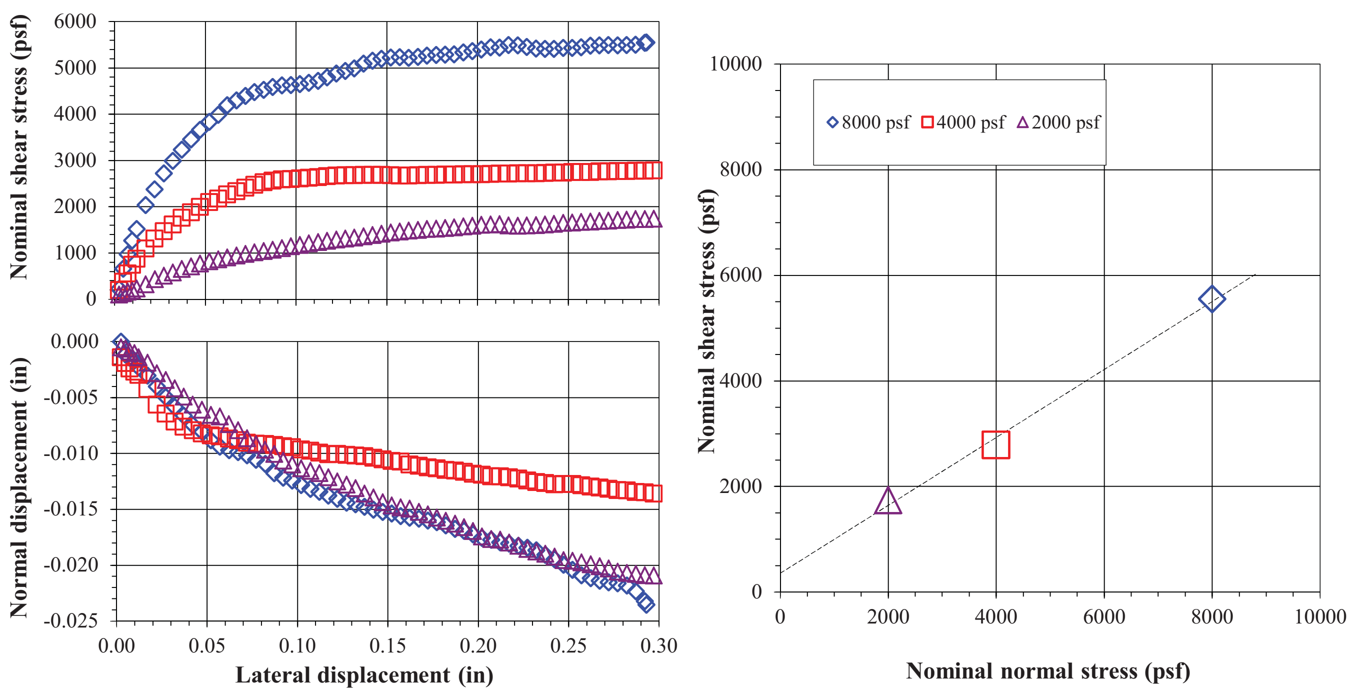
Test type: Inundated
Lateral displacement (in.): 0.3
Shear rate (in./min): 0.0009
Specific gravity, Gs: 2.70 Assumed

	Sample 1		Sample 2		Sample 3	
Nominal normal stress (psf)	8000		4000		2000	
Peak shear stress (psf)	5552		2783		1739	
Lateral displacement at peak (in)	0.293		0.297		0.297	
Load Duration (min)	1161		1183		1164	
	Initial	Pre-shear	Initial	Pre-shear	Initial	Pre-shear
Sample height (in)	1.0000	0.9295	1.0000	0.9513	1.0000	0.9590
Sample diameter (in)	2.416	2.416	2.416	2.416	2.416	2.416
Wt. rings + wet soil (g)	196.77	193.40	200.03	197.45	194.76	195.13
Wt. rings (g)	44.13	44.13	45.63	45.63	45.29	45.29
Wet soil + tare (g)	275.92		275.92		275.92	
Dry soil + tare (g)	249.25		249.25		249.25	
Tare (g)	122.09		122.09		122.09	
Water content (%)	21.0	18.3	21.0	19.0	21.0	21.3
Dry unit weight (pcf)	104.8	112.8	106.1	111.4	102.7	107.0
Void ratio, e, for assumed Gs	0.61	0.49	0.59	0.51	0.64	0.57
Saturation (%)*	93.2	100.0	96.1	100.0	88.3	100.0

ϕ' (deg)	33
c' (psf)	354

Average of 3 samples	Initial	Pre-shear
Water content (%)	21.0	19.5
Dry unit weight (pcf)	104.5	110.4

*Pre-shear saturation set to 100% for phase calculations



Entered by:___________
Reviewed:___________

Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah

Boring No.: BH-5
Sample:
Depth: 36.0'

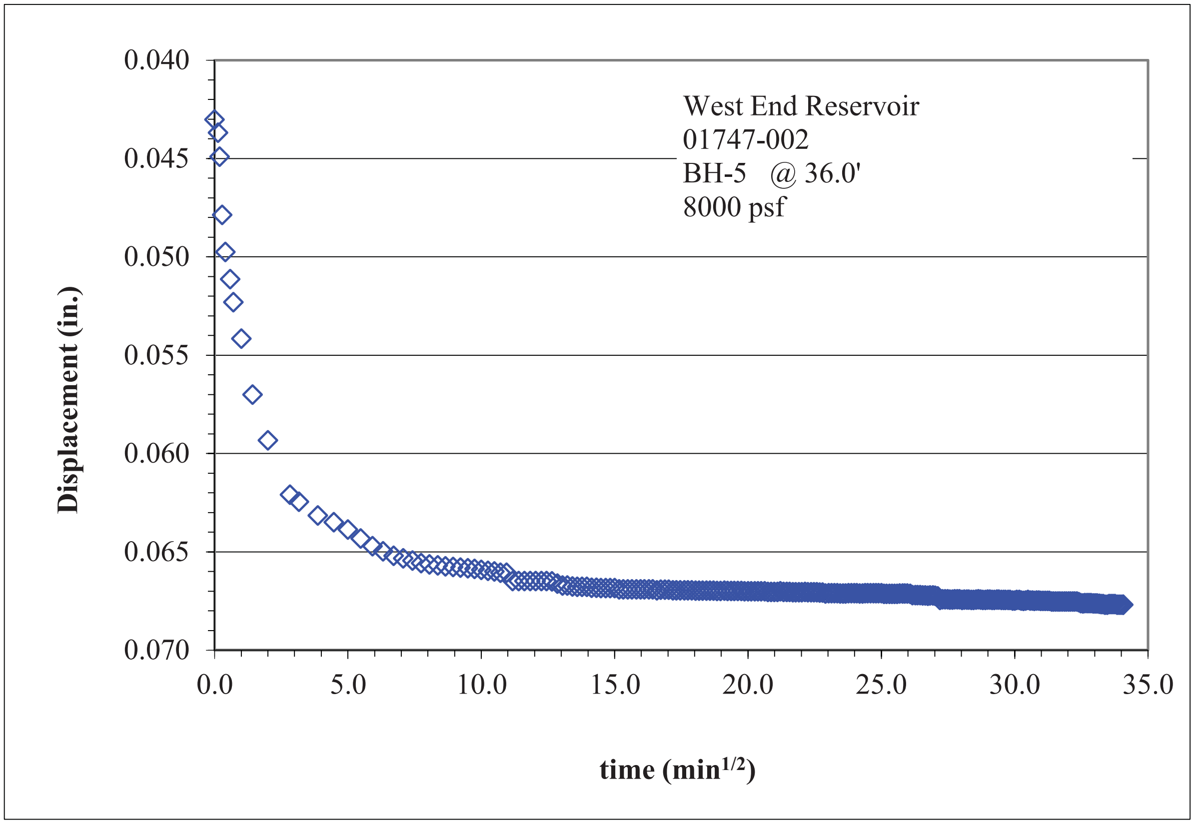
Nominal normal stress = 8000 psf			Nominal normal stress = 4000 psf			Nominal normal stress = 2000 psf		
Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)	Lateral Displacement (in.)	Nominal Shear Stress (psf)	Normal Displacement (in.)
0.002	221	0.000	0.002	196	-0.001	0.002	98	-0.001
0.005	660	-0.001	0.005	377	-0.002	0.005	128	-0.001
0.007	967	-0.001	0.007	554	-0.002	0.007	164	-0.001
0.010	1270	-0.002	0.010	742	-0.003	0.010	184	-0.001
0.012	1517	-0.002	0.012	877	-0.003	0.012	231	-0.001
0.017	2033	-0.003	0.017	1095	-0.004	0.017	322	-0.002
0.022	2377	-0.004	0.022	1312	-0.006	0.022	430	-0.003
0.027	2723	-0.005	0.027	1469	-0.006	0.027	504	-0.003
0.032	2991	-0.006	0.032	1613	-0.007	0.032	578	-0.004
0.037	3231	-0.007	0.037	1758	-0.008	0.037	653	-0.005
0.042	3452	-0.007	0.042	1874	-0.008	0.042	710	-0.006
0.047	3661	-0.008	0.047	1992	-0.008	0.047	768	-0.006
0.052	3833	-0.009	0.052	2095	-0.008	0.052	817	-0.007
0.057	3985	-0.009	0.057	2177	-0.008	0.057	858	-0.007
0.062	4192	-0.010	0.062	2265	-0.009	0.062	900	-0.007
0.067	4301	-0.010	0.067	2334	-0.009	0.067	942	-0.008
0.072	4393	-0.010	0.072	2407	-0.009	0.072	977	-0.009
0.077	4475	-0.011	0.077	2469	-0.009	0.077	1009	-0.009
0.082	4529	-0.011	0.082	2526	-0.009	0.082	1043	-0.010
0.087	4587	-0.012	0.087	2564	-0.009	0.087	1069	-0.010
0.092	4622	-0.012	0.092	2586	-0.009	0.092	1105	-0.011
0.097	4631	-0.012	0.097	2597	-0.009	0.097	1140	-0.011
0.102	4651	-0.013	0.102	2607	-0.010	0.102	1173	-0.011
0.107	4676	-0.013	0.107	2623	-0.010	0.107	1205	-0.012
0.112	4718	-0.013	0.112	2639	-0.010	0.112	1234	-0.012
0.117	4793	-0.014	0.117	2661	-0.010	0.117	1262	-0.012
0.122	4877	-0.014	0.122	2670	-0.010	0.122	1287	-0.013
0.127	4938	-0.014	0.127	2679	-0.010	0.127	1307	-0.013
0.132	4990	-0.015	0.132	2681	-0.010	0.132	1329	-0.013
0.137	5091	-0.015	0.137	2686	-0.010	0.137	1358	-0.014
0.142	5155	-0.015	0.142	2685	-0.010	0.142	1386	-0.014
0.147	5195	-0.015	0.147	2683	-0.011	0.147	1415	-0.014
0.152	5226	-0.015	0.152	2679	-0.011	0.152	1439	-0.015
0.157	5230	-0.016	0.157	2675	-0.011	0.157	1461	-0.015
0.162	5215	-0.016	0.162	2672	-0.011	0.162	1481	-0.015
0.167	5236	-0.016	0.167	2677	-0.011	0.167	1496	-0.015
0.172	5266	-0.016	0.172	2684	-0.011	0.172	1514	-0.015
0.177	5281	-0.016	0.177	2688	-0.011	0.177	1526	-0.016
0.182	5288	-0.016	0.182	2693	-0.011	0.182	1537	-0.016
0.187	5297	-0.017	0.187	2694	-0.012	0.187	1552	-0.016
0.192	5333	-0.017	0.192	2699	-0.012	0.192	1569	-0.017
0.197	5366	-0.017	0.197	2700	-0.012	0.197	1589	-0.017
0.202	5401	-0.018	0.202	2701	-0.012	0.202	1606	-0.017
0.207	5446	-0.018	0.207	2707	-0.012	0.207	1617	-0.018
0.212	5437	-0.018	0.212	2711	-0.012	0.212	1618	-0.018
0.217	5495	-0.018	0.217	2713	-0.012	0.217	1594	-0.018
0.222	5485	-0.018	0.222	2718	-0.012	0.222	1587	-0.018
0.227	5456	-0.018	0.227	2724	-0.012	0.227	1593	-0.019
0.232	5420	-0.019	0.232	2724	-0.013	0.232	1603	-0.019
0.237	5414	-0.019	0.237	2730	-0.013	0.237	1617	-0.019
0.242	5415	-0.019	0.242	2734	-0.013	0.242	1630	-0.019
0.247	5433	-0.020	0.247	2737	-0.013	0.247	1645	-0.020
0.252	5435	-0.020	0.252	2745	-0.013	0.252	1657	-0.020
0.257	5447	-0.021	0.257	2749	-0.013	0.257	1669	-0.020
0.262	5479	-0.021	0.262	2751	-0.013	0.262	1679	-0.020
0.267	5488	-0.021	0.267	2759	-0.013	0.267	1688	-0.020
0.272	5497	-0.022	0.272	2764	-0.013	0.272	1698	-0.020
0.277	5491	-0.022	0.277	2769	-0.013	0.277	1709	-0.021
0.282	5498	-0.022	0.282	2770	-0.013	0.282	1720	-0.021
0.287	5501	-0.022	0.287	2774	-0.013	0.287	1728	-0.021
0.292	5546	-0.023	0.292	2779	-0.014	0.292	1733	-0.021
0.293	5552	-0.024	0.297	2783	-0.014	0.297	1739	-0.021
			0.300	2783	-0.014	0.301	1739	-0.021

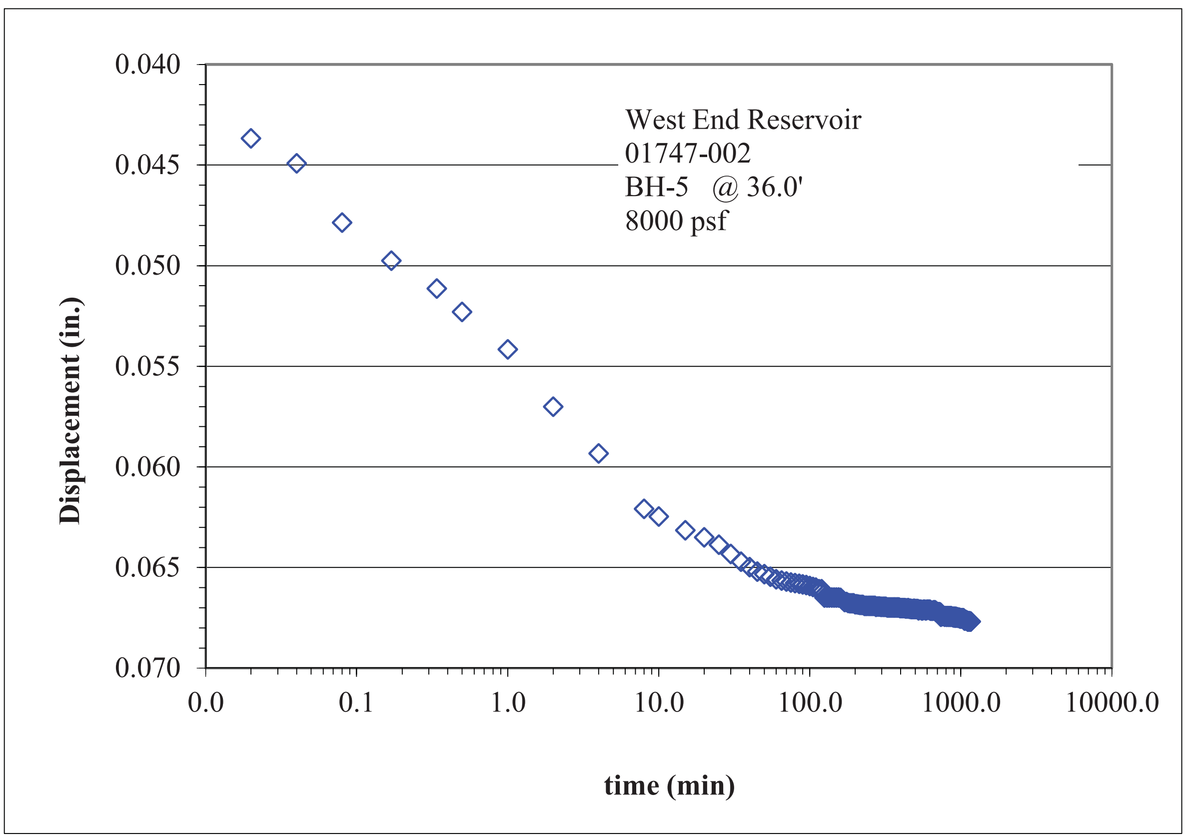
Direct Shear Test for Soils Under Drained Conditions

(ASTM D3080)

Project: West End Reservoir
No: 01747-002
Location: South Weber, Utah

Boring No.: BH-5
Sample:
Depth: 36.0'





APPENDIX C

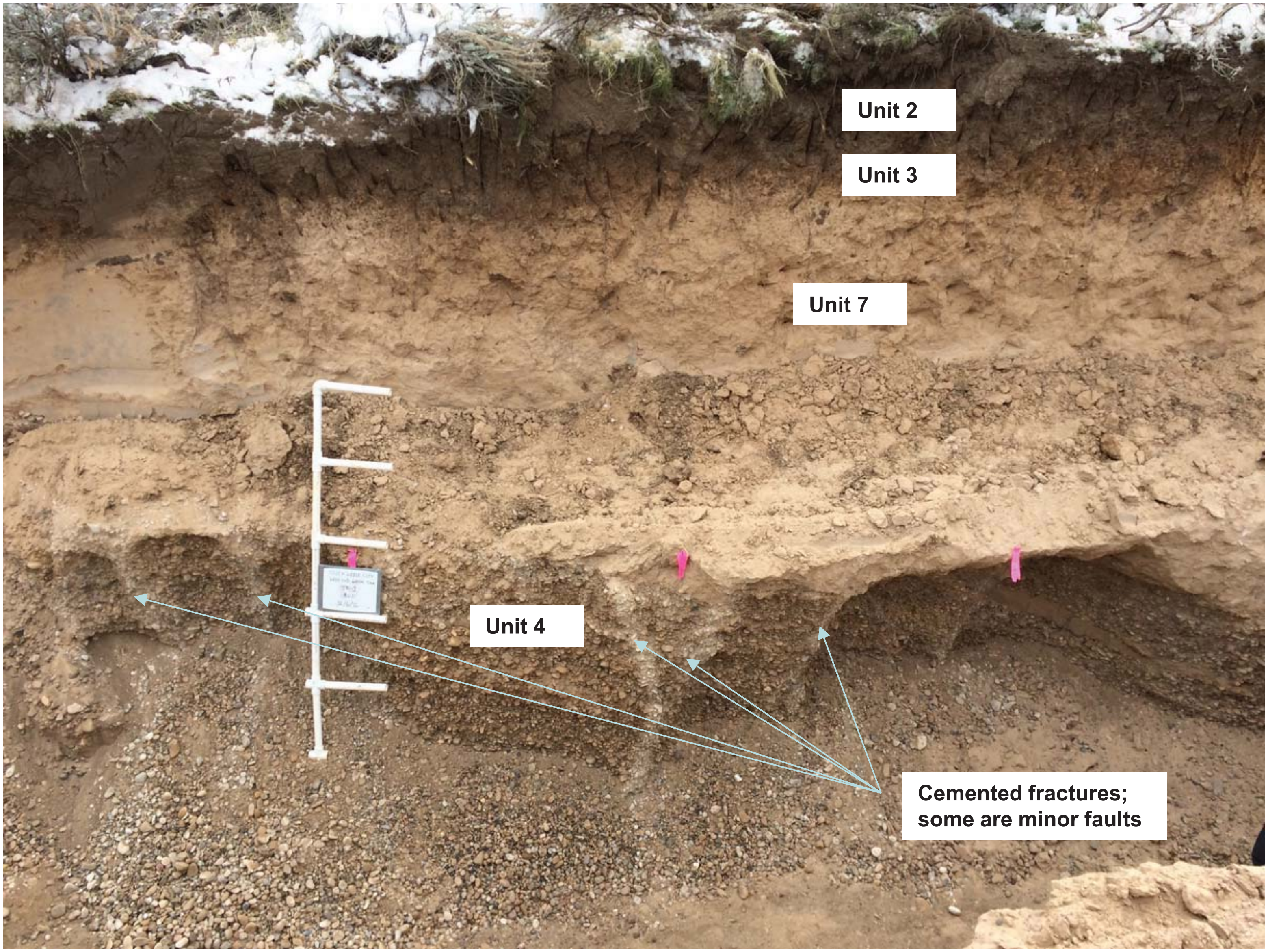


Figure C-1	Westside Reservoir Site Photos Trench 1 Project Number: 01747-002	**Overview of lithologic units in TR-1. Placard and scale at Station 80.**

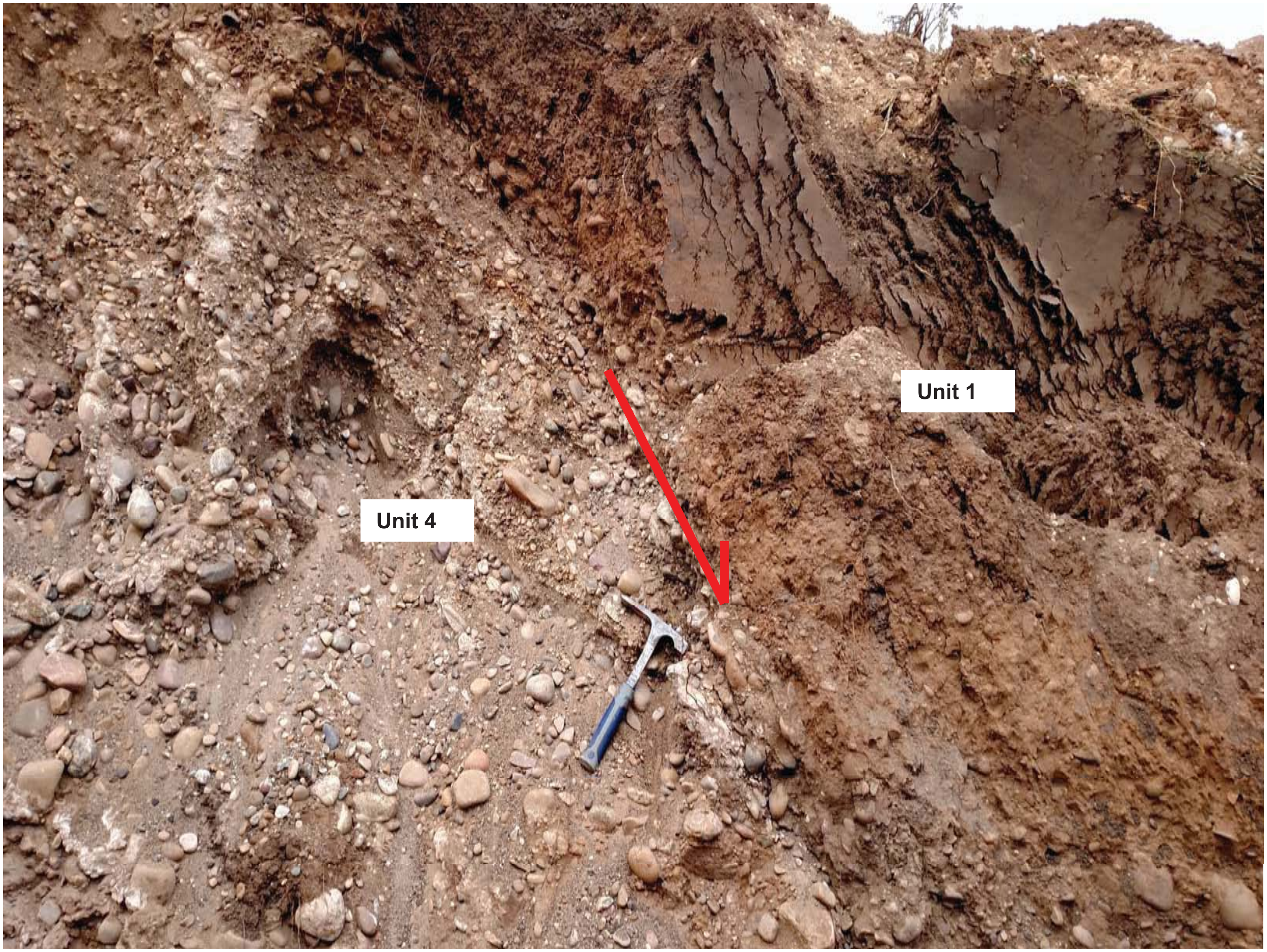


Figure C-2

Westside Reservoir
Site Photos
Trench 1
Project Number: 01747-002

Active scarp in TR-1, west wall of trench at Station 20. Red arrow is along the slide plane, indicating direction of movement downslope to the north.

