UNITED ENGINEERING

Wallsburg Church Camp

Culinary Water Tank and Delivery System Design

4/9/2012

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Final Design Report

Contents

Abstract

This report contains the design of a potable water tank and piping system for the Wallsburg Church Camp in Wallsburg, Utah. Insufficient water pressure throughout the camp necessitated a new design for the tank. Alternatives included a new concrete tank, a new fiberglass tank, and a booster pump. Both new tanks would require a more elevated location and a new access road whereas the booster pump could be installed at the current tank location. After much deliberation, it was decided that either a concrete or fiberglass tank at a higher elevation would be most appropriate to produce the required pressures throughout the system.

General Project Information

The Wallsburg Church Camp is located in beautiful Provo Canyon near the town of Wallsburg, Utah. The property is located approximately 7 miles south-east from Deer Creek Reservoir. It consists of approximately 93 acres with a stream flowing through the center. There are two large camp grounds (Oak and Legacy); each with a metal pavilion, refrigerators, flushing restrooms, showers, amphitheater and several camping sites. There is also a small campsite (Maple) which has a canvas canopy, electricity, water, and a fire pit. The restrooms for the Maple camp are located approximately 500 feet from camp. “This entire property can facilitate two separate large groups and one small group at the same time” (Utah Salt Lake Area Recreation Properties). The total capacity is a 250-occupant maximum. The camp is owned by The Church of Jesus Christ of Latter-day Saints. We worked with their Water Resources Division for the project, specifically Roy McDaniel.

The Wallsburg Camp is not expecting any future growth, but is struggling to keep up with water pressure demands. The camp is currently using a well and tank to supply its water needs. The pumped water is stored in a 24,000 gallon tank above the camp. The water is gravity fed to all needed areas throughout the camp. With the current design of the tank and piping system, the

Wallsburg Church camp is not getting enough pressure head at the valves at the higher elevations and does not satisfy maximum demands and pressures. The current reinforced concrete tank was constructed mainly by volunteers and is currently in a state of disrepair.

Major Client and Stakeholder Information

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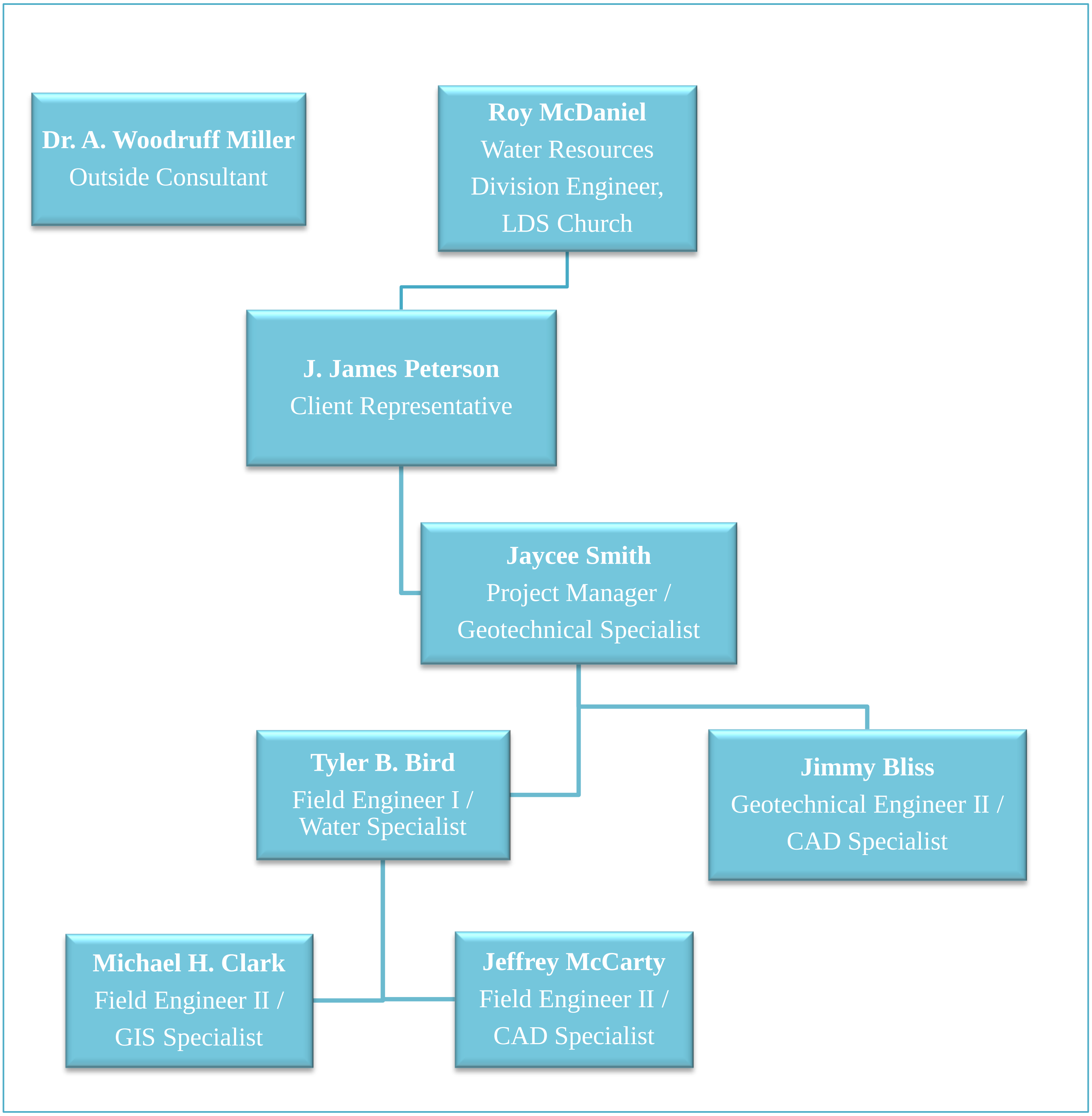
Organizational Structure



Work Completed / Work Plan

When we first began our project, several requirements and restraints were changed by the project sponsor. We discovered that there was an existing tank above the camp with adequate capacity, whereas we had previously thought the tank's storage was inadequate according to drawings provided by our sponsor. The real issue resided in the pressure at the first couple of taps near the tank; the pressure was 30-40 psi lower than the range required by Utah Code R309-550-5. We changed our scope to include analyzing different options for the tank site and the design of the new storage tank.

