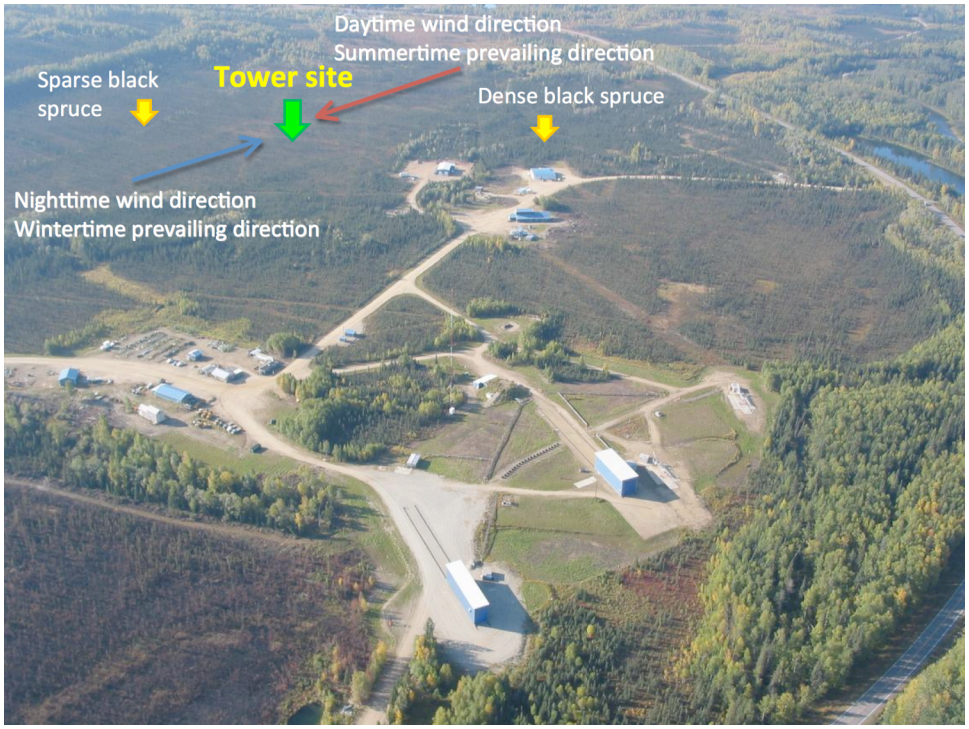
A WORKPLAN FOR THE POKER FLAT IARC SUPER-SITE TOWER INSTALLATION



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International Arctic Research Center
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University of Alaska Fairbanks

A WORKPLAN FOR THE POKER FLAT IARC SUPER-SITE TOWER INSTALLATION

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Introduction

In 2009, the International Arctic Research Center (IARC) and JAMSTEC agreed to build a super-site tower or research plot with a focus on interdisciplinary research looking at land surface hydrology, gas and vapor fluxes, and refinements of these processes in large scale global climate models (GCMs). After evaluating several potential site locations, the floodplain out at Poker Flat Research Range (PFRR) was selected as shown in Figure 1. In January 2010 a memorandum of understanding was reached between IARC and PFRR allowing work on the site to commence. This document is focused on procedures and activity goals for the project from ground breaking of the trail to instrumentation of the plot / site. Figure 2 shows the site prior to tower construction. Figure 3 is a top view of the super-site showing the tower in relation to the other infrastructure. Not shown in Figure 3 is the short radiation and snow tower, which is located further to the east from the main tower.