IGES

Figure C-3

Westside Reservoir
Site Photos
Trench 1
Project Number: 01747-002

Bedded clay of Unit 5 at a depth of approximately 18 feet at Station 18.

IGES

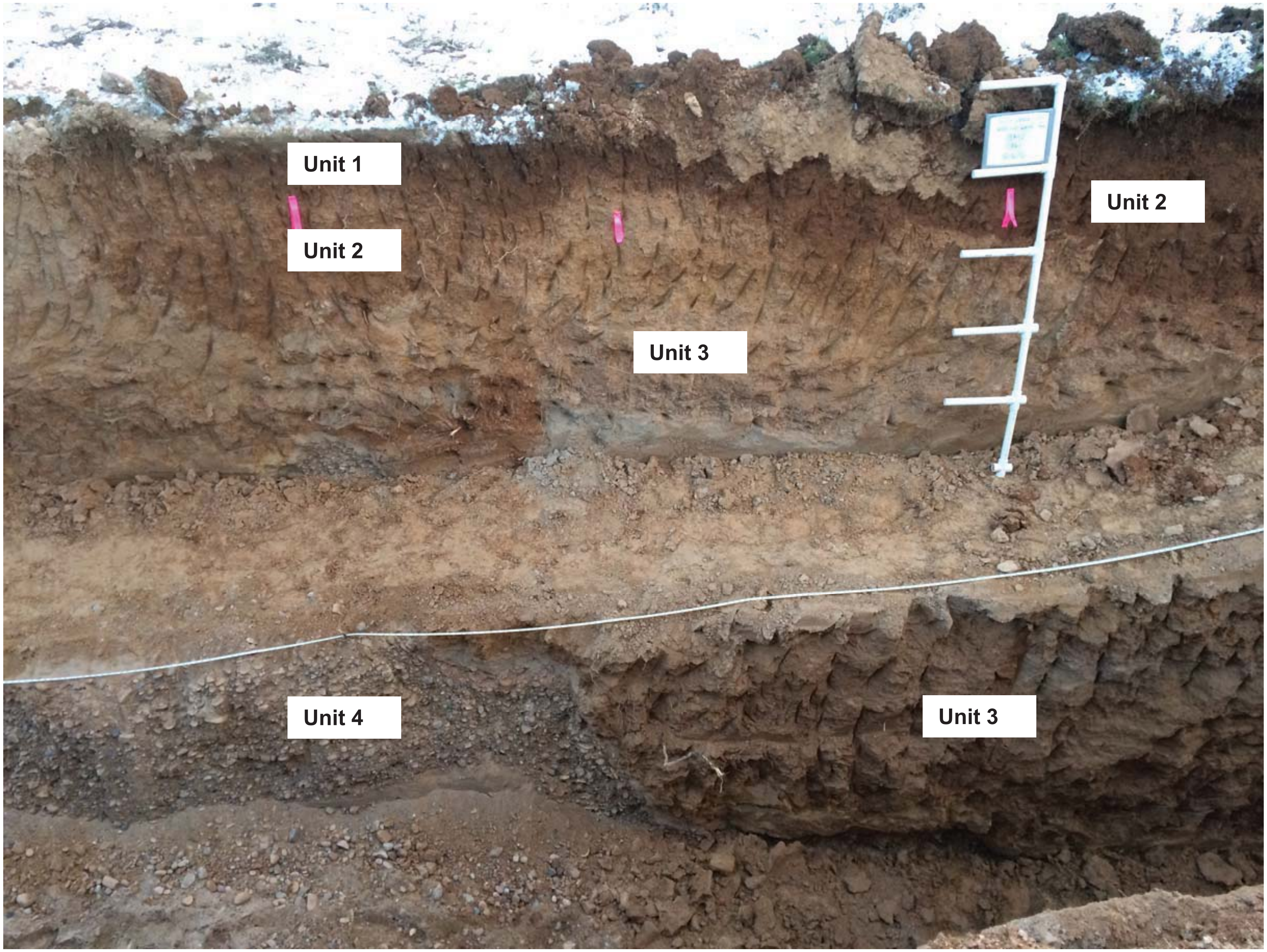


Figure C-4

Westside Reservoir
Site Photos
Trench 2
Project Number: 01747-002

Overview of lithologic units in TR-2. Placard and scale at Station 60.

IGES

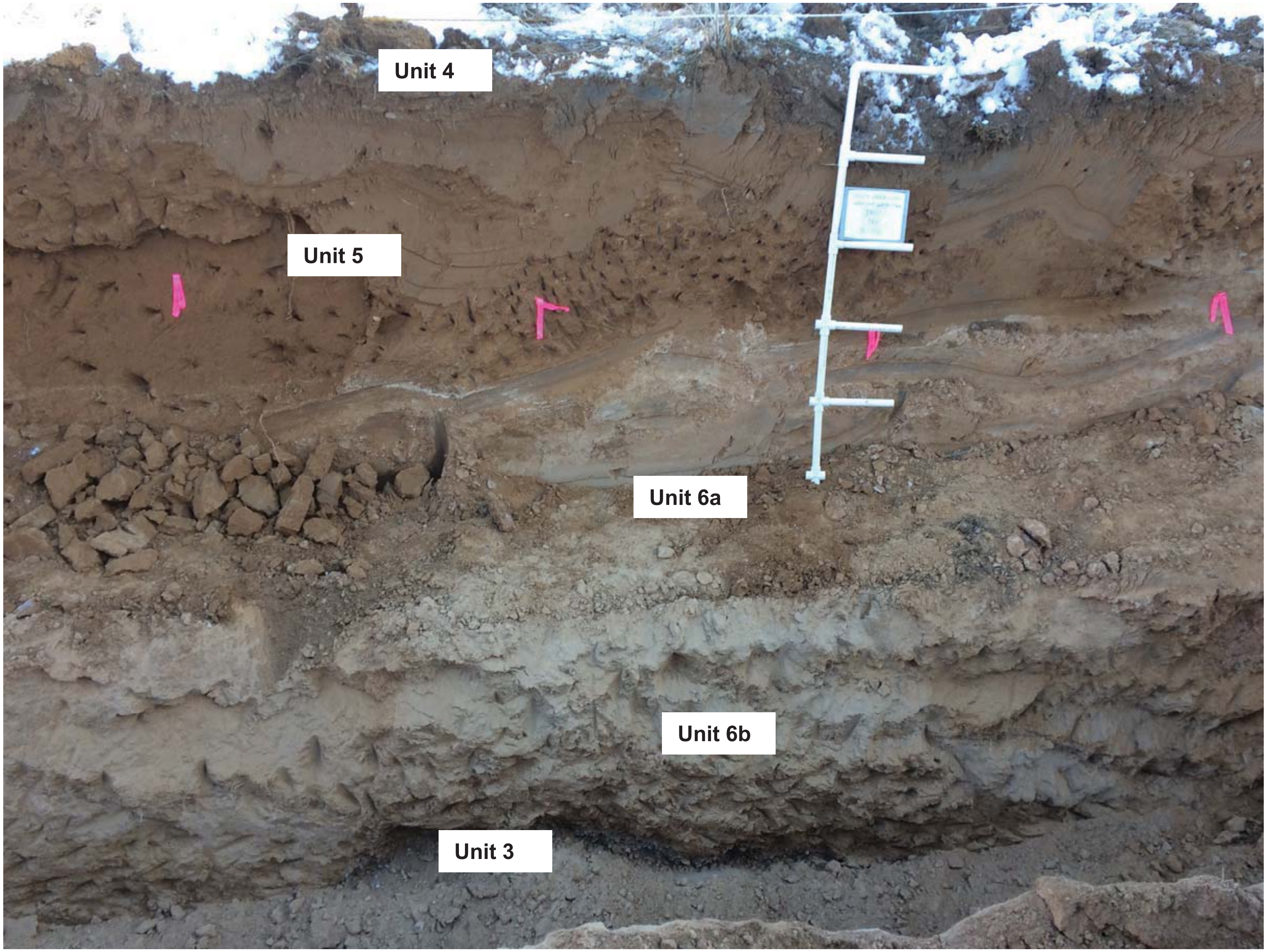


Figure C-5

Westside Reservoir
Site Photos
Trench 3
Project Number: 01747-002

Overview of lithologic units in TR-2. Placard and scale at Station 50.

IGES

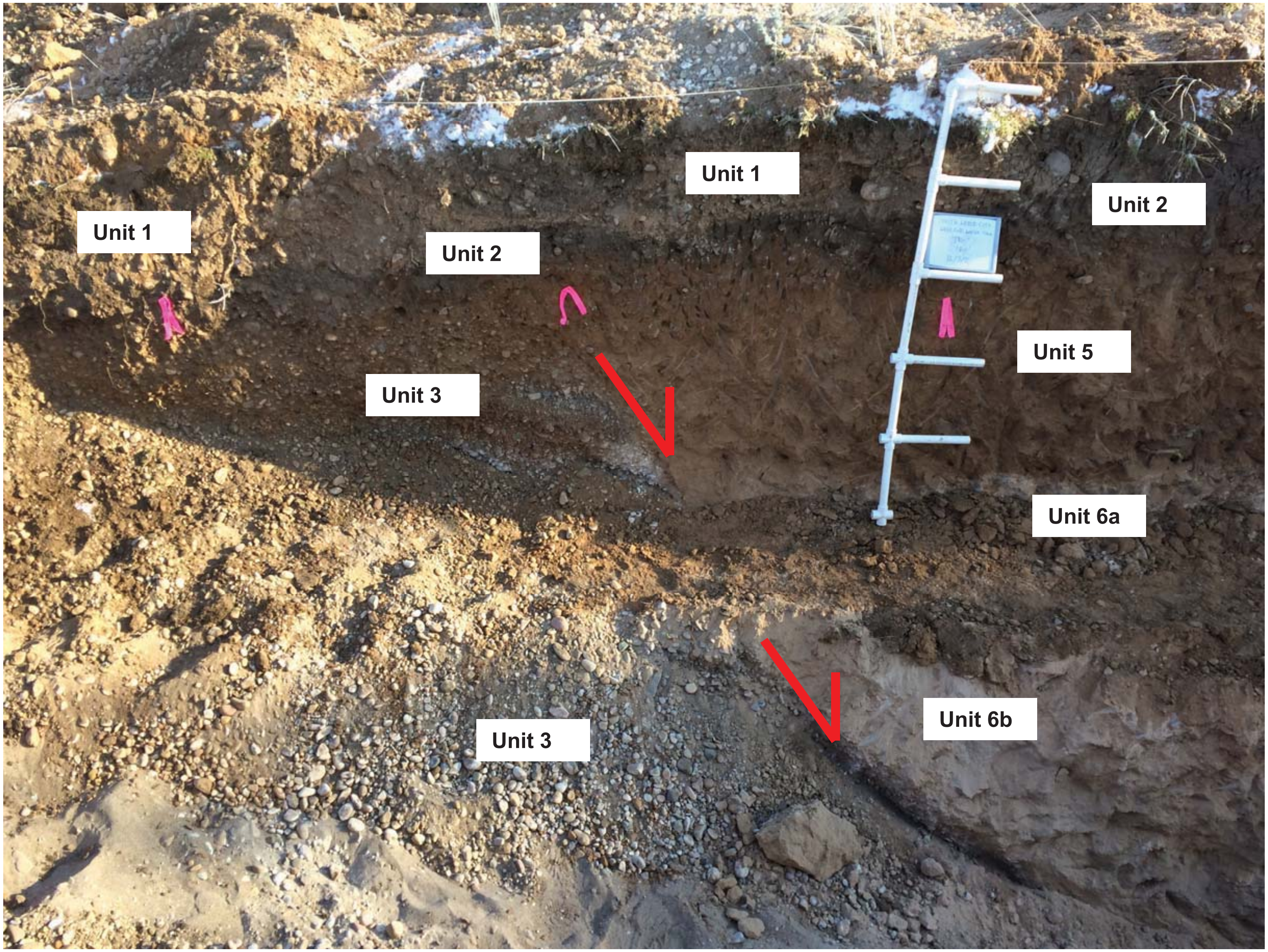


Figure C-6

Westside Reservoir
Site Photos
Trench 3
Project Number: 01747-002

Subsurface slide plane in TR-3. Scale and placard are at Station 20. Red arrows are along the slide plane, indicating direction of movement upslope to the south.

IGES

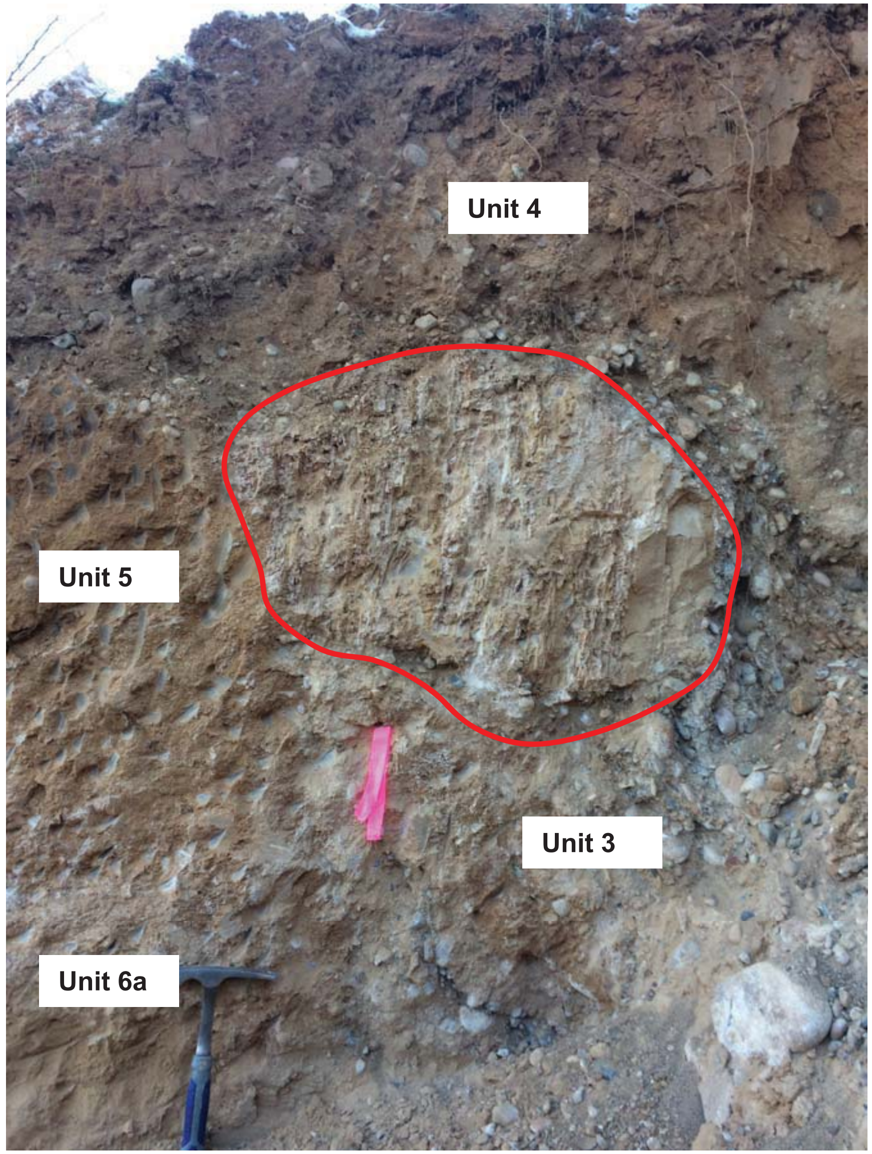


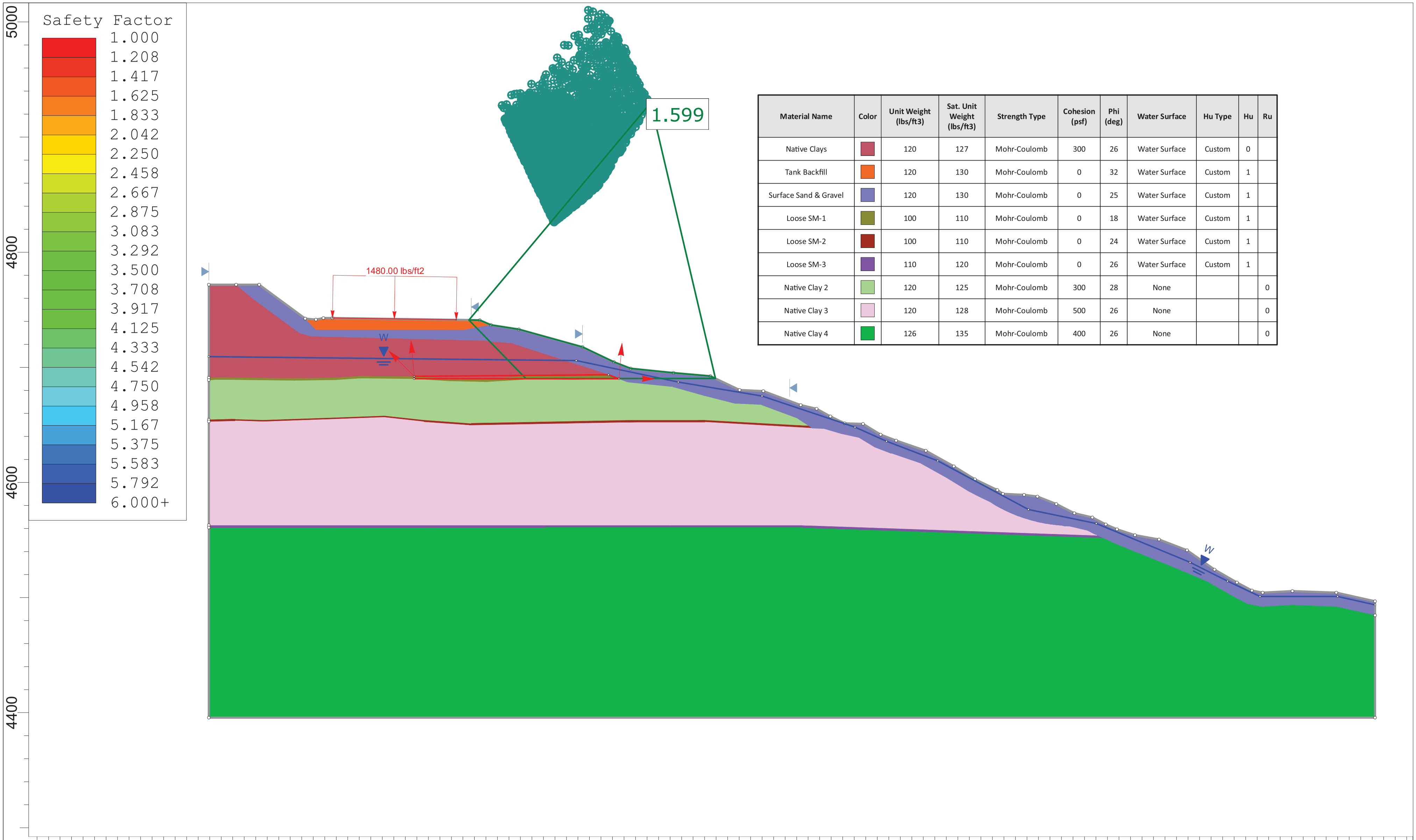
Figure C-7

Westside Reservoir
Site Photos
Trench 3
Project Number: 01747-002

Anomalous block of tilted clay in TR-3 within Unit 3, outlined in red. Pink flag is Station 75. Note vertical bedding within block. Block likely landslide-related.