After receiving the initial spatial information of the Wallsburg Camp area, we noticed that the spatial data (i.e. northings, eastings, elevations) were not correct. There were different values on many different documents, and the points did not line up with the CAD drawings we received. We did not know which source to trust. Without correct data, we could not move on with our project. Taking some initiative and working outside the scope of our project, we visited the site to map the correct data. After renting GPS equipment, we drove to Wallsburg and took GPS points around the well and tank area. Inserting these points into the CAD drawing solved our problems with contradicting sources and made it possible for the project to continue.

Meanwhile, we continued with some aspects of the project that we could do without the survey data. We had previously met with our sponsor and received answers to our questions, which resulted in more specific information for our project. From that meeting, we determined the final scope of our project. The Water Resources Division wants to replace the current tank and either move it higher or design a booster pump to increase the pressure in the closer pipes. We decided to consider two different types of tanks, with recommendations from our sponsor. Each of us read through the codes and we summarized them to include the ones we needed to focus on.

Design Procedures

Our team initially split into two groups that worked concurrently on the pump/pipe system and the design of the storage tank. These groups worked together often as site selection was a common unknown for both groups because of the missing survey data. Because much of designing a pipe system is an iterative process, strong communication was needed throughout the project to keep everyone updated on the most recent decisions. At team meetings, prior assignments were reviewed, the team as a whole was updated, and future assignments were divided amongst the team members.

Given the nature of the project, members of the group with the most experience in each area (i.e.: water resources, environmental, geotechnical, or structural engineering) were chosen to lead sub-committees in charge of each portion of the project, which has helped with organization and minimized wasted time due to a lack of knowledge in any particular subject. The water resource engineer determined pressures and peak demands in the water delivery system with EPANET 2.0. The CAD specialist has designed the tanks, and pump-tank connections. The geotechnical engineer helped determine the site based on soil properties. Field engineers used GIS, CAD, and other applications to help with scheduling, design work, etc. Due to the magnitude of the project, we sought technical advice from Dr. Miller and James, our assigned mentor.

Due to the diverse curriculum that our group has experienced at Brigham Young University, we have been able to cover all aspects of this project with some review and hardship. We used the BYU CAEDM computers and programs necessary for the project. We used AutoCAD Civil 3D 2011 for the majority of our design work. ArcGIS was also implemented to create topographical maps of the area. EPANET 2.0 was used to model the pipe network. We used part of the topographic survey data that was previously collected by professional surveyors in addition to our own survey data to create an accurate CAD drawing of the site. We used the given data regarding water used during peak times, well capacity, and soil structural bearing capacity in the area where the tank is to be installed.

Tanks

One of the options for the water storage tank suggested by our sponsor was a prefabricated fiberglass tank. The sponsor even went so far as to specify a company that makes fiberglass tanks that the Church has used in such situations before.

The recommended company, Xerxes, made it fairly simple to design a tank. Xerxes is a pretty large supplier of prefabricated fiberglass tanks and has a lot of material to help decide what to order and how to install their products. The tanks are formed in a pill type shape, a cylinder with semicircular ends. Xerxes makes tanks in a variety of diameters and for a variety of capacities. Since we knew the capacity we were looking for, 24,000 gallons, we knew we would want one of the 25,000 gallon capacity tanks that are available. We then decided we would want the 12 ft diameter tank because it had the shortest length, about 35 ft. Other options had much longer lengths and we decided it would be most cost effective to implicate the design that required the least excavation of the mountainside.

The anchor system for these tanks consists of two concrete beams, one on each side of the tank buried a couple feet lower than the tank itself. Each beam has straps that hang over the top of the tank and connect to the opposite beam. Xerxes fabricates all the items needed for this anchoring system.

From provided Xerxes information we were able to calculate the weight associated with the anchors, 21.4 kip, and the system both empty, 10.6 kip, and full of water, 224 kip, in order to ensure ground stability around the tank. The tanks also have options for inlet and outlet connections, vents, overflow pipes, and access hatches that are part of the prefabricated tank. This makes design extremely easy because it’s all prefabricated and ready for installation, all the contractor will need is the installation manual and a good head on their shoulders.

One problem with the existing tank drawings was the rough manner in which they were presented. In response to this we redrew the tank on AutoCAD in order to provide all information that would be needed by the customer and installer in one succinct location.

The second tank option was a concrete tank similar to the existing tank. We also made AutoCAD drawings of this tank. These drawings are mostly reproductions of the existing tank with all its design and installation instruction because the existing tank provided adequate service for over 30 years. From our calculations with a reinforced concrete specific weight of 150 lb/ft^3, the concrete tank weighs about 160 kip empty and 360 kip full. This weight would produce a pressure on the bottom of the tank of 661 psf if it were to lie flat on the soil. The current footing would increase this pressure as the contact area is a lot smaller than the entire bottom of the tank.

