Design Study Report

APU Nordic Ski Facility

Prepared For:
Alaska Pacific University
4101 University Drive
Anchorage, AK 99508

Prepared By:
Seawolf Engineering 2016
3211 Providence Drive
Anchorage, AK 99508

Authors:
Riley Bronga
Jessica Farrell
Joshua Smith
Gabriel Thomas

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UAA College of Engineering
UNIVERSITY *of* ALASKA ANCHORAGE

ALASKA PACIFIC UNIVERSITY

NOTICE TO USERS

This report reflects the student engineer's opinions and design decisions as of April 2016. As this project proceeds in the design process, changes may need to be made to address the required conditions. Anyone intending to use this document for planning purposes should be aware that changes may have occurred in the project since publication. Additionally, it should be noted that engineering students at the University of Alaska Anchorage have conducted this design and the design has not been certified by a registered professional engineer.

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List of Acronyms

APU	Alaska Pacific University
ATC	Applied Technical Council
DEC	Department of Environmental Conservation
CGP	Contractors General Permit
LRFD	Load and Resistance Factor Design
IBC	International Building Code
mph	miles per hour
NDS	National Design Specifications
NSIDC	National Snow and Ice Data Center
psf	pounds per square foot
RPP	Reinforced Polypropylene
SIP	Structurally Insulated Panels
SWPPP	Storm Water Pollution and Prevention Plan

ABSTRACT

Alaska Pacific University (APU) owns a training facility that is located on Eagle Glacier in the Chugach National Forest. During the summer months, skiers from around the state travel to the APU Nordic Ski Facility to continue their training on Eagle Glacier. APU depends on a natural detention reservoir to collect water in which they can use as their water source throughout the summer season for all their personal use. Due to a warmer climate, the water has been draining earlier in the season causing APU to venture farther from their site to seek a reliable water source. APU has reached out to University of Alaska Anchorage (UAA) engineering students to design a way to maintain a reliable water source throughout the training season.

In addition to the water reservoir modifications, APU has asked UAA engineering students to design a covered structure to hold their PistenBully 100 in which they use to groom the trails. The PistenBully 100 is a vital aspect to APU's operations with difficult maintenance operations as well as harsh winter conditions.

These improvements will help APU benefit from a more successful facility allowing them to focus on their training and not run the risk of being shut down due to mechanical issues or a water shortage along with getting multiple sessions throughout the summer season. The following document further explains the design considerations taken by the Seawolf Engineer 2016 team.

The recommended water reservoir design shows completing the grading to modify the water reservoir shape to fit the design recommendations of the liner. This includes some grading mechanisms and conforming the area to a reasonable shape, removing large boulders, and smoothing out the area as much as practical. The structure includes a stick-frame design, four windows, eighteen pillars, and a truss manufactured by Alaska Truss or equal. The estimated cost for the recommended designs is $32,100.

1.0 INTRODUCTION

Current conditions at the Alaska Pacific University (APU) Nordic Ski Facility provide difficulty in accessing water due to the location of the facility and the current conditions experienced. A natural detention pond is the most convenient source of water, which requires modifications to be made to the reservoir in order to maintain a reliable water source throughout the training season. Current environmental conditions also make maintenance on the Pistenbully 100 difficult. This facility typically houses eighteen skiers and four staff members. The season consists of eight, one-week long sessions throughout the summer months.

1.1 Project Need

The objective of this project is to provide APU with documents and phasing requirements needed in order to improve their current water source. The current water source is inadequate for their needs and must be improved in order to continue an efficient program at their facility. A major component to APU's program is the use of the PistenBully 100. Extending the life and allowing for annual maintenance to the PistenBully 100 is therefore an important aspect to APU.

1.2 Project Scope

The scope of this project will consist of the following:

- Provide a grading plan required for the new water reservoir
- Construct methods to install and anchor the appropriate liner
- Provide a structure that can house the Pistenbully year round and allow for maintenance as needed
- Suggested phasing of the construction to complete all aspects between July and August.

2.0 EXISTING CONDITIONS

The current conditions at the APU Nordic Ski Facility consist of shale and greywacke throughout the site. The site is covered in snow from roughly September to June. The natural detention pond used for water collection consists of shale and greywacke and is of an irregular shape. The stored water drains from the pond early in the training season requiring APU staff to explore farther from the facility in order to maintain water throughout the training season. Appropriate housing for the PistenBully 100 does not currently exist, exposing the machinery to the natural environment year round. The PistenBully is a major component of APU's operation making the desire to extend the life of the PistenBully a major priority.

3.0 DESIGN STANDARDS

The standard design guidelines used for the APU Nordic Ski Facility improvements were based on several sources. The following is a list documents and/or publications used for the basis of this design:

- American Society of Civil Engineers, ASCE 7-10
- American Society for Testing Materials, ASTM 2015
- International Building Code, IBC 2012
- International Code Council, ICC 2012
- Minimum Design Loads for Buildings and Other Structures, ASCE 7-10
- National Design Specifications for Wood Construction, NDS 2015
- National Design Specifications for Wood Construction Supplement, NDS Supplement 2015
- Special Design Provisions for Wind & Seismic, SDPWS 2015

4.0 PERMITTING

The APU Nordic Ski Facility is currently operating under a special use permit in the Chugach National Forest. The Department of Environmental Conservation (DEC) does not impose standards for food, water, or wastewater if the camp in question contains fewer than 25 individuals at one time. Therefore, the scope of this project will not be concerned with the permitting process because it is not required. Furthermore, the facilities listed in this report are all temporary structures. Nothing built on site is a permanent structure, there are no concrete slabs and the structure can easily be removed upon completion of use. Therefore, there are no immediate requirements for additional special use permits at this time.

5.0 ENVIRONMENTAL

The environmental impact of a project is important to consider during the design process. The design produce by Seawolf Engineering for the APU Nordic Ski Facility has carefully considered the environmental impacts of the implementation of a water reservoir and the shed. All earth work is planned to be done by hand. Therefore, by virtue of the lack of heavy equipment a large environmental impact is not possible. A more in depth investigation may be required to locate the nearest inlets and to investigate where the water flows from the site.

5.1 Contract General Permit

The total disturbed area is under one acre therefore a Storm Water Pollution and Prevention Plan (SWPPP) will not be needed in accordance to the Alaska General Permit 2016 (CGP 2016). A SWPPP may be needed if waterways are directly affected by the project site and are within the discharge areas. Runoff is not expected for the project and there are no storm drains within the vicinity.

5.2 Drainage and Erosion

The drainage basin is located in a geographical location where the predominant rock group is broken shale. Broken shale is naturally extremely permeable which will allow for enough natural infiltration that runoff is not an issue. The drainage basin will have no inlet and no outlet. Essentially, the proposed watershed relies entirely upon localized snowmelt as well as localized rainfall accumulation. Due to the fact that there is no surface runoff there are no drainage concerns.

The APU Nordic Ski Facility sits at an elevation of roughly 5,500 feet above sea level. At this elevation, high winds are likely and can be extremely intense. Due to these high winds and the required dirt work on site, this may produce issues in regards to wind erosion. Any loose material runs the risk of drying up during the summer months and blowing away as the wind speeds picks up. Additionally, wind erosion concerns were considered during the design of the bedding material for a membrane liner.

6.0 GEOTECHNICAL

A more detailed geotechnical investigation should be considered prior to a finalized structure design and grading plan for the project. A boring log and site investigation of the soil material may be necessary to understand the proper grading methods that are best suitable for this project site. The following information regarding soil types was gathered from pictures acquired during the summer and soil material based on its geological location.

6.2 On-site Geological Formations

Earthwork and re-grading will be necessary in the basin if any membrane liners are to be installed. Large boulders and sharp outcroppings should be broken up and leveled for installation and functionality of a liner. The large rock formations that must be removed are typically pre-fractured and should be reasonably easy to break using standard hand tools. This would require a good amount of manual labor but has been deemed necessary considering the site conditions and manufacturer's recommendations.

The site in question has typically held water throughout the summer months, and has lasted through APU's entire training season. However, in recent years, the reservoir has been experiencing water loss earlier in the training season and the basin is empty of water before the season is over. This water loss is potentially due to earlier thawing of a frost layer below the basin. The earlier thaw may be due to warmer summers as well as the glacier's recession. The native rock formations in the basin are extremely transmissive and allow water to easily flow through them. The ice layer below the rock essentially is creating its own liner; this ice liner melts around mid-summer and eventually creates a hole where all the water from the reservoir will drain through. Due to the recent warm summers this ice layer is melting earlier this creating the water shortage issues. Inserting a liner that would prevent the water from draining out of the basin would replace the need of frozen ground required to hold the water, removing the issue of water draining out early in the season.

7.0 HYDROLOGICAL

Hydrological considerations were taken into account to determine the amount of water needed to maintain an effective site. A further hydrological investigation may be needed to mitigate the effects of the assumptions taken for this investigation.

7.1 Assumptions

Based on historic aerial photos as well as firsthand accounts of the area, the snow basin under consideration is assumed to fill completely with snow come spring. This snow loading is quite possibly due to high winter winds which causes massive snow transportation and drifting. The snow is assumed to compact to approximately an approximant 30 to 50 percent moisture content. Also, the temperature change between weather stations in Girdwood is assumed to vary linearly with elevation following the adiabatic lapse.

7.2 Site Water Use

The required amount of snow to meet the water needs at the facility was analyzed using several different methods. Initially, computation of the current water use at the sight was done. Based on information from the client, a 1,500-gallon holding tank is refilled approximately every three days. The client also confirmed that the training camps are hosted for seven day long sessions approximately eight times per season and that a maximum 30 guests can attend, although 22 people is typical. Analyzing this information yielded an estimated water use of 500 gallons per day and a total 28,000 gallons per season. To confirm this estimate, another estimate was done to target each specific use of water at the facility. Since this site is so unique, engineering standards for water use per person would not accurately reflect the actual usage; therefore, analysis was done on the fixtures and their average use. On the site visit the brands and models of the toilets and washing machines were recorded to give the consumption per use. The head pressure to the showers and sinks is unknown so standard values for the pump capacity was assumed based on the total number of fixtures. Figure 5 shows a correlation between total number of fixtures and required pump capacity. This facility had a total of 11 fixtures requiring a flow rate of 8.5 gallons per minute.

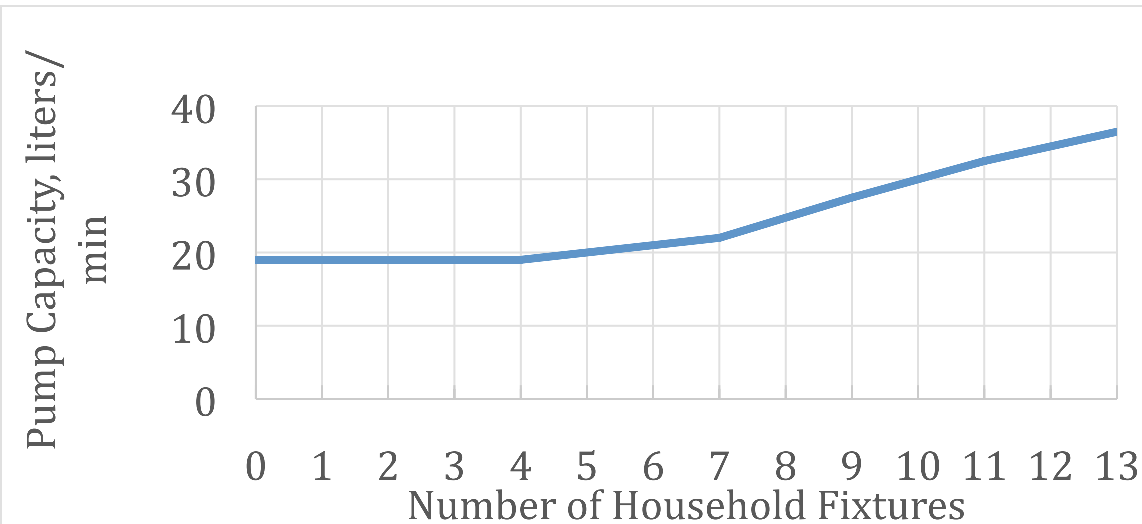


Figure 1. Recommended pump capacity.

With the pump capacity, more accurate flow rates at the fixtures could be assumed. Tabulation of the various contributors to water consumption was done and the client inputted average uses per person (i.e. showers taken each day, time spent using the sink, etc.) yielding a personal daily consumption. By this method an estimate of 563 gallons per day and 31,500 gallons per season was computed. This estimate is slightly higher than the original but confirmed that the original approximation was accurate. The estimate of 563 gallons per day translates to 71 liters per day per person. Referencing the Cold Regions Monograph, "A water supply objective of 60 liters per person per day (L/(p•d)) is generally considered minimum for adequate drinking, cooking, bathing, and laundering", which means that the estimate was above the standard minimum.

7.3 Required Snow

After the water consumption was calculated, an estimate as to the amount of snow to meet the requirement was done. Knowing that the necessary amount of water for the season was 31,500 gallons a factor of safety of two was implemented to reduce error and ensure adequate water quantities for the facility's needs. The contour elevation in the basin of 5,469 feet gave a total volume of 56,375 gallons. With knowledge that the depression drifts completely full of snow, the additional column of snow directly above the contour selected was added. This addition gave a total volume of 263,990 gallons. Next the volume of snow was converted into an equivalent volume of water. The snow in the basin by the end of the season when melt begins will be old snow that has been placed by drifting and natural accumulation. Snow compacts naturally over time and will be fairly dense by the end of the winter. The Cold Regions Monograph classifies "Snow, on ground", to have a density of 300 kg/m^3 making a 30% water content. They also specify "Snow, drifted and compacted", to have a density of 500 kg/m^3 making a 50% water content. As a conservative estimate, based on lack of exact information and variability of winters, the 30% water content was used. Table 1 shows the different contour elevations in the basin and the contour at 5,469 feet that will give 71,097 gallons of water.

Table 1 Difference in elevations of contours and the water they will accumulate if the snow has a 30% water content.

Contour Elevation	Total Volume	Water from 30% Snow Density
Feet	U.S. Gallons	U.S. Gallons
5,465	9,151	2,745
5,466	59,422	17,827
5,467	118,231	35,469
5,468	183,926	55,178
5,469	236,990	71,097
5,470	280,590	84,177
5,471	317,018	95,105
5,472	348,713	104,614
5,473	375,742	112,722
5,474	390,914	117,274

7.4 Additional Water

As the water is used during the summer months there will also be some level of recharge due to precipitation. Rain over the surface area of the catchment could contribute significantly to the total water volume storage. By analyzing several different weather stations in the Girdwood area, an approximate total rainfall was calculated for the area in question. An average of 7.8 inches of rainfall was calculated in Girdwood from June to August. Over the proposed lined area of 4,024 square feet, the rain would add 19,556 gallons each season. However, the site is located about 6.5 miles from Girdwood and there is an elevation change of 5,500 feet. With this discrepancy, and lack of information on weather patterns between the Girdwood Bowl and the mountains where the facility is located, the addition of rainwater was neglected as a conservative measure.

7.5 Melt Rate

Calculations were done to ensure adequate quantities of snow in the basin but the rate at which the snow melts is important to consider as well. If there is inadequate snowmelt, other measures would need to be taken to manually thaw the snow. Before running melt calculations, the average temperature on site was found. Weather data during the summer months was only available in Girdwood at sea level. Using several different sources, the average temperature in Girdwood was found to be 55 degrees Fahrenheit. This temperature is expected to be lower at higher elevations and the standard deduction of 3.5F for every 1000 feet of elevation change was used. This adiabatic lapse equation yielded an average temperature of 35.8F at the facility. Next two different methods of snowmelt rate were compared. The first method was and empirical degree-day method developed by the U.S. Army Corps of Engineers in 1956. By this method, the melt rate was 1,776 gallons per day, which is significantly higher than the consumption rate of 563 gallons per day. Figure 6 show the plot of mean temperature versus daily snowmelt.

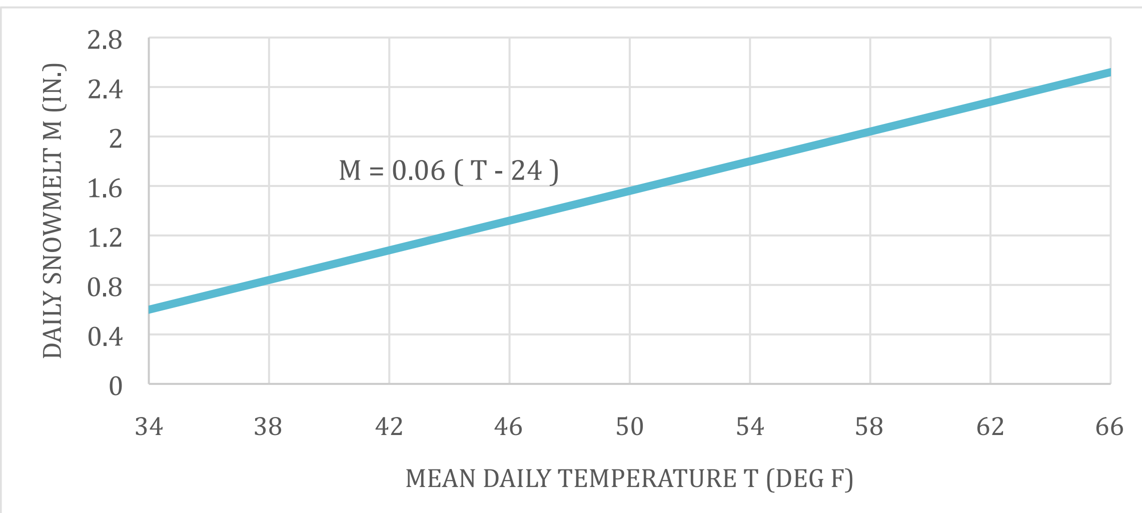


Figure 2. U.S. Army Corps of Engineers Imperical Method, 1956.

To ensure accuracy of the first melt method a second method was explored for comparison. This method was a standard degree-day calculation which was based on the snowpack density, an air index temperature, a base melt temperature, and a degree day melt factor. By this method and the previously approximated snow density of 300 kg/m^3 the melt rate was found to be 688 gallons per day. The two values of snowmelt rate were significantly different; however, they both proved to be more than adequate to provide water to the facility.

8.0 STRUCTURAL DESIGN

Many considerations were taken when developing the structure for the PistenBully 100. Some of the project needs requested by APU was to design a structure that could house the PistenBully throughout the year, withstand the current environmental conditions, and allow for maintenance as needed. With available data of the current environmental conditions, a design was created to address each issue with an emphasis to minimize costs and construction time.

8.1 Design Considerations

Due to the location, high snow loads and high wind loads were the biggest concern for the structure and ultimately the deciding load and resistance factor design (LRFD) criteria. Following ASCE 7-10 section 2.3.2, basic combination two (2.3.2.2) and basic combination four (2.3.2.4) governs for both the vertical and lateral support systems of the structure. The ground snow load was found to be 223 pounds per square foot (psf). This snow load was determined by interpolating data from the National Snow and Ice Data Center (NSIDC) using the longitude and latitude of the APU Nordic Ski Facility location. Using ASCE 7-10 section 7.12, figure 7-5 for balanced and unbalanced snow loads. The sloped roof load, p_s, is calculated using ASCE 7-10 section 7.4. Figure 7 displays the unbalanced and balanced snow loads experienced on the structure.