IGES

APPENDIX D

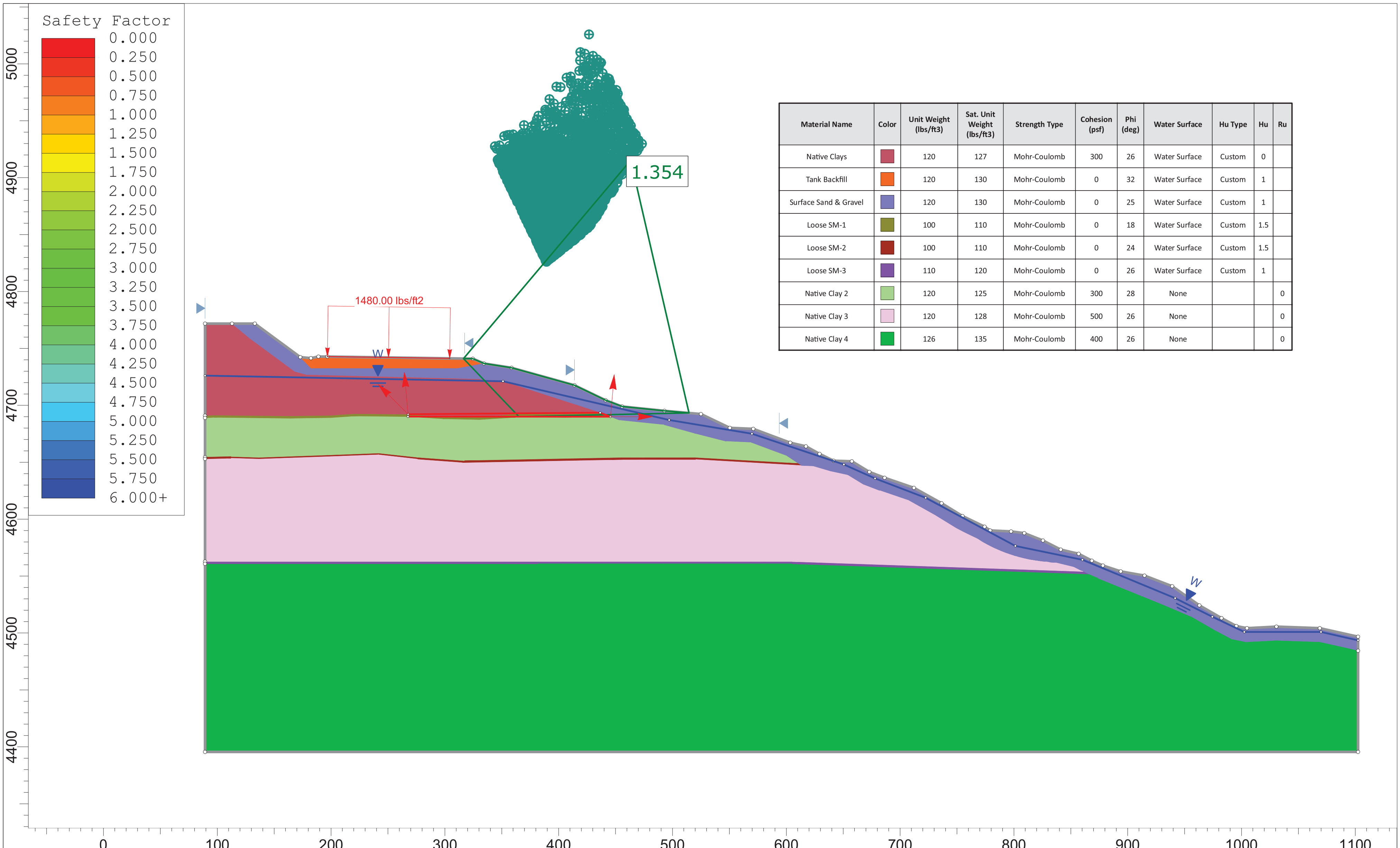


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	0	18	Water Surface	Custom	1	
Loose SM-2		100	110	Mohr-Coulomb	0	24	Water Surface	Custom	1	
Loose SM-3		110	120	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Global Stability (Existing Conditions)		
Drawn By JAH	*Scale* 1:1400	*Filename*	Global Stability.slim
Date	1/24/2017, 9:17:26 AM	*Figure*	D-1

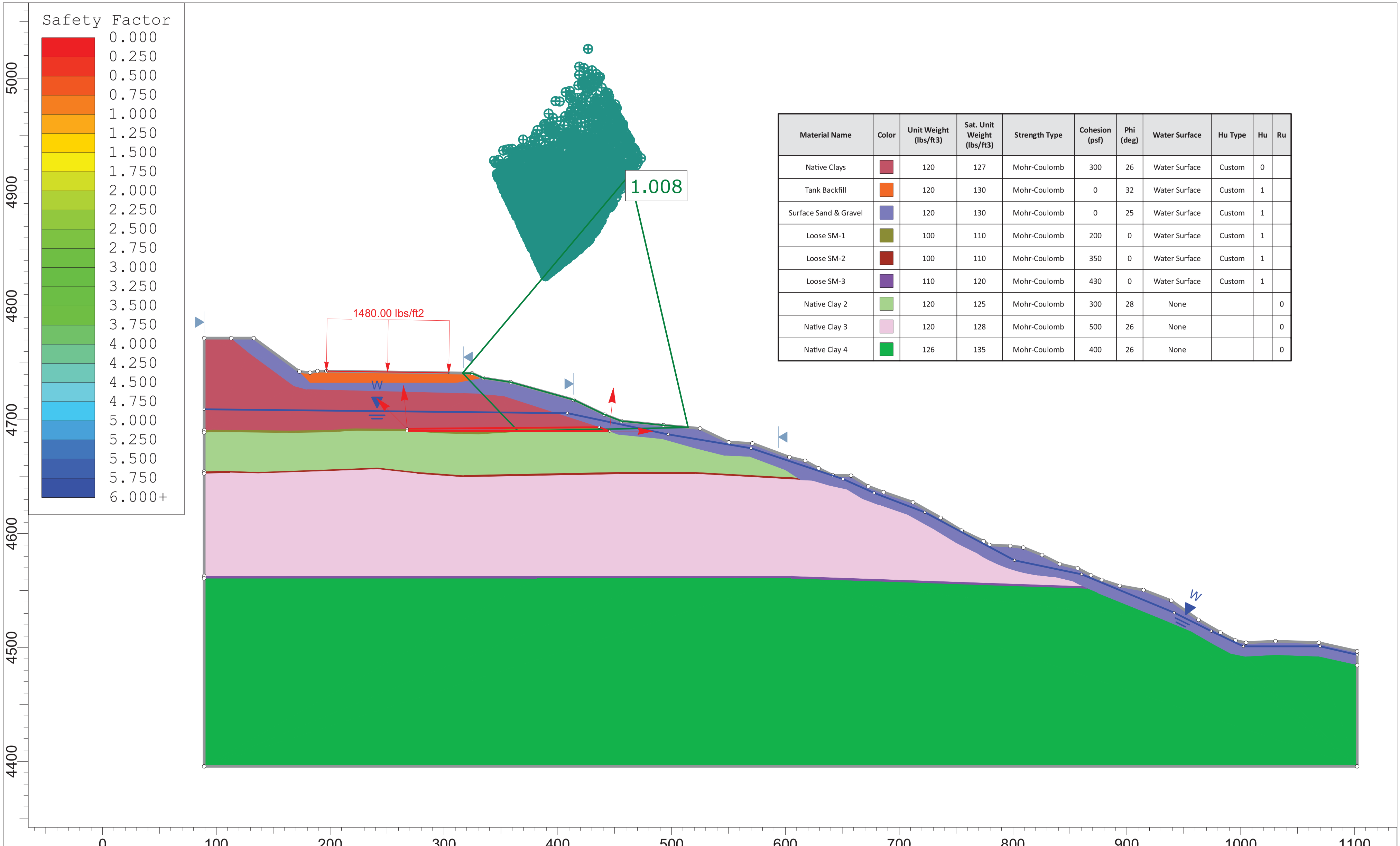


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	0	18	Water Surface	Custom	1.5	
Loose SM-2		100	110	Mohr-Coulomb	0	24	Water Surface	Custom	1.5	
Loose SM-3		110	120	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Global Stability (Increased Water)		
Drawn By JAH	*Scale* 1:1400	*Filename*	Global Stability (increased water).slim
Date	1/24/2017, 9:17:26 AM	*Figure*	D-2

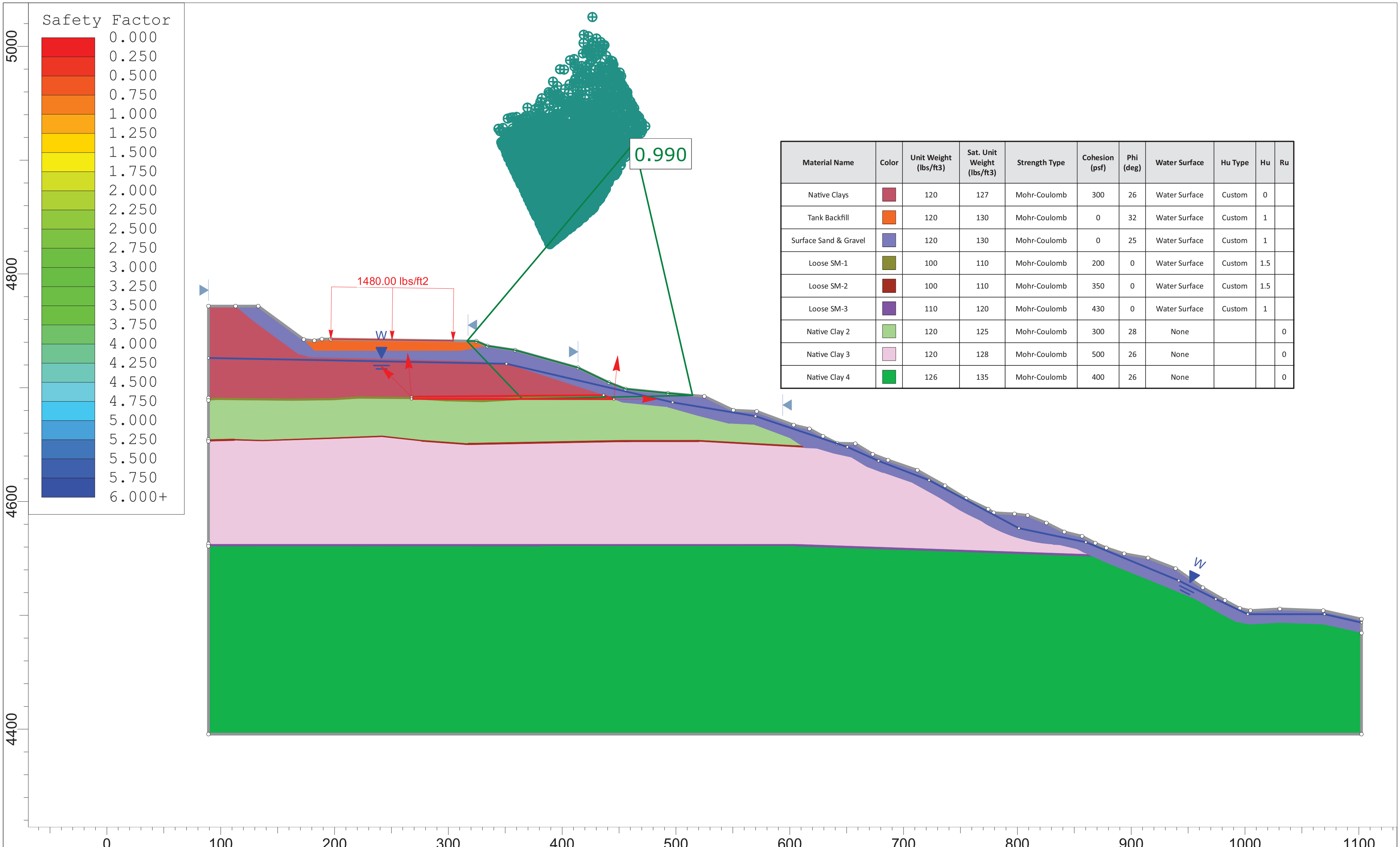


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	200	0	Water Surface	Custom	1	
Loose SM-2		100	110	Mohr-Coulomb	350	0	Water Surface	Custom	1	
Loose SM-3		110	120	Mohr-Coulomb	430	0	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Global Stability (Pseudo-static)		
Drawn By JAH	*Scale* 1:1400	*Filename*	Global Stability (post-seismic).slim
Date	1/24/2017, 9:17:26 AM	*Figure*	D-3

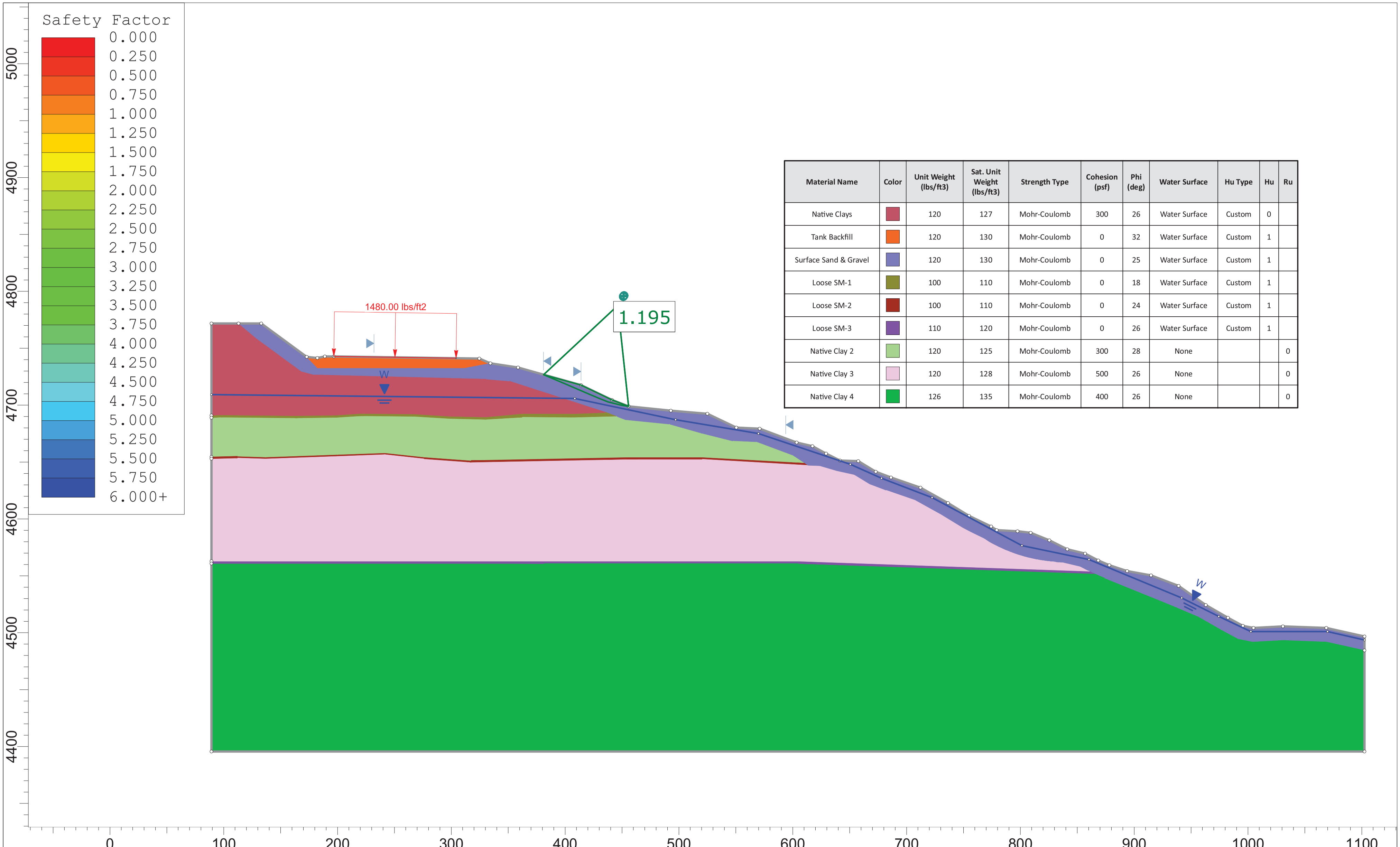


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	200	0	Water Surface	Custom	1.5	
Loose SM-2		100	110	Mohr-Coulomb	350	0	Water Surface	Custom	1.5	
Loose SM-3		110	120	Mohr-Coulomb	430	0	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah		
Analysis Description	Global Stability (Pseudo-static - Increased Water)		
Drawn By JAH	*Scale* 1:1400	*Filename*	Global Stability (increased water-post seismic).slim
Date	1/24/2017, 9:17:26 AM	*Figure*	D-4

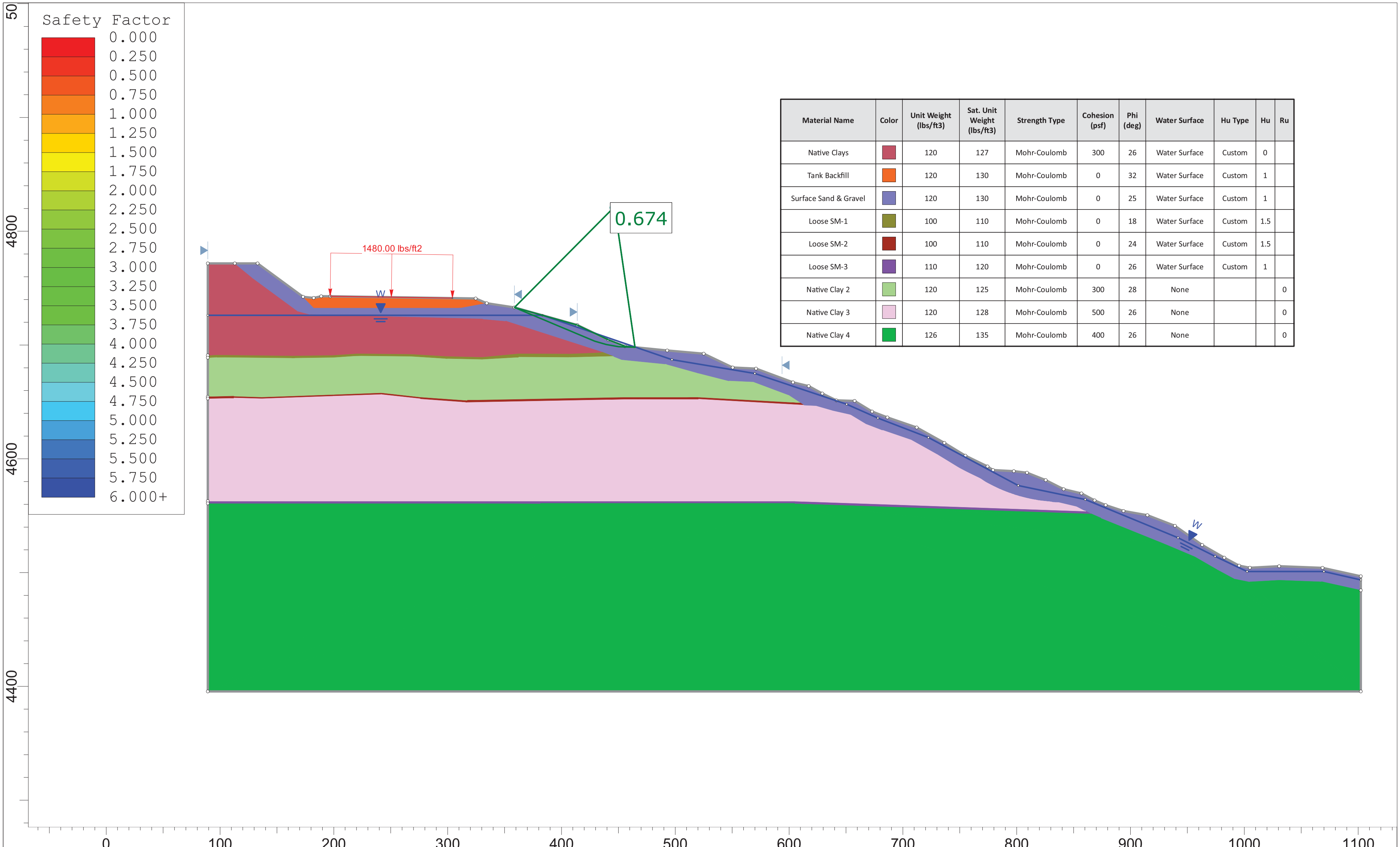


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	0	18	Water Surface	Custom	1	
Loose SM-2		100	110	Mohr-Coulomb	0	24	Water Surface	Custom	1	
Loose SM-3		110	120	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah
Analysis Description	Shallow Failure (Existing)
Drawn By	JAH
Scale	1:1400
Filename	Global Stability (Shallow).slim
Date	1/24/2017, 9:17:26 AM
Figure	D-5



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Hu Type	Hu	Ru
Native Clays		120	127	Mohr-Coulomb	300	26	Water Surface	Custom	0	
Tank Backfill		120	130	Mohr-Coulomb	0	32	Water Surface	Custom	1	
Surface Sand & Gravel		120	130	Mohr-Coulomb	0	25	Water Surface	Custom	1	
Loose SM-1		100	110	Mohr-Coulomb	0	18	Water Surface	Custom	1.5	
Loose SM-2		100	110	Mohr-Coulomb	0	24	Water Surface	Custom	1.5	
Loose SM-3		110	120	Mohr-Coulomb	0	26	Water Surface	Custom	1	
Native Clay 2		120	125	Mohr-Coulomb	300	28	None			0
Native Clay 3		120	128	Mohr-Coulomb	500	26	None			0
Native Clay 4		126	135	Mohr-Coulomb	400	26	None			0

IGES®

SLIDEINTERPRET 7.022

Project	Westside Reservoir - South Weber, Utah
Analysis Description	Shallow Failure (Increased Water)
Drawn By	JAH
Scale	1:1400
Filename	Global Stability (Shallow increased water).slim
Date	1/24/2017, 9:17:26 AM
Figure	D-6

A R W ENGINEERS
structural consultants

November 29, 2010

Mark Larsen
Public Works Director
South Weber City
1600 East South Weber Drive
South Weber City, UT

Re: South Weber 1MG Water Tank Investigation
ARW Job # 10318

Mr. Larsen:

Per your request, ARW Engineers has performed a limited investigation of the above-referenced concrete water tank. The purpose was to look at cracks in the base slab, which have resulted in some leaking. It is our understanding that the City wants our opinion regarding the cracking, and whether or not there are structural concerns with the tank.

The following information was provided (verbally) by you:

- The water tank in question is a 1 million gallon capacity tank,
- there are no existing drawings,
- the date of construction is not known, however you believe that the tank is at least 20+ years old.

You indicated that the tank floor slab had been given a coat of Xypex coating about a year ago due to some leakâge concerns that were evident from seepage through the hill on the east side of the tank.

The cracking in question was located in the floor slab near the slab to wall interface along the south west portion of the tank. At the time of the visit, the crack was not visible because a new coating of Xypex had just been installed over it the day before. You indicated that the crack was about ¼" wide prior to patching. Also, at the exterior side of the tank there was a visible depression in the soil where water had apparently been seeping out. This leads to the reasonable conclusion that the water was leaking through the crack in the slab and running out beneath the slab through the soil.

Without existing structural drawings of the tank, it is hard to tell how the tank was constructed. Typical construction of a concrete tank such as this would have a thickened slab footing under the perimeter wall. Alternatively, the footing may be below the wall, with a thinner floor slab poured over the top. In either of these cases, cracks are possible at the slab to footing interface. The cracking would be exacerbated for a number of reasons, including poorly compacted soil or a discontinuity in reinforcing steel.

During our investigation of the inside perimeter of the tank, we found what appeared to be a visible crack in the slab just about 6" off of the wall near the east side. If it was a crack, it was not very wide. It was very hard to determine if it was actually a crack due to the possibility of it being some type of seam from previous water proofing membranes etc. If it was a crack it could possibly be due to the same reasons as stated above. We also noted during our investigation that there are numerous cracks throughout the slab that have been filled in with some type of joint filler material.

You also stated your concern about the condition of the soils below the tank, due to the fact that perhaps the seeping water could be washing away some of the soil. This is a very real possibility, and based on the visible soil depression on the exterior where you have already seen the water leaking, it is probable that some soil has been removed. If any significant amount of soil gets washed away from beneath the tank slab and wall footing, there could be further cracking and other problems with the tank. Because we don't know anything about the reinforcing of this tank structure, we cannot comment on what capacity the tank might have to bridge over some "soft spots" in the subgrade.

Based on our review of the situation, particularly noting that the walls do not seem to be leaking / cracking, it is our opinion that the issues at the slab are related in some way either to inadequate reinforcing and/or thickness of the slab/footing, or problems with the supporting soils.

We recommend that the city engage the services of a qualified, licensed geotechnical engineer to provide qualified recommendations regarding the subgrade soils. If it is determined that there are issues with the supporting subgrade, then the geotechnical engineer should have recommendations for possible remedial actions. If the walls need additional support, helical piers or micropiles may be an option. If the slab needs additional support, polymer injections into the subgrade may be an option.

Obviously, the City should continue to monitor this situation in two ways. One, the tank should be monitored to see if there are any signs of settlement / movement over time, or if there are any more signs of seepage as previously observed. Second, it would probably be good to monitor the amount of water that is leaking i.e. perform a leak test occasionally to see what the rate of water loss is when the tank is at operating capacity.

Please feel free to contact us with any questions or concerns.