Soil Stability, Geotechnical Analysis

We were given the soil stratification and geologic data in the *Combined Preliminary Evaluation Report (PER) and Drinking Water Source Protection (DWSP) Plan* for the Wallsburg Girls Camp Well. The soil at the site of the well and the location of the water tank are included in the Granger Mountain Member of the Oquirrh Formation. This formation is described as “gray, tan-weathering, limey, silty sandstone”. The surrounding area consists of poorly graded sand, silt, and gravel deposited by debris flow and landslides. Without further soil investigation of the site, the soil properties were estimated. Slope stability higher than the existing tank location will not be stable for such a large load unless we put the tank at the top of the hill. The soil bearing pressure at the current tank location is adequate. If the new tank is comparable in weight and size, and remains in the same place, minimal settlement will occur. The bearing pressure was assumed to be the same higher on the hill, but slope stability is the main issue with that option.

Pumps and Pipes

As per code, the required working pressure for a water distribution system should be between 40 and 60 psi, and a pressure reducing valve must be provided on distribution mains when the static pressure exceeds 80 psi (R309-550-5). Initial hydraulic analysis done using EPANET revealed that the camp’s current water delivery design does not meet the minimum pressure requirements at the upper camp bathrooms and at Taps 1 – 12. The maximum and minimum pressures in the current system are 53 and 16 psi at Taps 17 and 2, respectively. In addition, the camp’s current design does not maintain the required flow rates and pressures for the camp’s plumbing appurtenances (International Plumbing Code, IPC). As a result, the distribution system develops negative pressures when the maximum demand is required from every appurtenance. Negative pressures can be thought of as the pressure with which an attached pump would need to pull from the distribution system in order to withdraw the specified demand. The hydraulic analysis results of the camp's current water delivery system are summarized in Tables 1 and 2.

Table 1. Current design's nodal elevations and static pressures

Node ID	Elevation (ft)	Pressure (psi)
Tap 2	6327	15.8
Tap 1	6307	24.4
Tap 4	6308	24.2
Tap 3	6304	25.8
Tap 5	6302	26.6
Tap 8	6304	25.7
Tap 7	6308	24.0
Tap 6	6305	25.3
Tap 9	6293	30.5
Tap 10	6291	31.4
Tap 11	6278	37.0
Tap 12	6277	37.4
System Drain	6272	39.6
Tap 13	6265	42.6
Tap 14	6269	41.1
Tap 15	6267	41.8
Tap 16	6245	51.2
Tap 20	6255	47.1
Lower Camp Bathroom	6261	44.4
System Drain 2	6240	53.3
Tap 17	6241	53.1
Tap 18	6246	51.0
Tap 19	6250	49.3
Upper Camp Bathroom 1	6305	25.3
Upper Camp Bathroom 2	6310	23.1
Water Tank	6356	3.0

Table 2. Current design's nodal elevations, demands, and dynamic pressures

Node ID	Elevation (ft)	Base Demand (gpm)	Pressure (psi)
Tap2	6326.85	5	11.08
Tap1	6307.13	5	15.6
Tap4	6307.63	5	15.24
Tap3	6303.816	5	16.2
Tap5	6302	5.75	2.1
Tap8	6304	5	2.21
Tap7	6308	5	-4.09
Tap6	6305	5	-2.7
Tap9	6293	5	15.67
Tap10	6291	5	3.96
Tap11	6278	5	-6.59
Tap12	6277	5	-6.59
SystemDrain	6272	0	-8.58
Tap13	6265	5	-17.23
Tap14	6268.5	5	-20.01
Tap15	6267	5	-23.5
Tap16	6245.259	5	-24.72
Tap20	6254.7	5	-103.09
LowerCampBathroom	6261	53	-140.95
SystemDrain2	6240.3	0	-22.78
Tap17	6240.85	5	-23.22
Tap18	6245.6	5	-25.36
Tap19	6249.6	5	-27.52
UpperCampBathroom1	6304.9	35	0.82
UpperCampBathroom2	6310	32	1.5
Tank WaterTank	6356.39	#N/A	3.03

Relocation of the water tank or the installation of a booster pump system, are two viable options for increasing the nodal pressures within the camp. To provide the required head, the tank relocation option would require the new tank location to be at least 57 feet in elevation higher than the tank's current location. The 55% slope of the abutting hillside would make it more advantageous to construct the new tank on the top of the hill rather than in the hillside. Alternatively, the booster pump option will increase the camp's nodal pressures while allowing the tank to remain in its current location. In order to adequately present both alternatives they will be discussed individually.

Alternative 1: Relocate the Tank

Constructing a new tank on top of the abutting hill will easily provide sufficient nodal pressures throughout the camp's distribution system. This design will require a new road to be built around the back of the hill in order to facilitate construction and maintenance. In addition, a new well pump will be required to overcome the increased pressure head. In an effort to maintain the 17 gpm well pumping rate specified in the 2009 Drinking Water Source Protection plan, we recommend the 4 in. submersible, 2 HP, 15 gpm, STA-RITE Signature 2000 HS stainless steel series pump. This pump will provide the required 302 ft of head at a flow rate of 16.5 gpm with 63% efficiency. Currently the tank supply pipe is reduced from 2 in. to 1.5 in. after the check valve in the well vault. To reduce the friction losses, the proposed design will require the 1.5 in. galvanized supply pipe to be replaced with a 2 in. PVC pipe. The accompanying pump curve and analysis calculations can be found in Appendix A. Due to the significant increase in elevation, a 4 in. Watts pressure reducing valve will be installed in the current tank's location to reduce the static pressures to the previously specified range.