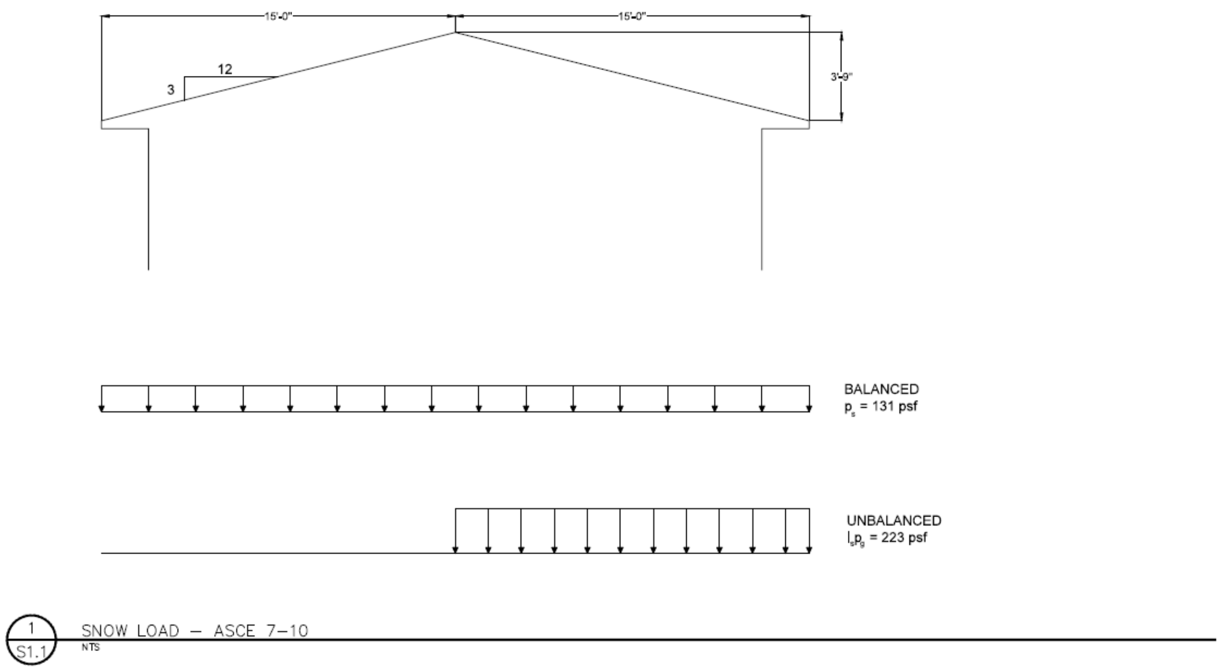


Figure 3. Snow load per ASCE 7-10 per section 7.12, figure 7-5.

The balanced snow load displays a lower load on the roof but the unbalanced snow load creates a larger reaction on the roof. Without knowing the dominant wind direction, both sides of the structure must be designed for the worst-case scenario. The wind data was collected from

Applied Technical Council (ATC), which gave a value of approximately 50 psf and 140 miles per hour (mph) for a 3-second gust value. With the high snow load value, a proper design of the roof and walls becomes important in order to withstand the environmental conditions it would experience.

8.2 Exterior Framing Design

For the exterior wall framing, a 2x6 Douglas Fir Larch North grade No.2 was chosen for design specifications. The structure will be an open floor structure with one door on the two 26-foot walls (two doors total) and two windows on the 32-foot wall (four windows total). The windows are to be placed equal distance from the exterior edge of the building with the centerline of the window measuring at six feet from the bottom of the wall. The windows are four feet by two feet as shown in detail 3/S2.2 in figure 8.

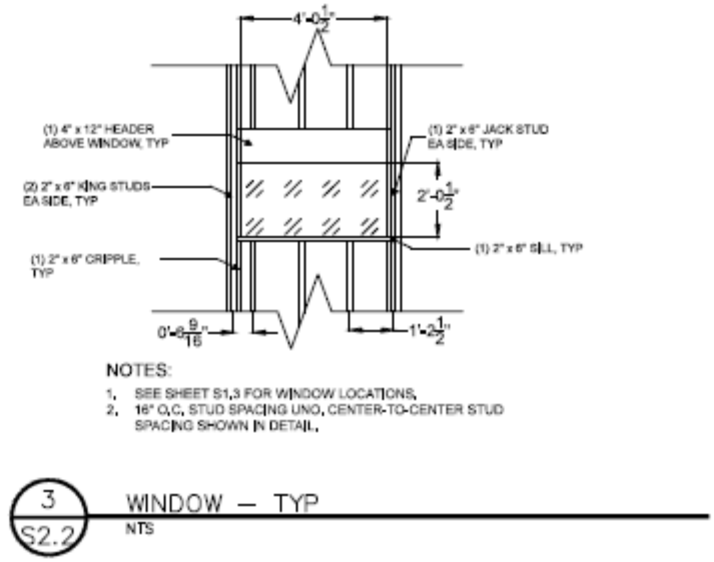


Figure 4. Window detail per International Code Council 2012.

There will be one eight-foot wall and one four-foot wall on either side of the door. Alaska Truss will manufacture the trusses per the snow load, wind load, roof pitch, and dimensions of the structure. The estimate and design recommendation provided by Alaska Truss can be seen in Appendix G located within the plan documents.

8.3 Pillar Design

There will be a total of 18 pillars supporting the structure and anchoring it into the ground or rock below. Seven (7) pillars shall be spaced out equally at a distance of five feet one inches along each 32-foot side of the structure. There will be an additional pillar supporting underneath each side of the doorframe on either side of the structure. See figure 7 and figure 8 in section 9.2 of this report for the layout of the concrete pillars along the building. Due to the assumed soil conditions, the bearing capacity of the concrete pillars exceeds the expected bearing capacity of the structure. A soil sample may be taken to verify these assumptions but was unable to be completed at the time of site investigation. The tensile strength needed for the structure shall be calculated to prevent uplift as the design furthers. The concrete pillars shall be sonotubes filled with concrete and cast-in-place. The sonotubes will be 12 inches diameter with two anchor rods drilled into the rock at a depth of six-inches if possible leaving six-inches to be in contact with the concrete. The base plates shall be placed within the sonotube prior to curing to allow for the best cohesion between the concrete and the base plate. See figure 5 for the concrete pillar detail including the base plate and figure 6 for the detail including the anchor rods.

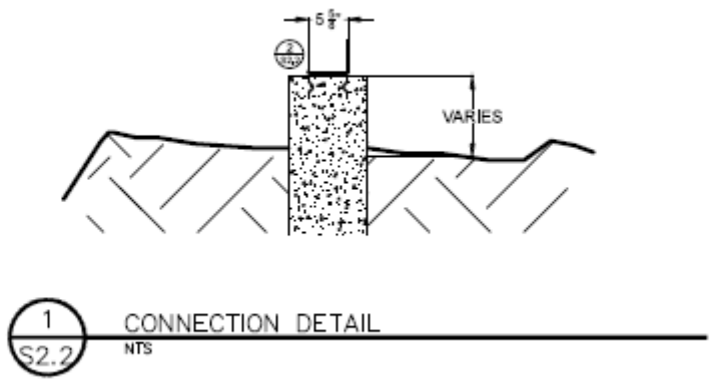


Figure 5. Base plate connection to each concrete pillar.

The figure above shows the detail and placement of the base plate connection to the concrete pillar to be cast-in-place. The base plate shall be placed in the middle of the concrete pillar and oriented in a way that the structure's wall may sit within the base plate running the length of the building. The exact location and orientation shall be confirmed by the owner on-site to determine the best location; in regards of maneuverability of the PistenBully within the given space.

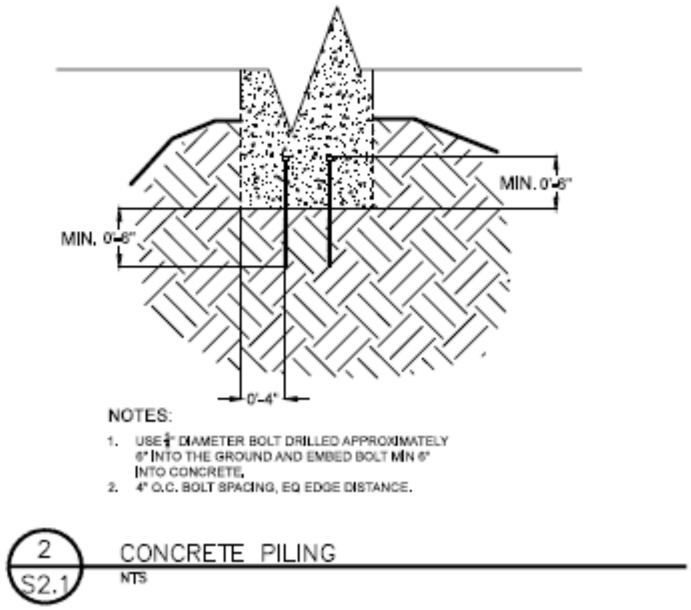


Figure 6. Anchor rod connection to each concrete pillar.

The above figure shows the anchor rod embedment and detail for each concrete pillar location. The depth of six-inches should be achieved if possible leaving six-inches to be left in contact with the concrete. The anchor rods should be placed at approximately four inches from the edge and four inches in between the two of them approximately in the middle of the sonotube area.

8.3.1 Anchor System

Due to the high wind and snow loads, the chosen anchoring system may be investigated further. The anchor system described within this design study report (DSR) was determined assuming hard rock could easily be found within a few feet from the top of the grade. A further investigation of the soil type and depths as well as a further investigation of the current anchoring system of the housing structure on site may be needed. Figure 5 above shows the current anchoring system within each pillar for a total of eighteen (18) anchor points located around the structure. The concrete pillars are adequate to hold the load displayed by the structure and the anchor rods are in place to keep the structure from uplifting in the event of high wind. More anchor rods may be required depending on further investigation of the site location.

8.4 PistenBully Ramp

A ramp, which would allow the PistenBully to drive up on and sit two feet six inches off the ground to allow adequate space for maintenance around and underneath the machine, was considered. This would require a ramp at a slope that would prevent the machine from teetering on the way up or down. This ramp would have to be able to hold the 11,500 lb PistenBully safely so that the maintenance crew would be able to work underneath the machine. In addition, the ramp would have to be in light enough sections that one or two people could easily move the sections around in order to close the door or move the ramp from one side of the door to the other as needed as well as being able to place in the correct location without the help from any machinery. After talking with a local steel fabrication shop, this did not seem very likely or possible in order to achieve all these goals at a reasonable price.

Therefore, after much consideration, the ramp for the PistenBully to drive up to allow for maintenance underneath does not seem like the best option. After further site investigation, more options may be considered but none will be further investigated for the current design study report.

9.0 ALTERNATIVES

The requirements for this project, as presented by the client, is to provide a reliable water source for the duration of the training season as well as provide a structure that can house the PistenBully 100 throughout the year. The scope of this project was to design a resolution to the current water reservoir issue on site that could be considered with minimal excavation work. In addition, the structure shall be able to hold the PistenBully 100 and allow for room to complete maintenance work.

Additional requests from the client include low maintenance of the reservoir, minimal costs, low overall weight, and easy constructability. Due to the location of the project site, these were taken into consideration in order to make the project reasonable and plausible. This criteria was taken into consideration when choosing the alternatives and deciding which was the best choice for the project.

Due to the cost and time constraint of the project, the alternatives have been broken up between the water reservoir and the structure to allow for the two to be built in separate seasons as needed. The ability to tackle different stages of the project in different seasons will allow for the completion of one alternative in the short construction season.

9.1 Alternative 1 - No build

This alternative would not provide a resolution to APU's current situation. If the no build alternative is chosen, APU will still have trouble maintaining a reliable water resource throughout the training season. Additionally, the conditions for the PistenBully would not be improved and the environment suited for maintenance would not be improved. Lack of budget may be a potential reason for taking the no build alternative. The preferred alternative for the water reservoir is a costly solution and if water is accessible at the previously used reservoir that is further away, that may continue to be the best option until funding is raised or a more cost effective alternative is found.

9.2 Alternative 2 - Preferred Alternative (Structure)

This alternative involves the construction of the structure. The structure would be 32 feet long, 26 feet wide, 12 feet high on the edge, and 15 feet 9 inches tall in the middle at the eave. This length allows for the structure to house the PistenBully 100 without removing any of the extra components. The doors, one on either end of the structure, will be 14 feet wide allowing for easy entrance and exit of the PistenBully 100. This was requested by the client to prevent the need of having to back up the PistenBully in the current environment. One side of the door will have a width of eight feet to allow room for storage and any maintenance that may be required. The other side of the door will have a width of four feet, which allows room to maneuver while the Pistenbully is housed within the structure. Figure 7 shows the front elevation view of structure showing the various dimensions and door openings.

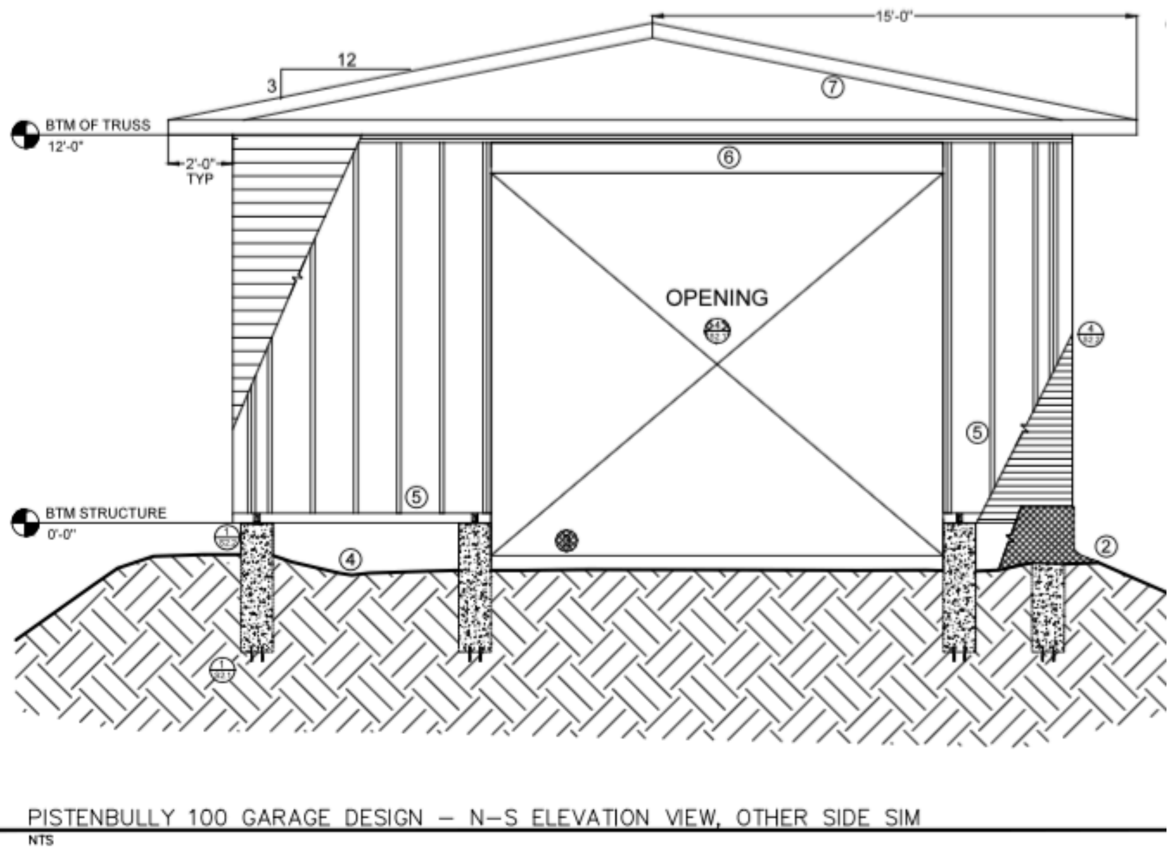


Figure 7. Front elevation view of the structure showing dimensions of walls and openings.

This option utilizes enough space to allow for easy maneuvering of the PistenBully in and out of the structure. With room for storage on either side of the PistenBully, there is space to hold the extra equipment and materials needed for the PistenBully to help protect from the environment.

While there are no lights in the structure, the main use of the structure will be in the summertime when the sun stays up for the majority of the day. There will be two windows located on either side of the structure, four total. The windows will allow light to enter the structure promoting ease of maintenance without the need of additional lighting. If more light is needed beyond the windows, then the two 14 foot doors may be left open allowing for more natural light to enter into the structure. The window layout is shown in figure 8 below.

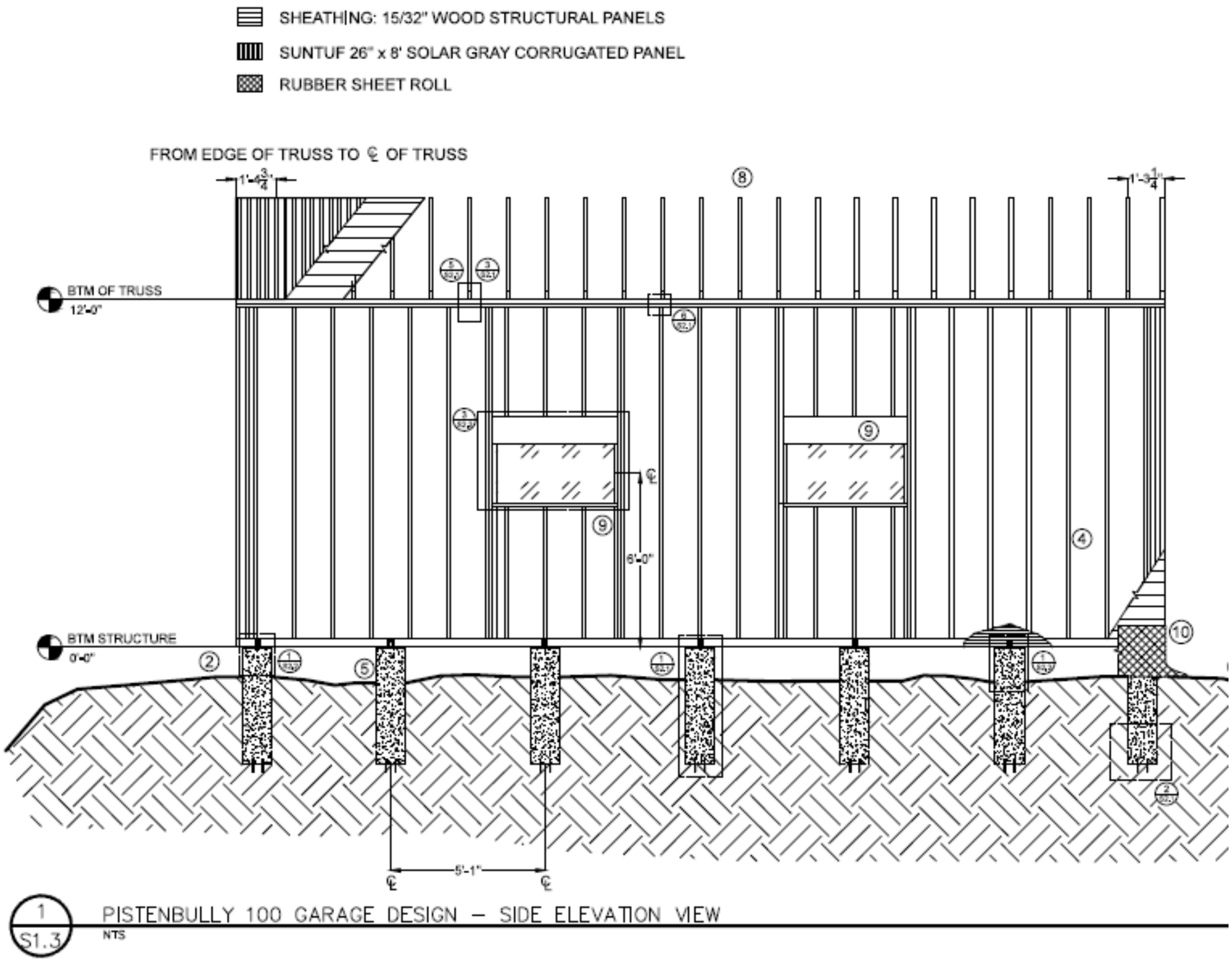


Figure 8. Side elevation view of the structure showing dimensions of walls and openings.