Sincerely,

LICENSED PROFESSIONAL ENGINEER
Todd A. Bischoff
No. 5337957
11/29/10
STATE OF UTAH

Todd Bischoff, PE

/10318_South Weber City Water Tank Inv Letter_112910.doc

GeoStrata
Engineering & Geosciences
781 West 14600 South, Bluffdale, Utah 84065
Phone (801) 501-0583 | Fax (801) 501-0584

Water Tank Assessment for the City of South Weber
South Weber, Utah

GeoStrata Job No. 683-002

March 15, 2011

Prepared for:

Jones & Associates
1716 East 5600 South
South Ogden, UT 84403

Prepared for:

Jones & Associates
Attention: Mr. Brandon Jones, P.E.
1716 East 5600 South
South Ogden, UT 84403

Water Tank Assessment for the City of South Weber
South Weber, Utah
GeoStrata Job No. 683-002

Prepared by:

Mike Vorkink.
Project Geologist

Reviewed by:

REGISTERED PROFESSIONAL ENGINEER
03/11/11
HIRAM ALBA
175774
STATE OF UTAH

Hiram Alba P.E., P.G.
Principal

GeoStrata, LLC
781 West 14600 South
Bluffdale, UT 84065
(801) 501-0583

March 11, 2011

TABLE OF CONTENTS

APPENDICES

1.0 EXECUTIVE SUMMARY

The purpose of this investigation and report are to assess the presence of voids within and below the concrete base of the water tank located on the banks of the Weber River valley in the city of South Weber (Plate A-1) To asses these issues GPR data, Manometer studies, and coring of the concrete base were performed at the subject site.

GeoStrata conducted GPR surveys along the base of the water tank using a Mala 2.6 Ghz system. Plate A-2 shows the locations of the different survey lines performed at the site. Plates A-5-through A-7 show the results of the GPR surveys.

Plate A-4 shows the results of the Manometer survey of the tank floor. 268 relative elevation points were acquired across the base of the water tank. Data points were contoured in ArcGIS using the Kriging contouring algorithm in the 3D analyst plug-in. The contour values are normalized from the drain elevation in the northern part of the tank.

GeoStrata extracted four 2.5 inch cores from the concrete base of the water tank. Plate A-2 shows the locations of the 4 cores. The cores range from 6-13 inches in length.

The GPR data while noisy indicates that there are numerous "anomalies" at the base of the concrete slab (Plate A-5). The noise in the GPR data is likely a result of water at the surface, water within the concrete and possibly water beneath the concrete slab. The presence of water as apposed to air in the void spaces diminishes the contrast in dielectric constants giving a weakened signal response.

Overall the tank bottom topography shows the base sloping towards the drain area. There is over 8-inches of relief from the drain to the highest elevations in the southeast part of the tank. There is approximately a 2-inch elevation difference between the northwest and southeast sides of the tank bottom.

The results of the coring verify that at least one of the GPR "anomalies" at the base of the concrete was indeed a ~1 inch void space beneath the concrete slab. The fact that all of the cores (Plate A-2) had ~ 1 inch of void space beneath the concrete slab suggests void spaces might be more wide spread.

To minimize the potential for additional leaks and to aid in supporting the tank floor we recommend that consideration be given to grouting under the tank floor. This can be accomplished by hiring a specialized contractor to perform the work. The grouting should be completed through a series of core holes strategically placed around the bottom of the tank.

NOTICE: This executive summary is not intended to replace the report of which it is part and should not be used separately from the report. The executive summary is provided solely for purposes of overview. The executive summary omits a number of details, any one of which could be crucial to the proper application of this report.

2.0 INTRODUCTION

2.1 PURPOSE AND SCOPE OF WORK

The purpose of this investigation and report is to assess the conditions of the concrete base of the water tank located on the banks of the Weber River valley in the city of South Weber (Plate A-1). It is our understanding that the tank has been leaking and that several attempts have been made to minimize the leakage through the use of a Xypex sealing system. Flows have been noted emanating from the bottom of the tank and concerns about undermining of the tank floor were made to us. In an effort to asses the presence of void spaces within and below the concrete slab our scope of work included performing a GPR survey, a manometer survey, a site reconnaissance of the surrounding land area and coring from the concrete base. This scope was developed in discussions with Brandon Jones of Jones and Associates and Hiram Alba (GeoStrata).

The recommendations contained in this report are subject to the limitations presented in the "Limitations" section of this report.

2.2 GEOLOGIC SETTING

The site is located at an elevation of approximately 4745 feet in South Weber, Utah. The site is located adjacent to terraces of the Weber River valley within a broad sediment filled valley associated with basin and range style uplift characterized by sediments deposited in the past 30,000 years, mostly by Pleistocene Lake Bonneville (Scott and others, 1983; Hintze, 1993; Machette, 1992). Lake Bonneville deposits represent a variety of materials ranging from poorly graded beach sands and alluvial gravels to deeper water sands, silts, and clays. The area directly beneath the site is mapped as Quaternary landslide deposits (Qms2), the exact age of which is unavailable. The landslide deposit is characterized by unsorted, unstratified deposits of sand, silt and clay re-deposited by single to multiple slides, slumps and flows. The thickness of these deposits is uncertain (Yonkee and Lowe, 2004). Several other slides are mapped near the project site area and the general vicinity is known to be susceptible to landsliding activities. Plate A-3 presents a geologic map of the subject site and the surrounding site vicinity.

3.0 METHOD OF STUDY

3.1 GPR DATA

Ground Penetrating Radar (GPR) is a geophysical method which uses electromagnetic energy to image the subsurface. A GPR unit consists of a transmitter and antenna, the frequency of the antenna used depends on the type of study. Higher frequency antennas are typically used to resolve shallow small features while low frequency antennas are used for larger deeper features. Pulses of electromagnetic radiation are emitted from the transmitter of the GPR unit into the subsurface. When the electromagnetic energy encounters changes in the subsurface materials such as voids, the electromagnetic energy reflects off of the boundary and is received by the antenna.

GeoStrata used a MALA CX concrete imaging system with a 2.6 Ghz antenna to conduct field investigations at the subject site. This system is designed to image small features in the shallow subsurface. Raw GPR data was imported and processed in IXPGR software.

3.2 MANOMETER

GeoStrata conducted a monometer survey of the floor of the interior of the water tank. Manometers work on the principle that water equalizes to the same elevation on both sides of a water-filled tube. The manometer consists of a water reservoir connected to a stadia rod via plastic tubing. Relative elevation measurements are read by observing the water level on the graduated cylinder connected to the stadia rod. 268 relative elevation points were recorded across the base of the water tank. Manometer data was recorded on a map of the base of the water tank and data points were then contoured using the Kriging algorithm in the 3D analyst plug-in of ArcGIS. Plate A-4 shows the results of the contouring. It should be noted that data point distribution across the tank bottom is not equal. The data point density is greater in the southern half of the tank and data is sparser in the northern half of the tank. It is possible that the data density may impact on the contouring presented on the plate.

3.3 CORING

GeoStrata extracted four cores from the concrete base of the water tank. Plate A-2 shows the locations of the 4 cores. The cores are 2.5-in diameter and range from 6- to 13-inches in length. Core locations were chosen based on results of GPR surveys and locations of surface fractures. It was noted that water was emanating from the concrete cores when removed from the tank floor indicating that the void spaces in the concrete were saturated.

4.0 FIELD WORK RESULTS

4.1 GROUND PENETRATING RADAR

GeoStrata conducted GPR surveys along the base of the water tank using a Mala 2.6 Ghz system. Plate A-2 shows the locations of the different survey lines performed at the site. Plates A-5- through A-7 show the results of the GPR surveys. The GPR data shown in the profiles have been filtered to try and remove as much noise as possible and minimize the returns off of the rebar. Most of the small parabolic shapes in the upper 8 inches of the profiles are from rebar. The noise in the GPR data is a result of water at the surface, water within the concrete and possibly water beneath the concrete. The presence of water as apposed to air in the void spaces diminishes the contrast in dielectric constants giving a weakened signal response. Line 1 (Plate A-5) shows several examples of returns at or near the base of the concrete slab (see Plate A-2 for line location). The anomalies are subtle but suggest a small 1- to 2-inch feature at the base of the concrete slab. This was one of the more distinct features visible from the GPR data and we later cored near these features.

4.2 MANOMETER SURVEY

Plate A-4 shows the results of the Manometer survey of the tank floor. Data points were collected and these points were contoured in ArcGIS using the Kriging contouring algorithm in the 3D analyst plug-in. The contour values are normalized from the drain elevation in the northern part of the tank.

Overall the tank bottom topography shows the base sloping towards the drain area. There is over 8-inches of relief from the drain to the highest elevations in the southeast part of the tank. There is approximately a 2-inch elevation difference between the northwest and southeast sides of the tank bottom. There also appear to be small scale undulations of the bottom as seen by the contour lines. A slope towards the drain should be anticipated; in discussing typical slopes with tank designers it is not uncommon to have a 1% slope to a drain. The subject tank has a diameter of 105 feet with a maximum differential elevation of 8 inches (0.7 ft) as noted. This lies within the general design limits.

4.3 CORING

Cores were extracted at four locations concentrated near the southern part of the water tank. The cores ranged from 6 to 12 inches in length. The field technicians noted that once the cores were extracted water was seeping out of the cores through the visible voids. To test for void space beneath the concrete a wire was placed into the hole which was used to probe several inches around the base of the core. Probing in each of the 4 core holes indicated that there was approximately 1-inch of space between the base of the concrete and underlying soils.

4.4 FIELD STUDIES

In conjunction with conducting GPR studies inside the water tank, a qualified engineering geologist from Geostrata reviewed the geology of the area in the vicinity of the water tank. The area underlying the water tank is mapped as landslide deposit by Yonkee (2004). At the time of our visit, to the water tank site, the ground was covered with snow making the local geomorphology difficult to assess. A review of stereographic aerial photographs of the subject site resulted in the identification of several features. Stereographic aerial photographs were downloaded from the AGRC (http://agrc.its.state.ut.us/) website. Approximately 270 feet north and east of the water tank there appears to be a head scarp of a landslide. The landslide is approximately 500 feet in width and 270 ft long as mapped by Yonkee et al., 2004 (Plate A-2). The pronounced head scarp and other goemorphological features, visible on the stereographic aerial photographs, suggest that this landslide might still be active. The topographic slope around the water tank is shallower than the topography in the area of the active landslide area to the north.

There is a topographic depression approximately 70 feet southwest of the water tank. There was water visible in the depression at the time of our visit. The water in the topographic depression is likely fed by the runoff from the water tank when it is leaking. These types of depressions or sag ponds are often found in active landslides areas. Sag ponds will generally develop at the bottom of a landslide scarp and at the head of the slope mass. No particular scarp was noted in the area of the sag pond at the time of our site visit.

Plate A-8 is presents a photograph of the water tank where water has been observed by city officials to flow in a small stream to the south. Small mounds of soils can be seen collecting at the edge of the tank.

Plate A-9 and A-10 show photographs taken from the inside of the water tank. Cracks that have been sealed can be seen in the vicinity of the pillars. The diamond-shaped pattern of fractures around the pillar may be the result of settlement. Most of the pillars have this type of fracturing around the base.

5.0 DISCUSSION OF RESULTS

GeoStrata conducted field studies at the subject site including a GPR survey, Manometer studies, coring, and field observations. The GPR data while noisy indicates that there are numerous "anomalies" at the base of the concrete slab. The GPR data also shows there are 2 layers of rebar in the concrete base. The GPR signal from rebar produces a narrow parabola. Strong GPR signals like those produced from rebar often produce multiples. Multiples are similar to an echo where similar size and shaped features are repeated at depth multiple times. The GPR signals from rebar in this study have multiples and it is difficult to differentiate whether all small parabolas seen in the upper 8 inches are related to rebar. It is possible that some of these might reflect actual "anomalies" within the concrete. Additional field studies would have to be conducted to investigate these phenomena.

The results of the coring verify that at least one of the GPR "anomalies" at the base of the concrete was indeed a ~1 inch void space beneath the concrete slab. The fact that all of the cores (Plate A-2) had approximately 1-inch of void space beneath the concrete slab suggests this issue might be more wide spread.

It should be noted that both water tanks are built in an area of mapped landslides (Yonkee et al. 2004). There are active landslide features in close proximity to the water tanks. Adding excess water into the subsurface in an already landslide susceptible area may increase the probability of a slope failure. Due to the topographic slope in the area of the water tank being shallow GeoStrata does not believe that the leaking and or cracking observed is a result of landslide movement.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

As previously indicated, concerns about the undermining of the floor slab areas have been noted by City personnel. Based on the results of our study, the anomalies noted in the GPR survey which we attribute to be voids are generally small and localized. The coring substantiated that voids do exist beneath the slabs and that the voids are likely a combination of settlement and washing out of material from the tank leaks.

Several of the photographs indicate that some settlement of the tank has been occurring. It's unclear if the settlement is occurring in the column spread footings or in the floor slab. Based on a review of localized contouring, it seems evident that the settlement may be occurring in the floor slab. The contouring indicated a low in the middle of the slab between columns. We recommend that tank floor surveys be completed periodically to check movement that the tank may be experiencing.

6.2 RECOMMENDATIONS

To minimize the potential for additional leaks and to aid in supporting the tank floor we recommend that consideration be given to grouting under the tank floor. This can be accomplished by hiring a specialized contractor to perform the work. The grouting should be completed through a series of core holes strategically placed around the bottom of the tank. The grout should be slightly pressurized to allow the grout to flow beneath the tank floor and fill any existing voids. The grouting plan should be developed in conjunction with GeoStrata personnel and should include monitoring techniques to measure the lateral flow, volume and pressures of the grout. GeoStrata can aid in identifying a competent grouting contractor.

7.0 LIMITATIONS

The recommendations contained in this report are based on limited field exploration and our understanding of the purpose of the subject site. The subsurface data used in the preparation of this report were obtained from the geophysical studies and cores across the subject site. It is possible that variations in the soil and groundwater conditions might exist. The nature and extent of variations may not be evident without additional subsurface exploration. If any conditions are encountered at this site that are different from those described in this report, our firm should be immediately notified so that we may make any necessary revisions to recommendations contained in this report. In addition, if the purpose of the subject site changes from that described in this report, our firm should also be notified.

This report was prepared in accordance with the generally accepted standard of practice at the time the report was written. No warranty, expressed or implied, is made.

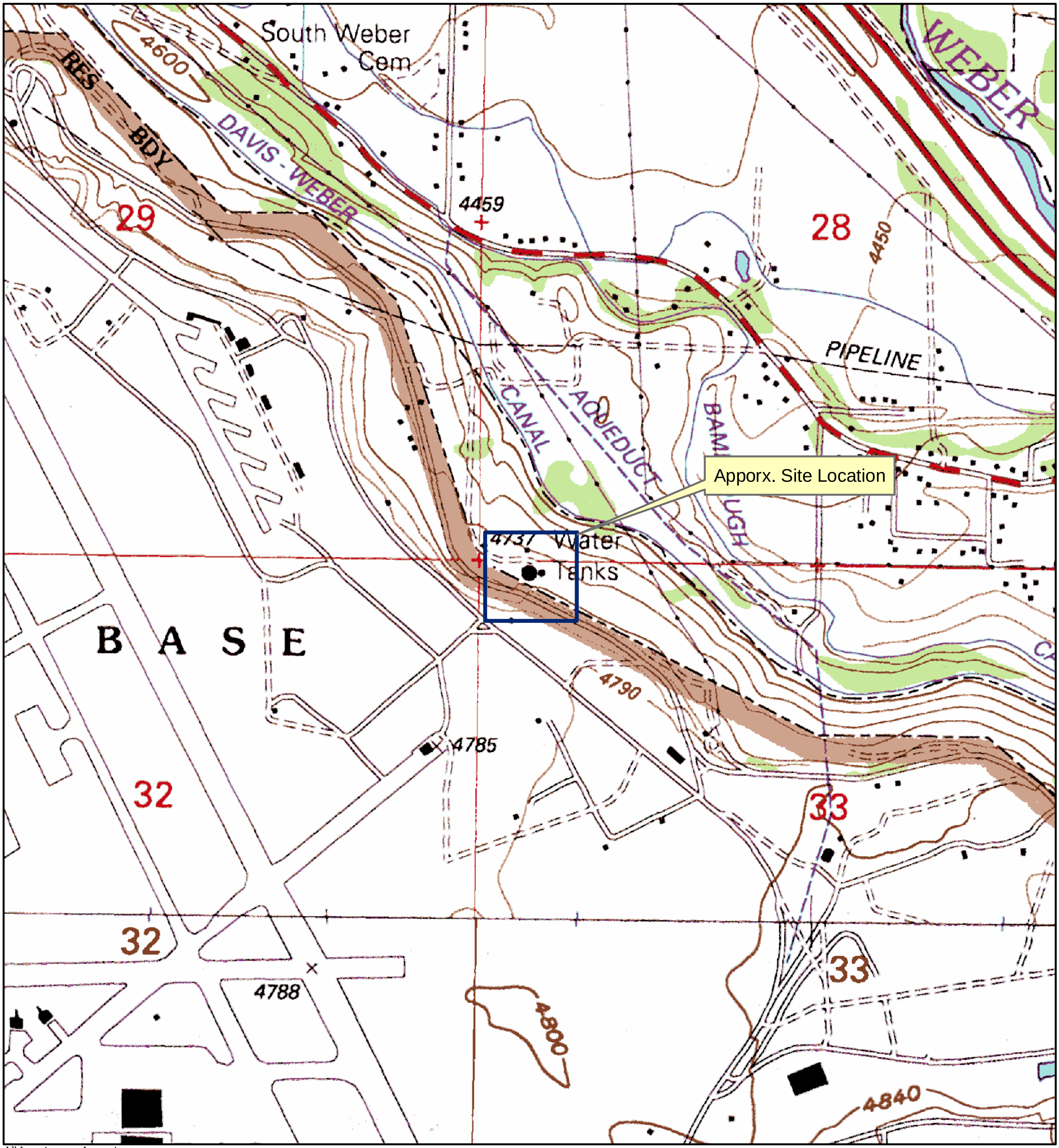
It is the Client's responsibility to see that all parties to the project including the Designer, Contractor, Subcontractors, etc. are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

8.0 REFERENCES CITED

Hintze, L.F. (1993). "Geologic History of Utah" Brigham Young University Studies, Special Publication 7, 202p.

Machette, M. 1992, Surficial geologic map of the Wasatch Fault Zone, Eastern Part of Utah Valley Utah County and Parts of Salt Lake and Juab Counties, Utah, 1:50,000, 1992 United States Geological Survey, I-2095.

Yonkee, Adolph, and Lowe, Mike, 2004, Geologic map of the Ogden 7.5' quadrangle, Weber and Davis Counties, Utah. Utah Geological Survey, scale 1: 24000.



All Locations are Approximate
Base Map: USGS Topographic Map

0 300 600 1,200 1,800 2,400 Feet

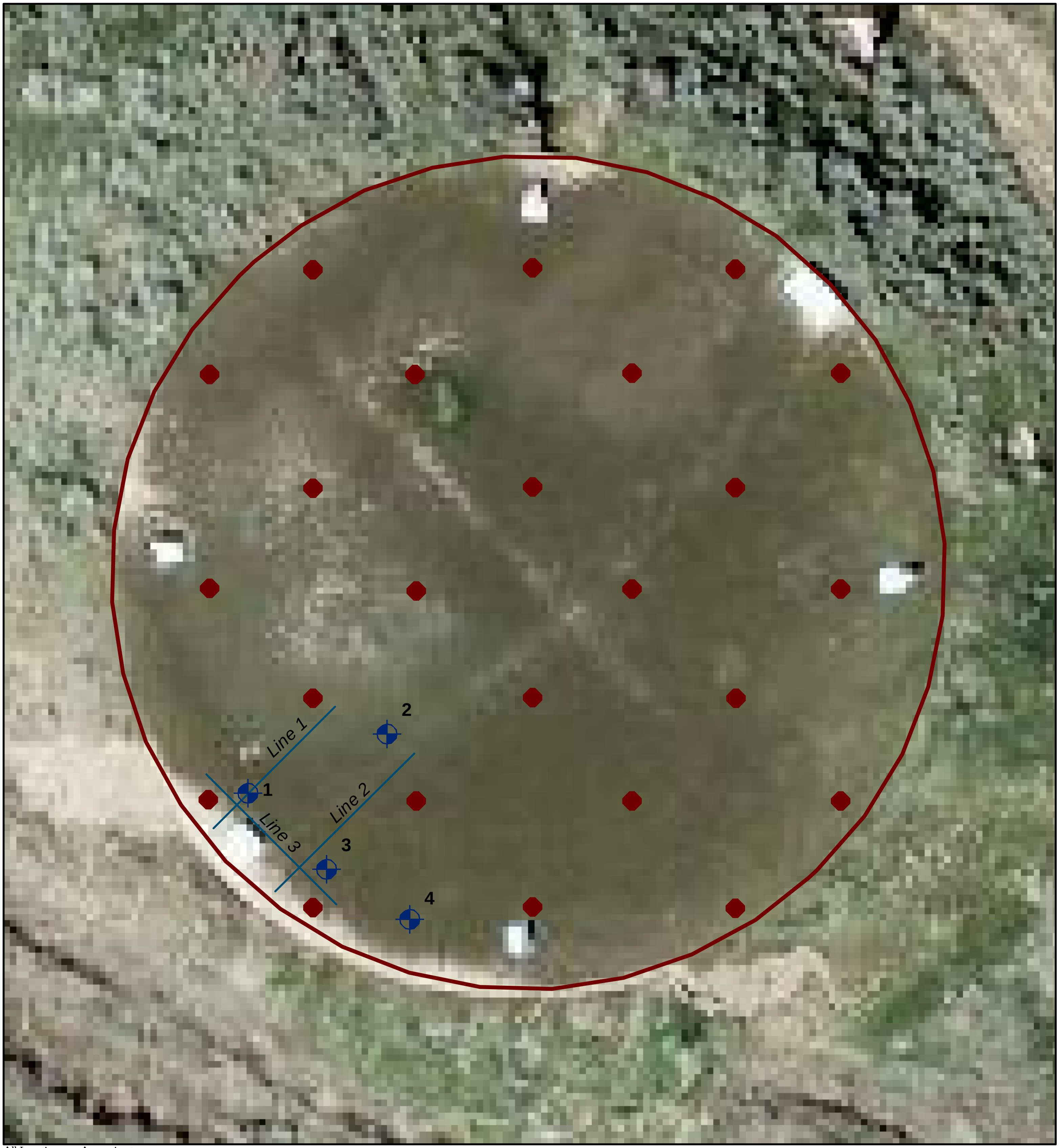
1:12,000

N

South Weber Water Tank Leak Investigation
Jones and Associates
South Weber, Utah
Project Number: 683-002