After executing another EPANET hydraulic analysis, it was determined that in order to maintain the minimum required pressures during maximum demands approximately 900 LF of 2 in PVC pipe will need to be replaced with 4 in PVC pipe. This replacement will occur between nodes 11 and 38 on the provided EPANET map. The proposed design's maximum static pressure is 81 psi, and the design maintains the required minimum working pressure of 8 psi under maximum demands at all locations. Figure 1 shows the nodal pressures under maximum demand. Tables 3 and 4 give the proposed designs accompanying elevations, pressures, and demands. The proposed tank location and pipe plan and profile drawing can be found in Appendix B.

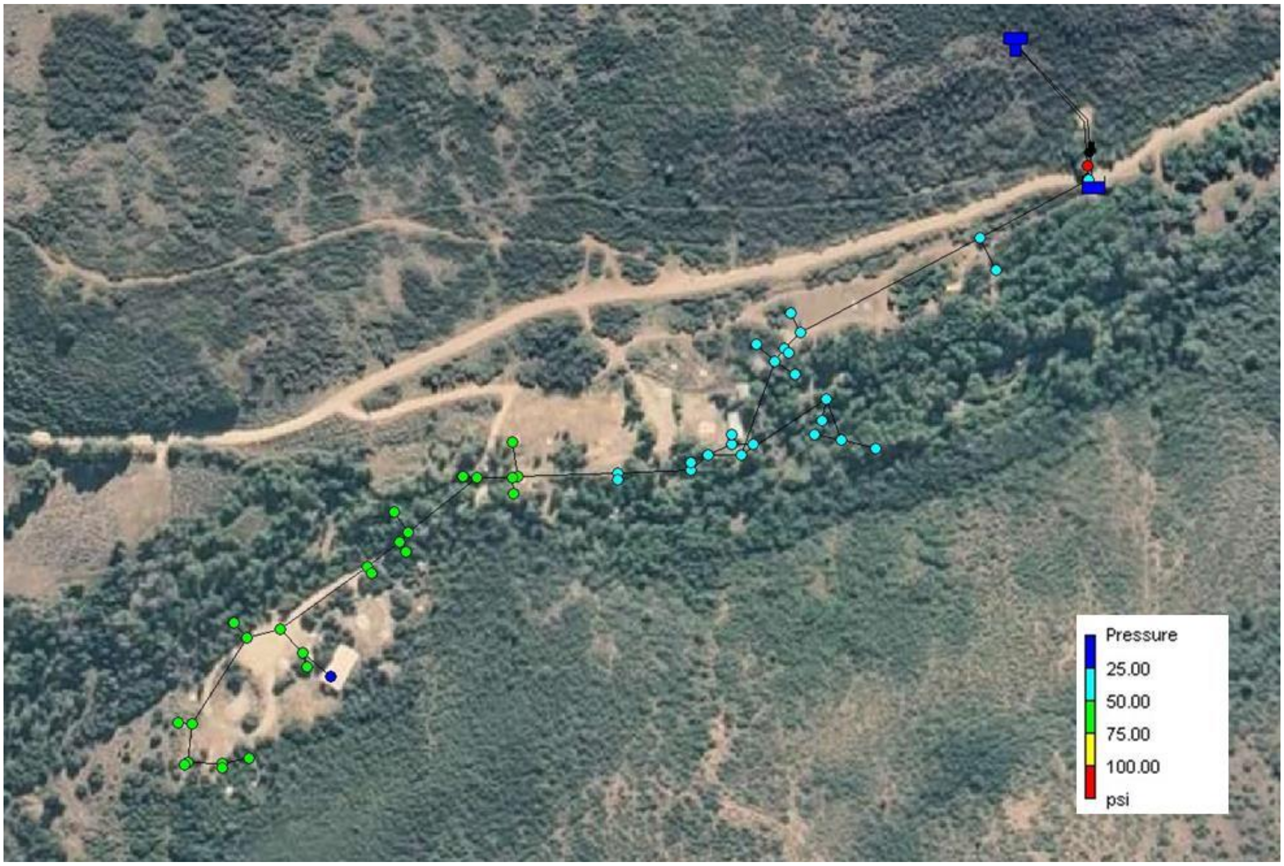


Figure 1. Proposed design under maximum demands

Table 3. Proposed design's nodal elevations and static pressures

Node ID	Elevation (ft)	Base Demand (gpm)	Pressure (psi)
Tap2	6326.85	0	43.81
Tap1	6307.13	0	52.35
Tap4	6307.63	0	52.13
Tap3	6303.816	0	53.78
Tap5	6302	0	54.57
Tap8	6304	0	52.01
Tap7	6308	0	48.59
Tap6	6305	0	50.46
Tap9	6293	0	58.47
Tap10	6291	0	59.33
Tap11	6278	0	64.97
Tap12	6277	0	65.4
SystemDrain	6272	0	67.57
Tap13	6265	0	70.6
Tap14	6268.5	0	69.08
Tap15	6267	0	69.73
Tap16	6245.259	0	79.15
Tap20	6254.7	0	75.06
LowerCampBathroom	6261	0	72.33
SystemDrain2	6240.3	0	81.3
Tap17	6240.85	0	81.06
Tap18	6245.6	0	79
Tap19	6249.6	0	77.27
UpperCampBathroom1	6304.9	0	53.31
UpperCampBathroom2	6310	0	51.1
Resvr 1	6251	#N/A	0
Tank WaterTank	6545	#N/A	3.03