The windows are spaced along the length of the building to allow for maximum light when combined with the open door. The side elevation view also displays the truss spacing and column spacing described in more detail in section 8 of this report.

The open-air floor plan allows for easy drainage, adequate ventilation, low cost, and ease of installment. Use of the open air floor plan best complies with the goals set forth by APU. Leaving the floor open to the ground below lowers the cost for the material needed to withstand the high load the PistenBully exerts, as well as decreases the construction time. These are both very useful due to a limited budget and small construction time frame due to environmental aspects. A rubber skirt can be placed around the structure that is flexible and will help keep wind and snow from entering the structure from underneath. The skirt will allow for water to drain out through the soil as needed to prevent the buildup of water.

9.3 Alternative 3 - Preferred Alternative (Reservoir)

After careful consideration of several different reservoir solutions, it was determined that the most cost effective and least labor intensive solution is the implementation of an RPP (Reinforced Polypropylene) liner as a means of water catchment.

Polyethylene liners are widely used in industry as a means of separating and storing liquids. Due to the harsh environment at the APU Nordic Ski Facility along with the less than desirable native soil at the site, it is necessary to use a material that will not easily be compromised. The liner was chosen for this project due to several logistical reasons. The primary reason is because the APU Nordic Ski Facility cannot, under any circumstance, run out of water. The liner spec'd out for this project showcases the lowest possibility for failure out of all the different alternatives.

The native rocks in the area consist primarily of broken shale and greywacke, which are extremely harsh and jagged thus the possibility of a sharp stone puncturing the liner is a major concern. The RPP liner has an extremely high tear and rupture resistance and has lasted the test of time in other commercial applications making it ideal for this project.

The required size of the water basin was calculated based on the facility's current yearly water demand. Based on the snow depth and its corresponding density above the liner, the volume of potential stored water from snow was calculated. The size of the liner was determined by how much snowmelt and rainwater recharge may be produced in the given area. The potential storage volume was then compared with the perceived required volume. As a way to save on costs, minimizations of the liner size were made accordingly.

The liner alternative was also selected due to its relative ease of construction and reliability. As long as no holes are punctured in the liner itself, it will continue to function properly for many years to come. The membrane material that will be used for the liner will be shipped up on pallets having a total weight of around 1,940 lbs. The RPP sheets will then be placed in the natural depression and keyed into the existing slopes according to manufacturer's recommendations. The liner comes in 12-foot wide sections and can be installed in one piece prefabricated by at the Polar Supply factor or can be field welded on site. The liner will come in four sections and will have three seams that will need to be bonded. If the welding is done at the facility, roughly 12 personnel will be needed to move it into position. The factory welding is complementary of Polar Supply. If 12 personnel are not available on site at the time of installation, then a field welder from Enconsol can be utilized. Enconsol is a local company that uses a wedge welder and heat guns to fuse the section on site. It would take one day to field weld the liner and Enconsol charges a day rate of $2,300. With a field-welding technician, only four additional personnel (five total) would be needed on site to help position the sheets. Enconsol also does vacuum testing to check for leaks and provides a report certifying all of their work.

The liner alternative has the potential of providing up to a total volume of 56,000 gallons of water. However, this volume will likely never be reached due to the fact that much of the available water will be held in snow form for most of the summer. As the snow melts, the liner will continuously be recharged at a calculated rate exceeding the needs of the facility. The liner will be supplied from Polar Supply Co. The pricing and quote details are discussed in the cost estimate section of this report.

Due to the fact that no outside base material, such as the recommended fine sand, can be flown to the site, special provisions were built into the design as a way to compromise with this unique situation. The first installation recommendation is to crush the native rock into the smallest possible size. Crushing the rock should be achievable using typical eight-pound double jacks as well as pick axes. Although this may seem extremely labor intensive, it is highly recommended. Crushing the native rocks into smaller sizes will minimize the large and sharp rocks that may puncture the liner and cause total failure. After the native ground is prepared and all large rocks are removed, two layers of the 12-ounce geotextile fabrics are to be placed over the native rock in the basin. Installation of the geotextile fabrics will be done in much the same fashion as the liner material. The geotextile material will be the same size and fit in the same area as the liner material. The geotextile fabric will also be placed in the key trench below the RPP liner as to remove the possibility of it sliding down hill. The two layers of geotextile fabric are recommended as mediation for the small sharp rocks.

9.3.1 Earthwork Required

Earthwork is required to properly anchor or “key in” the liner. The key holds the perimeter of the liner against down slope subsidence, wind affects, and potential mechanical damage. The technique most suited to this project was the anchor trench because it required the least amount of earthwork since it is not feasible to transport large machinery to the site. The anchor trench is a rectangular excavation that surrounds the perimeter of the basin that the RPP liner and geotextile underlay is laid inside as shown in figure 9 below. The trench is then backfilled with the excavated soil to hold the liner in place and protect it. The grading plan with an anchor trench key in will require 22 cubic yards of cut and five cubic yards of fill. This earthwork can be done by manual labor with a sufficient crew of workers and adequate time. Sledge hammers and pick axes may need to be utilized to break up large rocks.

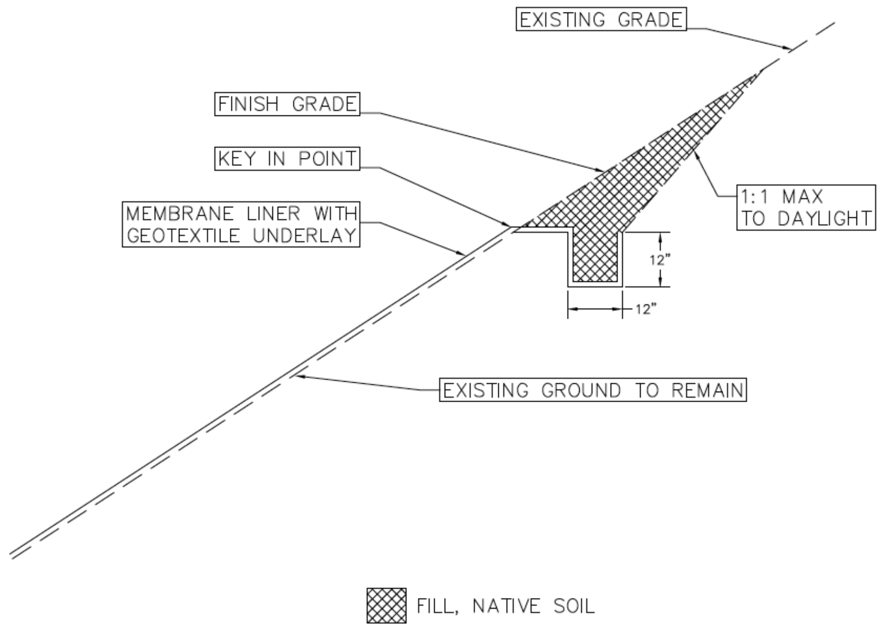


Figure 9. Liner key in detail.

9.3.2 Manufacturer's Requirements

Typical liners used on large-scale projects, such as the APU Nordic Ski Facility, are specifically regulated to ensure the long life of the liner and overall success of the project. However, due to a number of different constraints, many of the manufacturers requirements had to be compromised in the design process. Typically, designers call for a one and one half foot layer of fine sand as a protective layer for the liner material. Due to the unique location, this is not possible at Eagle Glacier. In this design, the requirement of the sand layer was accounted for through a Geotextile fabric material.

The strength of the RPP material goes above and beyond the minimum requirements for this application being that the depth of water inside the reservoir should not exceed five feet. But due to the adverse rock conditions, it was determined that the RPP liner was necessary for the longevity of the drainage basin. The manufacturer also recommends side slopes of 3:1 and will be adhered to as specified in the grading plan drawings.

Due to the lack of heavy equipment, all earthwork and construction in general must be completed by hand. Side slopes that exceed the manufactures requirements run the risk of collapsing on themselves and in the process losing all available stored water. The manufacture also requires a system for keying in the liner. Do the high wind loads in the area this requirement is critical to the success of the liner and basin in general and cannot be avoided even though it does require a substantial amount of dirt work.

9.4 Alternative 4 - Water Well (Reservoir)

Another solution investigated for APU's water issue was the use of drilling a water well to reach the groundwater table. The Alyeska Ski Resort has drilled a water well for its Seven Glaciers restaurant. A well of this size would produce far more water than would be required for the APU Nordic Ski Facility. After contacting the drilling contractors and explaining the geographical situation it became evident that although there is quite possibly a very deep water table near the facility, it is impossible to drill due to the heavy equipment that would be required for such an operation. The drilling contractors were also unwilling to risk flying their heavy equipment to the location. The well at Seven Glaciers was accessible by road making it possible for the drilling of the 400+ foot deep well. This alternative is not effectively possible and is not recommended.

9.5 Alternative 5 – Bentonite Clay (Reservoir)

An interesting alternative to the membrane liner is the use of a bentonite clay as an impermeable layer. Bentonite has an extremely low permeability and is used in a plethora of containment and seepage barrier applications. One method using bentonite clay is taking it in a powder form and mixing it with topsoil. The mixture is then spread evenly around the area to be lined and once wet, the bentonite expands and changes the porosity of the top soil to prevent seepage. Another method is to take a pond of standing water that is leaking and simply sprinkle bentonite clay powder on the surface. The powder then follows the seepage paths and expands when it reaches the leak. Both of these methods are not applicable to the reservoir in question due to the native soil. The coarse, porous gravel and rocks would allow the bentonite to drain through and upon application, when there was no standing water, the wind could blow the clay away. Also, ice action in the winter could render the bentonite ineffective if rocks are shifted. Another application of bentonite is a geosynthetic clay liner. These liners are essentially layers of geotextile fabric with bentonite clay trapped in between. Unfortunately, these liners are expensive and heavy and require extensive site preparation, grading, and protection on both sides.

Ruling out the geosynthetic clay liner made way for another possible application of bentonite: cement bentonite grout. Grout is a mixture of water and cement and other optional materials like pozzolans, sand, water reducers, or bentonite clay. The water to cement ratio of an average grout mix is around 0.5 but can range significantly to meet desired application. Grout could be an excellent way to seal the coarse gravel of the reservoir since it is less viscous than traditional cement mixes and can fill voids and seal cracks in the rocks. Adding bentonite to a grout mixture can yield many advantageous outcomes. Bentonite reduces permeability and allows the mixture to stay homogeneous as the viscosity of the mixture is varied. Bentonite can also improve the strength of the mixture. By applying bentonite to the reservoir in the form of a grout many issues are avoided such as the effects of ice action and wind on the clay itself. The proper mix ratio of the cement bentonite grout would depend on the porosity of the native soil. The water content and cement/bentonite ratio would need to be varied in tests to find a mixture that would seal the ground and still have adequate strength. Further reinforcement and prevention of cracking could be achieved by adding fiber reinforcement to the mixture. Once a grout seal is achieved a coarse grade of bentonite chips could be spread on top to provide additional water barrier and healing for the grout if cracks occur. A highly favorable reason to use cement bentonite grout over a traditional liner is that no earthwork would need to be done. The components of the mix could be flown out and mixed on site and then applied to the reservoir in its current condition. The cost of this alternative is potentially considerably lower than using a liner. Bentonite clay for the grout mixture is only $1,400 per 3,800-pound sack at Polar Supply Co. and the bentonite chips to cover it only cost $125 per ton. This seems like a much cheaper alternative but the quantities of each component can only be found by applying sample patches on the native soil at the site to determine the ideal mixture and required thickness. With this information an estimate of the cost and weight could be determined and compared to the liner alternative. Unfortunately, further pursuit of this alternative was halted by the project time frame. Bentonite was not proposed as an alternative until very late in the design process and the manufacturers and distributors contacted were not quick enough in providing information for using it in this application. There are very few available documents on the use of bentonite grout for a project like this, and mix designs are unique and don't have documented standards. Ultimately, a cement bentonite grout of similar product could be the best solution for this project; however, additional investigation needs to be done before this alternative can be objectively accessed.

9.6 Alternative 6 – Structural Insulated Panels (Structure)

The use of Structural Insulated Panels (SIP) was investigated for use with the PistenbBully structure. SIP's are four times stronger than conventional stick framing, are quicker and easier to assemble on-site, and hold up much better against water and wind. The SIP structure would be manufactured and put together off-site to ensure that everything fit together the way it was designed. The dry fit of the structure off-site would help to ensure that the structure would be built the same way once all the pieces arrived on-site. However, there were several drawbacks that could not be overlooked. One of which was the cost. A supplier and manufacturer of SIPs in Wasilla would not give an estimate due to the high cost, where the structure would be located, and the use in which it would be used for. The SIP structure would also weigh significantly more. Given that the materials would need to be flown up by helicopter, this was not feasible, and this alternative is not recommended.

10.0 COST ESTIMATION

A cost estimation was calculated for the 35% design of the APU Nordic Ski Facility. Values were based on the 2016-dollar. Price to fly the material up to the project site was not included in the current cost estimation considering APU would contact the Army National Guard to fly material up there as a training exercise as done for the original structure. Prices were obtained from local retail stores where applicable.

10.1 Divisions

The cost estimate is broken up into two separate divisions, which allows for the owner to gather money for one project at a time as needed. The two divisions are the water reservoir and the structure. The cost estimation for the reservoir will include the price of the liner and underlay. The labor cost for installation is neglected under the assumption that adequate manpower will be on site. The cost estimate for the structure will include the materials, machinery, and all costs applicable to the structure determined thus far.

10.2 Costs

The following costs were determined in March 2016 and may need to be adjusted depending on the actual construction date.

10.2.1 Water Reservoir

Polar Supply Company is the local dealer of liner products in Anchorage. This company can provide the RPP liner as well as the geotextile underlay at a price much lower than the out of state competitors. Table 2 displays the quote that Polar Supply has provided for the liner, and geotextile.

Table 2 Quote from Polar Supply Company

Material Description	Area (Square feet)	Price Per Square Foot	Total Cost	FOB Point	Approx. Availability
45 Mil RPP Liner	8,806	$1.10	$9,719	Anchorage	1-3 Weeks
12 OZ. Non-Woven Geotextile	17,612	$0.22	$3,878	Anchorage	Stock-4 weeks
Total			$13,579		

Out of state suppliers will charge shipping which significantly raises the price since the liner and underlay are extremely heavy. The additional field welding charge from Enconsol of $2,300 should be added to this quote if 12 personal are not available.

10.2.2 Structure

The structure cost estimate is broken down into four separate sections. A summary of the cost estimate can be found in table 3 below.

Table 3 Summary of the cost estimate for the structure.

Section	Cost
Walls	$2,500
Concrete Pillars	$900
Roof	$5,700
Hardware	$4,100
Labor (10%)	$1,300
Contingency (30%)	$4,000
Total	$18,500

This cost estimate was created by estimating the quantities of each material that would be needed in order to construct the structure at the project site location. The material cost was collected from local retail stores in order to ensure availability of the material and to get an accurate value. A labor cost of 10% has been added to the cost as well as a contingency of 30%. The final cost has been rounded up to the nearest one thousand to total $18,500 for the structure. See appendix B for a breakdown of the cost estimate for the structure.

10.3 Total Cost

From the two cost estimations given, the total cost of the project is roughly $32,100. This includes roughly $18,500 needed for the structure and $13,600 needed for the liner but does not include the amount needed for the welding technician to weld the fabric on-site (an additional $2,300).

In order to reduce costs, the cost estimation does not include travel, lodging, and food for any workers brought to site assuming those can be provided by APU. Material delivery is assumed to be the same method as prior applications with donated material delivery by the Army National Guard. It will also be investigated to use the Army National Guard to construct the structure as a remote practice as well as use them for the welding technician to help reduce the costs of the project.

Table 4 Summary of the cost estimate for the total project.

Division	Cost
Water Reservoir	*$13,600*
Structure	*$18,500*
Total	***$32,100***

11.0 PHASING

Due to the location, the project will have to be phased out with some items prefabricated in town and other items constructed on-site. With the short construction period, the utilization of items constructed in town is preferred. All phases of construction will need to be completed between the months of July and September to avoid heavy snowfall and winter weather conditions in addition to the naturally standing water in the reservoir. There are no accessible roads or trails for the materials to be transported to the site, and therefore all of the items will need to be flown up to the project site.

11.1 Material Delivery

The material may only be delivered to location by means of air transportation. With that being said, the material must first be delivered to the helicopter staging area in Girdwood, which lies approximately seven air miles from the actual site. All construction material will be placed into 40-foot steel conex containers, which will then be prepared, strapped, and airlifted to the project site. The initial design carefully considered weight issues as to avoid unnecessary weight. According to APU managers, the Air National Guard may be willing to volunteer to hoist the containers to location.

11.2 Material Storage

All material shall be kept inside of a conex for storage in order to keep it protected from the elements as much as possible. All material must be covered while not in use. Procedures for proper storage of all materials are specific to the manufacturer they are purchased from and should be stored in compliance with such standards.

11.3 Construction Phasing

There will be three phases of construction for the proposed project. The first phase consisting of ground work and preparatory measures for both the shed and the water basin. The second phase will consist of the structural foundation for the shed, as well as the lining of the basin with the selected liner, and securing it to the ground. At the end of the second phase of construction, the liner and basin should be almost fully complete. Lastly, the third phase will consist of the main structure being built, including the trusses for the roof and the metal sheathing. This phase will also include the securing of the liner to the basin. The first phase of construction would start somewhere in July, while the third and final phase would need to be completed in September (earlier if possible).

11.3.1 Phase 1

Phase one will consist of leveling the area in which the shed will be built, to the degree specified at 95% design, as well as doing any necessary dirt work in the basin to prepare the surface for the liner. The bottom of the basin will need to be satisfactory for the liner, and in accordance with any grading plan provided. Once the basin has been graded accordingly, the basin will be ready for the second phase of construction.

Once the ground for the shed has been leveled in accordance with a grading plan, the holes for the concrete pilings will be dug. Once the holes are dug for each of pile, a sonotube will then be inserted to make sure the hole retains its shape and structure prior to being filled.

11.3.2 Phase 2

Sonotubes that were previously placed for the pilings for the structure will now be filled with concrete, and allowed the proper amount of time to cure. The curing procedure will follow all specifications and guidelines provided at 95% design, including limitations for amount of time to cure as well as curing temperature and moisture levels.