Site Vicinity Map

Plate A-1



All Locations are Approximate
Base Map: 1 Foot NAIP 2009 Orthophotography

0 5 10 20 30 40 Feet

1:200

N

Legend

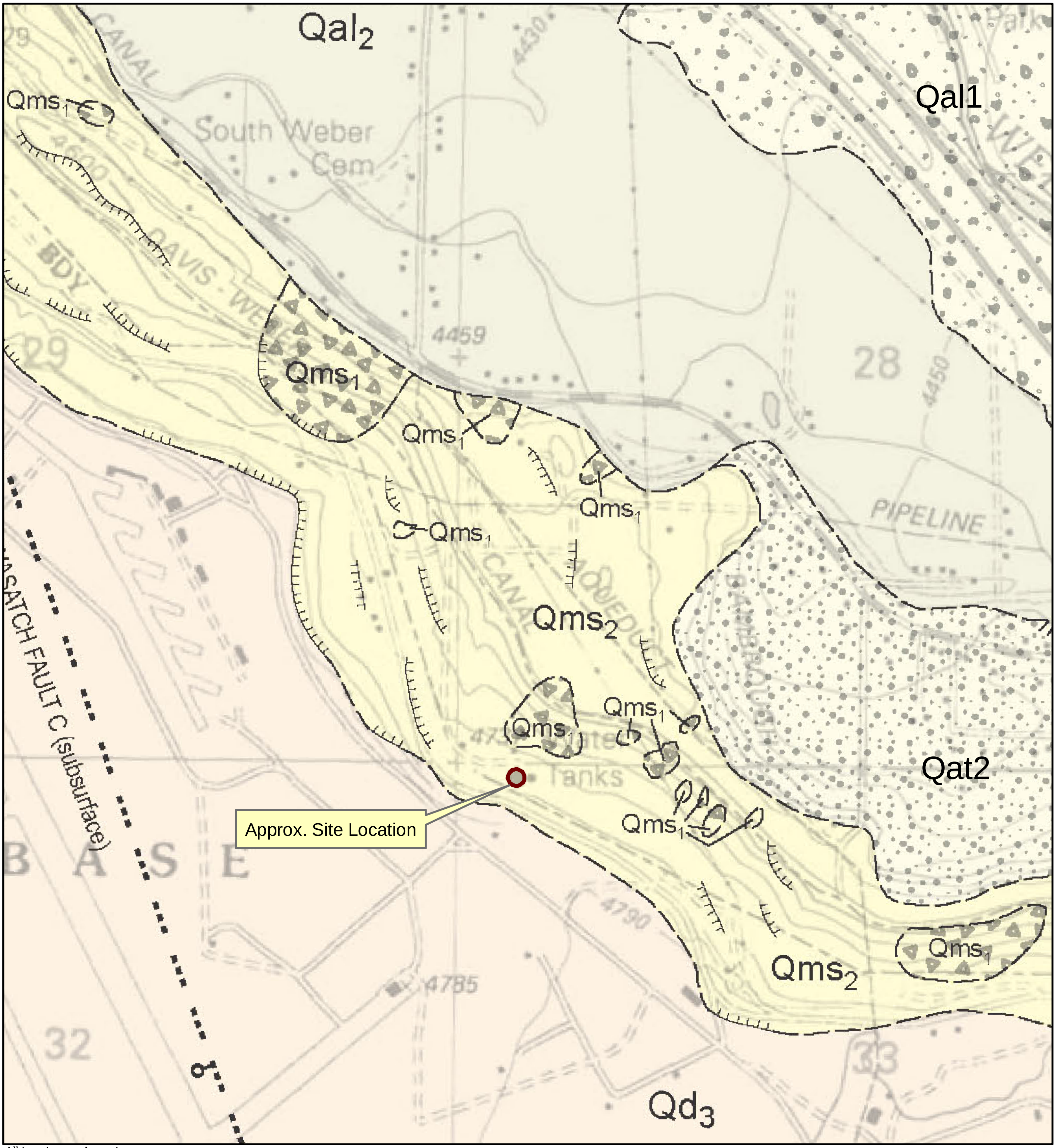
- Coring Location
- GPR Line
- Pillar

GeoStrata

South Weber Water Tank Leak Investigation
Jones and Associates
South Weber, Utah
Project Number: 683-002

Site Exploration Map

Plate A-2



All Locations are Approximate
Base Map: Geologic Map of the Ogden 7.5' Quadrangle

0 250 500 1,000 1,500 2,000 Feet

1:10,000

N

Qd_3 – Deltaic Deposits

Qms_1 – Younger Landslide Deposits

Qms_2 – Older Landslide Deposits

Qat_2 – Older Alluvial Terrace Deposits

Qal_1 – Younger Stream Alluvium

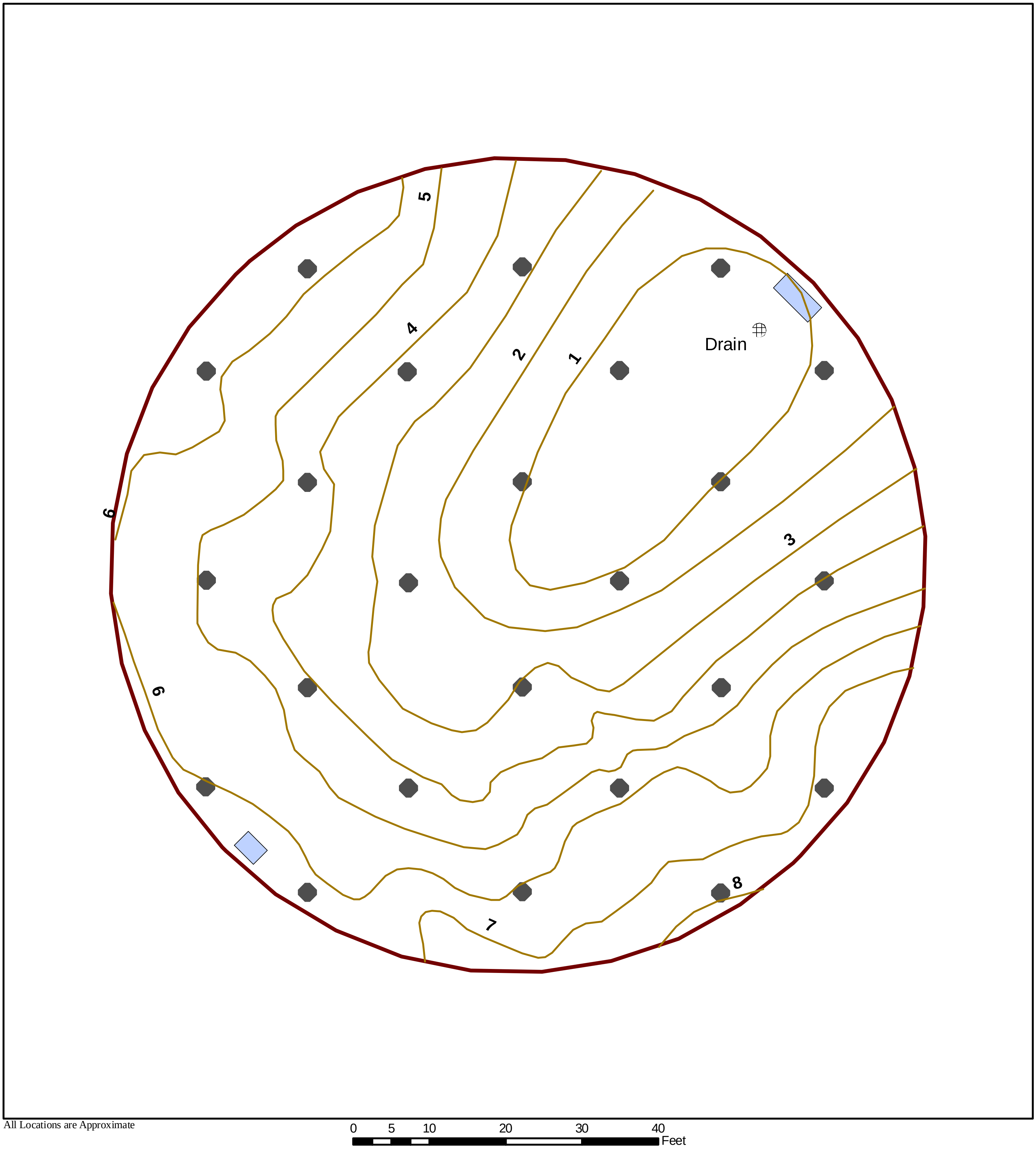
Qal_2 – Older Stream Alluvium

GeoStrata

South Weber Water Tank Leak Investigation
Jones and Associates
South Weber, Utah
Project Number: 683-002

Surfical Geologic Map

Plate A-3



Legend

- Contour (in.)
- Pillar
- Roof Access

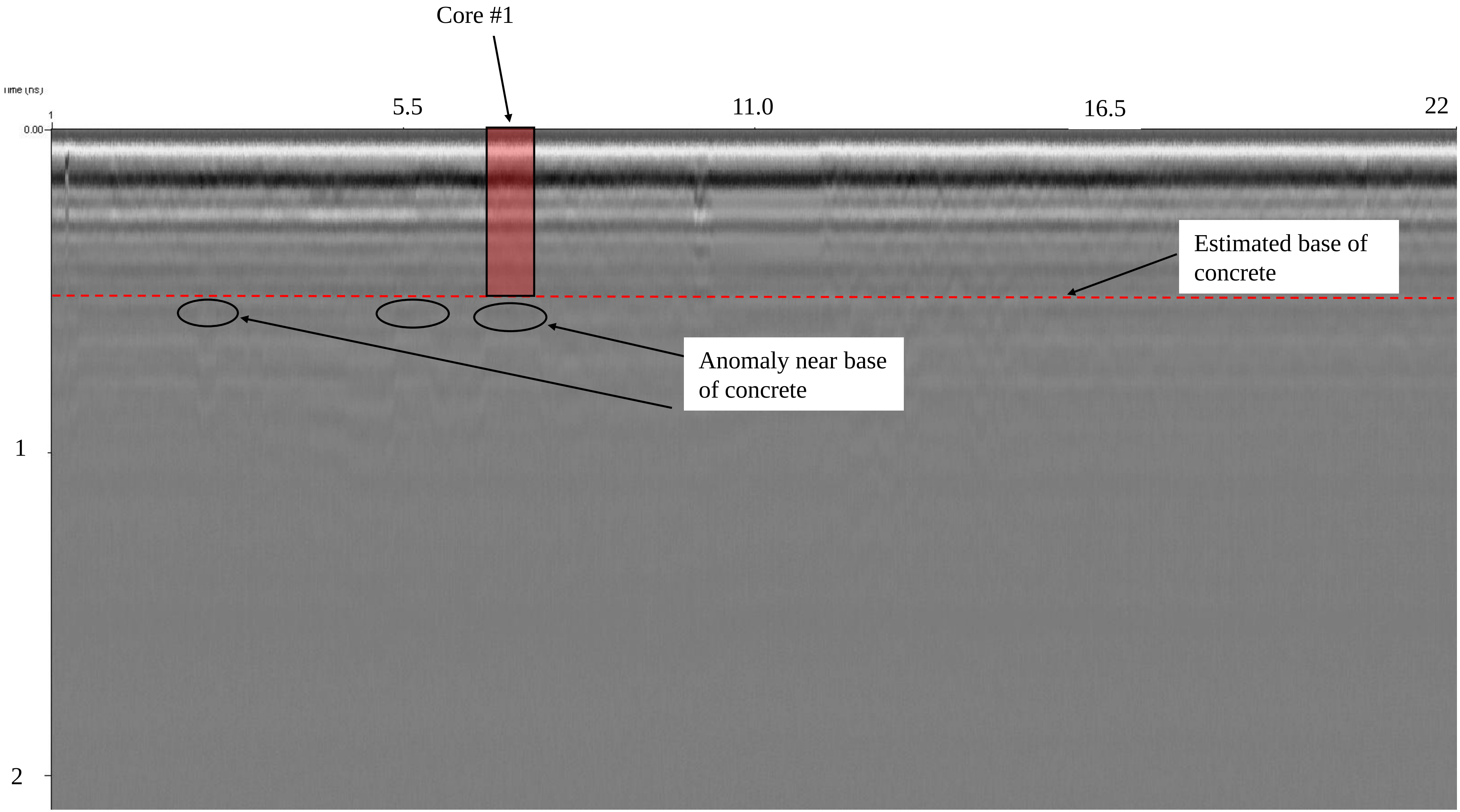
GeoStrata

South Weber Water Tank Leak Investigation
City of South Weber
South Weber, Utah
Project Number: 683-002

Tank Floor Topography

Plate A-4

Line 1



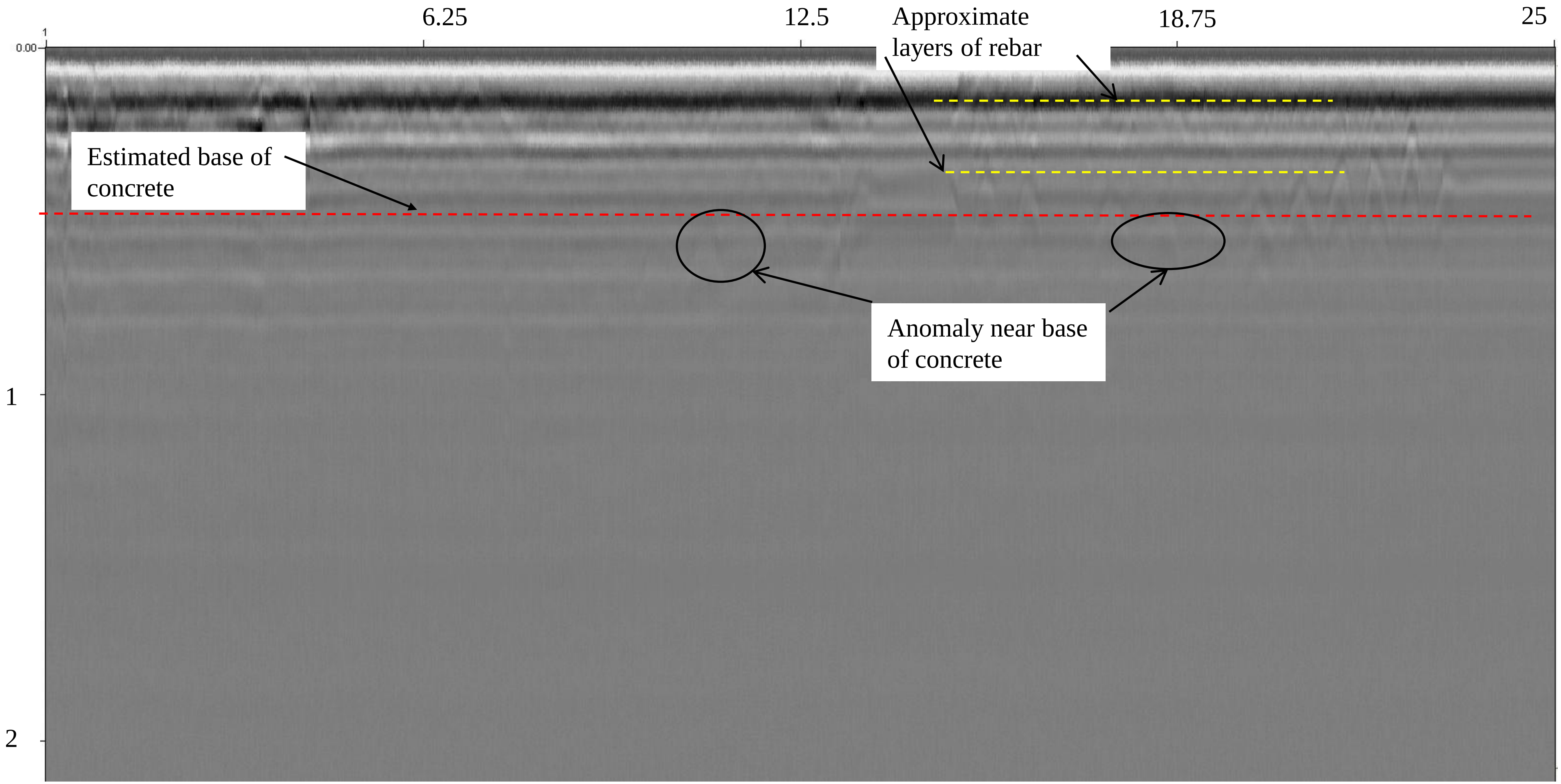
GeoStrata

South Weber Water Tank Leak Investigation

Jones and Associates
South weber, UT
Project Number 683-002

Plate A-5

Line 2

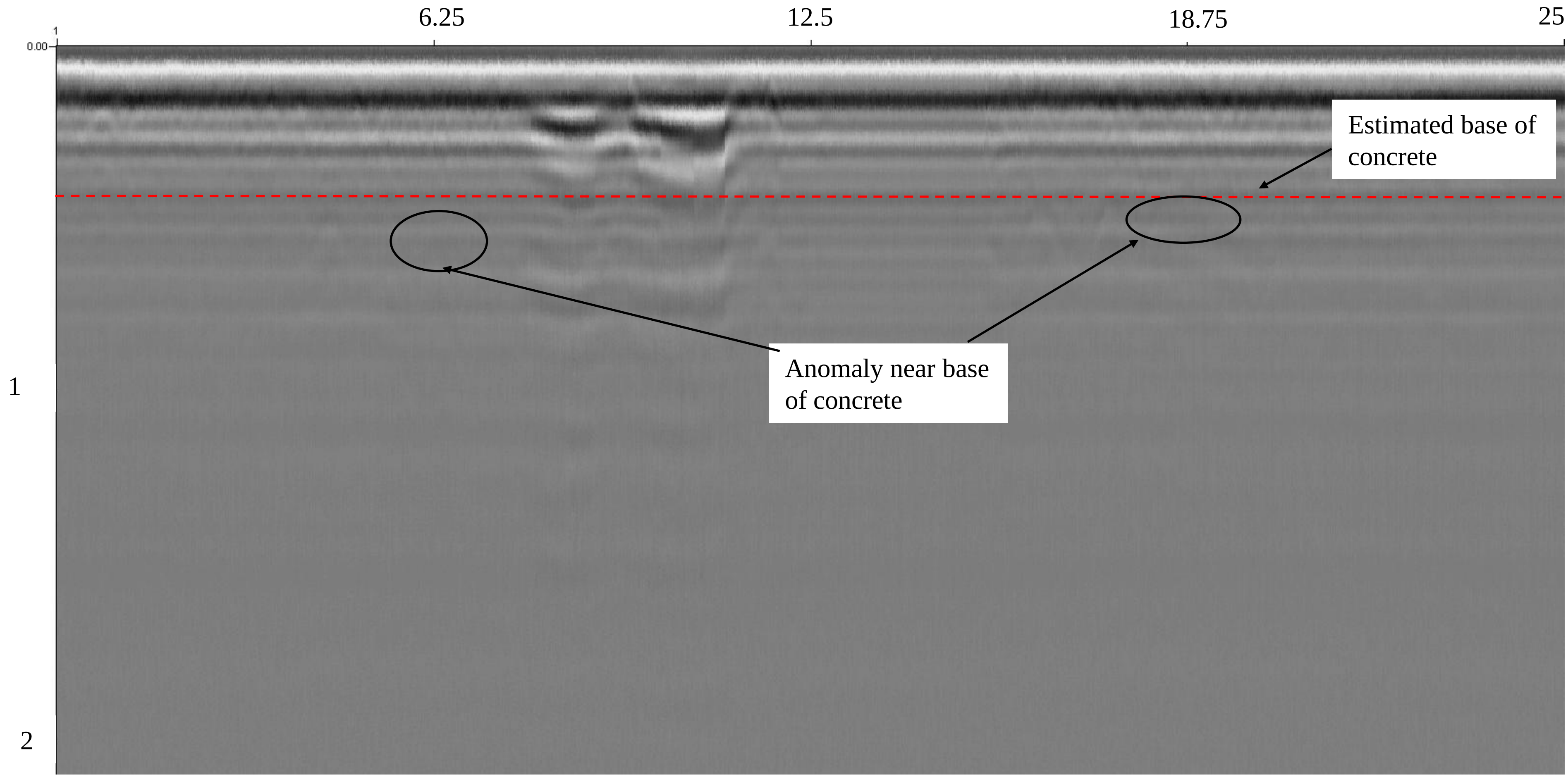


GeoStrata

South Weber Water Tank Leak Investigation
Jones and Associates
South weber, UT
Project Number 683-002

Plate A-6

Line 3



GeoStrata

South Weber Water Tank Leak Investigation

Jones and Associates
South weber, UT
Project Number 683-002

Plate A-7

GeoStrata

South Weber Water Tank Leak Investigation

Jones and Associates
South weber, UT
Project Number 683-002

Plate A-8

GeoStrata

South Weber Water Tank Leak Investigation

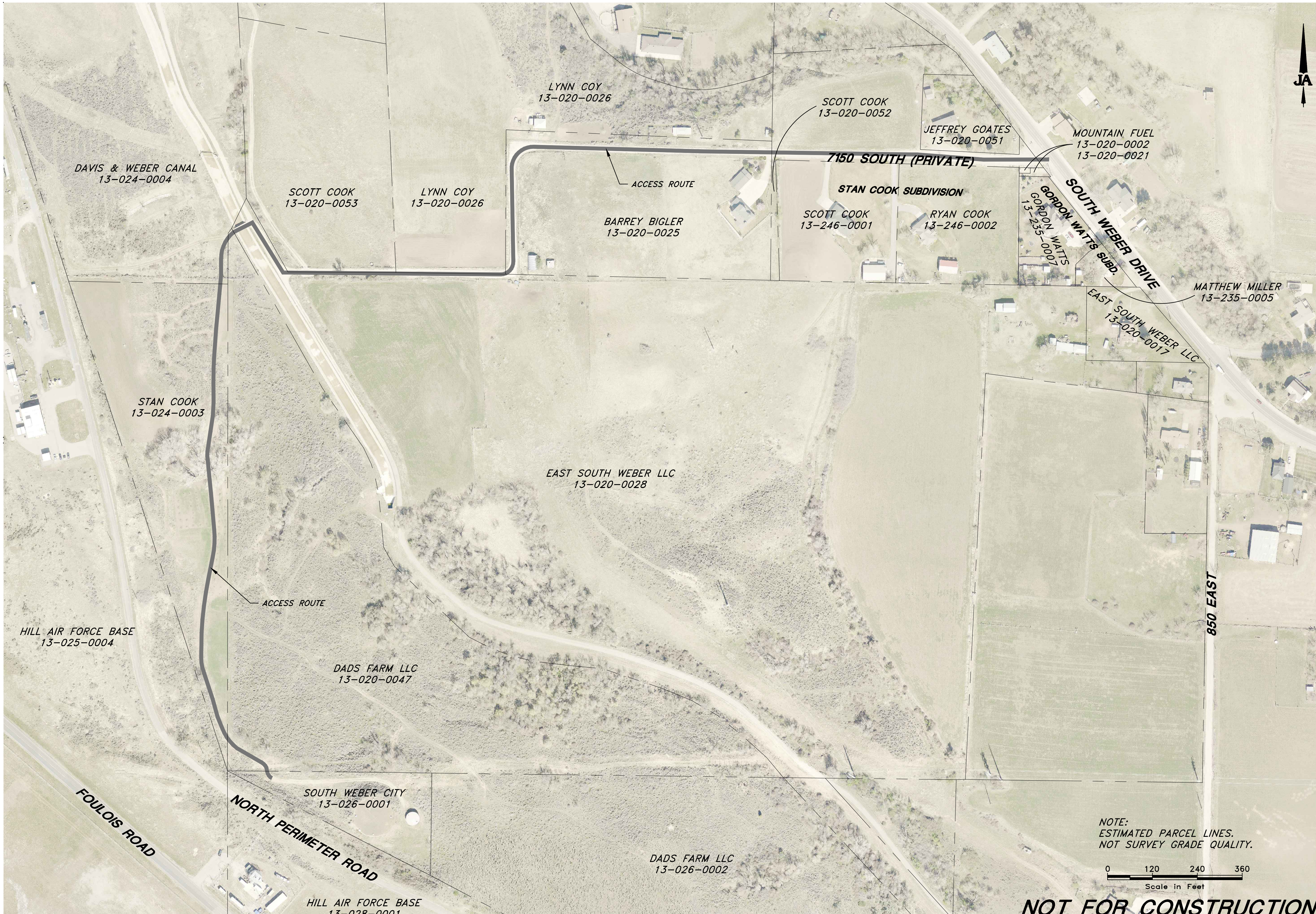
Jones and Associates
South weber, UT
Project Number 683-002