Table 4. Proposed design's nodal elevations, demands, and dynamic pressures

Node ID	Elevation (ft)	Base Demand (gpm)	Pressure (psi)
Tap2	6326.85	5	40.33
Tap1	6307.13	5	44.85
Tap4	6307.63	5	44.48
Tap3	6303.816	5	45.45
Tap5	6302	5.75	31.34
Tap8	6304	5	31.45
Tap7	6308	5	25.16
Tap6	6305	5	26.55
Tap9	6293	5	48.69
Tap10	6291	5	49.12
Tap11	6278	5	53.66
Tap12	6277	5	54.38
SystemDrain	6272	0	56.66
Tap13	6265	5	58.87
Tap14	6268.5	5	57.57
Tap15	6267	5	58.07
Tap16	6245.259	5	66.82
Tap20	6254.7	5	60.66
LowerCampBathroom	6261	53	22.8
SystemDrain2	6240.3	0	68.76
Tap17	6240.85	5	68.31
Tap18	6245.6	5	66.18
Tap19	6249.6	5	64.02
UpperCampBathroom1	6304.9	35	30.07
UpperCampBathroom2	6310	32	30.74
Resvr 1	6251	#N/A	0
Tank WaterTank	6545	#N/A	3.03

Alternative 2: Booster Pump

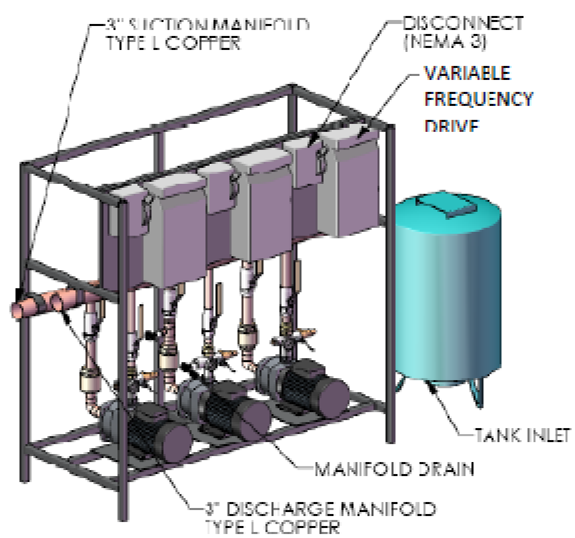
The booster pump system would require the addition of an air-bladder style, pressure tank in order to minimize the pump starts caused by pressure fluctuation during the water system use. The booster pump would have additional maintenance and utility costs that the other options do not. Further analysis needs to be done in order to approximate these costs.

Because the existing tank rests at the boundary of the Church's land, any new tanks would have to be placed on the side of an extremely steep incline. As an alternative to this, we decided to research booster pumps for the existing tank. This seems an expensive option because we'd have to consider energy costs to run the system in addition to installation costs. When compared with building an entire road out to the top of the incline however, the booster system might still be a viable solution. In accordance with the required flow rate for the entire camp, we needed a pump with a conservative maximum capacity 300gpm. Most pumps on the market are for small residential boosters or require large pressure bladders to be buried nearby. Through much research we were able to find a pump system by Towle Whitney which combines three pumps in series and includes a pre-fabricated pressure bladder. The TW3000-360W-40 Triplex boosts pipe pressure by 40psi which would put our current pressure in the range of 40-80psi. The booster pump specification sheet is included below for further consideration and review.

TOWLE WHITNEY

TW3000-360W-40 TRIPLEX

The *TW3000H-360W-40 Triplex Booster System* is equipped with centrifugal pumps and variable frequency drives that regulate the water flow to maintain constant pressure. This system will supply *360 GPM with 40 PSI* overboost.



All parts shown included
Actual system components may vary
Some assembly required

Please inquire for other frame options if space is a constraint

Features and Benefits:

- Commercial application
- Quiet, Compact & Powerful
- Variable Frequency Drive controlled pumps
- Energy efficient operation
- Prewired & Factory Tested

Special Circumstances:

Issues such as water softeners, filters, low producing wells, and galvanized pipes can affect the performance of the system. Please consult our design team to help select or custom design a booster system to fit your application.

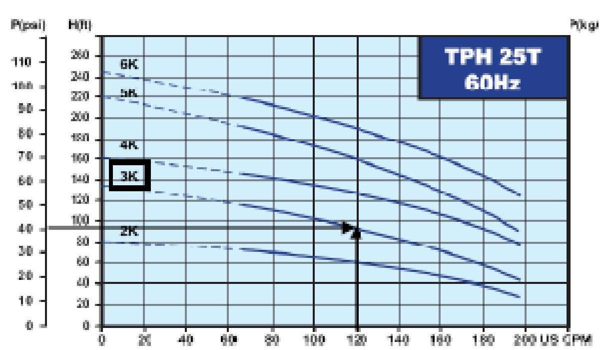
Standard system components:

- Centrifugal Pumps
- Pneumatic tank
- Relief valves
- Check valves
- VF drive with transducers
- Disconnect Boxes
- Pressure Gauges
- Union End Ball Valves
- Suction & Discharge Manifolds with roll grooved ends
- Primed and Painted Steel Frame

Technical Specifications:

Pumps:	Walrus of America [25T 3K]
Controllers:	Emerson or equal
Flow Rate:	360 GPM (120 GPM per pump)
Boost:	40 PSI Overboost
Horse Power:	5 HP per pump
Suction:	3 inch
Discharge:	3 inch
Tank (Qty 2):	35 Gallons (20" Diam. x 36"H)
Decibel rating:	<80 db @ 3500 RPM
Power Options:	Three Independent circuits required 208-220V/1PH/15A 208-220V/3PH/15A 360-480V/3PH/15A

Performance curve for each pump



Warrantees are passed through and as published in the original equipment manufacturer's literature that is included with this system. In no event shall Towle Whitney LLC be liable for incidental or consequential damages or limitation on how long a warranty lasts. It being intended that purchaser's exclusive remedy is limited to replacement of defective products. Water damage exclusion: It is understood that Towle Whitney LLC accepts no responsibility for water damage regardless of what or who caused water damage or any consequential personal injuries, liabilities or property damages resulting.