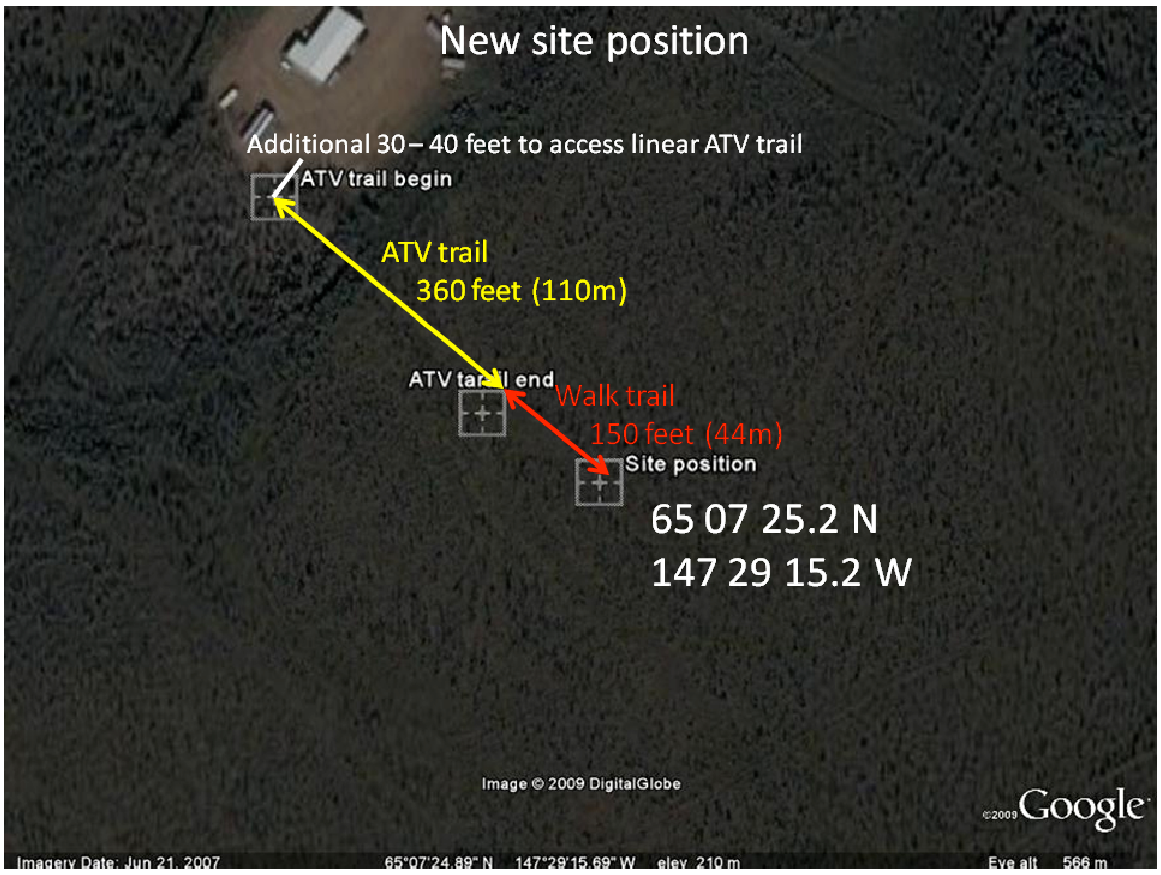


Figure 1 Location of super-site at PFRR.

Figure 2 Spruce forest at the super-site location (Fall 2009).

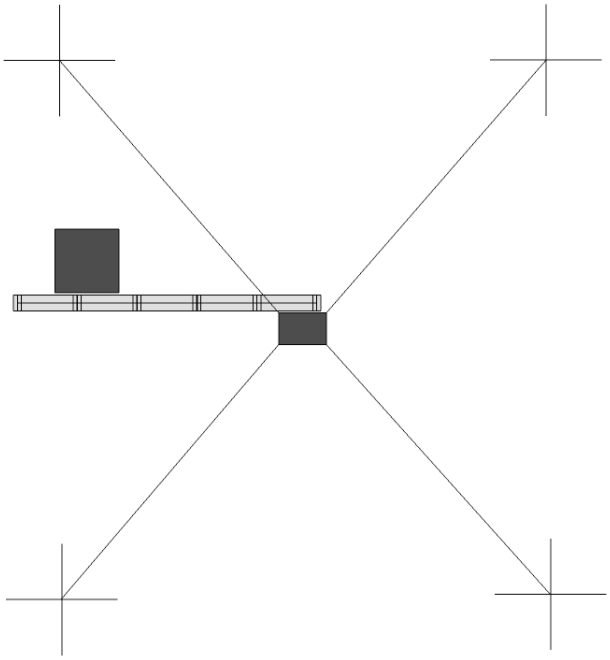


Figure 3 Top view of super-site. The tower and shed are in dark gray, the boardwalk is shown in light gray and the four tees are the guy wire anchors system.