Plate A-9

GeoStrata

South Weber Water Tank Leak Investigation
Jones and Associates
South weber, UT
Project Number 683-002

Plate
A-10



NOT FOR CONSTRUCTION

JA JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

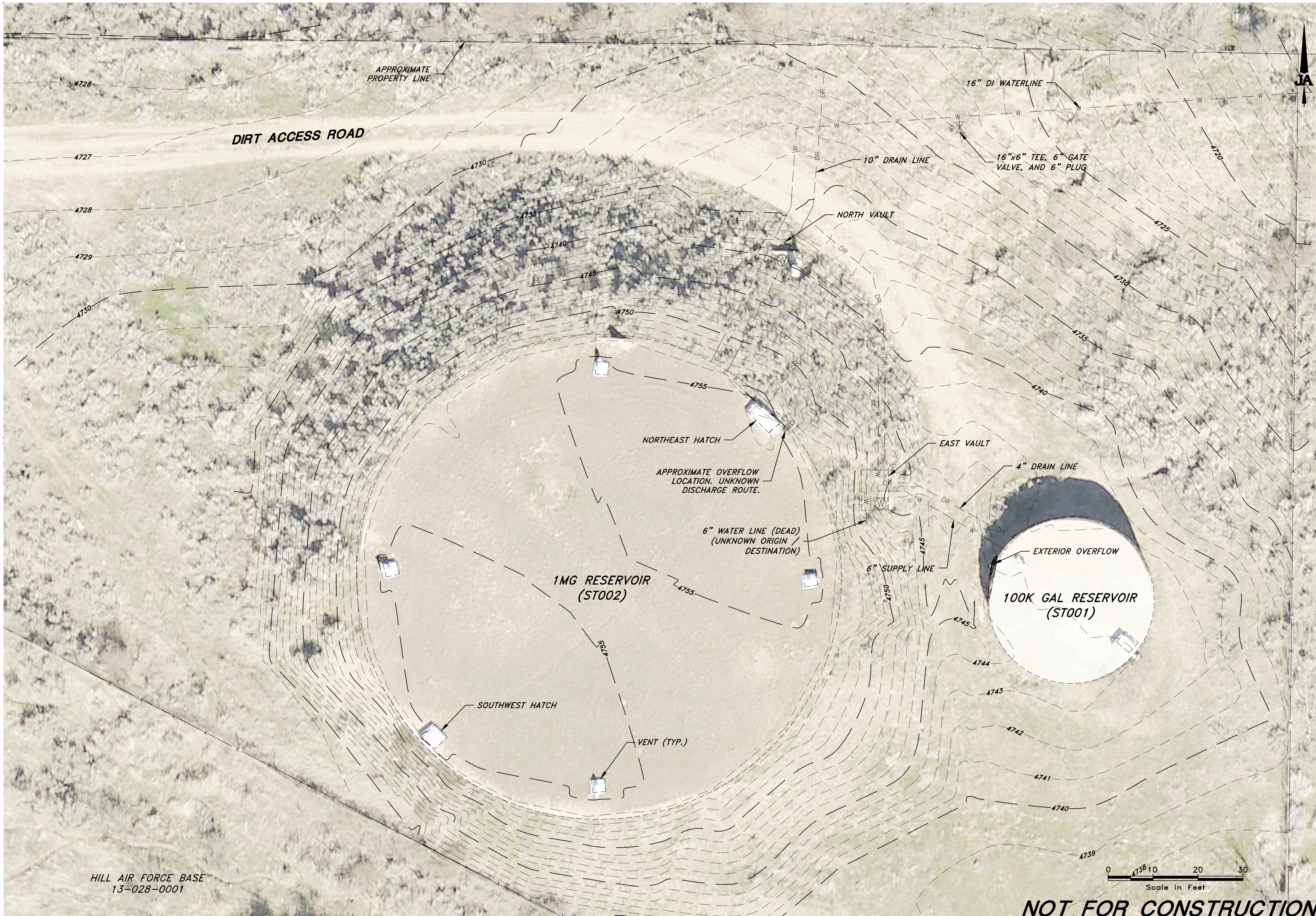
LOCATION AND PARCEL MAP

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE:
24"x36" H:1"=120'
11"x17" H:1"=240'

SHEET: 1
OF 1 SHEETS



CONSULTING ENGINEERS
JONES & ASSOCIATES
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

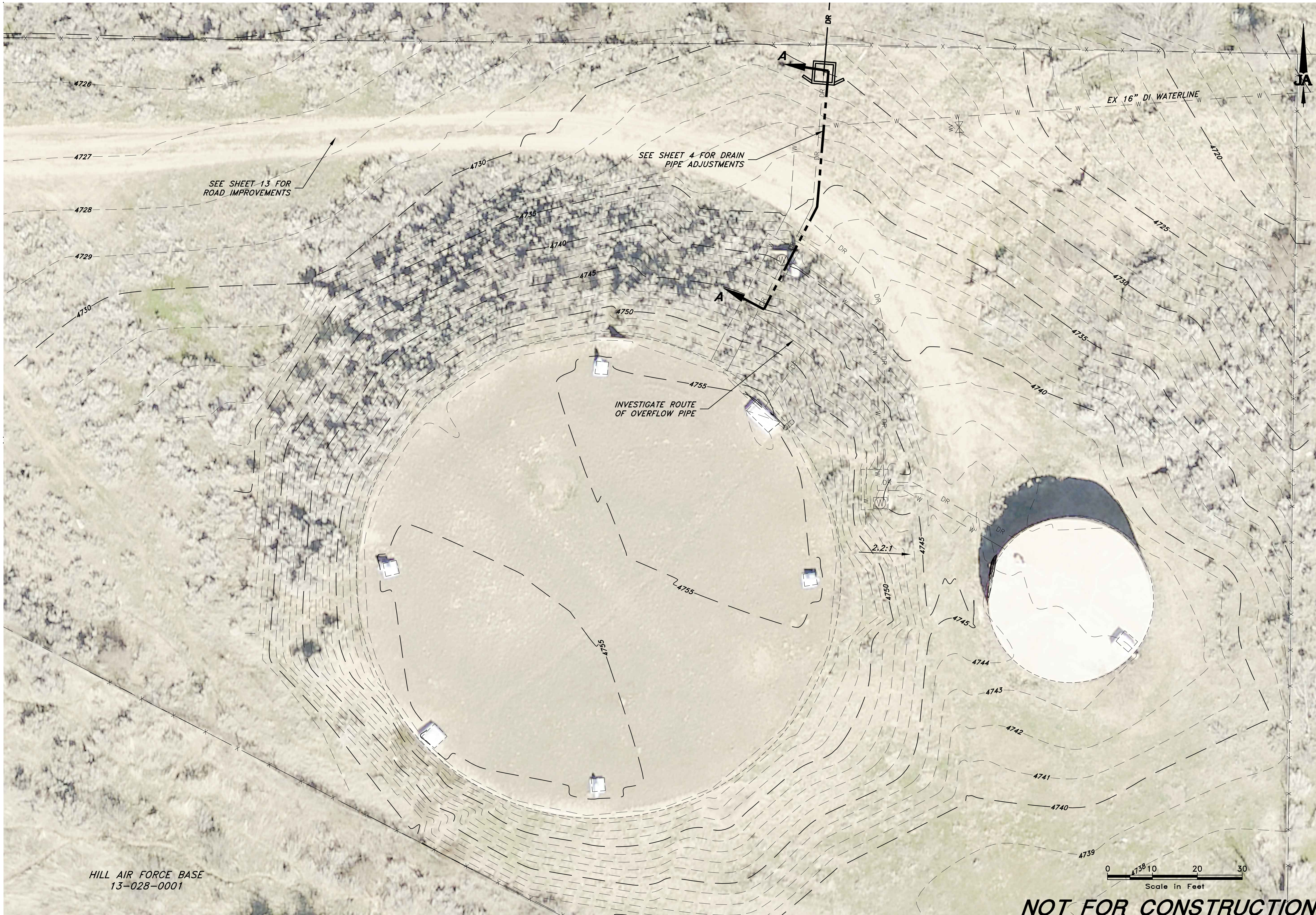
EXISTING SITE PLAN

REV.	DATE	APPR.

DOS DESIGNED
TWE DRAWN
DOS CHECKED

SCALE: 24"x36" H:1"=10'
11"x17" H:1"=20'

SHEET: 2
OF 1 SHEETS



JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

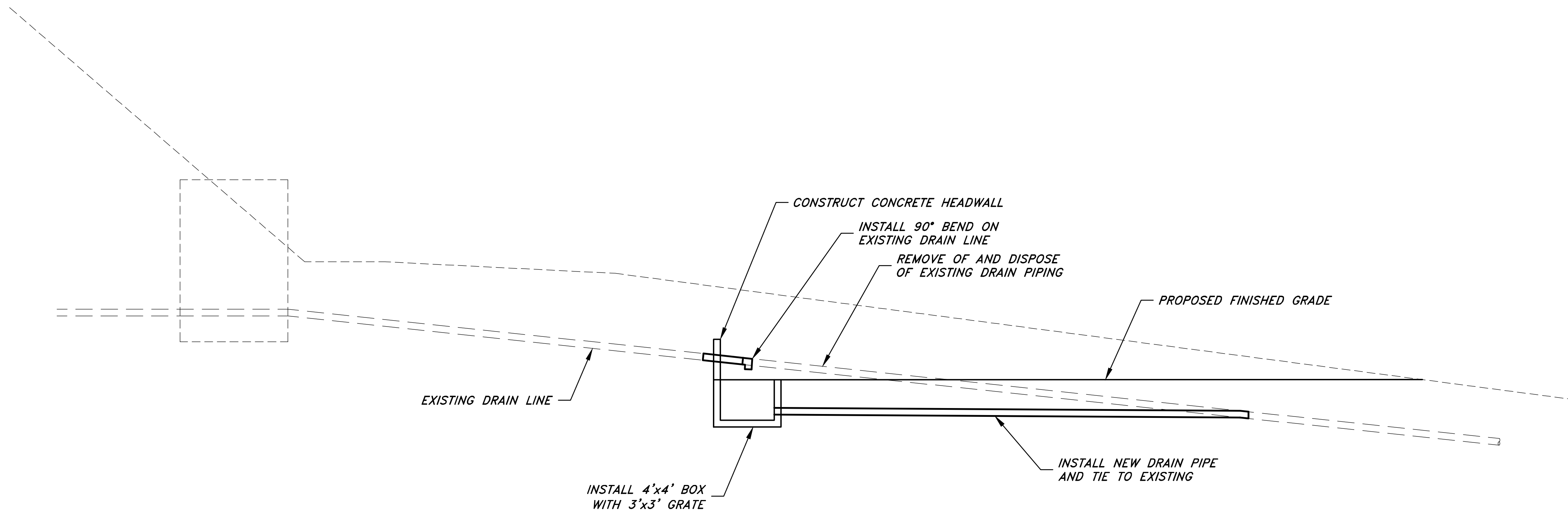
YARD PIPING IMPROVEMENTS

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE:
24"x36" H:1"=10'
11"x17" H:1"=20'

SHEET: 3
OF 1 SHEETS



SECTION A-A WITH AIR GAP STRUCTURE

0 5 10 15
Scale in Feet

NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

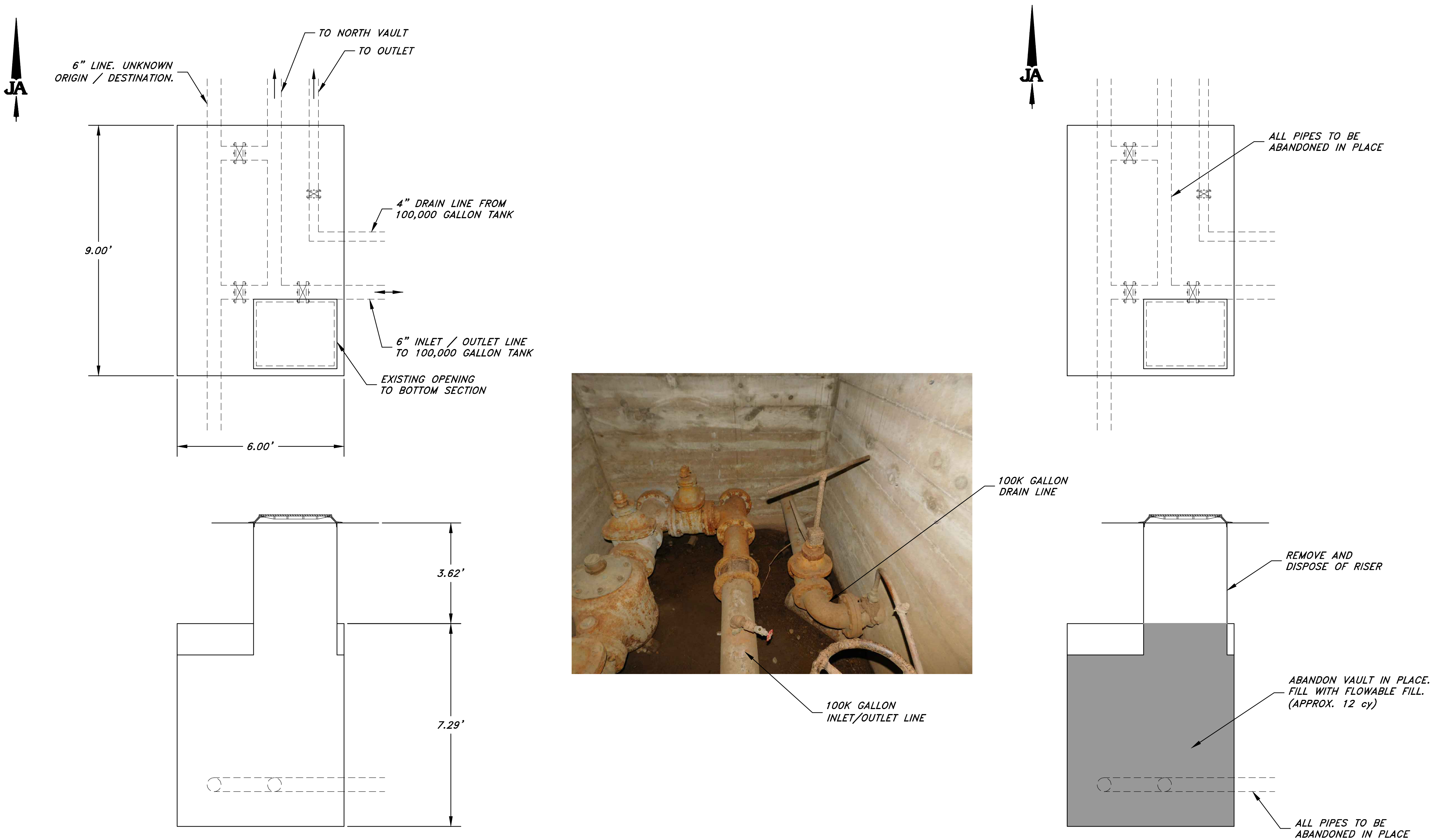
AIR GAP STRUCTURE

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=5'
11"x17" H:1"=10'

SHEET: 4
OF 1 SHEETS



EXISTING EAST VAULT

POPOOSED EAST VAULT

0 2 4 6
Scale in Feet

NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

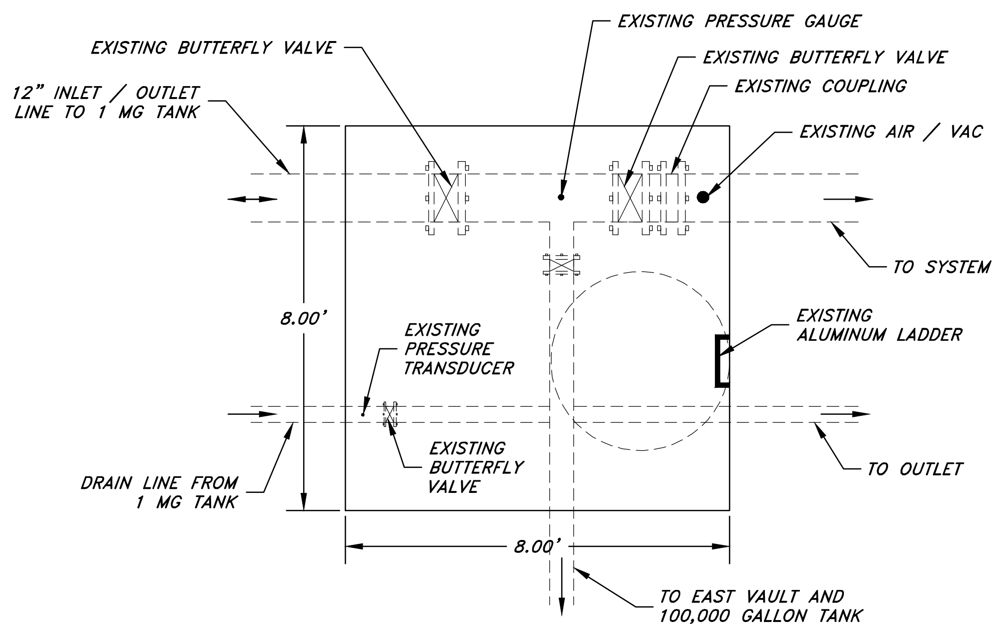
EAST VAULT

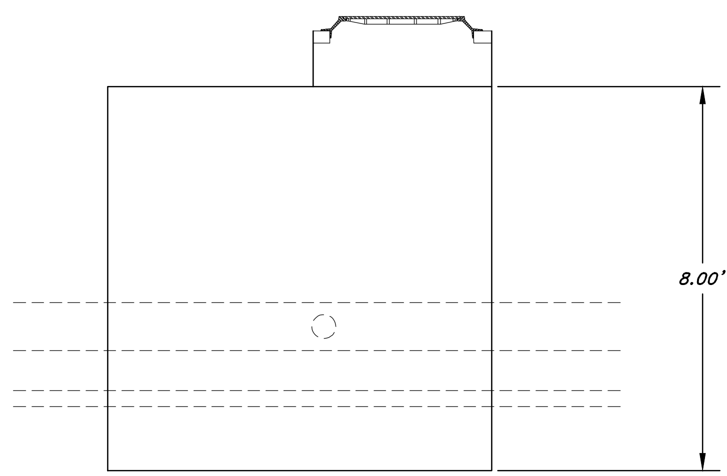
REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

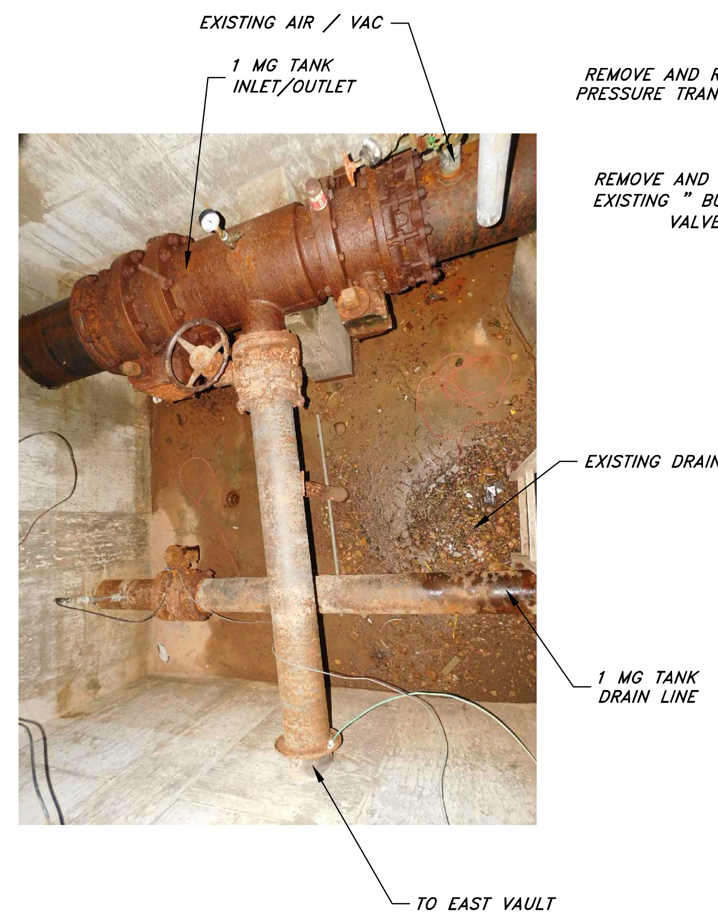
SCALE: 24"x36" H:1"=2'
11"x17" H:1"=4'

SHEET: 5
OF 1 SHEETS

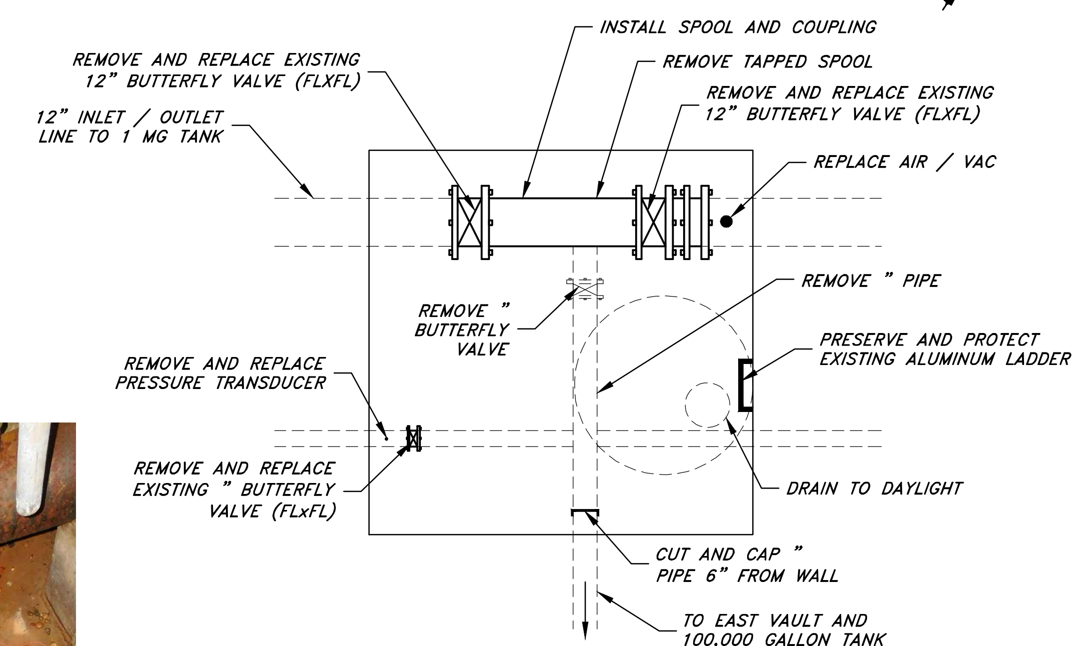


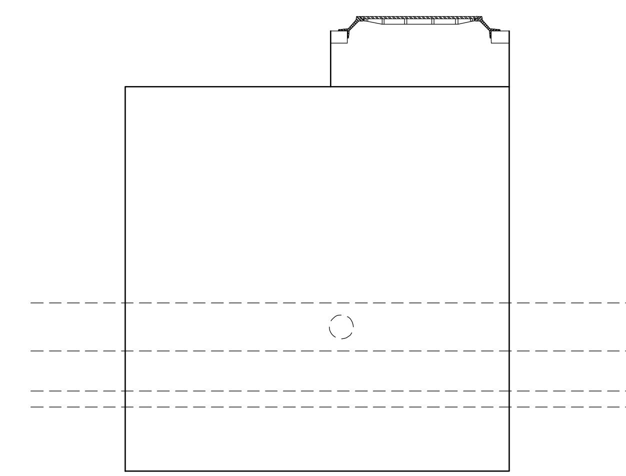


EXISTING NORTH VAULT



NOTE:
CONTRACTOR TO FIELD VERIFY ALL MEASUREMENTS PRIOR TO FABRICATION OF CUSTOM APPURTENANCES.