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Alternative 3: No Action

The no action alternative would leave the camp with insufficient pressures throughout the water system and a crumbling concrete tank. Without a new system Utah codes will continue to be violated and eventually the corroding tank will provide insufficient protection for the potable water. Something certainly needs to be done and this alternative would not be viable if the camp is to meet Utah requirements.

Recommendations

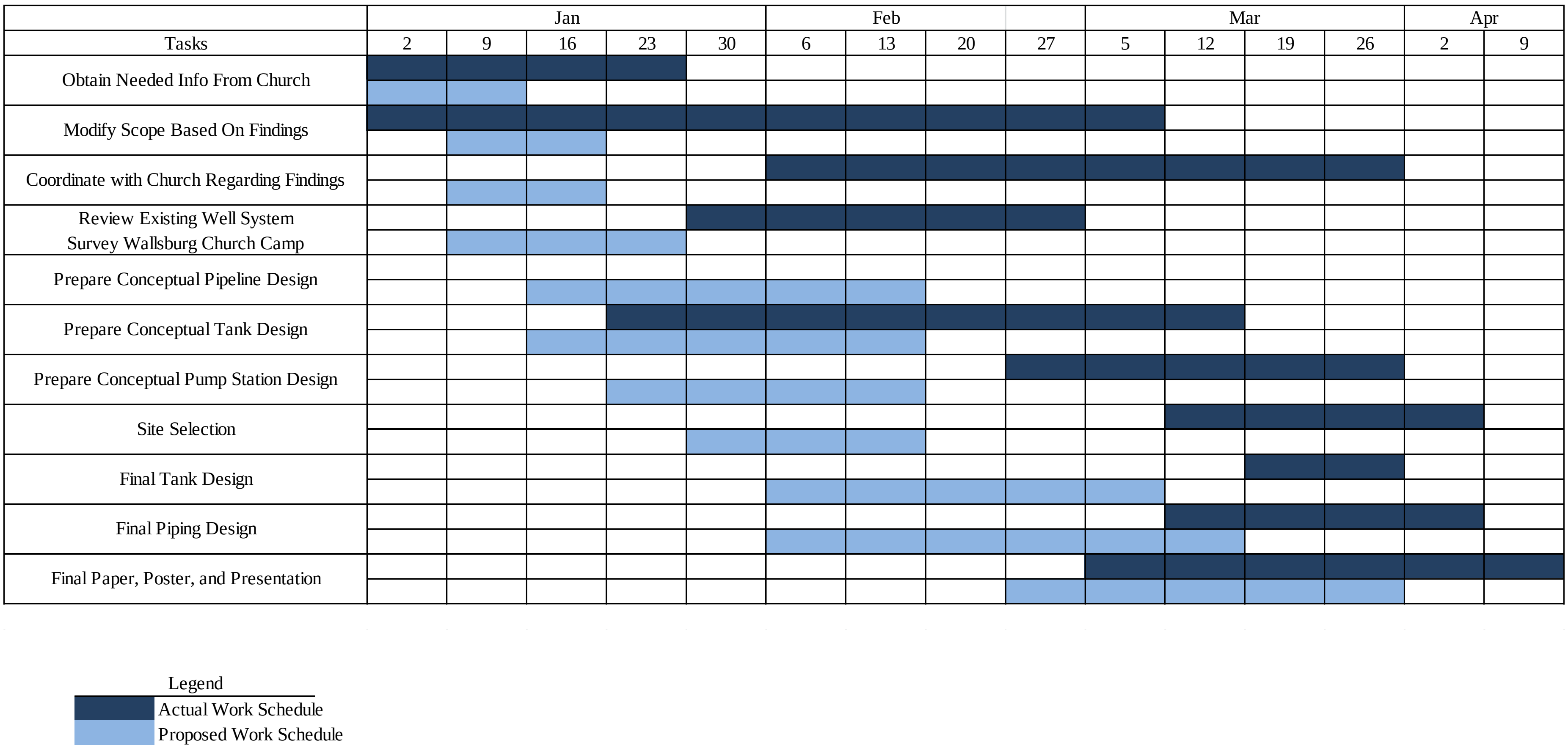
We have taken into account the environmental impacts, proximity to the camp for maintenance, required elevation for a gravity-fed system, as well as the aesthetic relationship between the tank and its natural surroundings. Operating under the given pressure requirements, we have decided that the best location for the tank would be farther up the hill. Placement of the water tank depended on pressures needed at different parts of the camp, and the feasibility of the location. Design of the storage tank was dependent on the amount of water needed above current deliverable volumes provided by the well. This was calculated due to the specifications given and tests performed at several possible site locations. After exploring several different options, we propose the site on top of the hill as the best location to fulfill the given requirements. This location will sufficiently provide for appropriate pipe pressures throughout the system utilizing gravity flow alone.

Project Schedule

January 14	Determine capacity needed
January 21	Determine structural and ground bearing capacity concerns
January 28	Address non-technical concerns (environmental impacts, aesthetics, economics, maintainability, etc.)
February 15	Select site of the new water storage tank
March 7	Design water storage tank
March 14	Select and configure pump and pipe system

Table 1 describes our plan of work for the duration of the project design phase of the project.