ATV Trail and Boardwalk

To access the site, situated in an open spruce forest, we require a combination ATV trail and boardwalk. The carbon and vapor flux research is sensitive to small changes in the natural conditions. Thus, the construction of a combination ATV trail boardwalk to minimize disturbance is required. The last 150 feet to the station site will be made of boardwalk to the tower. The ATV trail will be used to transport larger instrumentation closer to the station and then it will be transported by wheelbarrow from the start of the boardwalk. The boardwalk is designed to be wide enough to facilitate easy wheelbarrow usage. Instrumentation at the site is sensitive to spurious environmental damage. Therefore, the ATV trail will be limited to approximately the first 360 feet (Figure 1), beginning behind the Warm Storage building.

ATV Trail Overview

The ATV trail should look similar to the path built for the Caribou-Poker Creeks Research Watershed (CPCRW) in the late 1990s as shown in Figure 4. The trail is predominately pressure treated 4”x4” lumber trail. 2”x4” wood spacers separate the 4”x4”s. A steel wire rope is used to tie the 4”x4”s and maintain the continuity of the trail over time as it sinks into the soil (Figure 4).

Figure 4 ATV trail at CPCRW. The PFRR ATV trail is modeled after this one.

The ATV trail will run from behind the warm storage building towards the site, a distance of about 360 feet. The site is located at coordinates N65 7' 25.2", W147 29' 15.2" and is shown in Figure 1. At the end of the ATV trail there will be a 10 foot square-shaped turn around. The turn around will be built the same as the main trail however it will consist of a 10-foot trail section alongside a regular 30-foot section. Prior to construction, Taro Nakai will mark the precise location of the end of the ATV trail / start of the walking boardwalk. A hydro-axe should be

used to remove vegetation on the path of the ATV trail to allow it to sit more level on the ground surface.

See Table 1 for a list of materials for the ATV trail. The 360 foot ATV trail should be broken into roughly 30 foot long sections to make construction of the trail manageable.

Table 1 Materials List for ATV trail construction. Estimated required quantities are listed here. Supplies purchased will be at least 10% more quantity than listed.

Quantity	Item
864	5-foot 4" x 4" Pressure Treated Lumber
1728	4-inch 2" x 4" Pressure Treaded Lumber
24	31-foot sections of 3/8" Steel Wire Rope
2	11-foot sections of 3/8" Steel Wire Rope
52	3/8" Wire Rope Cable Clamps
52	1/2" Steel Washers

ATV Trail Procedure

Part I Materials

1) Create a jig to increase efficiency of drilling holes in the 2”x4” and the 4”x4”s. For the 2”x4”s, the hole should be in the center of the 4 inch long piece of wood. For the 4”x4”s the hole should be located 6" in from each edge of the lumber. See the appendix for drawings of the lumber and hole locations.

2) Drill the 3/4" holes in either end of the 4”x4” lumber.

3) Either cut the 2x4s to the final 4" long size and then drill the 3/4" holes in the center of the cut lumber or else drill all of the 3/4" holes in the 2x4 before cutting into 4" pieces, which ever is deemed safer in the judgment of the operators.

4) Once the lumber is cut, cut the cable to size. Each cable should be 31 feet long (30 feet for the trail plus 6 inches on either end for the cable clamps to attach to).

Part II Building the ATV trail

1) Slip one end of the wire rope through a 1/2" washer.

2) Make a small 'U' (like a candy cane shape) with the wire rope.

3) Attach a cable clamp to the wire rope so that both parts of the 'U' go through the clamp. Then tighten the clamp. See Figure 5 for what this should like in the final configuration.

4) Repeat steps 1 to 3 of this section for the second steel cable.

Figure 5 As-built image of one side of the cable clamped ATV boardwalk at CPCRW.

5) Select a 4"x4" piece of lumber. String one of the steel cables through one of the holes in the lumber. String the second steel cable through the other hole in the lumber.

6) Select a 2"x4" piece of lumber. String one of the steel cables through the hole in the wood.

7) Select another 2"x4" piece of lumber. String the second steel cable through the hole in the wood.

8) Repeat steps 5 to 7 to until the trail extends to nearly the entire length of the steel cables. The last piece of lumber placed on the cables should be a 4"x4" rather than the 2"x4".

9) Pull the steel cable taut and repeat steps 1 to 3 of this section on the loose end of the steel cable.

10) Repeat steps 1 to 9 of this section for each additional segment of ATV trail until the location selected by Taro Nakai for the ATV turn around is reached.