Once the concrete has been poured for the pilings, work will begin on the basin. The liner will be rolled out and placed in the basin according to specifications to be determined at 95% design. This will include making sure that the liner covers the entire basin and has enough room to be placed in the anchor trench which was dug during phase one.

11.3.3 Phase 3

After the required amount of curing time for the concrete pilings has taken place, the final phase of construction will begin. This will be the primary construction of the structure on site. The building of the structure will be in accordance with building specifications and guidelines outlined in the final design report. Once the structure is built, some additional clean up and final touches may be required.

11.4 Time frame Considerations

Given the location and condition of the job site, there are several considerations to make in direct relation to time. The primary window for construction of this job will be between July and September, which will be heavily dependent on weather conditions. With such a small window, the project will need to be completed with efficiency and accuracy. If the shed is left incomplete before the winter months, irreparable damage could be done to compromise its structural integrity.

References

"ASCE 7 Windspeed." *ASCE 7 Windspeed*. Web. 5 Feb. 2016.

Bedient, P. B., Huber, W. C., & Vieux, B. E. (1988). *Hydrology and Floodplain Analysis (Fifth ed.).* Reading, MA: Addison-Wesley.

Domestic Sealand Traveler 510 Plus White Toilet. (n.d.). Retrieved February 02, 2016, from http://www.amazon.com/Dometic-Sealand-Traveler-White-Toilet/dp/B001Q9178I/ref=sr_1_2?ie=UTF8

GIRDWOOD, ALASKA Precipitation and Temperature Data. (n.d.). Retrieved February 26, 2016, from http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak3283

Indoor Water Use in the United States. (2016, January 14). Retrieved February 02, 2016, from http://www3.epa.gov/watersense/pubs/indoor.html

Lunardini, V. J. (1981). *Heat Transfer In Cold Climates*. New York: Van Nostrand Reinhold.

"National Snow and Ice Data Center." *NSIDC Scientific Data Search*. Web. 22 Jan. 2016.

Smith, D. W., & Low, N. (1996). *Cold Regions Utilities Monograph (Third ed.).* New York: American Society of Civil Engineers.

Water System Planning-Estimating Water Needs (Water Quality). (2016, January 1). Retrieved February 02, 2016, from http://extension.psu.edu/naturalresources/water/drinking-water/best-practices/water-system-planning-estimatingwater-use

APPENDIX A

APU Nordic Ski Facility

Structure - Cost Estimate

NOTE: This estimate is for 35% design only, a revised estimate should be completed as the design progresses.

Dimensions of the structure:

Height:	12	ft
Width 1:	8	ft
Width 2:	4	ft
Length:	32	ft
Door Width:	14	ft
Door Height:	11.83	ft

NOTE: Width 1 is taken as the larger dimension, width 2 is the smaller dimension. The width is on either side of the doors. The length dimension is the wall which includes the (2) windows on each side for a total of (4) windows.

Wood type: Douglas Fir Larch No. 2

Walls:

NOTE: Studs are 16" O.C. with variations around the openings

Type of Material	Quantity		Price		Comments
Number of studs:	94				
Stud length:	11.5	ft			(94) 2x6
Base plate:	114.167	ft	$16.73	per 16' board	(1) 4x6
Top plate:	114.167		$11.24	per 16' board	(2) 2x6
2x6 total length:	1195.17	ft			
Number of required sheets:	33	sheets	$18.57	per sheet	1/2" plywood
Suntuf 26in x 8ft Solar Gray Corrugated panel:	41	sheets	$23.71	per sheet	Each sheet is 17.33 sf
2x6 total cost:			$839.60		
4x6 total cost:			$119.38		
Total sheathing and panel cost:			$1,584.92		
Total Cost:	$2,543.90				

Concrete Pilla

NOTE: Cost of concrete per bag used for calculations and to be mixed on site. Concrete is assuming four feet depth of sonotube is used.

Type of Material	Quantity		Price		Comments
Concrete needed:	2.09	cy			
(1) 50 lb bag of quickcrete:	0.375	cy/bag			4,000 psi in 28 days, exceeds ASTM C387
Number of bags needed:	6	bags	$6.25	per bag	
12" sonotube at 4' deep:	18	sonotube	$15.00	per sonotube	
Grace water shield:	4	rolls	$150.00	per roll	
Concrete cost:			$37.50		
Sonotube cost:			$270.00		
Grace water shield cost:			$600.00		
Total cost:	$907.50				

APU Nordic Ski Facility
Structure - Cost Estimate

Roof:

NOTE: Quote from Alaska Truss from March 2016 given truss is 2 feet on center, snow load of 223 psf, wind load of 50 psf, pitch is 12:4, width of truss is 30 feet, height at eave is 3'-6".

Type of Material	Quantity		Price		Comments:
Number of trusses required:	25				Trusses at 2ft on center
Cost per end truss:			$144.00	per truss	
Number of required sheets:	31	sheets	$18.57	per sheet	
Grace tri flex undelayment:	1	roll	$113.13	per roll	Each roll is 1000 sf
Suntuf 26in x 8ft Solar Gray Corrugated panel:	58	sheets	$23.71	per sheet	Each sheet is 17.33 sf
Total truss cost:			$3,600.00		
Total Sheathing Cost:			$688.80		
Total metal panel cost:			$1,375.18		
Total cost:	$5,663.98				

Hardware:

NOTE: Connector manufacturer is Simpson Strong Tie. Exact nail count hasn't been tallied.

Type of Material	Quantity		Price		Comments
16d nails:	5	boxes	$53.00	per box	
8d nails:	5	boxes	$50.00	per box	
Roofing nails:	100	packs	$12.04	per pack	
Anchor rods:	36	rods	$49.75	per rod	(2) at each conc. Pillar
Simpson strong tie - H10A:	50	units	$2.50	per unit	
Simpson Strong tie - TSP:	94	units	$2.50	per unit	
Simpson Strong tie - PB 4x6:	18	units	$10.87	per unit	
Total cost:	$4,065.66				

Total Material Cost:	$13,181.04
Labor Cost (10%):	$1,318.10
Contigency (30%):	$3,954.31
Total Cost:	$18,453.46
Cost Estimate for Structure:	$18,500.00

APPENDIX B

APU Nordic Ski Facility

Shed Calculations - Weight Estimate

Number of studs (per 32' wall) based on Spacing

16" o.c.	24.00	so use 24 studs per 32' wall if spacing is at 16" O.C.
24" o.c.	16.00	so use 16 studs per 32' wall if spacing is at 24" O.C.

Stud weight per 12'

w_{stud} 24 lb

Equivalent Uniform Weights of Wood Framing (Design of Wood Structures)

16 in. o.c. (2x6)		24 in. o.c. (2x6)		16 in. o.c. (2x8)		24 in. o.c. (2x8)	
Weight, psf	1.40	Weight, psf	1.00	Weight, psf	1.90	Weight, psf	1.30
Board Feet (per ft^2)	0.75	Board Feet (per ft^2)	0.50	Board Feet (per ft^2)	1.00	Board Feet (per ft^2)	0.67

16 in. o.c. (2x4)		24 in. o.c. (2x4)	
Weight, psf	0.90	Weight, psf	0.60
Board Feet (per ft^2)	0.50	Board Feet (per ft^2)	0.34

Equivalent Uniform Weight of Each 4 foot section of wood frame

16" o.c. (2x6)		24" o.c. (2x6)		16" o.c. (2x8)		24" o.c. (2x8)		16" o.c. (2x4)		24" o.c. (2x4)	
67.20	lb	48.00	lb	91.20	lb	62.4	lb	43.20	lb	28.80	lb

Equivalent weight of the wood walls of the structure (minus the garage door)

Number of 4' sections for the structure, n 22

Weight of all of the sections based off of stud size and spacing

16" o.c. (2x6)		24" o.c. (2x6)		16" o.c. (2x8)		24" o.c. (2x8)		16" o.c. (2x4)		24" o.c. (2x4)	
1478.40	lb	1056.00	lb	2006.40	lb	1372.8	lb	950.40	lb	633.60	lb

Garage Doors, Per door (Excluding hinges and hardware)

Each door is 7'x12'

Height	h_{gd}	12	ft	
Width	b_{gd}	7	ft	

Number of vertical 2x4's: n 24 at 12ft long

Bracing: 1 - 2x4 at 7' long; 2 - 2x4 at 13.9' long

Total Length of 2x4's needed (per door): L 322.8 ft

For all 4 doors L_{total} 1291.2 ft

Weight of all 4 doors: W_{doors} 1653 lb

Additional weight from door jams: W_{jams} 604 lb

Total Weight of Doors and Door jams: $W_{d\text{-}total}$ **2257** lb

Roof Weight

The overall weight of the roof varies greatly depending on materials and sizes, spacing, and load applied. The calculated range is:

W_r **6501** lb **<u>to</u>** **12168** lb

Overall weight of the structure (Minus windows and hardware)

The overall weight of the structure will be dependent on the weight and design of the roof, and will be between

16" o.c. (2x4)		24" o.c. (2x4)		16" o.c. (2x6)		24" o.c. (2x6)		16" o.c. (2x8)		24" o.c. (2x8)	
9708	lb	**9391**	lb	**10236**	lb	**9814**	lb	**10764**	lb	**10130**	lb

and

16" o.c. (2x4)		24" o.c. (2x4)		16" o.c. (2x6)		24" o.c. (2x6)		16" o.c. (2x8)		24" o.c. (2x8)	
15375	lb	**15058**	lb	**15903**	lb	**15481**		**16431**	lb	**15797**	lb

The design being used for all calculations has been with 2"x6" studs at 16" O.C.. The weight of the structure using these would be

10236 **lb** **<u>to</u>** **15903** **lb**

APPENDIX C

APU Nordic Ski Facility

Water Reservoir - Water Usage Calculations

(orange)	= assumed value
(white)	= known value
(yellow)	= calculated value

Variables				
	Guests per day	30		
	Sessions per season	8		
	Days of use per session	7		
	Days of use per season	56		
Toilets				
	Gallons per flush	0.125	gal/flush	From Domestic Sealand Traveler 510 Plus Toilet
	number of toilets	3	Toilets	
	Estimated flushes/day/person	5	Flushes	
	Total flushes/day	100	Flushes	
	Total	12.5	gal/day	
Drinking				
	Consumption/person/day	1	gal	Assumed use for drinking and cooking
	Total	30	gal/day	
Showers				
	Number of showers	4		
	Estimated shower length	7	min	
	Estimated shower consumption	2	gallons/min	
	Gallons per shower	14	gallons	
	Estimated showers/person/day	0.75	showers	
	Total showers taken per day	22.5	showers	
	Total	315	gal/day	
Kitchen Sinks				
	Number of sinks	1		
	Estimated time of use per day	60	min	For doing dishes etc.
	Estimated sink consumption	2	gpm	
	Total	120	gal/day	
Bathroom Sink				
	Number of bathroom sinks	2		
	Time of use/person/day	1	min	
	gal/min	2	gpm	
	Consumption/person/day	2	gal	
	Total	60	gal/day	
Clothes Washer				
	Number of washers	1		
	Estimated Loads/day	0.5		
	Consumpton/load	50	gal	
	Total	25	gal/day	
Additional Water Use				
	Cleaning		gal/day	
	Etc.		gal/day	
	Total	0	gal/day	
Totals				
	Total consumption/day	562.5	gal/day	Summation of above totals
	Season Consumption	31500	gal/season	

APPENDIX D

APU Nordic Ski Facility

Structure Calculations - Wall Construction

NOTE: Load combination chosen based on load combinations from ASCE 7-10 2.3.2.

Load Combinations

1. 1.4*D
2. 1.2*D + 1.6*L + 0.5*S

3.1 1.2*D + 1.6*S + 0.5*L

3.2 1.2*D + 1.6*S + 0.5*W

4. 1.2D + 1.0W + (0.5 or 1.0)*L + 0.5(Lr or S or R)
5. 1.2D + 1.0E + (0.5 or 1.0)*L + 0.2S
6. 0.9*D + 1.6*W

Section Properties

Nominal Size	*Standard Dressed*	*Area, A [in^2]*	*Section Modulus, S_{xx}, [in^3]*
2 x 6	1.5 x 5.5	8.25	7.56

NOTE: Reference design values taken from National Design Specification Design Values for Wood Construction 2015 Edition, Table 4A.

Reference Design Values [psi] **Type: Douglas Fir Larch, No.2**

F_b	F_t	F_v	F_{cL}	F_c	E	E_{min}	G
900	575	180	625	1350	1600000	580000	0.50

Adjustment Factors

C_M* (F_b)	(F_t)	(F_v)	(F_{cL})	(F_c)	(E and E_{min})	C_t
0.85	1.0	0.97	0.87	0.8	0.9	1.0

C_L	C_F [F_b]	C_F [F_t]	C_F [F_c]	C_{fu}	C_i	C_r	C_P
0.9	1.3	1.3	1.1	1.0	1.0	1.15	1.0

C_T**	C_b
1.0	1.25

	K_F	ϕ	λ***	λ****
F_b	2.54	0.85	0.8	1.0
F_t	2.70	0.80	0.8	1.0
F_v	2.88	0.75	0.8	1.0
F_c	2.40	0.90	0.8	1.0
F_{cL}	1.67	0.90	--	--
E_{min}	1.76	0.85	--	--

*Assume moisture content exceeds 19%, see NDS2015.
**See NDS2015 4.4.1.2, ensure proper blocking and nailing
***For load combination 1.2D + 1.6S + (L or 0.5W)
***For load combination 1.2D + 1.0W + (0.5 o 1.0)L + 0.5(Lr or S or R)

APU Nordic Ski Facility

Structure Calculations - Wall Construction

Calculations for C_L

d [in]	b [in]	l_u [in]	l_e	R_B	F_b^*	F_{bE}	F_{bE}/F_b^*
6	2	132	233.2	18.7	1975.4	2530.5	1.3

Nominal Design Values [psi]

F_{bn}	F_{tn}	F_{vn}	F_{cLn}	F_{cn}	E_n	E_{min_n}
2286	*1552.5*	*518.4*	*1043.75*	*3240*	*1600000*	*1020800*

Adjusted Design Values [psi]

F_b'	F_t'	F_v'	F_{cL}'	F_c'	E'	E_{min}'
1769.6	1291.7	301.7	1021.6	2052.864	1440000	780912

NOTE: The ground snow load is from interpolating NSIDC data from the nearest four sites using a 50-year return. An on-site record of snowfall may be used to get a more accurate account for snow with the appropiate amount of data. Wind loads taken from Applied Technology Council - Windspeed by Location using latitude and longitude of the project, measure on-site for exact wind speeds and wind direction.

Shed Design Loads [psf]

ρ_g = 223
C_e = 0.7
C_t = 1.2
I_s = 1.00
ρ_s = 131
w_L = 20
w_W = 50

Plywood = 0.0
Loose Insulation = 0.5
12 gage steel = 4.9
Truss (guess) = 4.0

w_D = 9.4

Reactions

Total square footage of roof:

L =	34.0	ft
b =	28.0	ft
Pitch =	12:3	
H =	3.5	ft
Roof area =	981.3	sf

Vertical

Load combination 3:

$w_U = 1.2*D + 1.6*S + 0.5*W$

w_{U1} = 153.4 psf

Lateral

Load combination 4:

$w_U = 1.2*D + 1.0*W + 1.0*L + 0.5*S$

w_{U2} = 115.7 psf

Snow Load:	**Balanced**	**Unbalanced**	**Units**
Tributary area =	490.6		sf
Load on each side =	1836	2342	plf
Load at each truss (@ 2' O.C.) =	3671	4683	lbs
	3.67	4.68	kip
Load at end trusses =	1836	2342	lbs
	1.84	2.34	kip

APU Nordic Ski Facility

Structure Calculations - Wall Construction

NOTE: Wood capacites calculated from values interpolated from online resources. For more accurate calculations, conduct an on-site investigation with the appropriate time frame to gather data that better represents the area.

Column Capacity

$(l_e/d)_y$ =	0	because of sheathing
$(l_e/d)_x$ =	26.2	
E_{min}' =	737528	
c =	0.8	for visually graded sawn lumber
F_{cEn} =	884.4	psi
F^*_{cn} =	2052.9	psi
F_{cEn}/F^*_{cn} =	0.4	
C_p =	0.4	
F'_{cn} =	835.8	psi
P'_n =	6895.6	lbs
Spacing =	20.8	in
SPACING =	16	in

Bearing of Stud on Wall Plates

C_b =	1.25	
F'_{cLn} =	998.09	psi
P'_{Ln} =	8234.21	lbs
Capacity =	3987.23	lbs

Wind loads - Bending OK

$M_u = (w_u*L^{2)}) / 8$ =	7155	k-in
f_{bu} =	946	ksi
$M'_n = F'_{bn}*S$ =	13378	k-in

Wind loads - Axial OK

P_U =	2147.0	lbs
f_{cu} =	260.2	psi
$(l_e/d)_x$ =	26.2	
F_{cEn} =	884.4	psi
C_p =	0.4	
F'_{cn} =	835.8	psi
P'_n =	6895.6	lbs

Combined Bending and Axial Compression OK

$(f_{cu}/F'_{cn})^2 + f_{bxu}/(F'_{bxn}*(1-f_{cu}/F_{cExn}) \leq 1.0$

$F_{cExn} = F_{cEn}$ =	884.4	psi
f_{cu} =	260.2	psi
F'_{cn} =	835.8	psi
w_U =	204.47333	plf
M_U =	26.17	kip-ft
f_{bxu} =	41.5	psi
F'_{bxn} =	2212.0	psi

$(f_{cu}/F'_{cn})^2 + f_{bxu}/(F'_{bxn}*(1-f_{cu}/F_{cExn}) = 0.12$

Combined Bending and Axial Tension

P =	6896	lbs
f_t =	836	psi
F'_t =	1098	psi
M_U =	26.17	k-ft
f_b =	42	psi
F'_b =	1770	psi
$(f_t/F'_t)+(f_b/F'_b) \leq 1.($	OK	
$(f_t/F'_t)+(f_b/F'_b)$:	0.78	

Shearwall

Diaphragm Reactions

R_{U32} =	22.22	kip
R_{U26} =	18.05	kip
v =	855	lb/ft

Sheathing Material: 15/32 in Wood Structural Panels - Sheathing

Fastener Type and Size: 8d

Panel Edge Fastener Spacing: 2 in O.C.

v_w = 1790 plf

APU Nordic Ski Facility

Structure Calculations - Bearing Capacity

Ultimate bearing capacity of a circular foundation

NOTE: The ultimate bearing capacity that is first evaluated in these equations are from that of Terzaghi's Bearing Capacity Theory. Where the bearing capacity of a shallow foundation is evaluated. A shallow foundation can be defined as foundations with D_f (Embedment depth) equal to 3 to 4 times their width. Under the assumed conditions, the proposed foundation for this shed is a shallow foundation.

Assuming a 1' diameter sauna tube filled with concrete, at a height of 4', and an embedment depth of 3'.