Table 1. Work Schedule



Appendix A (Codes)

In accordance with Utah Code on Hydraulic Modeling (R309-511), any public water systems would require a professional hydraulic analysis before we can do anything to connect our system to it (R309-511-3). We also need to account for 100% of the water distributed in our system (R309-511-5). Any pipes 8in in diameter or larger need to be included and carefully labeled throughout our plans (R309-511-5). All pump systems, storage tanks, undersized pipes, or pipes at higher elevation than the distribution system, need to be specially labeled as well (R309-511-5). The plans need to specifically state whether or not fire hydrants will be present anywhere in the system (R309-511-7). Minimum pressure requirements need to be met throughout the system and have been the biggest problem in designing this system (R309-511-7).

The Utah Code on Minimum Size Requirements (R309-510) states that the system must meet both peak daily demand and the average yearly demand for the camp (R309-510-7). For a population of 150 persons, peak daily demand would be 9000gal, which is much lower than the 24000gal tank capacity. Should the Church decide to put a hotel there and each of the 150 people had their own unit, the capacity would still be sufficient under Utah Code which would require (150ppl)*(150gal/person/day) = 22500gal/day (R309-510-7). The tank is however, insufficient for fire suppression which would create a demand of 120000gal (R309-510-7).

The Utah Code on Plan Review (R309-500) requires that we report any modifications to the system that may affect the quality or quantity of water delivered to the system (ex: re-coating or re-lining the inside of the tank or the pipes, any change in filtration design or applications, etc.) (R309-500-5). If the pump capacity is changed, we would need to re-notify this in our report (R309-500-5).

Utah Code on Site Development (R309-515) states that we need to show proof of owner’s right to divert water (R309-515-5).

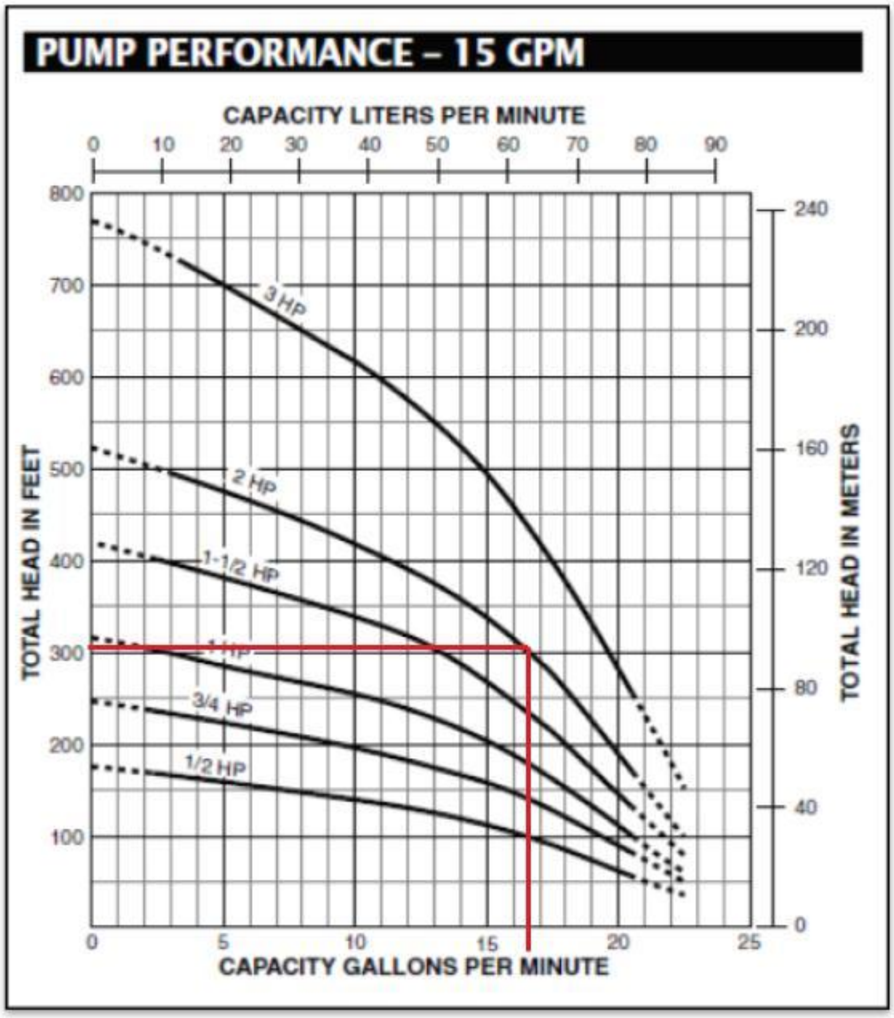
Utah Code on Source Protection (R309-600) applies to our project only if we draw more on the well or start grazing livestock on the camp grounds.
The Utah Code on Storage Tanks (309-545) states that pipe volume does not count as storage