PROPOSED NORTH VAULT

0 2 4 6
Scale in Feet

NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476–9767 fx – (801)476–9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT
NORTH VAULT

REV.	DATE	APPR.

DESIGNED: DQS
DRAWN: TWE
CHECKED: DQS

SCALE: 24"x36" H:1"=2' 11"x17" H:1"=4'

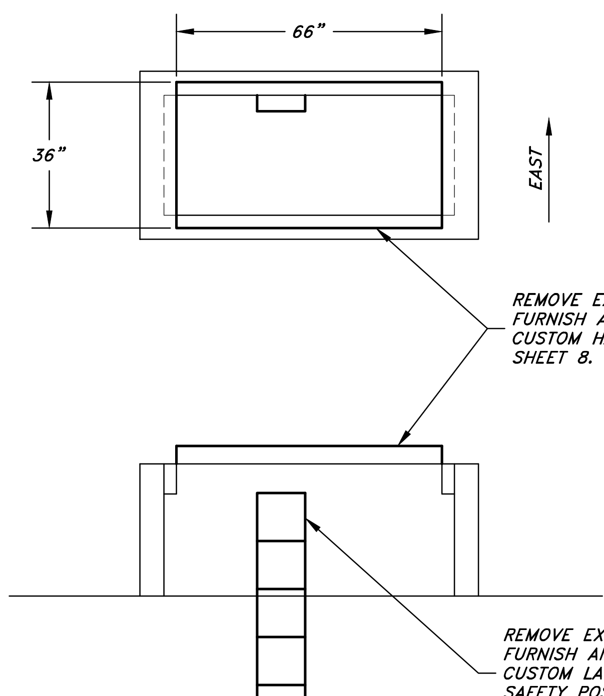
SHEET: 6
OF 1 SHEETS

REMOVE EXISTING HATCH. FURNISH AND INSTALL CUSTOM HATCH. SEE SHEET 8.

REMOVE EXISTING HATCH. FURNISH AND INSTALL CUSTOM HATCH. SEE SHEET 8.

REMOVE EXISTING LADDER. FURNISH AND INSTALL CUSTOM LADDER. SEE SHEET 8.

REMOVE EXISTING LADDER. FURNISH AND INSTALL CUSTOM LADDER. SEE SHEET 8.

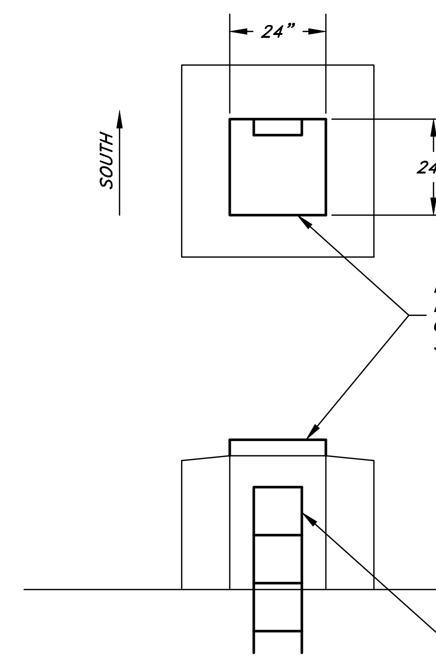


REMOVE EXISTING HATCH. FURNISH AND INSTALL CUSTOM HATCH. SEE SHEET 8.

REMOVE EXISTING LADDER. FURNISH AND INSTALL CUSTOM LADDER WITH SAFETY POST. SEE SHEET 8.

NORTHEAST HATCH

NOTE:
CONTRACTOR TO FIELD VERIFY ALL MEASUREMENTS PRIOR TO FABRICATION OF CUSTOM APPURTENANCES.



REMOVE EXISTING HATCH. FURNISH AND INSTALL CUSTOM HATCH. SEE SHEET 8.

REMOVE EXISTING LADDER. FURNISH AND INSTALL CUSTOM LADDER WITH SAFETY POST. SEE SHEET 8.

SOUTHWEST HATCH

0 2 4 6
Scale in Feet

NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

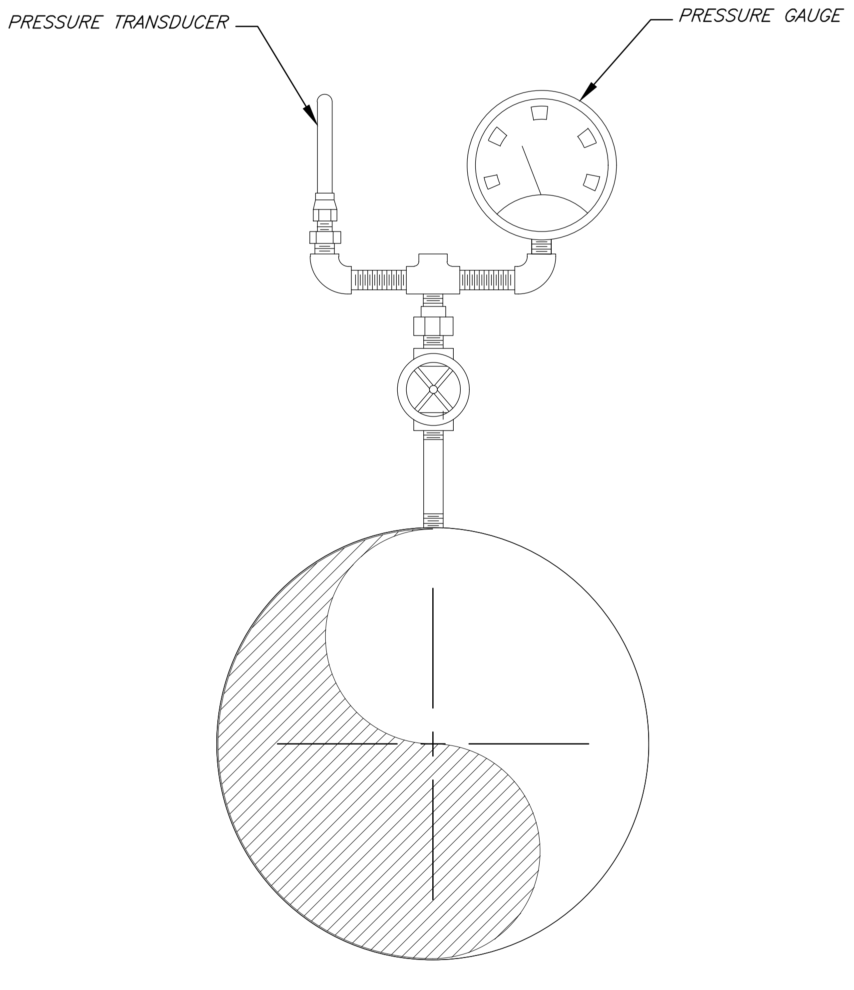
HATCHES

REV.	DATE	APPR.

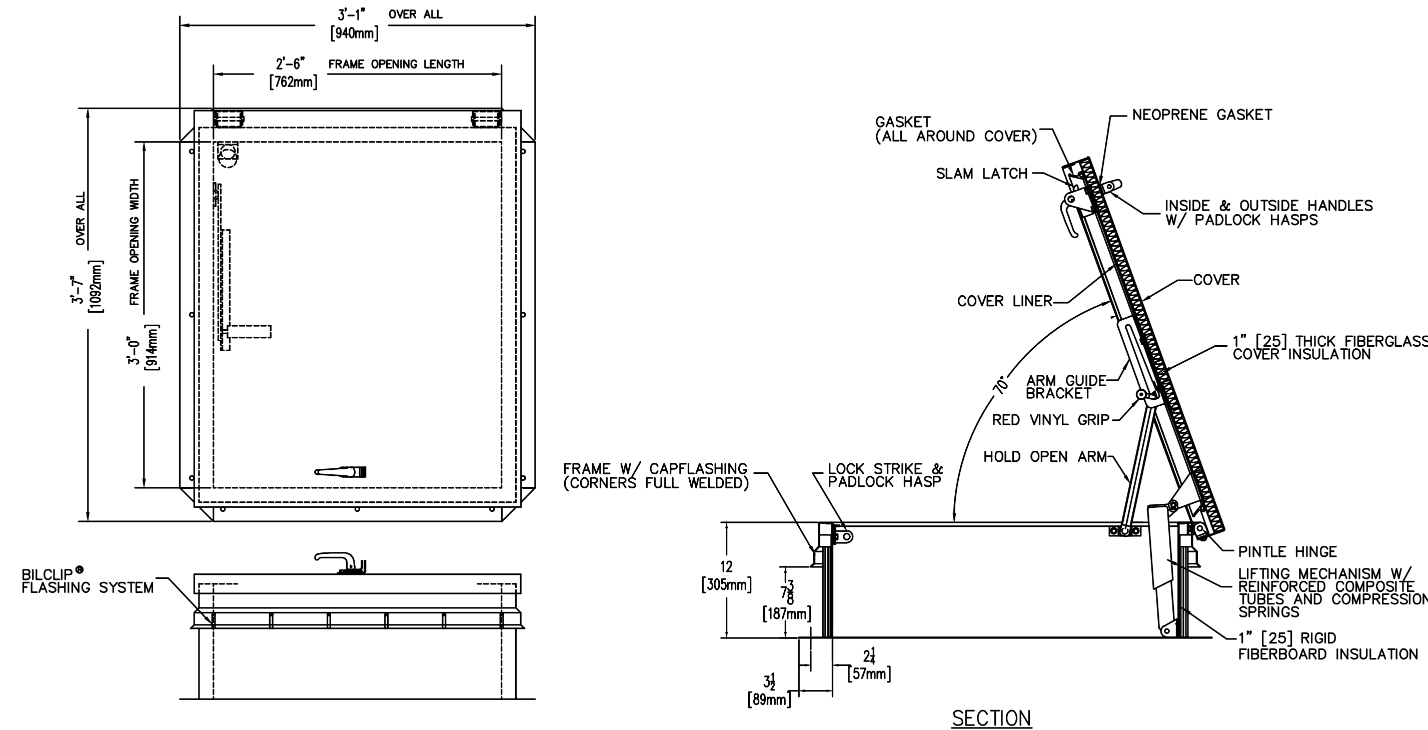
DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=2' 11"x17" H:1"=4'

SHEET: 7 OF 1 SHEETS

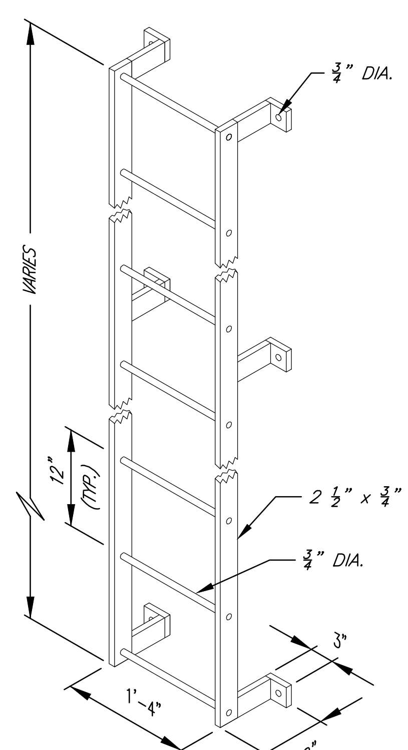


PRESSURE GAUGE AND TRANSDUCER DETAIL



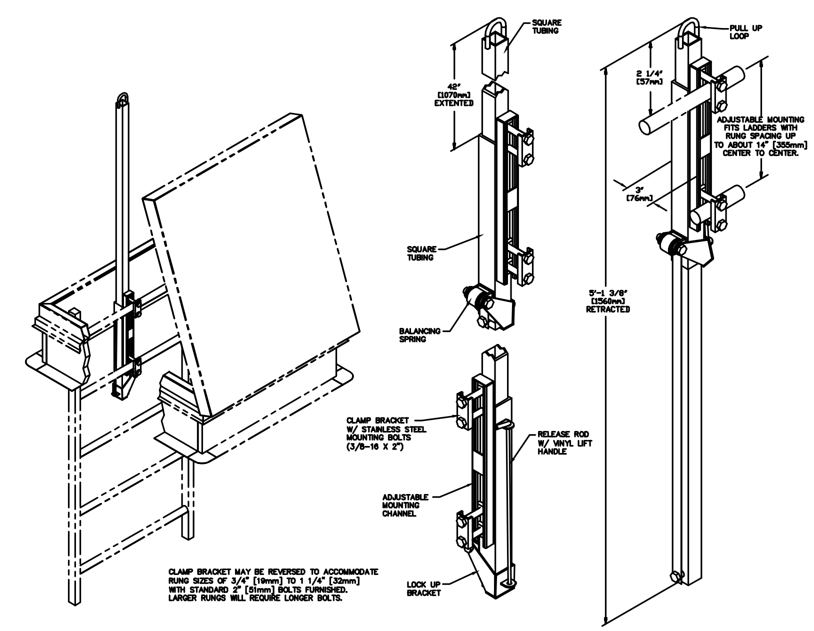
BILCO TYPE S ROOF SCUTTLE

(OR APPROVED EQUAL)



LADDER DETAIL

HOT DIP GALVANIZE AFTER FABRICATION



BILCO
LADDER UP SAFETY POST

BILCO LADDER UP SAFETY POST

(OR APPROVED EQUAL)

NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

MISCELLANEOUS DETAILS

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=2'
11"x17" H:1"=4'

JA JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801) 476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

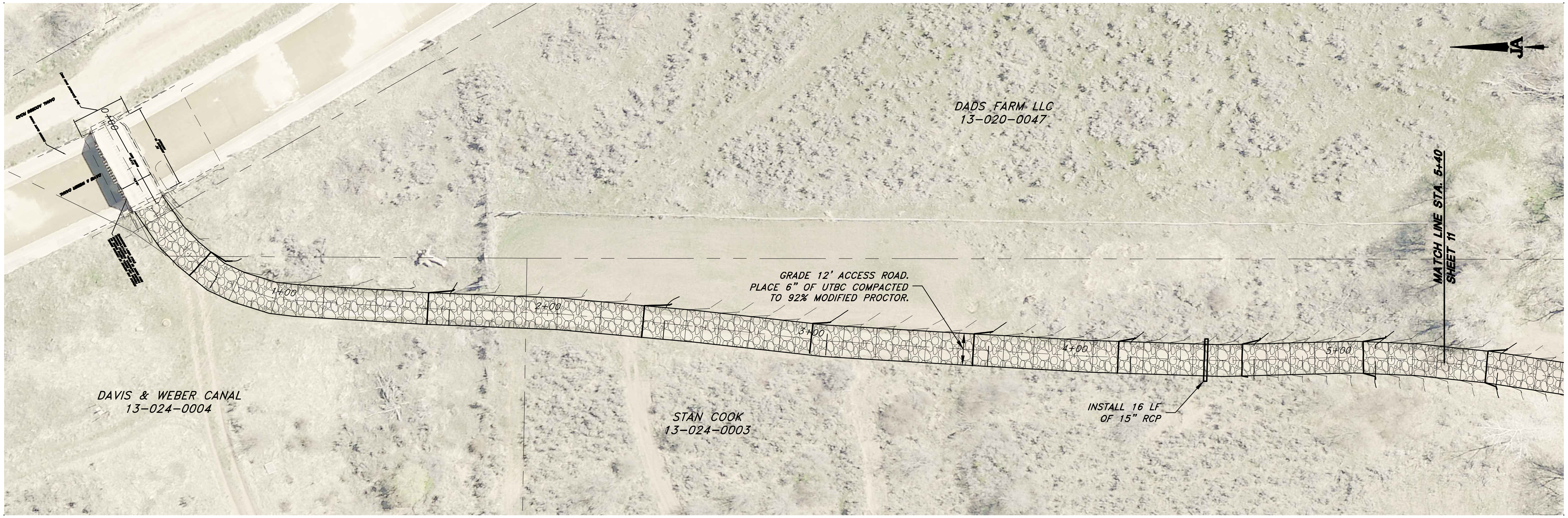
EXISTING ACCESS ROAD

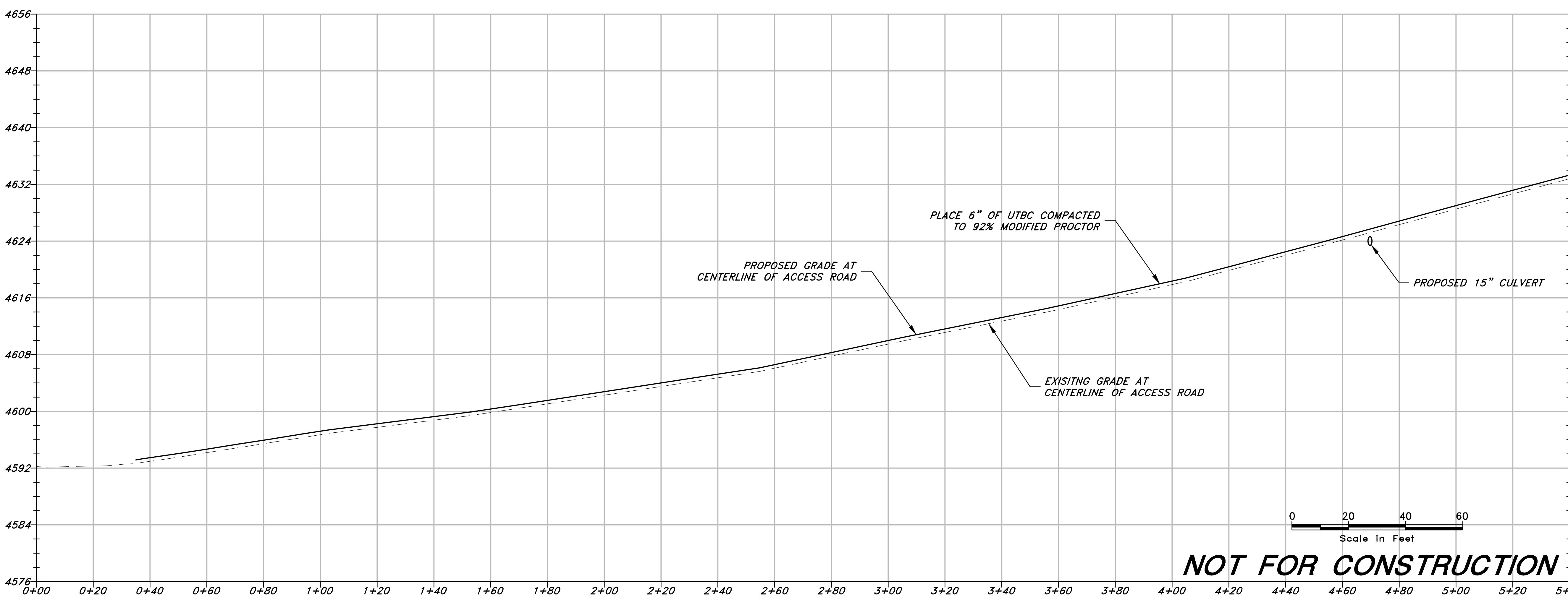
REV.	DATE	APPR.

DOS DESIGNED
TWE DRAWN
DOS CHECKED

SCALE:
24"x36" H:1"=60'
11"x17" H:1"=120'

SHEET:
9
OF 1 SHEETS





NOT FOR CONSTRUCTION

JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

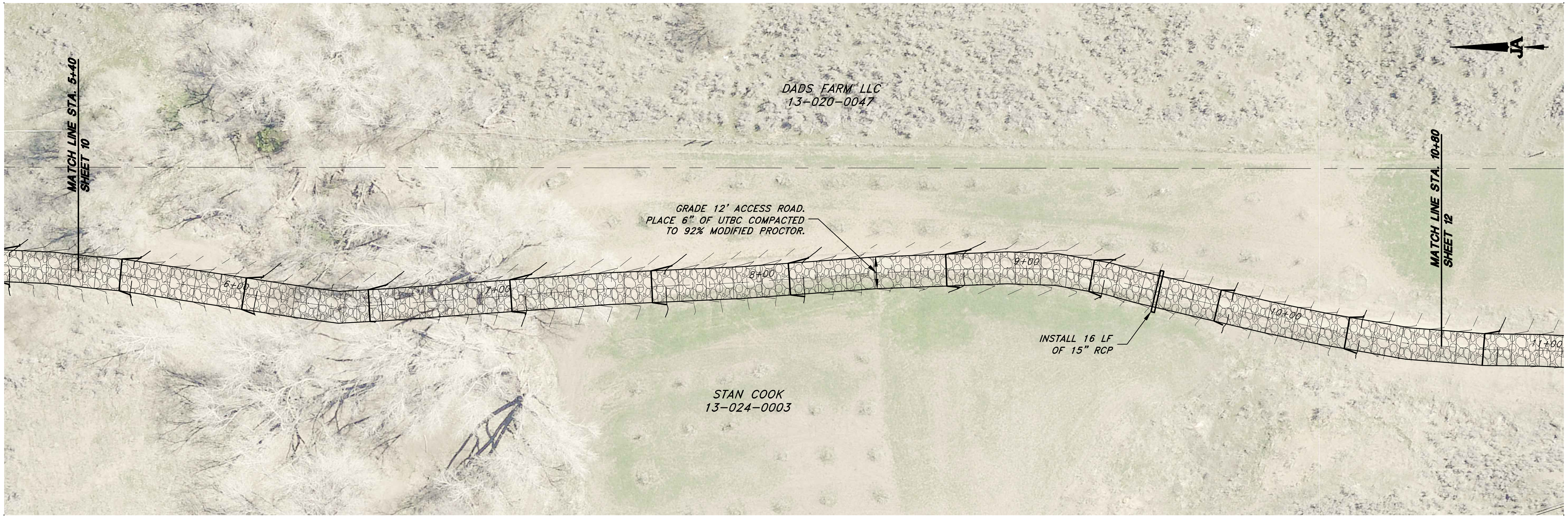
EXISTING ACCESS ROAD IMPROVEMENTS PLAN AND PROFILE STA. 0+00 5+40