$q_u = 1.3 * c' * N_c + q * N_q + 0.3 * \gamma * B * N_\gamma$ — Factor of Safety, F.S. = 3

The material examined on site was that of shale and greywacke. The following assumptions were made in order to determine an approximate bearing capacity:

Friction ange, ϕ' , between 32° ~ 40°	Use low end of range;	ϕ' (deg)	32
Unit weight, ϒ , between 22 kN/m^3 ~ 26 kN/m^3	Use low end of range;	ϒ (kN/m^3)	22
Cohesion, c' , is 0		c'	0

Given these assumptions, the bearing capacity factors are:

ϕ'	N_c	N_q	N_γ	Width **B (m)**	Depth D_f **(m)**	Area A_p **(m^2)**	Area A_p **(ft^2)**
32	44.04	28.52	26.87	0.3048	0.9144	0.0730	3.14

$q = \gamma * D_f =$ 20.1168 kN/m^2 $\quad$ q_u 627.7850 kN/m^2 = 13.11 kips/ft^2

$q_{allow} = q_u$/F.S. $\quad$ q_{allow} 4.37 kips/ft^2

Total Allowable Gross load; **Q** **13.73** **kips** **> 12.48 kips per pillar**

The calculated load on each pillar from the structure as well as the snow load is estimated at 12.48 kips, on the high end. The allowable bearing capacity (being very conservative) is adequate.

Point Bearing Capacity of Piles Resting on Rock

Typical unconfined compressive strength of rocks; Shale is 5,000 psi to 10,000 psi ; Sandstone is 10,000 psi to 20,000 psi ; and limestone is 15,000 psi to 30,000 psi. Given the soil type witnessed upon site visit, the soil present is a mixture of those rocks. In order to best design these piles, the lowest end of the strength range will be used.

radius, r_{pile} 6 in. $\quad$ A_p 113.10 in^2

Typical values of ϕ' range from 10 to 45 degrees given the mix of rock found on site. To be conservative, a value of 10 degrees will be used.

ϕ' [deg] 10 $\quad$ $N_\phi = \tan^2(45 + \phi'/2)$ $\quad$ N_ϕ 0.0739

$q_{u(Design)} = q_{u(Lab)}/5 =$ 1000 psi $\quad$ **FS** 3

$$Q_{p(allow)} = \frac{[q_{u(Design)}(N_\phi + 1)] * A_p}{FS}$$

$Q_{p(allow)}$ 40486.205 lb = **40.49** **kips**

$Q_{p(allow)}$ **40.49** **kips** **> 12.48 kips per pillar**

APU Nordic Ski Facility

Structure Calculations - Bearing Capacity

If the footing were to have a 3'x3'x1' square footing at the bottom of the pillar, the ultimate bearing capacity (Per Terzaghi's Bearing Capacity Theory) would be as follows:

$q_u = 1.3*c'*N_c + q*N_q + 0.4*\Upsilon*B*N_\Upsilon$ Factor of Safety, F.S. = 3

The material examined on site was that of shale and greywacke. The following assumptions were made in order to determine an approximate bearing capacity:

Friction ange, ϕ' , between 32° ~ 40°	Use low end of range;	ϕ' (deg)	32
Unit weight, Υ , between 22 kN/m^3 ~ 26 kN/m^3	Use low end of range;	Υ (kN/m^3)	22
Cohesion, c' , is 0		c'	0

Given these assumptions, the bearing capacity factors are:

ϕ'	**N_c**	**N_q**	**N_Υ**	Width **B (m)**	Depth **D_f (m)**
32	44.04	28.52	26.87	0.9144	0.9144

$q = \Upsilon*D_f =$ 20.1168 kN/m^2 **q_u** 789.9465 kN/m^2 = 16.50 kips/ft

q_{allow} = q_u/F.S. **q_{allow}** 5.50 kips/ft

Total Allowable Gross load; **Q** **49.50** **kips** **> 12.48 kips per pillar**

If the footing were to have a 5'x5'x1' square footing at the bottom of the pillar, the ultimate bearing capacity (Per Terzaghi's Bearing Capacity Theory) would be as follows:

$q_u = 1.3*c'*N_c + q*N_q + 0.4*\Upsilon*B*N_\Upsilon$ Factor of Safety, F.S. = 3

The material examined on site was that of shale and greywacke. The following assumptions were made in order to determine an approximate bearing capacity:

Friction ange, ϕ' , between 32° ~ 40°	Use low end of range;	ϕ' (deg)	32
Unit weight, Υ , between 22 kN/m^3 ~ 26 kN/m^3	Use low end of range;	Υ (kN/m^3)	22
Cohesion, c' , is 0		c'	0

Given these assumptions, the bearing capacity factors are:

ϕ'	**N_c**	**N_q**	**N_Υ**	Width **B (m)**	Depth **D_f (m)**
32	44.04	28.52	26.87	1.524	0.9144

$q = \Upsilon*D_f =$ 20.1168 kN/m^2 **q_u** 934.0901 kN/m = 19.51 kips/ft

q_{allow} = q_u/F.S. **q_{allow}** 6.50 kips/ft

Total Allowable Gross load; **Q** **162.57** **kips** **> 12.48 kips per pillar**

APPENDIX E

Mirafi® 1120N

Mirafi® 1120N is a nonwoven geotextile composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. Mirafi® 1120N is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Value	
			MD	CD
Grab Tensile Strength	ASTM D 4632	N (lbs)	1335 (300)	1335 (300)
Grab Tensile Elongation	ASTM D 4632	%	50	50
Trapezoid Tear Strength	ASTM D 4533	N (lbs)	512 (115)	512 (115)
CBR Puncture Strength	ASTM D 6241	N (lbs)	3560 (800)	
Apparent Opening Size (AOS)[1]	ASTM D 4751	mm (U.S. Sieve)	0.15 (100)	
Permittivity	ASTM D 4491	sec^{-1}	0.8	
Flow Rate	ASTM D 4491	$l/min/m^2$ ($gal/min/ft^2$)	2648 (65)	
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70	

[1] ASTM D 4751: AOS is a Maximum Opening Diameter Value

Physical Properties	Test Method	Unit	Typical Value
Weight	ASTM D 5261	g/m^2 (oz/yd^2)	414 (12.2)
Thickness	ASTM D 5199	mm (mils)	2.7 (105)
Roll Dimensions (width x length)	--	m (ft)	4.5 x 91 (15 x 300)
Roll Area	--	m^2 (yd^2)	418 (500)
Estimated Roll Weight	--	kg (lb)	183 (404)

Made in USA

TenCate materials that make a difference

POLYPROPYLENE (REINFORCED) GEOMEMBRANE

PRODUCT DESCRIPTION

PPR[6] is a flexible polypropylene geomembrane produced from first quality resins. PPR is chemically inert, enabling the material to maintain flexibility throughout its use. With a low coefficient of thermal expansion and a low modulus of elasticity, PPR has fewer wrinkles thereby conforming better to uneven subgrade. PPR geomembranes have been formulated to be resistant to chemicals, ultraviolet degradation and leaching additives.

PROPERTY	METHOD	FREQUENCY[1]	PPR36	PPR45
Thickness (nominal)[2](mils) Thickness (minimum)[3](mils)	ASTM D751 ASTM D5199	per roll	36 34	45 41
Weight per Unit Area (g/sf)	ASTM D5261	50,000 sf	70	84
Tensile Properties • Grab Strength (lb/4") • Grab Strength (%)	ASTM D751	50,000 sf	 225 22	 250 22
Tear resistance[4](min. ave.) (lb.)	ASTM D5884	50,000 sf	75	75
Ply Adhesion[4] (lb. of FTB)	ASTM D413	50,000 sf	20	20
Puncture Resistance (min. ave.) (lb.)	ASTM D4833 FTMS 101B[5] Method 2031	50,000 sf certified	85 200	90 250
Dimensional Stability (max)(%)	ASTM D1204	resin batch	+/-1.0	+/-1.0
Hydrostatic Resistance (psi)	ASTM D751 Method A, Proc. 1	certified	300	350
Low Temp Flexibility	ASTM D2136 1/8" Mandrel, 4 Hrs	certified	-40F	-40F
Stress Crack Resistance (hrs)	ASTMD1693	certified	5,000	5,000
UV Resistance (hrs)[7]	QUV	certified	5,000	5,000
Reinforcing Scrim	9 X 9, 1000 denier weft-inserted polyester for all material thicknesses.			

NOTES:

[1] Testing frequencies are rounded to the nearest full roll.
[2] Nominal thickness is based on no coupon being less than 10% under specified thickness. Average thickness may be less than specified thickness.
[3] Minimum thickness is based on average thickness being equal to or greater than specified thickness.
[4] Peak value.
[5] FTMS 101b has been replaced with D4833. Value shown for comparison purposes only.
[6] RPP black/black and tan/black is available in accordance with ANSI/NSF 61 standard and can be used for both potable and industrial applications.
[7] Allow four (4) months lead-time to fully evaluate long term UV resistance of the color.

APPENDIX F

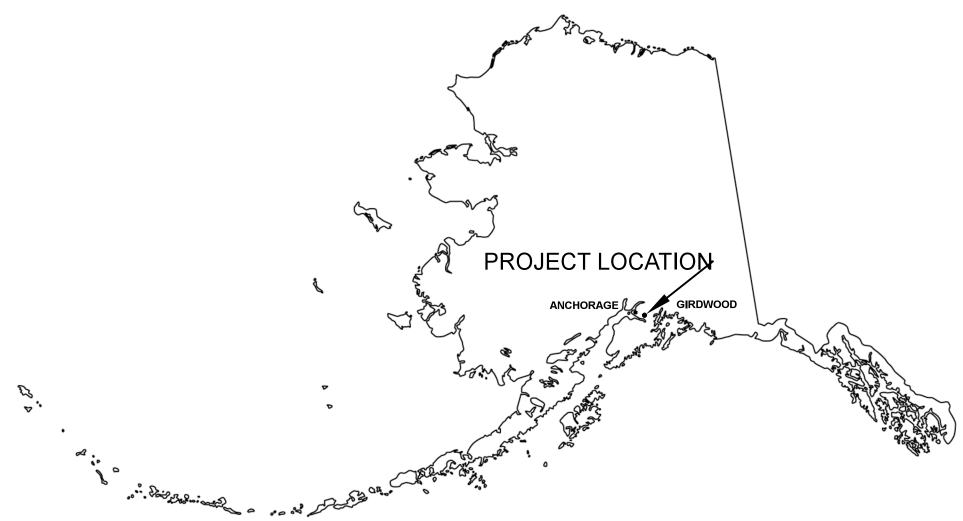
35% SCHEMATIC DESIGN

APU Nordic Ski Facility

Girdwood, Alaska

APRIL 15, 2016

SITE LOCATION



PROJECT LOCATION

PROJECT SUMMARY
1. Modifications to the current water reservoir in order to provide the proper size, care, and installation of a liner that will increase the dependability and capacity of the current water reservoir. The modified water reservoir will provide an efficient amount of water needed for Alaska Pacific University (APU) to maintain a successful training season at the APU Nordic Ski Facility by Eagle Glacier, north of Girdwood, AK. 2. A structure for the Pistenbully 100 to be stored throughout the year. There should be adequate room to maneuver around the Pistenbully to provide the required maintenance as needed. Adequate strength to withstand the natural conditions and proper drainage are required.

Sponsored by:
University of Alaska Anchorage
CE438 - SENIOR DESIGN

ABBREVIATIONS

&	AND	MAX	MAXIMUM
@	AT	MIN	MINIMUM
#	NUMBER	MISC	MISCELLANEOUS
APPROX	APPROXIMATE	N.T.S.	NOT TO SCALE
AVG	AVERAGE	O.C.	ON CENTER
B.O.	BOTTOM OF	PSF	POUNDS PER SQUARE FOOT
CONC	CONCRETE	PSI	POUNDS PER SQUARE INCH
CTR	CENTER	REINF	REINFORCING OR REINFORCED
EQ	EQUAL	REQ'D	REQUIRED
E.S.	EACH	THRU	THROUGH
EST	ESTIMATE	T.O.	TOP OF
EXT	EXTERIOR	TYP	TYPICAL
FT	FOOT OR FEET	UNO	UNLESS NOTED OTHERWISE
HT	HEIGHT	W/	WITH
IN	INCHES	W/O	WITHOUT
INT	INTERIOR	WT	WEIGHT
LB	POUND		
LP	LOW POINT		

LEGEND

DETAIL IDENTIFICATION

(2 / S1.1) ← DETAIL NUMBER ← SHEET NUMBER

(2) NOTE REFERENCE

℄ CENTERLINE

2 GENERAL NOTE

RISE / RUN ROOF SLOPE

PAGE INDEX

SHEET NUMBER	SHEET INDEX	SHEET NUMBER	SHEET INDEX
G0.1	COVERSHEET	S1.0	STRUCTURAL OVERVIEW
		S1.1	SNOW LOAD
C1.0	VICINITY MAP	S1.2	ELEVATION N-S
C1.1	SECTION VIEW	S1.3	ELEVATION E-W
C1.2	KEY IN DETAIL	S2.1	STRUCTURAL DETAILS
		S2.2	STRUCTURAL DETAILS

GENERAL NOTES

1. ALL DESIGN ELEMENTS SHALL BE IN ACCORDANCE WITH THE IBC 2009 AND ITS REFERENCED STANDARDS HEREIN REFERENCED TO AS "THE CODE".
2. NO MECHANICAL OR ELECTRICAL COMPONENTS DESIGNED FOR THIS STRUCTURE AND SITE IMPROVEMENTS. CONSULT MECHANICAL/ELECTRICAL FOR COMPONENTS AS DESIRED.
3. VERIFY ALL DIMENSIONS AND CONDITIONS AT THE PROJECT SITE PRIOR TO STARTING WORK AND NOTIFY THE OWNER IMMEDIATELY OF ANY DISCREPANCIES.
4. PROVIDE TEMPORARY ERECTION BRACING AND SHORING AS REQUIRED FOR STABILITY OF THE STRUCTURE DURING ALL PHASES OF CONSTRUCTION.

STRUCTURAL DESIGN DATA

SNOW LOADS: IN ACCORDANCE WITH THE REQUIREMENTS OF THE CODE AND ASCE 7-10.

Pg = 223 lb / ft²
Ce = 0.7
Ct = 1.2
I = 1.00
Ps = 131

WIND LOADS: CRITERIA IN ACCORDANCE WITH THE CODE.

BASIC 3-SEC GUST	V = 140 MPH
WIND IMPORTANCE	I = 1.00
OCCUPANCY CATEGORY	II
WIND EXPOSURE CATEGORY	EXPOSURE B

STRUCTURAL WOOD NOTES

1. ALL CONVENTIONAL AND COMPOSITE FRAMING MATERIALS SHALL CONFORM TO THE FOLLOWING:
   SPECIES: DOUGLAS FIR LARCH NORTH
   GRADE: NO. 2
2. ALL NAILS SHALL BE COMMON WIRE NAILS. NAILING SHALL CONFORM TO TABLE 2304.9.1 OF THE CODE.
3. STANDARD WASHERS SHALL BE USED UNDER ALL BOLT HEADS AND NUTS CONTACTING WOOD.

STRUCTURAL CONCRETE NOTES

1. ALL CAST-IN-PLACE CONCRETE SHALL HAVE MINIMUM 28 DAY COMPRESSIVE STRENGTHS OF 4,000 PSI.
2. ALL REINFORCING BARS SHALL BE NEW BILLET STEEL CONFORMING TO THE STANDARDS OF ASTM A615, GRADE 60.
3. ALL CONCRETE REINFORCEMENT SHALL BE DETAILED, FABRICATED, SUPPORTED AND SPACED IN FORMS, AND SECURED IN PLACE IN ACCORDANCE TO "BUILDING CODE REQUIREMENTS FOR REINFORCED CONCRETE", ACI 318-14.
4. ALL CAST-IN-PLACE CONCRETE SHALL HAVE A MINIMUM CEMENT CONTENT OF 610 LB PER YARD.
5. MAXIMUM SLUMP SHALL BE 4 INCHES, UNO.
6. MAXIMUM WATER-CEMENTITIOUS MATERIALS RATIO SHALL BE .40.
7. ANCHOR BOLTS, F1554 GRADE 36, HOT DIP GALVANIZED. SET ALL ANCHOR BOLTS BY DETAIL ON SHEET S2.2.
8. ALL CONCRETE SHALL FOLLOW ACI 318-14 SPECIFICATIONS.

GEOTECHNICAL NOTES

1. FOR UNKNOWN VALUES, THE LOW END OF THE RANGE IS ASSUMED TO BE CONSERVATIVE. (E.G. FRICTION ANGLE = 32°, UNIT WEIGHT = 22 kN/m³, COHESION = 0).
2. MATERIAL ON-SITE ASSUMED TO BE THAT OF SHALE AND GREYWACKE. CONTRACTOR TO VERIFY ON-SITE CONDITIONS FOR PROPER VERIFICATION.
3. ON-SITE BORING LOGS MAY BE REQ'D IF ON-SOTE CONDITIONS VARY VISIBLY AND DRASTICALLY FROM ASSUMED.