volume in capacity measurements (309-545-4). The tank we design needs to take into account seismic concerns, which are important because the camp lies along 8 different faults and is likely to have seismic activity throughout the life of the tank (309-545-6). A certified structural engineer needs to sign off on the design in order to meet code specifications. Section 309-545-7 reiterates the need for a sufficient minimum pressure at all points in the system. Normal working pressures within the pipe system need to be between 40 and 60psi while anything over 80psi needs to have a pressure reducer accompanying it in the system (309-545-7). Any tanks in the design need to be located at least 50 horizontal feet from any sewer systems (309-545-4). When choosing a location for the tank we must take into account potential vandalism (309-545-9). The bottom of the storage tank needs to be above the local ground water table elevation which in this case doesn't seem to be a problem (309-545-8). Our tank design needs to be not only water proof, but needs to keep out animals, insects, and even excessive dust (309-545-9). The roof needs to be designed for drainage unless proper water-proofing is in place to prevent contamination (309-545-9). The floor of the storage structure needs to be sloped for drainage in case of contamination (309-545-10). A silt trap is required on both input and output pipes in order to keep water as pure as possible (309-545-10). Tank overflow systems need to drain significantly faster than the filling rate (309-545-13). Overflow systems cannot be linked into sewer systems, and all overflow must be visible (309-545-13). Any paint on or in the system needs to be specially approved paint (309-545-13). The access hatch needs to have a shoe-box lid and a locking mechanism (309-545-14). Elevated tanks need to have railings or handholds inside and out for safety reasons (309-545-19). All tanks need to be disinfected and drained through the overflow system before first use (309-545-20).

Utah Code on Transmission and Distribution (R309-550) requires the system to meet minimum pressure requirements in the lowest pressure sections, especially at peak flow (R309-550-5). All water mains need to be sized based on flow demands and pressure requirements. If calculations are complex, computerized methods are required to prove the system is sufficient (R309-550-5).

We took care of this by analyzing the system in EPANet2.0. For PVC pipe, a Hazen-Williams coefficient of 140 was used as required by R309-550-5. Since our system does not have the capacity for fire suppression, minimum pipe diameters were chosen above 4in in diameter. If we were to add any fire hydrants, we would need to up those pipe sizes to at least 8in. Also, water velocities in any of the water mains should not exceed 5fps and should take into account any anticipated future connections (R309-550-5). All materials that might come in contact with drinking water need to be ANSI-certified as meeting the requirements of NSF Standard 61, Drinking Water System Components –Health Effects. These components need to be stamped with the NSF logo (R309-550-6). Pipes need to be buried for freeze protection as required in (R309-550-8). All pipes used need to be pressure tested and leakage tested in accordance with AWWA Standard C600-99 (R309-550-8).

Appendix B (Pump curve and calculations)



3-0235 — 50 SHEETS — 5 SQUARES
3-0236 — 100 SHEETS — 5 SQUARES
3-0237 — 200 SHEETS — 5 SQUARES
3-0137 — 200 SHEETS — FILLER
COMET

Well Pump System Curve

$$P_1/\gamma + V_1^2/2g + z_1 + h_p = P_2/\gamma + V_2^2/2g + z_2 + H_L$$

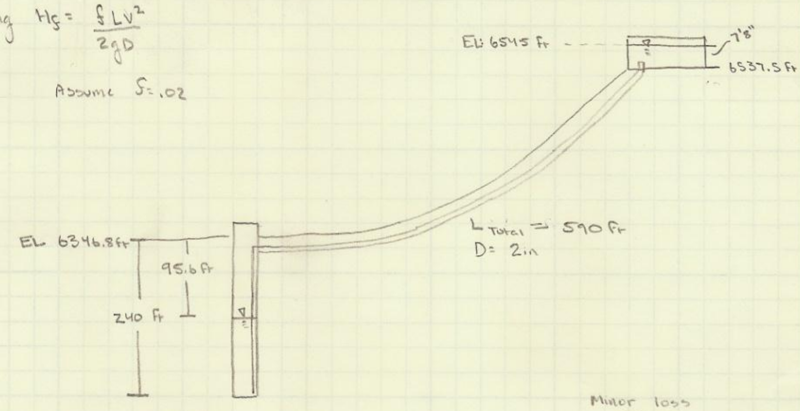
H_L = major + minor losses

$P_1 = P_2 = 0$
$V_1 = V_2 = 0$
$z_1 = 6346.8\text{ ft} - 95.6\text{ ft} = 6251.2\text{ ft}$
$z_2 = 6545\text{ ft}$
$C_{HW} = 145$
$L =$

V in the equation

using $H_f = \dfrac{fLV^2}{2gD}$

Assume $f = .02$



Minor loss estimate

thus

$$H_p = Z_2 - Z_1 + H_L$$
$$= (6545\text{ ft} - 6251\text{ ft}) + \left(\frac{.02\ (590\text{ ft})}{(2/12)} + (.5 + 100 + 1) \right) \frac{V^2}{62.4\text{ ft/s}^2}$$
$$= 294\text{ ft} + 2.761\ V^2$$
$$= 294\text{ ft} + 2.761 \left(\frac{Q}{A} \right)^2$$
$$= 294\text{ ft} + 2.761 \frac{Q^2}{\left(\frac{\pi (2/12)^2}{4} \right)^2}$$
$$= 294\text{ ft} + 5801.31\ Q^2\ (\text{cfs}) = 294\text{ ft} + .0288\ Q^2\ (\text{gpm})$$

From curve, Duty point is 301.84 Ft @ 16.5 gpm

16.5 gpm ↓ Hp @ 16.5 gpm ↓

$$Power = \gamma Q H_p$$

$$= 62.4\ lb/ft^3\ (.03676\ cfs)(301.84\ ft)$$

$$= 692.368\ lb\text{-}ft/s$$

$BHP = 2\ hp$ ← From Pump curve

$$\eta = \frac{Power}{BHP\ (550)}$$

$$= \frac{692.368\ lb\text{-}ft/s}{2hp\ (550)}$$

$$= \underline{\underline{63\%}}$$

Appendix C (Proposed tank and maintenance road location)

Appendix D (Tank design drawing)