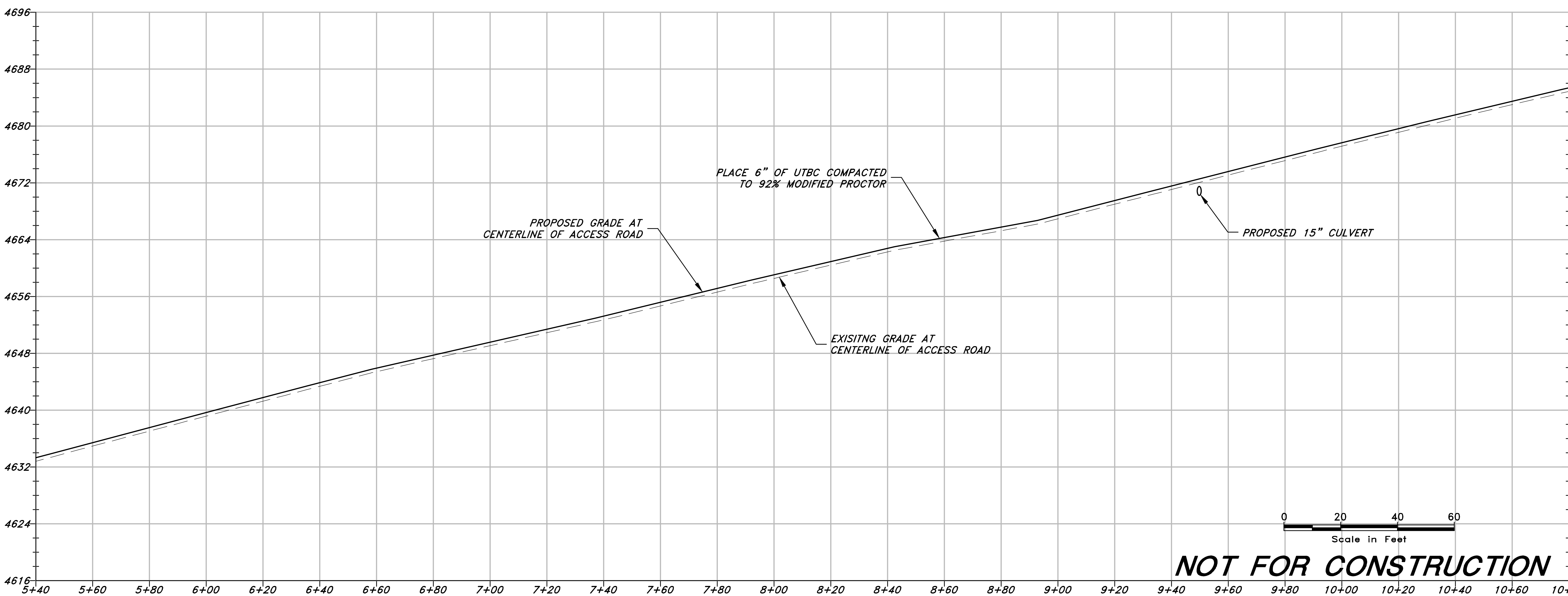
REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE:
24"x36" H:1"=20' V:1"=8'
11"x17" H:1"=40' V:1"=16'

SHEET:
10
OF 1 SHEETS





NOT FOR CONSTRUCTION

JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

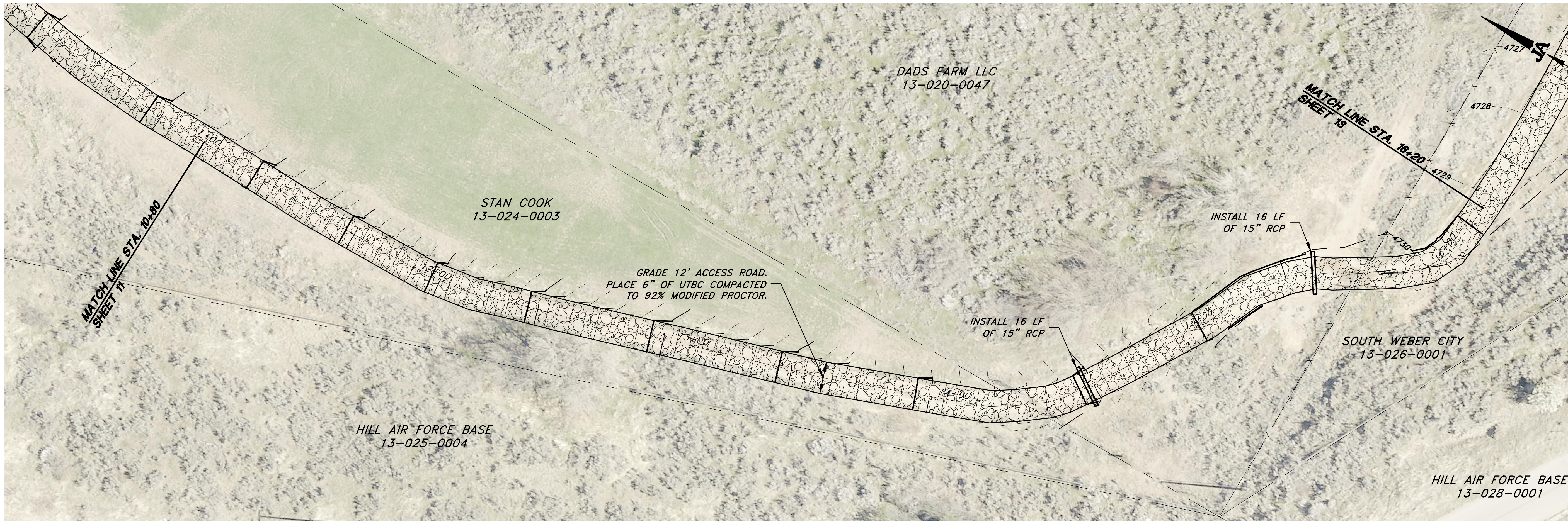
EXISTING ACCESS ROAD IMPROVEMENTS PLAN AND PROFILE STA. 5+40 10+80

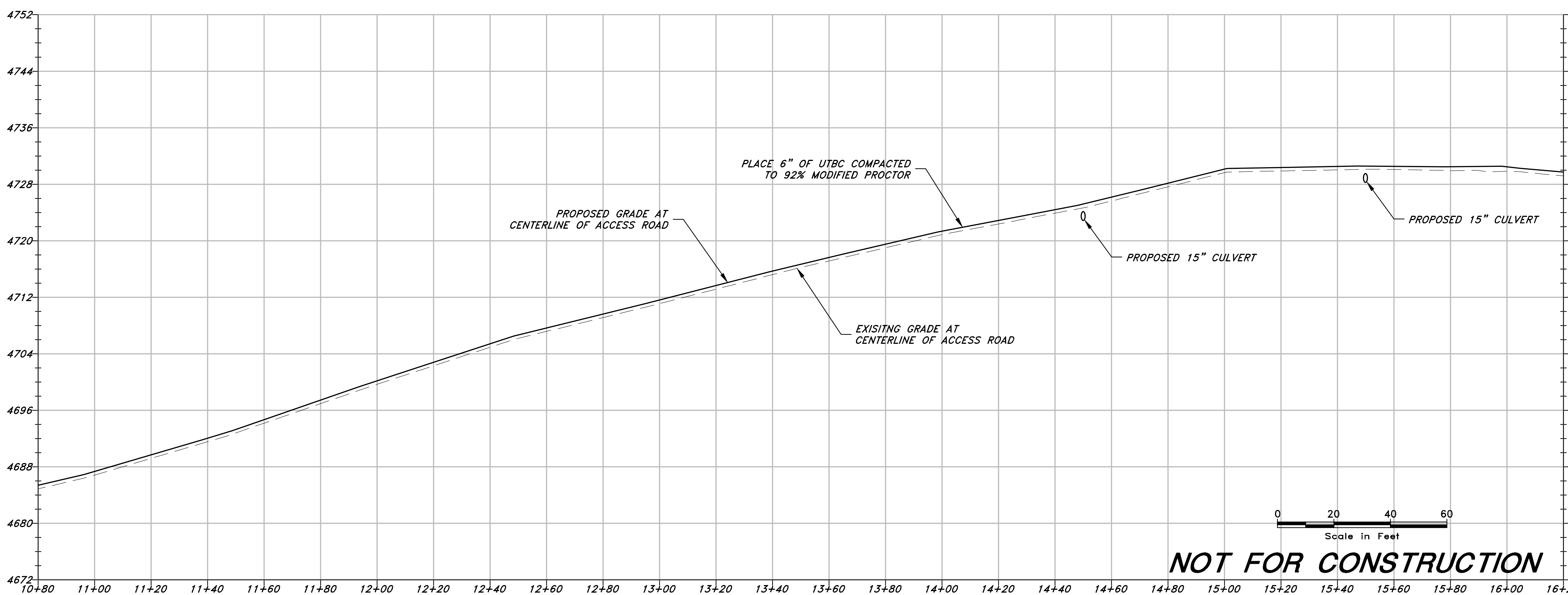
REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE:
24"x36" H:1"=20' V:1"=8'
11"x17" H:1"=40' V:1"=16'

SHEET:
11
OF 1 SHEETS





NOT FOR CONSTRUCTION

JA CONSULTING ENGINEERS
JONES & ASSOCIATES
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

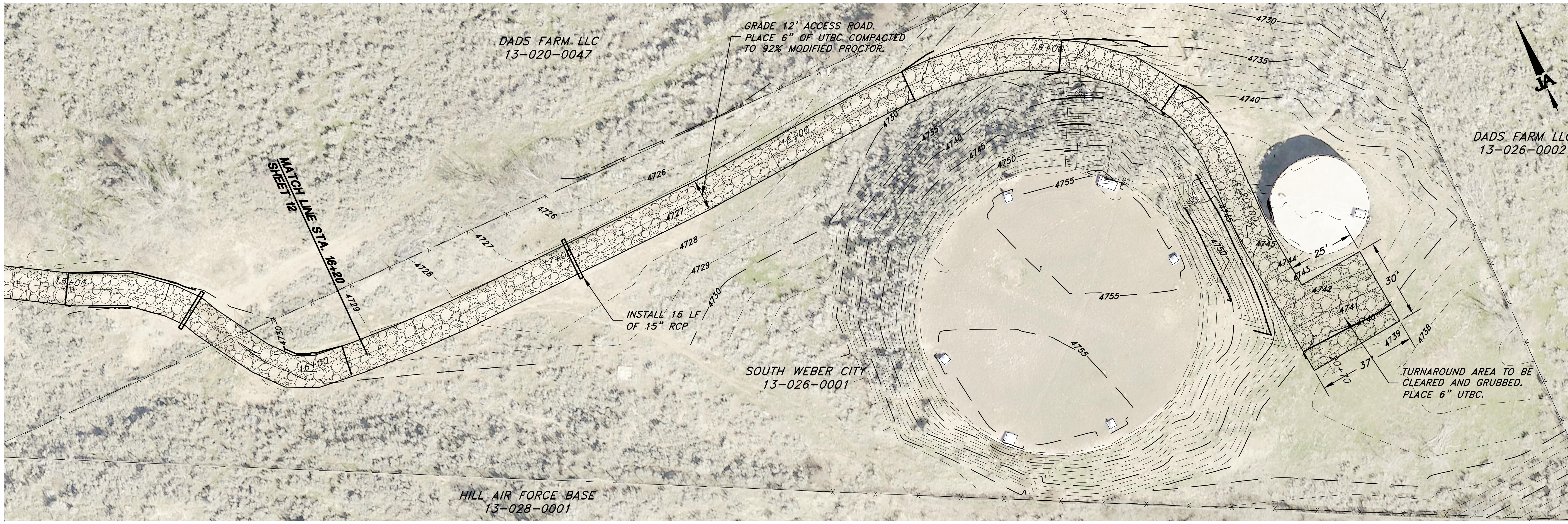
EXISTING ACCESS ROAD IMPROVEMENTS PLAN AND PROFILE STA. 10+80 16+20

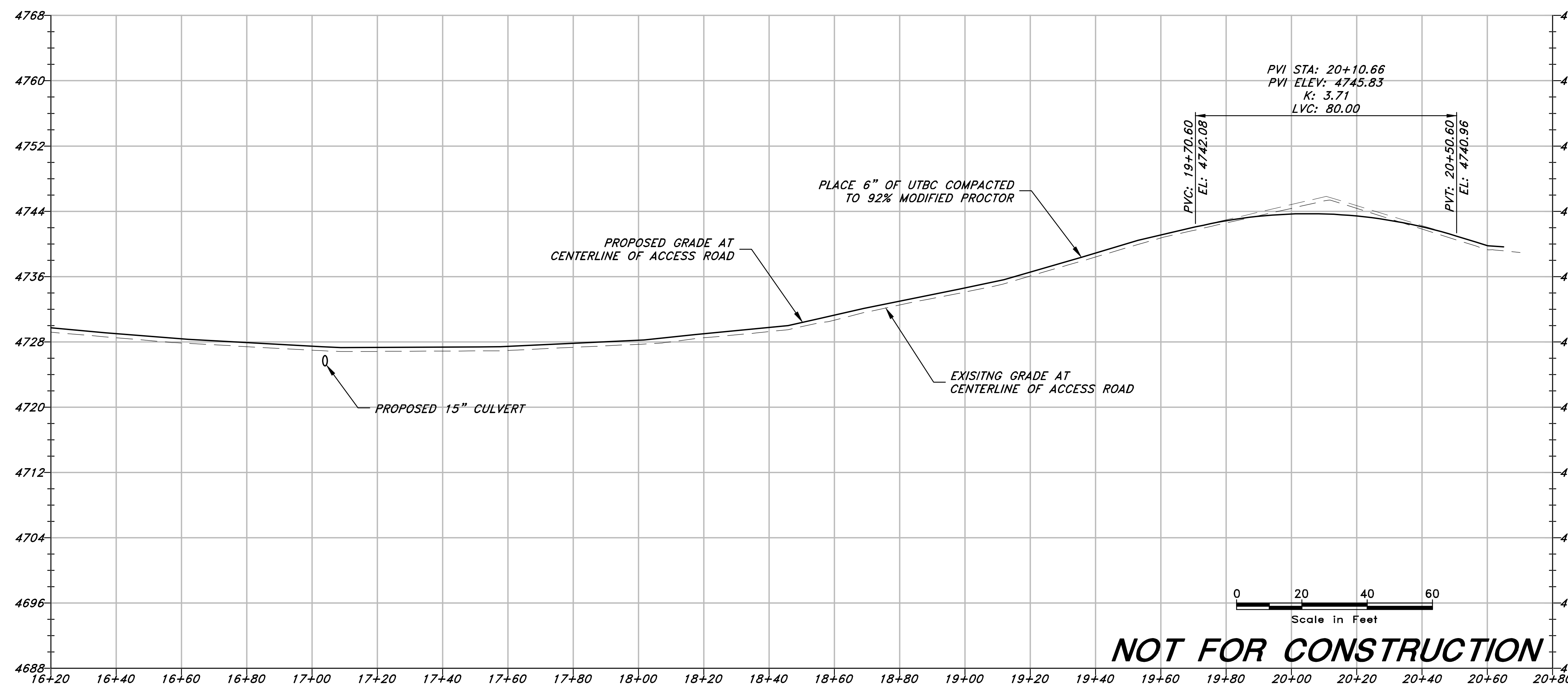
REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=20' V:1"=8'
11"x17" H:1"=40' V:1"=16'

SHEET:
12
OF 1 SHEETS





NOT FOR CONSTRUCTION

JONES & ASSOCIATES CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph - (801) 476-9767 fx - (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

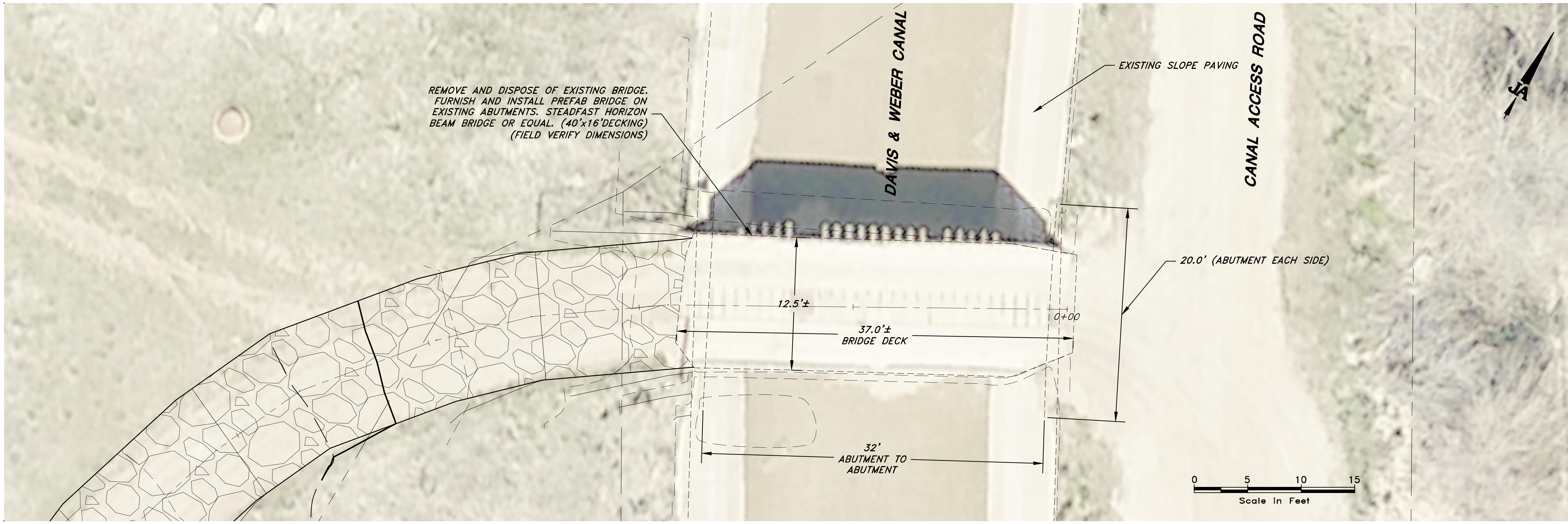
EXISTING ACCESS ROAD IMPROVEMENTS
PLAN AND PROFILE STA. 16+20 20+80

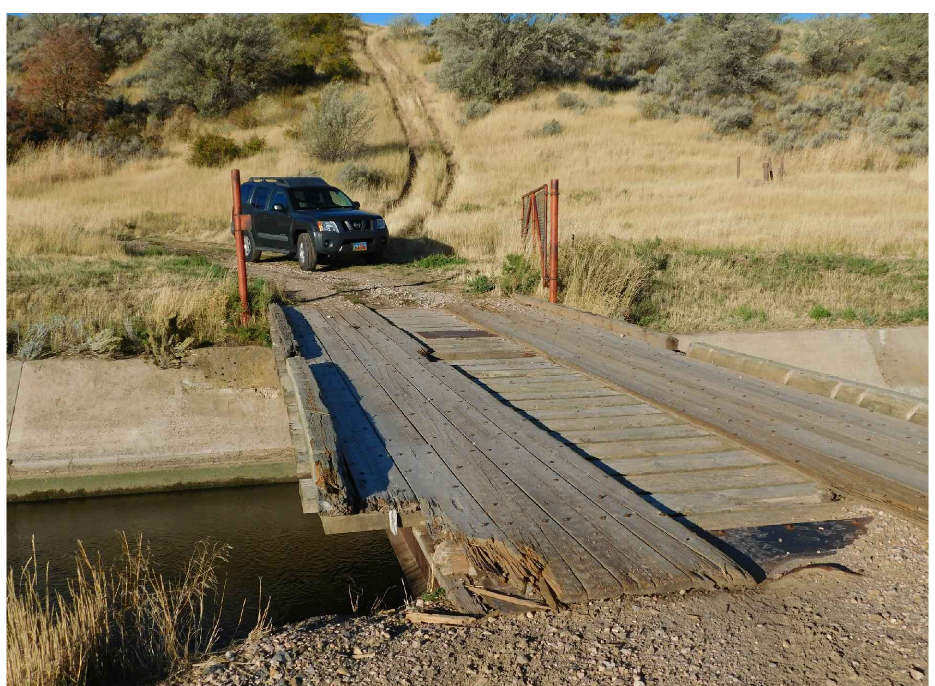
REV.	DATE	APPR.

DESIGNED: DQS
DRAWN: TWE
CHECKED: DQS

SCALE:
24"x36" H:1"=20' V:1"=8'
11"x17" H:1"=40' V:1"=16'

SHEET:
13
OF 1 SHEETS





NOT FOR CONSTRUCTION

JA JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
South Ogden, Utah 84403
ph – (801) 476-9767 fx – (801)476-9768

SOUTH WEBER CITY CORPORATION
WESTSIDE RESERVOIR PROJECT

BRIDGE IMPROVEMENTS

REV.	DATE	APPR.

DQS DESIGNED
TWE DRAWN
DQS CHECKED

SCALE: 24"x36" H:1"=5'
11"x17" H:1"=10'

SHEET: 14
OF 1 SHEETS

South Weber City
Westside Water Reservoir Project, Phase 2
Budgetary Estimate

No.	Description	Quantity		Unit Cost		Total Cost		Item Subtotal	
1	1 MG Tank Interior							$	156,600
1.1	Pressure grout under floor	1	ls	$	80,000	$	80,000		
1.2	Blast interior and rout out cracks	1	ls		20,000		20,000		
1.3	Crack seal	600	lf		6.00		3,600		
1.4	Coat interior surface (floor and walls)	15,000	sf		3.00		45,000		
1.5	Blast and paint piping	1	ls		2,000		2,000		
1.6	Replace ladders	2	ea		3,000		6,000		
2	Site Improvements (on-site)							$	41,660
2.1	Grading	75	cy	$	20	$	1,500		
2.2	6" UTBC	130	cy		50		6,500		
2.3	15" RCP culvert	16	lf		25		400		
2.4	Repair fencing and gate	1	ls		2,000		2,000		
2.5	Air gap for 1 MG drain/overflow	1	ls		8,500		8,500		
2.6	Inclinometers (install and monitor)	1	ls		22,760		22,760		
3	SCADA							$	12,000
3.1	Upgrade controls	1	ls	$	12,000	$	12,000		
4	North Vault							$	10,500
4.1	Revise piping	1	ls	$	6,000	$	6,000		
4.2	Replace air/vac	1	ls		2,500		2,500		
4.3	Add drain to daylight	1	ls		2,000		2,000		
5	East Vault							$	1,000
5.1	Abandon in place	1	ls	$	1,000	$	1,000		
6	1 MG Tank Exterior							$	4,200
6.1	Replace northeast hatch (65"x36")	1	ea	$	3,000	$	3,000		
6.2	Replace southwest hatch (24"x24")	1	ea		1,200		1,200		
7	Bridge							$	73,500
7.1	Remove and dispose of existing bridge	1	ls	$	9,500	$	9,500		
7.2	Furnish and install new 40x16 bridge	640	sf		100		64,000		
8	Access Improvements (off-site)							$	20,600
8.1	Grading	100	cy	$	20	$	2,000		
8.2	6" UTBC	340	cy		50		17,000		
8.3	15" RCP culvert	64	lf		25		1,600		
							Subtotal	$	320,060
							25% Engineering and Contingencies		80,015
							TOTAL	**$**	**400,075**

NOTES: THE PEDESTRIAN TRANSPORTATION PLAN IS NOT A COMPREHENSIVE SIDEWALK PLAN. ONLY SIDEWALK LINKS BETWEEN EXISTING OR FUTURE TRAILS ARE SHOWN ON THIS MAP.

SCALE: 1 in = 900 ft	DESIGNED BEB	JONES & ASSOCIATES CONSULTING ENGINEERS	SOUTH WEBER CITY CORPORATION
DATE: 09/23/2014	DRAWN BEB	1716 East 5600 South South Ogden, Utah 84403 (801) 476-9767	GENERAL PLAN
	CHECKED BKJ		PARKS AND TRAILS MAP

SHEET: 6 OF SHEETS

SOUTH WEBER city