REVISIONS

REV	DATE	DESCRIPTION	BY

ALASKA PACIFIC UNIVERSITY

UAA College of Engineering
UNIVERSITY of ALASKA ANCHORAGE

University of Alaska Anchorage

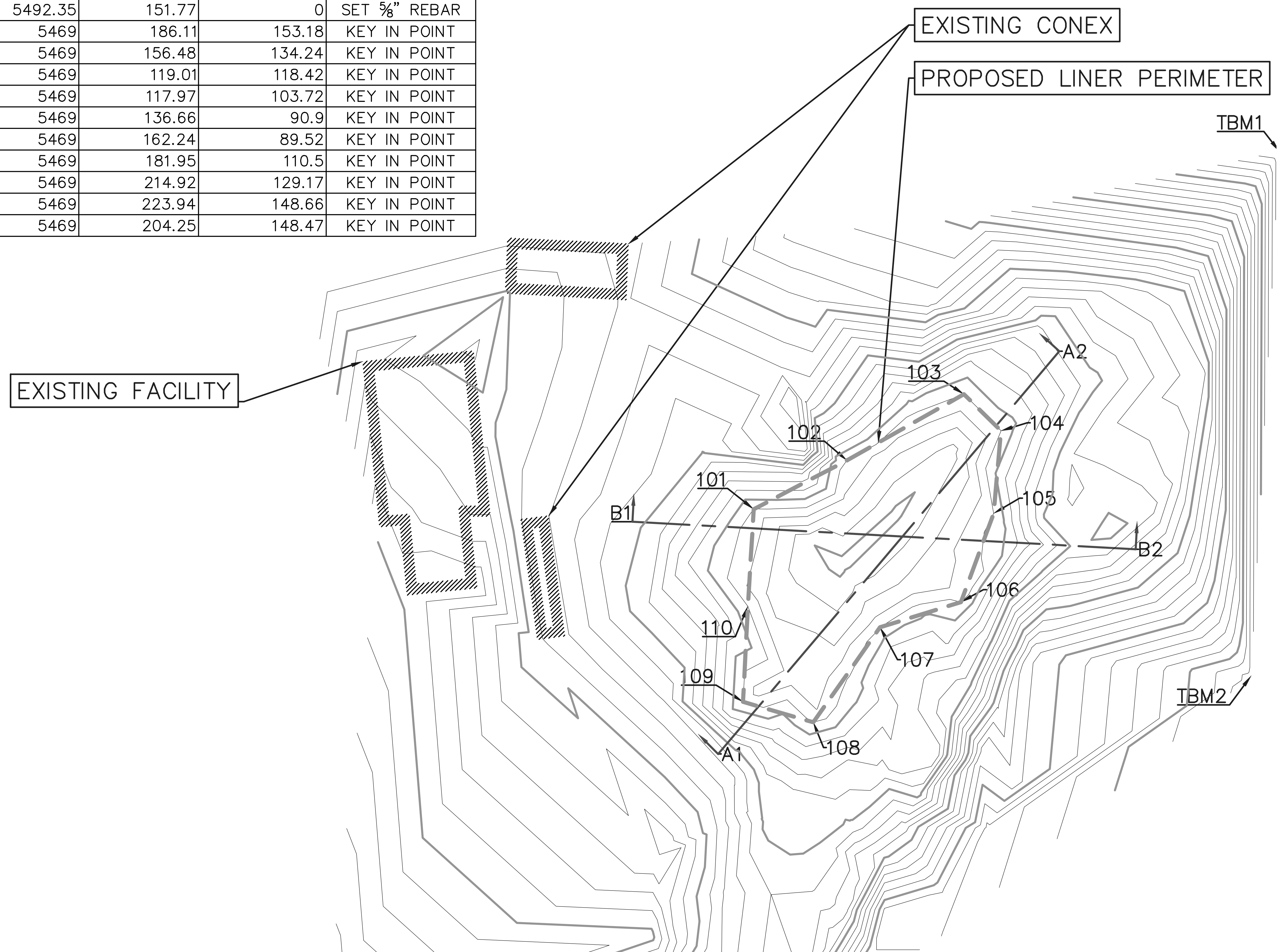
Riley Bronga
Jessica Farrell
Gabriel Thomas
Joshua Smith

APU NORDIC SKI FACILITY

DESIGNED BY: JESSICA FARRELL	SHEET
CHECKED BY: JOSHUA SMITH	G0.1
TITLE PAGE	
4/15/2016	
NTS	

SWING TIE SCHEDULE

POINT	ELEVATION	DISTANCE TO TBM1	DISTANCE TO TBM2	REMARKS
TBM 1	5500	0	151.77	SET ⅝" REBAR
TBM 2	5492.35	151.77	0	SET ⅝" REBAR
101	5469	186.11	153.18	KEY IN POINT
102	5469	156.48	134.24	KEY IN POINT
103	5469	119.01	118.42	KEY IN POINT
104	5469	117.97	103.72	KEY IN POINT
105	5469	136.66	90.9	KEY IN POINT
106	5469	162.24	89.52	KEY IN POINT
107	5469	181.95	110.5	KEY IN POINT
108	5469	214.92	129.17	KEY IN POINT
109	5469	223.94	148.66	KEY IN POINT
110	5469	204.25	148.47	KEY IN POINT



REVISIONS

REV	DATE	DESCRIPTION	BY

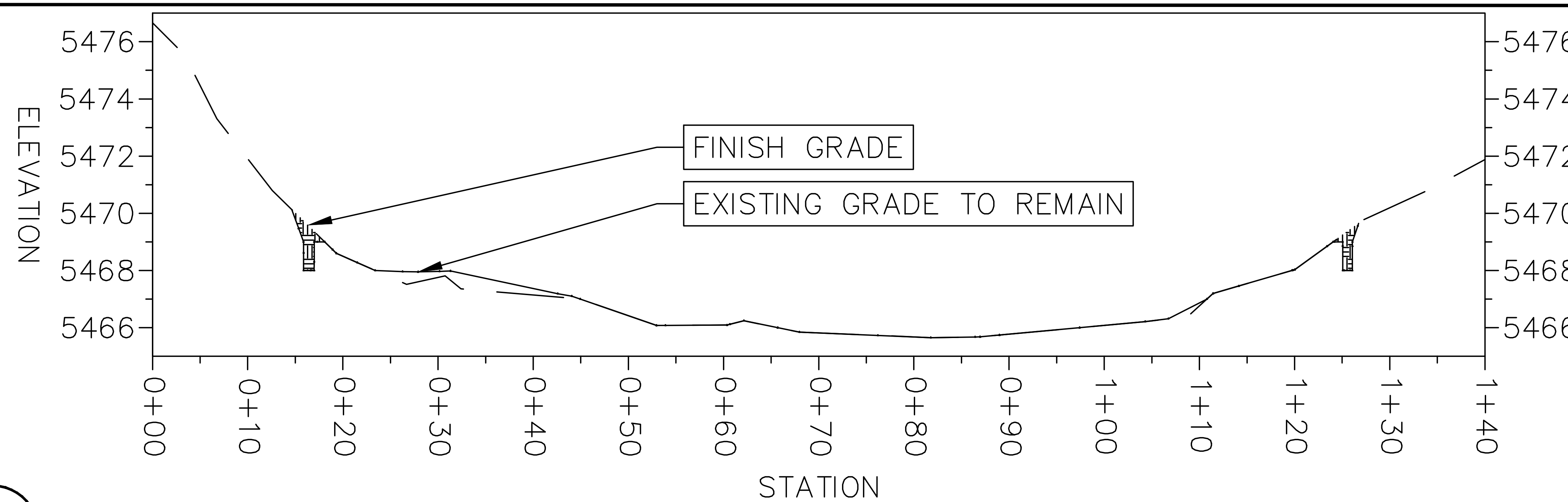
University of Alaska Anchorage

Riley Bronga
Jessica Farrell
Gabriel Thomas
Joshua Smith

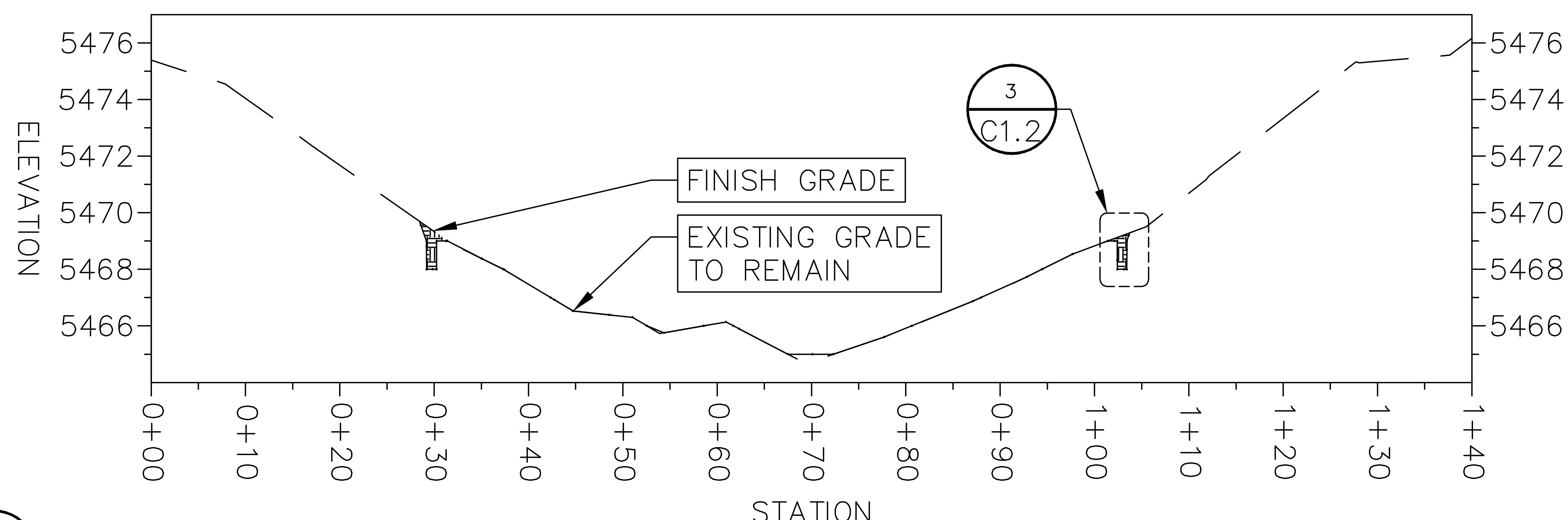
APU NORDIC SKI FACILITY

DESIGNED BY: RILEY BRONGA
CHECKED BY: GABRIEL THOMAS
VICINITY MAP
4/15/2016
SCALE 1:30

SHEET C1.0



1 / C1.1 SECTION VIEW A1 – A2
NTS



2 / C1.1 SECTION VIEW B1 – B2
NTS

REVISIONS

REV	DATE	DESCRIPTION	BY

ALASKA PACIFIC UNIVERSITY

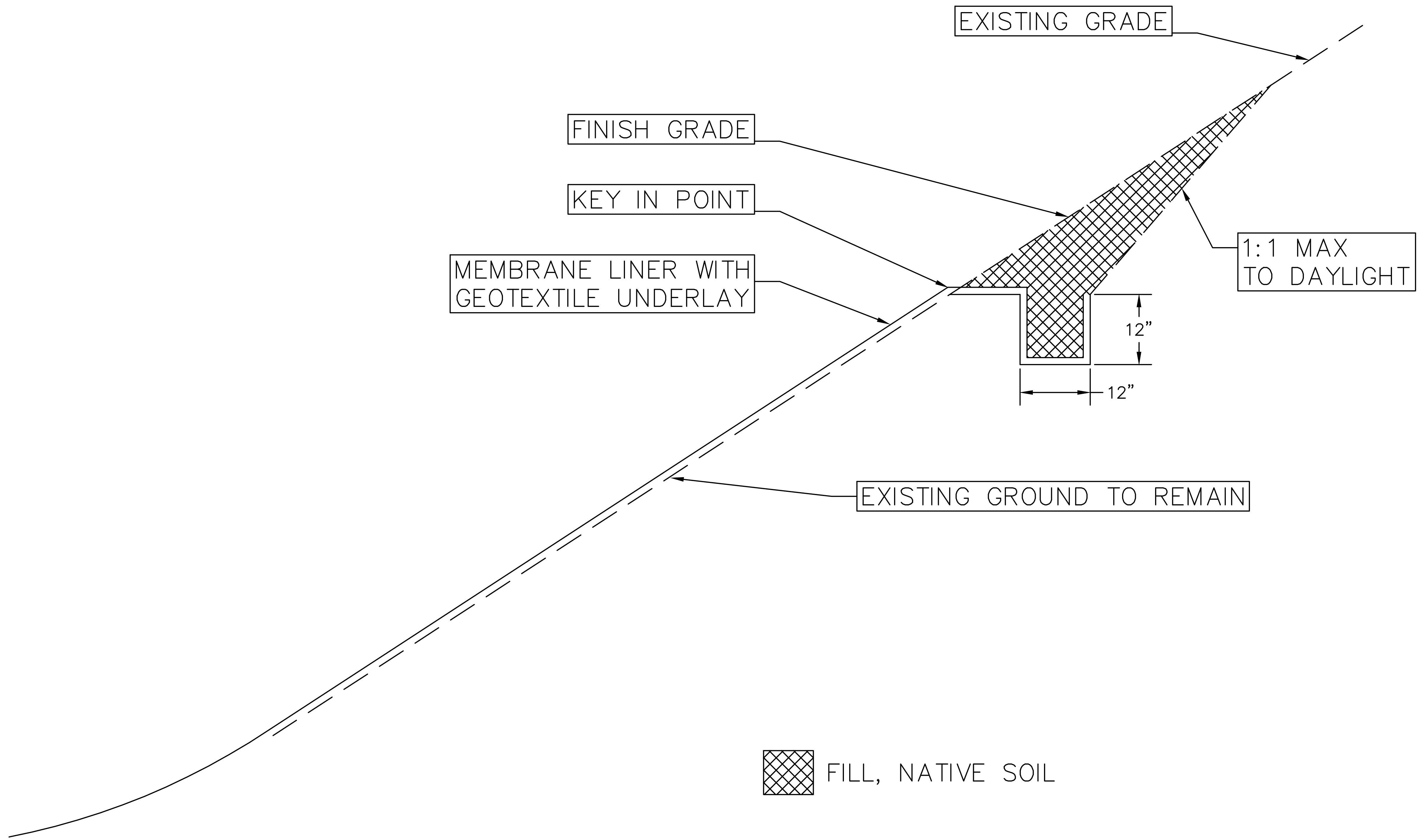
UAA College of Engineering
UNIVERSITY of ALASKA ANCHORAGE

University of Alaska Anchorage

Riley Bronga
Jessica Farrell
Gabriel Thomas
Joshua Smith

APU NORDIC SKI FACILITY

DESIGNED BY: RILEY BRONGA	SHEET
CHECKED BY: GABRIEL THOMAS	C1.1
SECTION VIEW	
4/15/2016	
NTS	



3
C1.2
LINER KEY IN
NTS

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ALASKA PACIFIC UNIVERSITY

UAA College of Engineering
UNIVERSITY of ALASKA ANCHORAGE

University of Alaska
Anchorage

Riley Bronga
Jessica Farrell
Gabriel Thomas
Joshua Smith

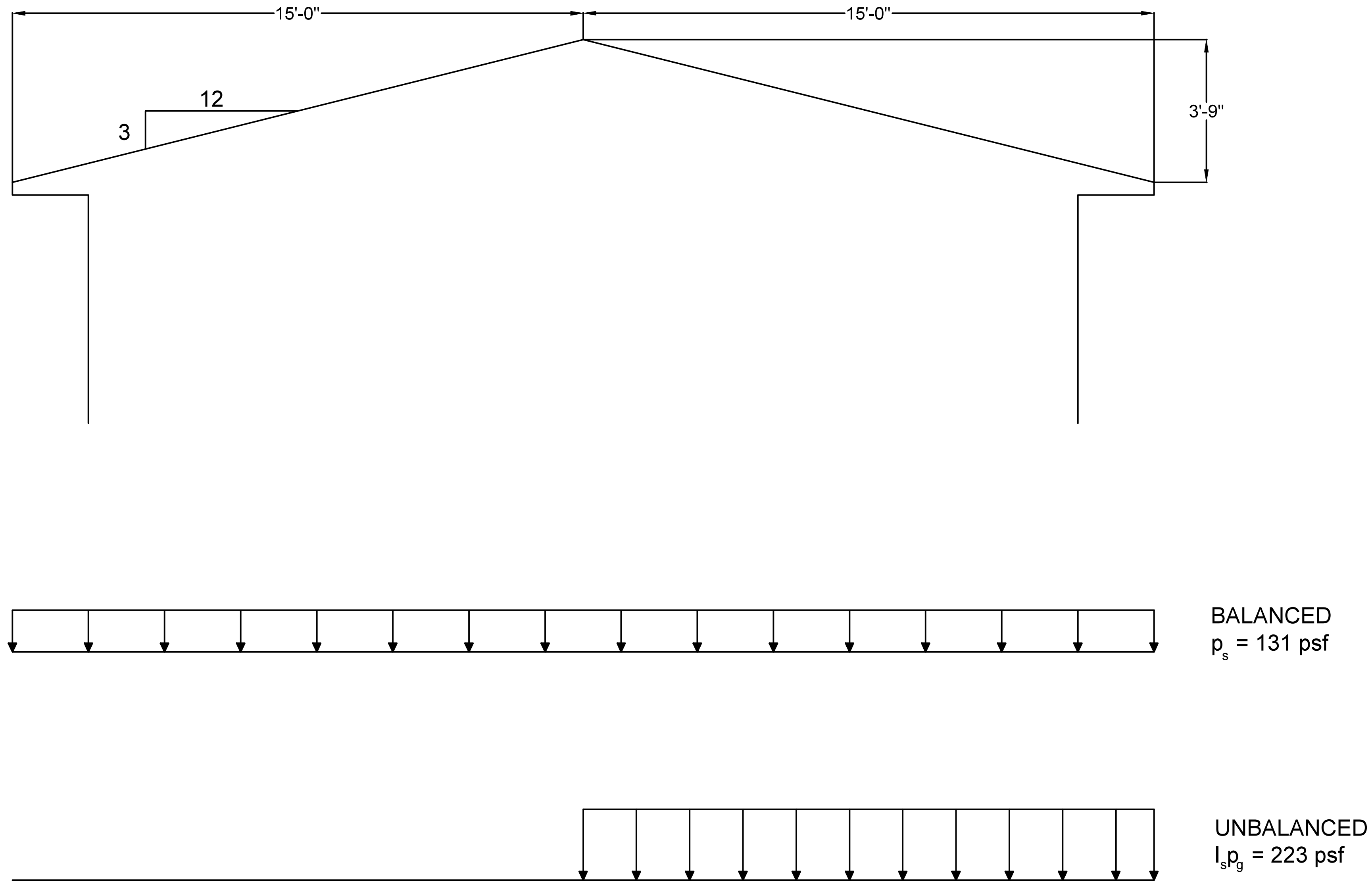
APU NORDIC SKI
FACILITY

DESIGNED BY: RILEY BRONGA
CHECKED BY: GABRIEL THOMAS
KEY IN DETAIL
4/15/2016
NTS

SHEET
C1.2

NOTES:

1. TRUSS TO BE MANUFACTURED BY ALASKA TRUSS OR EQUAL.
2. TRUSS SPACING TO BE 16" O.C.



1 / S1.1 SNOW LOAD – ASCE 7–10

NTS

REVISIONS

REV	DATE	DESCRIPTION	BY

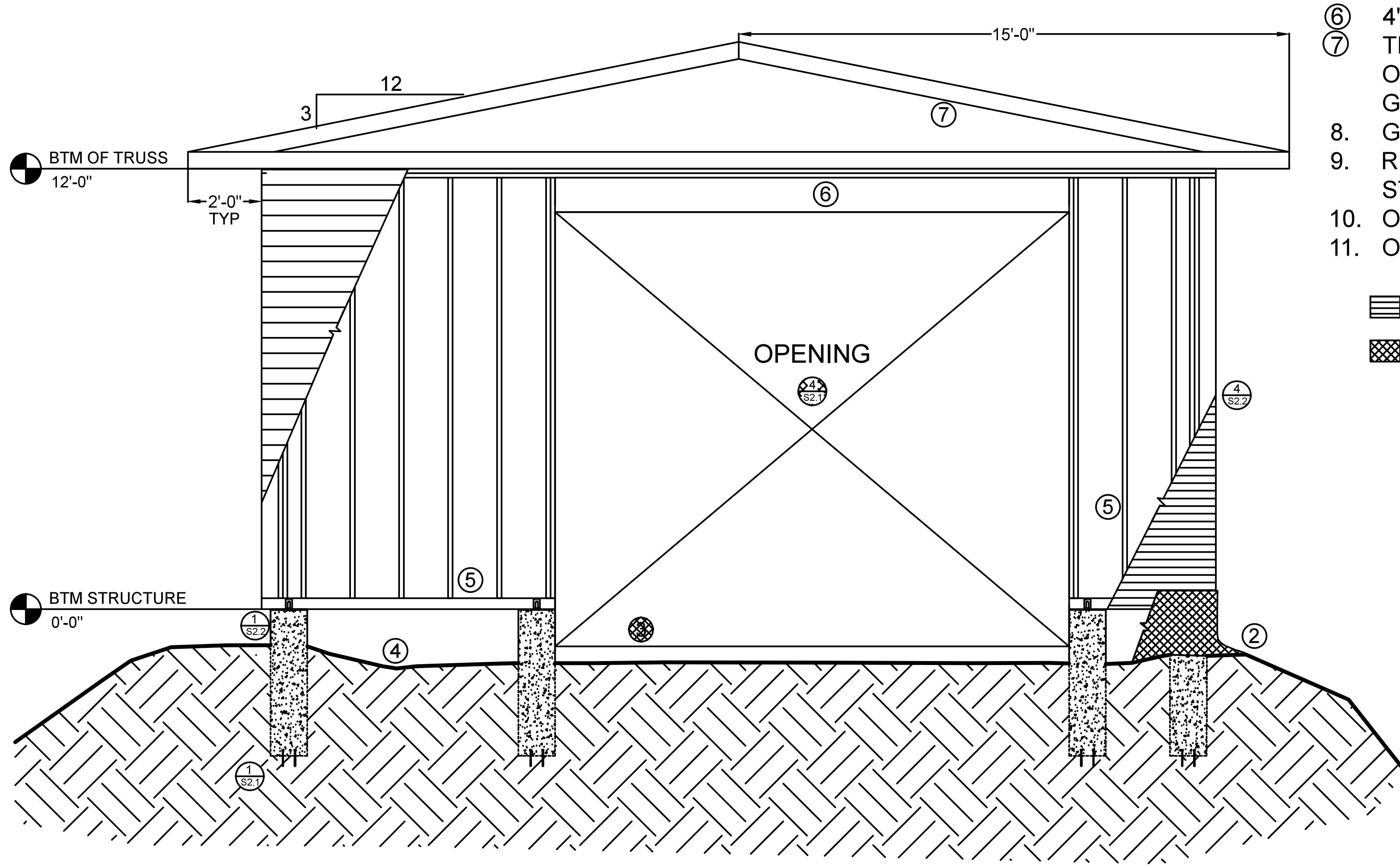
University of Alaska Anchorage

Riley Bronga
Jessica Farrell
Gabriel Thomas
Joshua Smith

APU NORDIC SKI FACILITY

DESIGNED BY: JESSICA FARRELL
CHECKED BY: JOSHUA SMITH
SNOW LOAD
4/15/2016
NTS

SHEET S1.1



1 S1.2 PISTENBULLY 100 GARAGE DESIGN – N-S ELEVATION VIEW, OTHER SIDE SIM
NTS

NOTES:

1. ALL CONSTRUCTION SHALL FOLLOW IBC AND ICC REQUIREMENTS.
2. GROUND ELEVATION VARIES, MAKE STRUCTURE LEVEL ABOVE GROUND.
3. MIN 12" FROM B.O. DOOR TO HIGHEST NATURAL GRADE POINT BENEATH THE DOOR FRAME.
4. CHECK FIELD GRADING, NOT TO SCALE.
5. STUD SPACING IS 16" O.C. TYP, SPECIES: DOUGLAS FIR LARCH - NORTH, GRADE 2.
6. 4" X 12" HEADER ABOVE DOOR FRAME.
7. TRUSS TO BE DESIGNED BY MANUFACTURER, ALASKA TRUSS OR EQUAL. SEE TRUSS DESIGN ON SHEET S2.3. SEE APPENDIX G FOR DETAIL.
8. GARAGE DOOR: 12'-0" x 14'-0", SEE DETAIL 4/S2.1.
9. RUBBER SHEET ROLL TO BE INSTALLED 6" FROM BOTTOM OF STRUCTURE.
10. OPEN AIR STRUCTURE, USE NATURAL GRADE AS FLOORING.
11. OVERALL WIDTH IS 26'.

SHEATHING: 15/32" WOOD STRUCTURAL PANELS

RUBBER SHEET ROLL

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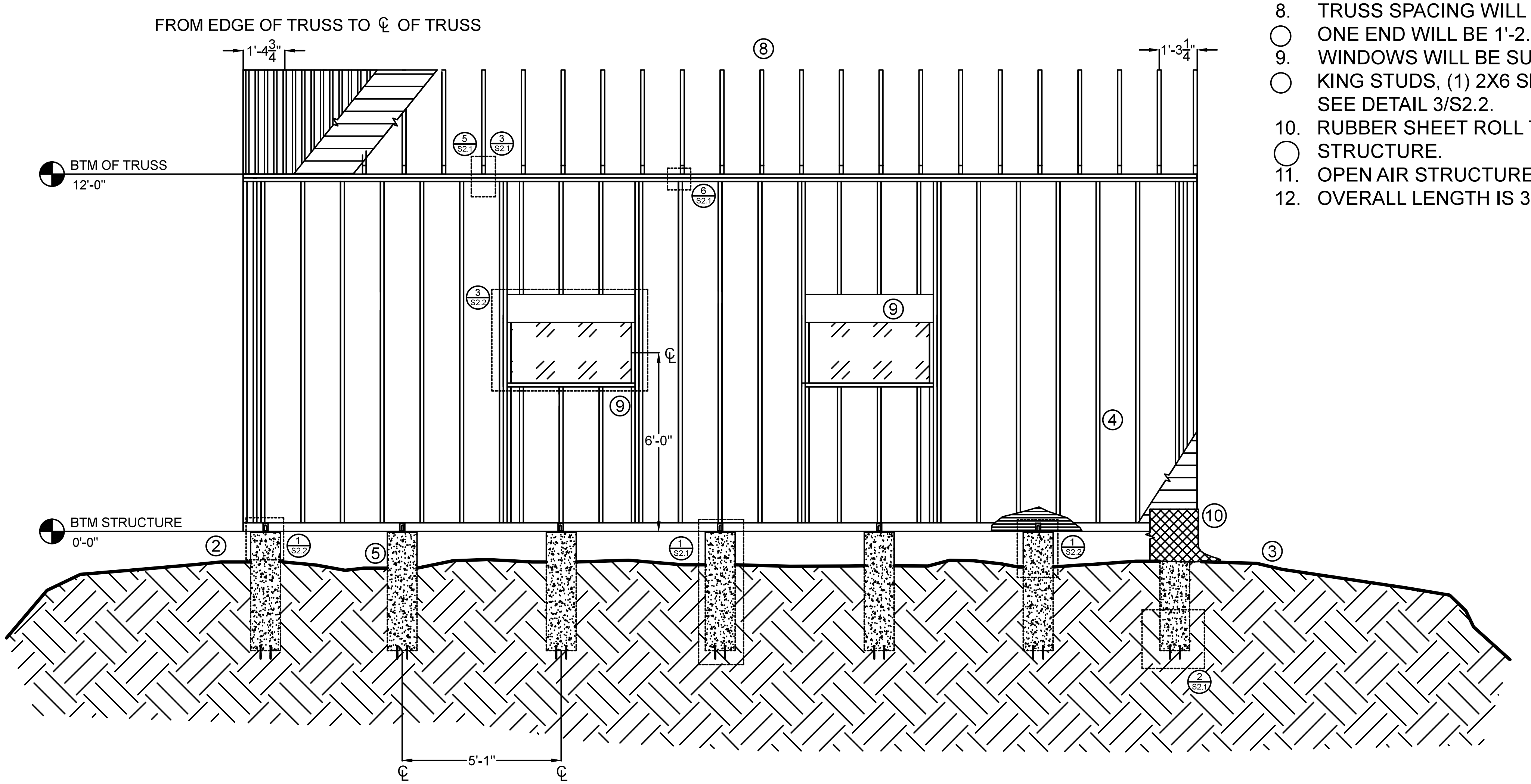
CHECKED BY: JOSHUA SMITH
ELEVATION VIEW N-S
4/15/2016
NTS

SHEET
S1.2

- SHEATHING: 15/32" WOOD STRUCTURAL PANELS
- SUNTUF 26" x 8' SOLAR GRAY CORRUGATED PANEL
- RUBBER SHEET ROLL



1
S1.3
PISTENBULLY 100 GARAGE DESIGN – SIDE ELEVATION VIEW
NTS

NOTES:

1. ALL CONSTRUCTION SHALL FOLLOW IBC AND ICC STANDARDS.
2. HEIGHT VARIES, MAKE LEVEL ABOVE GROUND. PLACE IN GROUND 3' OR UNTIL ROCK IS MET.
3. CHECK FIELD GRADING, NTS.
4. STUD SPACING IS 16" O.C. TYP, SPECIES: DOUGLAS FIR LARCH NORTH, GRADE 2.
5. PILING SPACING AT 5'-1" O.C. TYP FOR LENGTH OF BUILDING. EXTERIOR PILES TO START 9" IN FROM EXTERIOR WALL.
6. WINDOWS ARE EQ DISTANCE FROM EXTERIOR OF BUILDING.
7. WINDOWS TO BE 11'-0" FROM OUTSIDE EDGE OF EXTERIOR WALL TO CENTER OF WINDOW.
8. TRUSS SPACING WILL BE 16" O.C. TYP. TRUSS SPACING ON ONE END WILL BE 1'-2.5". SEE APPENDIX G FOR DETAIL.
9. WINDOWS WILL BE SUPPORTED BY (2) 2X6 JACK STUD, (4) 2X6 KING STUDS, (1) 2X6 SILL, (2) CRIPPLES, AND (1) 4X12 HEADER. SEE DETAIL 3/S2.2.
10. RUBBER SHEET ROLL TO BE INSTALLED 6" FROM BOTTOM OF STRUCTURE.
11. OPEN AIR STRUCTURE, USE NATURAL GRADE AS FLOORING.
12. OVERALL LENGTH IS 32'.

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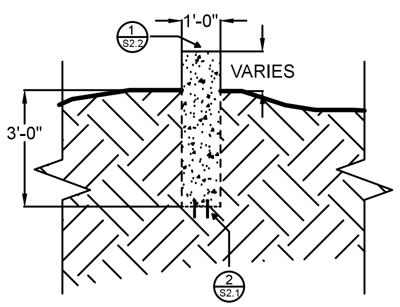
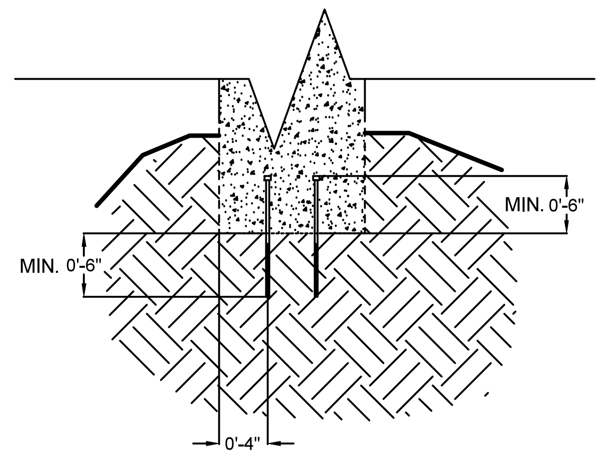
DESIGNED BY: JESSICA FARRELL
CHECKED BY: JOSHUA SMITH
ELEVATION VIEW E-W
4/15/2016
NTS

SHEET
S1.3



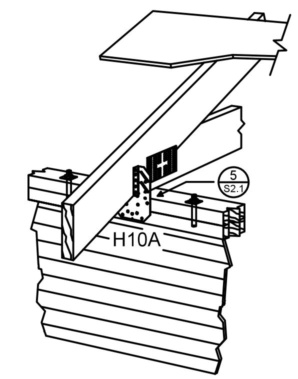
NOTES:
1. 3' DEPTH WHERE POSSIBLE OR WHEN SOLID ROCK IS MET. ANCHOR PILING INTO ROCK PER DETAIL 2/S2.1.

1 / S2.1 — CONCRETE PILING
NTS



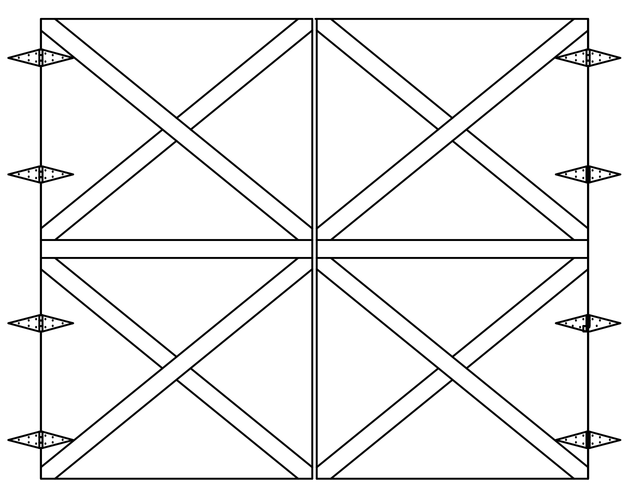
NOTES:
1. USE $\frac{5}{8}$" DIAMETER BOLT DRILLED APPROXIMATELY 6" INTO THE GROUND AND EMBED BOLT MIN 6" INTO CONCRETE.
2. 4" O.C. BOLT SPACING, EQ EDGE DISTANCE.

2 / S2.1 — CONCRETE PILING
NTS



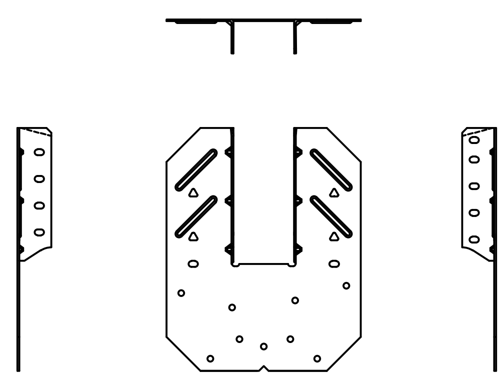
NOTES:
1. H10A CONNECTION INSTALLED AT TRUSS CONNECTION.
2. ¾" BOLT ADDED FOR EXTRA STENGTH AS NEEDED. USE ADEQUATE LBP, MANUFACTURER: SIMPSON STRONG TIE. LBP TO BE LOCATED X INCHES FROM TRUSSES.

3 / S2.1 — CONNECTION – H10A TYP
NTS



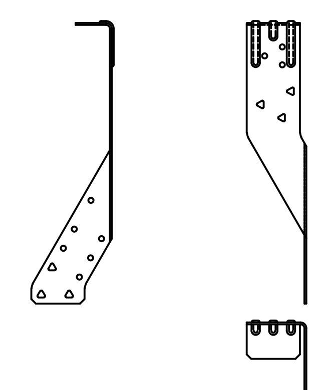
NOTES:
1. BARN STYLE DOOR RECOMMENDED FOR SITE LOCATION.
2. DOOR STRENGTH AND HINGE DESIGN TO BE DETERMINED AT NEXT DESIGN STAGE.

4 / S2.1 — DOOR – TYP
NTS



NOTES:
1. H10A/H10A-2 SEISMIC AND HURRICANE TIES. MANUFACTURER: SIMPSON STRONG TIE OR EQUAL.
2. TYPICAL OF ALL TRUSS-TO-WALL CONNECTIONS.

5 / S2.1 — CONNECTION – H10A TYP
NTS



NOTES:
1. TSP SEISMIC AND HURRICANE TIES. MANUFACTURER: SIMPSON STRONG TIE OR EQUAL.
2. TYPICAL OF ALL STUD CONNECTIONS TO FRAMING.

6 / S2.1 — CONNECTION – TSP TYP
NTS

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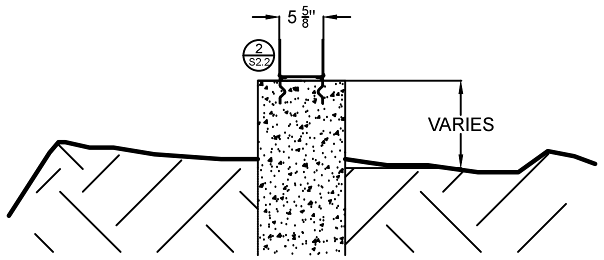
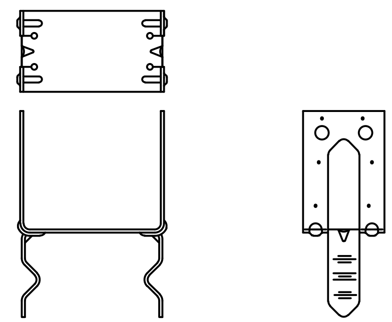
DESIGNED BY: JESSICA FARRELL	SHEET
CHECKED BY: JOSHUA SMITH	S2.1
STRUCTURAL DETAILS	
4/15/2016	
NTS	

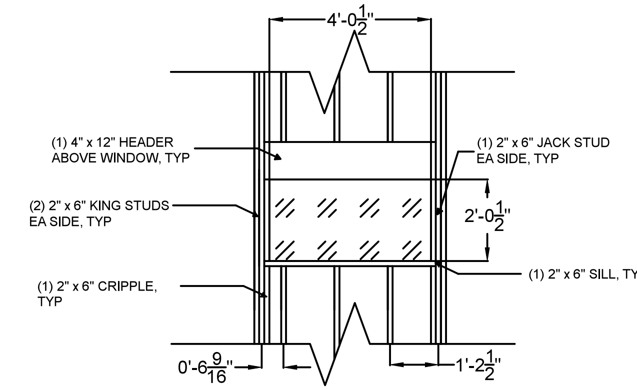


1 CONNECTION DETAIL
S2.2
NTS



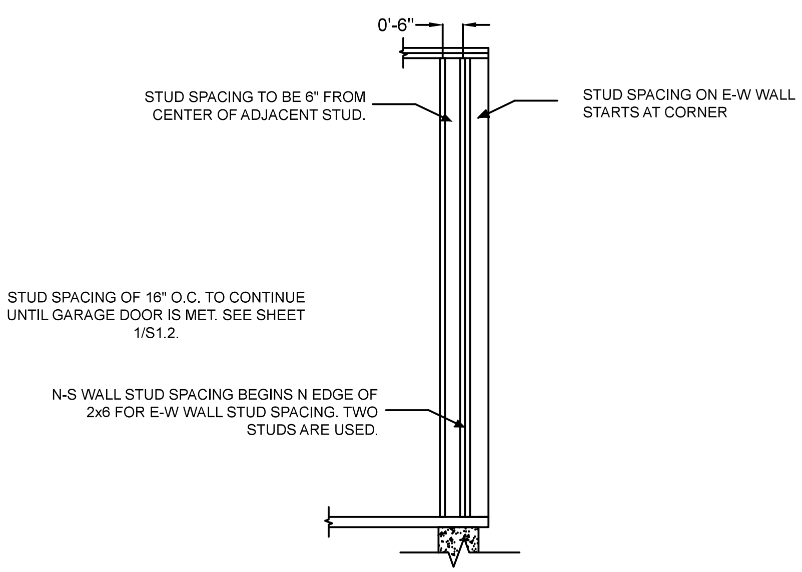
NOTES:
1. PB46 BASE PLATE CONNECTOR. MANUFACTURER: SIMPSON STRONG TIE OR EQUAL.
2. TYPICAL OF ALL PILLAR-TO-WALL CONNECTIONS.

2 BASE PLATE CONNECTION
S2.2
NTS

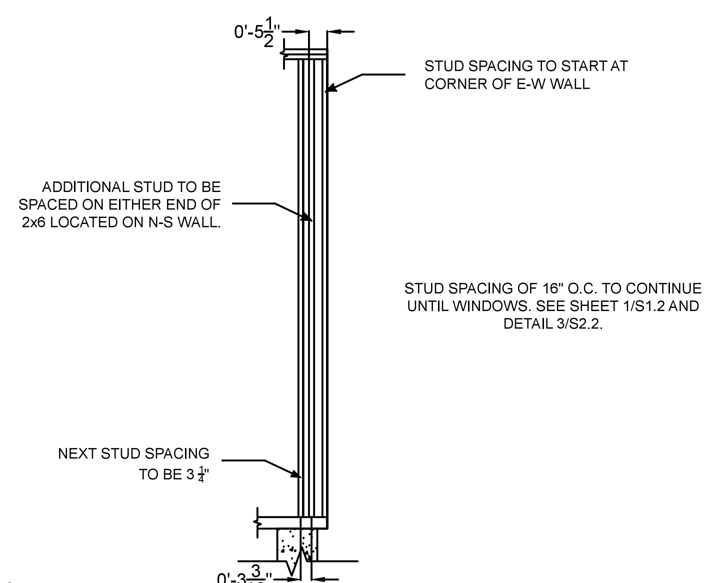


NOTES:
1. SEE SHEET S1.3 FOR WINDOW LOCATIONS.
2. 16" O.C. STUD SPACING UNO. CENTER-TO-CENTER STUD SPACING SHOWN IN DETAIL.

3 WINDOW – TYP
S2.2
NTS



4 CORNER DETAIL N–S – TYP
S2.2
NTS



5 CORNER DETAIL N–S – TYP
S2.2
NTS

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CHECKED BY: JOSHUA SMITH
STRUCTURAL DETAILS
4/15/2016
NTS

SHEET
S2.2

APPENDIX G

SIMPSON Strong-Tie

Component Solutions™
Truss
Version: 2016.1 [Build 38]

ALASKA TRUSS

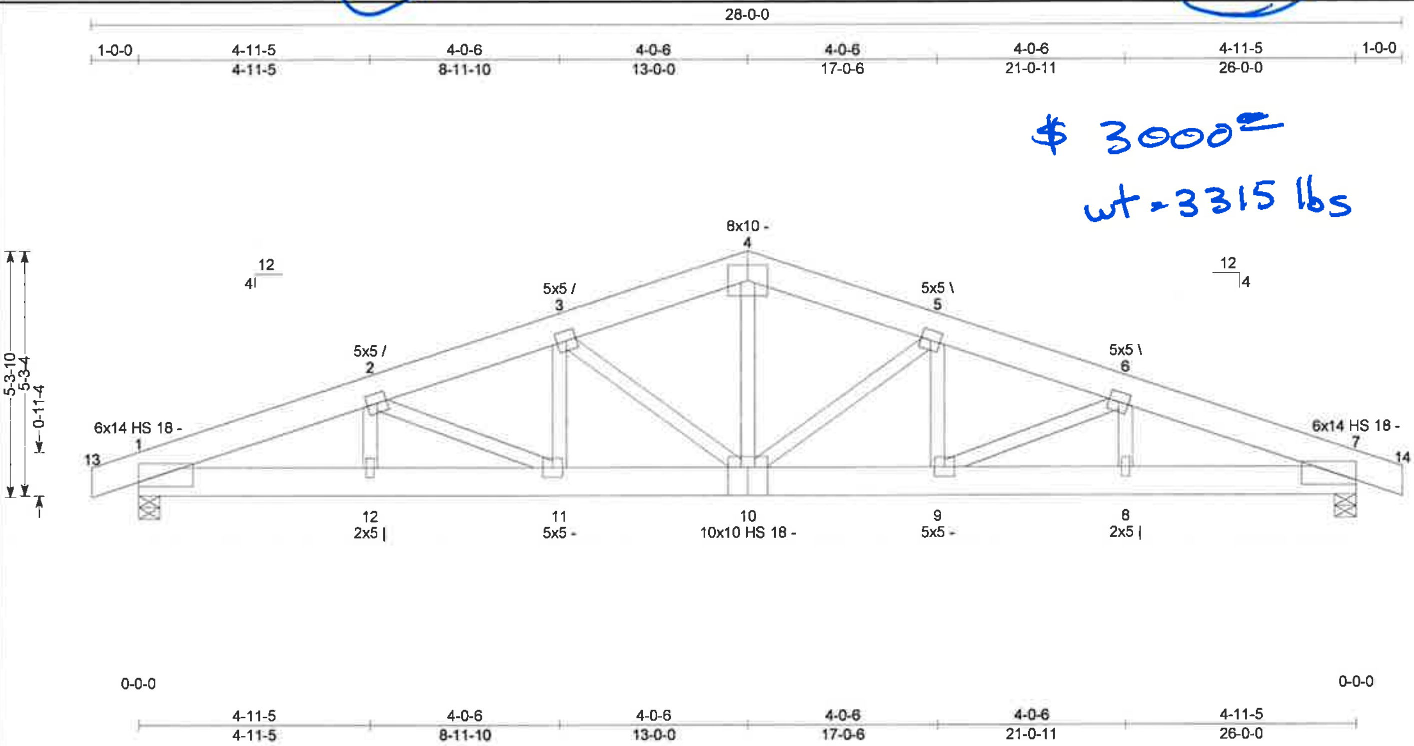
Alaska Truss Manufacturing, LLC

28275 Denaina Elders Road
Chugiak, AK 99567
P: 907-688-8778 F: 907-688-8703

Truss: to1
Project Name: 0175 joshua
Date: 3/28/2016 12:12:02 PM
Page: 1 of 1

Span	Pitch	Qty	OHL	OHR	CANT L	CANT R	PLIES	Spacing	WGT/PLY
26-0-0	4 / 12	17	1-0-0	1-0-0	0-0-0	0-0-0	1	24 in	195 lbs

$ 3000=
wt = 3315 lbs



Loading		General		CSI Summary		Deflection		L/	(loc)	Allowed
Load	(psf)	Bldg Code :	IRC 2009/ TPI 1-2007	TC :	0.71 (6-7)	Vert TL:	0.5 in	L / 604	(9-10)	L / 180
Roof Snow (Ps) :	223 psf			BC :	0.83 (7-8)	Vert LL:	0.04 in	L / 999	(9-10)	L / 240
TCDL :	10(rake)	Rep Mbr Increase :	Yes	Web :	0.87 (3-10)	Horz TL:	0.17 in		7	
BCLL :	0	D.O.L. :	100 %			Creep Factor, Kcr = 1.5				
BCDL :	10									

Plate Offsets (Jnt:X,Y,Ang): (1:7-0,5-13,0.) (2:1-12,7-1,18.) (3:1-12,7-1,18.) (4:0-0,7-10,0.) (5:1-12,7-1,18.) (6:1-12,7-1,18.) (7:7-0,5-13,0.) (8:0-0,7-4,90.) (9:1-12,7-4,0.) (10:0-0,5-0,0.) (11:1-12,7-4,0.) (12:0-0,7-4,90.)

Reaction Summary

JT	Type	Brg Combo	Brg Width	Material	Rqd Brg Width	Max React	Max Grav Uplift	Max Wind Uplift	Max Uplift	Max Horiz
1	Pin (Wall)	1	5.5 in	Douglas-Fir-Larch	7.54 in	7,067 lbs	-	-643 lbs	-643 lbs	6 lbs
7	H Roll (Wall)	1	5.5 in	Douglas-Fir-Larch	7.54 in	7,067 lbs	-	-643 lbs	-643 lbs	0 lbs

The following bearings may require additional considerations:

Brg #	Brg Area	Rqd Brg Area	Rqd Truss Width	Enhancement
1	8.25 in^2	11.31 in^2	2.06 in	Bearing enhancer
7	8.25 in^2	11.31 in^2	2.06 in	Bearing enhancer

Material Summary

TC DFL 2250/1.9 2x8
BC DFL 2250/1.9 2x8
Webs DFL #2 2x4 except:
3-10 DFL 2400/2.0 2x4
5-10 DFL 2400/2.0 2x4

Bracing Summary

TC Bracing: Sheathed or Purlins at 2-9-0, Purlin design by Others.
BC Bracing: Sheathed or Purlins at 8-4-0, Purlin design by Others.

Loads Summary

1) This truss has been designed for the effects due to 10 psf bottom chord live load plus dead loads.
2) This truss has been designed for the effects of a balanced design snow load (Ps = 223 psf) and unbalanced design snow loads (4 /12, 66.9 psf wind, 223 psf lee, 59.1 psf lee over peak to 14 ft) for hips/gables in accordance with ASCE7 - 05 except as noted, with the following user defined input: 223 psf ground snow load (Pg). NOTE: All flat/sloped roof factors have been ignored and the ground snow load has been used for the roof snow load (Ps = Pg), DOL = 1.15.
3) This truss has been designed to account for the effects of ice dams forming at the eaves.
4) This truss has been designed for the effects of wind loads in accordance with ASCE7 - 05 with the following user defined input: 125 mph nominal, Exposure D, Fully Enclosed, Gable/Hip, Building Category II (I = 1.00), Overall Bldg Dims 26 ft x 32 ft, h = 15 ft, End Zone Truss, Both end webs considered. DOL= 1.33 , CC Zone Width 3 ft.
5) In addition to the snow loading specified on this drawing, this truss has also been designed for a roof live load (TCLL) of 20 psf.
6) Minimum storage attic loading in accordance with IRC Table R301.5 has been applied

Member Forces Summary

Table indicates: Member ID, max CSI, max axial force, (max compr. force if different from max axial force)

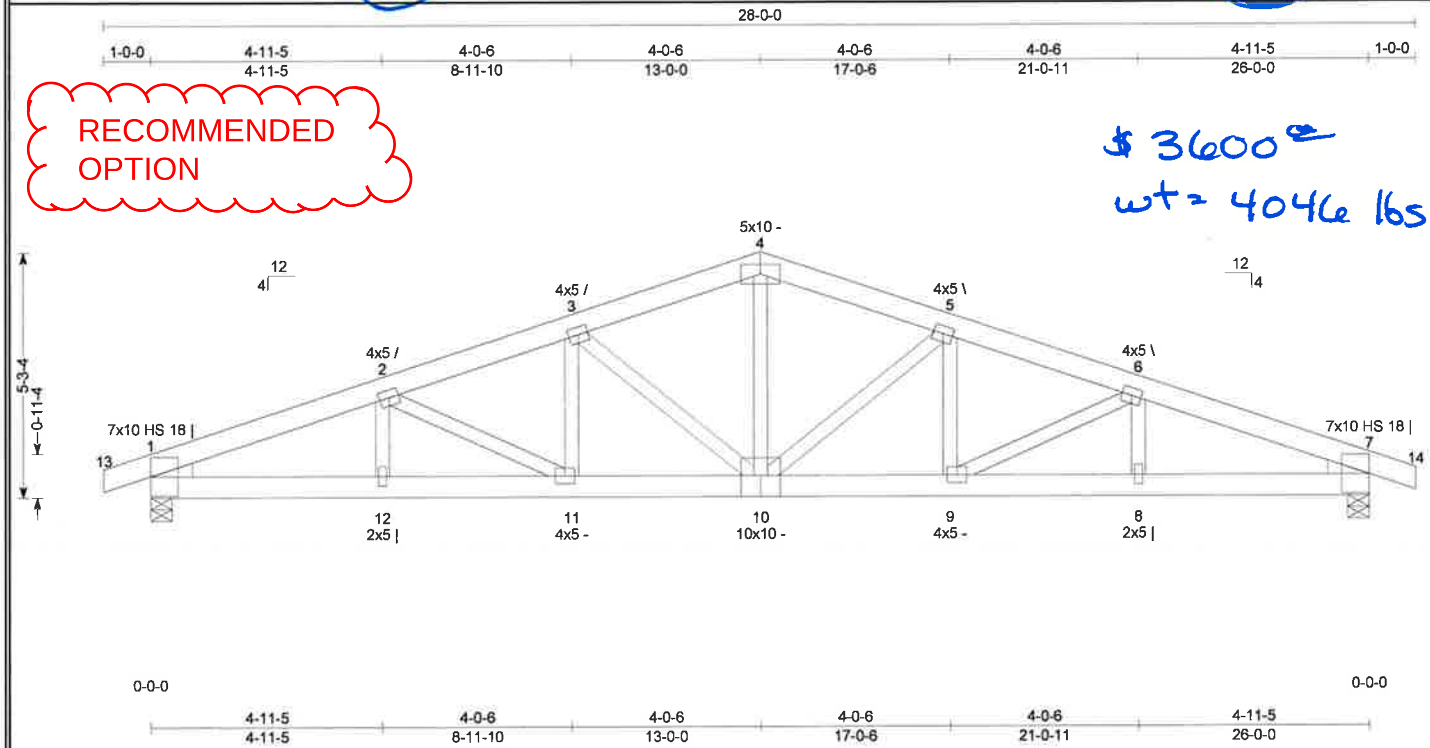
TC	13-1	0.124	185 lbs		2-3	0.490	-12,065 lbs		4-5	0.375	-9,751 lbs		6-7	0.710	-13,154 lbs	
	1-2	0.710	-13,154 lbs		3-4	0.375	-9,751 lbs		5-6	0.490	-12,065 lbs		7-14	0.124	185 lbs	
BC	7-8	0.831	12,042 lbs	(-1,808 lbs)	9-10	0.523	11,214 lbs	(-1,665 lbs)	11-12	0.831	12,042 lbs	(-1,802 lbs)				
	8-9	0.831	12,042 lbs	(-1,808 lbs)	10-11	0.523	11,214 lbs	(-1,659 lbs)	12-1	0.831	12,042 lbs	(-1,802 lbs)				
Webs	2-12	0.071	-625 lbs		3-10	0.871	-3,896 lbs		5-9	0.187	974 lbs	(-70 lbs)				
	2-11	0.490	-1,688 lbs		4-10	0.730	3,803 lbs	(-629 lbs)	6-9	0.490	-1,688 lbs					
	3-11	0.187	974 lbs	(-70 lbs)	5-10	0.871	-3,896 lbs		6-8	0.071	-625 lbs					

Notes:

1) When this truss has been chosen for quality assurance inspection, the Double Polygon Method per TPI 1-2007/Chapter 3 shall be used. Fabrication tolerance = 10 %.
2) Listed wind uplift reactions based on MWFRS Only loading.
3) Bearing material shown in the above table has only been checked for resistance perpendicular to grain, and does not indicate adequacy of material for other design considerations.

SIMPSON Strong-Tie Component Solutions™ Truss Version: 2016.1 [Build 38]	**Alaska Truss Manufacturing, LLC** 28275 Denaina Elders Road Chugiak, AK 99567 P: 907-688-8778 F: 907-688-8703	Truss: to2 Project Name: 0175 joshua Date: 3/28/2016 12:12:03 PM Page: 1 of 1

Span	Pitch	Qty	OHL	OHR	CANT L	CANT R	PLIES	Spacing	WGT/PLY
26-0-0	4 /12	25	1-0-0	1-0-0	0-0-0	0-0-0	1	16 in	162 lbs



Loading

Load	(psf)
Roof Snow (Ps) :	223 psf
TCDL :	10(rake)
BCLL :	0
BCDL :	10

General

Bldg Code :	IRC 2009/ TPI 1-2007
Rep Mbr Increase :	Yes
D.O.L. :	100 %

CSI Summary

TC :	0.92 (1-2)
BC :	0.80 (12-1)
Web :	0.62 (5-10)

Deflection

Deflection		L/	(loc)	Allowed
Vert TL:	0.41 in	L / 733	10	L / 180
Vert LL:	0.03 in	L / 999	10	L / 240
Horz TL:	0.14 in		7	
Creep Factor, Kcr = 1.5				

Plate Offsets (Jnt:X,Y,Ang): (1:3-8,5-12,90.) (2:1-12,5-3,18.) (3:1-12,5-3,18.) (4:0-0,5-13,0.) (5:1-12,5-3,18.) (6:1-12,5-3,18.) (7:3-8,5-12,90.) (8:0-0,5-8,90.) (9:1-12,5-8,0.) (10:0-0,5-0,0.) (11:1-12,5-8,0.) (12:0-0,5-8,90.)

Reaction Summary

JT	Type	Brg Combo	Brg Width	Material	Rqd Brg Width	Max React	Max Grav Uplift	Max Wind Uplift	Max Uplift	Max Horiz
1	Pin (Wall)	1	5.5 in	Douglas-Fir-Larch	5.03 in	4,712 lbs	-	-428 lbs	-428 lbs	-10 lbs
7	H Roll (Wall)	1	5.5 in	Douglas-Fir-Larch	5.03 in	4,712 lbs	-	-428 lbs	-428 lbs	0 lbs

Material Summary

TC	DFL 2400/2.0 2x6			
BC	DFL 2400/2.0 2x6			
Webs	DFL #2 2x4	except:		
3-10	DFL 2400/2.0 2x4		5-10	DFL 2400/2.0 2x4

Bracing Summary

TC Bracing: Sheathed or Purlins at 2-10-0, Purlin design by Others.
BC Bracing: Sheathed or Purlins at 9-6-0, Purlin design by Others.

Loads Summary

1) This truss has been designed for the effects due to 10 psf bottom chord live load plus dead loads.
2) This truss has been designed for the effects of a balanced design snow load (Ps = 223 psf) and unbalanced design snow loads (4 /12, 66.9 psf wind, 223 psf lee, 59.1 psf lee over peak to 14 ft) for hips/gables in accordance with ASCE7 - 05 except as noted, with the following user defined input: 223 psf ground snow load (Pg). NOTE: All flat/sloped roof factors have been ignored and the ground snow load has been used for the roof snow load (Ps = Pg), DOL = 1.15.
3) This truss has been designed to account for the effects of ice dams forming at the eaves.
4) This truss has been designed for the effects of wind loads in accordance with ASCE7 - 05 with the following user defined input: 125 mph nominal, Exposure D, Fully Enclosed, Gable/Hip, Building Category II (I = 1.00), Overall Bldg Dims 26 ft x 32 ft, h = 15 ft, End Zone Truss, Both end webs considered. DOL= 1.33 , CC Zone Width 3 ft.
5) In addition to the snow loading specified on this drawing, this truss has also been designed for a roof live load (TCLL) of 20 psf.
6) Minimum storage attic loading in accordance with IRC Table R301.5 has been applied

Member Forces Summary

Table indicates: Member ID, max CSI, max axial force, (max compr. force if different from max axial force)

TC	13-1	0.132	123 lbs		2-3	0.407	-7,786 lbs		4-5	0.310	-6,288 lbs		6-7	0.917	-8,270 lbs	
	1-2	0.917	-8,270 lbs		3-4	0.310	-6,288 lbs		5-6	0.407	-7,786 lbs		7-14	0.132	123 lbs	
BC	7-8	0.799	7,528 lbs	(-1,118 lbs)	9-10	0.374	7,239 lbs	(-1,066 lbs)	11-12	0.697	7,528 lbs	(-1,116 lbs)				
	8-9	0.697	7,528 lbs	(-1,118 lbs)	10-11	0.374	7,239 lbs	(-1,056 lbs)	12-1	0.799	7,528 lbs	(-1,116 lbs)				
Webs	2-12	0.061	-516 lbs		3-10	0.621	-2,599 lbs		5-9	0.116	603 lbs	(-39 lbs)				
	2-11	0.261	-854 lbs		4-10	0.487	2,535 lbs	(-422 lbs)	6-9	0.261	-854 lbs					
	3-11	0.116	603 lbs	(-39 lbs)	5-10	0.621	-2,599 lbs		6-8	0.061	-516 lbs					

Notes:

1) When this truss has been chosen for quality assurance inspection, the Double Polygon Method per TPI 1-2007/Chapter 3 shall be used. Fabrication tolerance = 10 %.
2) Listed wind uplift reactions based on MWFRS Only loading
3) Bearing material shown in the above table has only been checked for resistance perpendicular to grain, and does not indicate adequacy of material for other design considerations.