11) For the ATV turn around, use the same procedure for steps for Part II but use two 11-foot sections of steel cable rather than 31-foot sections. Lay this final section along the side of the last 31-foot section of ATV trail to create a roughly 10 foot by 10 foot square at the termination of the ATV trail.

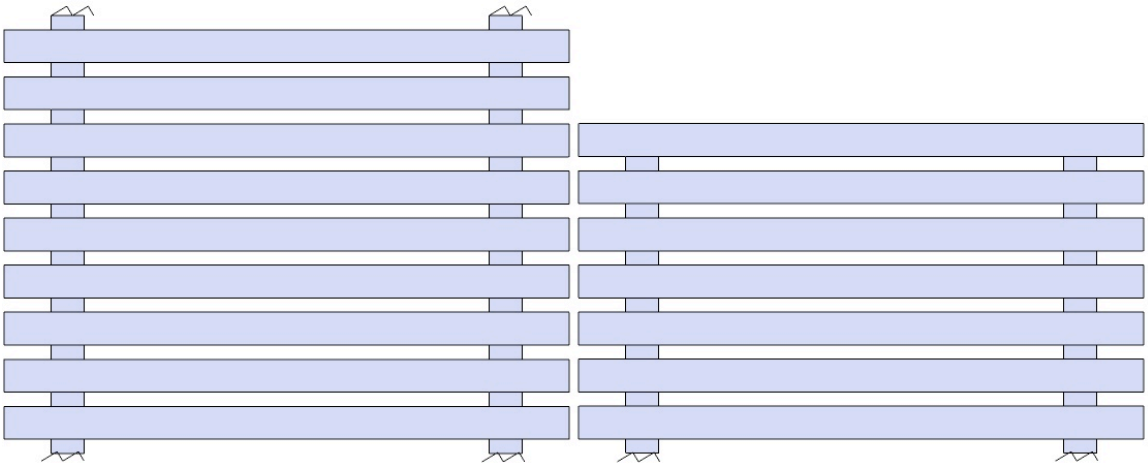


Figure 6 ATV turn around top view. Steel wire and the ten-foot length of the turn around omitted for clarity

Boardwalk Procedure

The walking trail will start at the end of the ATV trail and finish near the base of the tower. Prior to the start of construction Taro Nakai will mark these two points with surveyors tape. The walking trail is to be roughly 23 inches wide and 150 feet long with each trail segment roughly 8 feet long. However, extra materials have been purchased to allow some flexibility in both the path of the walking trail as well as for additional boardwalks between infrastructures at the site (e.g. large tower, instrumentation shed, small tower). The intention is for the initial boardwalk to get within 30 feet of the site. Once the site is instrumented the boardwalk to the tower will be finished.

See Table 2 for a list of materials for the boardwalk. The boardwalk top plank lumber should be broken up into roughly 8 or 16-foot long sections depending on the installer's preference. However, the lower base consisting of a 6"x6" and 2"x12" should be placed every 8 feet.

Table 2 Materials List for Boardwalk construction. Estimated required quantities are listed here. Supplies purchased are at least 10% more than what is listed.

Quantity	Item
38	8-foot long 2"x12" Pressure Treated Lumber
20	2-foot long 2"x12" Pressure Treated Lumber
20	2-foot long 6"x6" Pressure Treated Lumber
1	1 box of 3-inch long wood screws (safe for insertion into corrosive pressure treated lumber)

Part I Materials

1) Cut the 6"x6" lumber into 24 inch long pieces.

2) Cut the 2"x12"x12 foot long into 24 inch long pieces.

3) At the installers discretion, the 2"x12"x16 foot long pieces can be left at 16 feet long or cut into 8 foot pieces, which ever is easiest for project completion. If the preference is to leave them at 16 feet long, some boards may need to be cut to 8 foot sections if there are any corners in the trail.

Part II Building the Boardwalk

1) The main component to be built is the boardwalk base. It consists of two 24-inch pieces of lumber. A 6"x6" piece is secured to a 2”x12” piece using a pair of wood screws as shown in Figure 7.

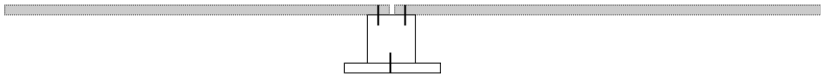
Side View Top View

Figure 7 Boardwalk base

2) Repeat step 1 for all of the 24-inch long lumber.

3) Now the boardwalk is ready to be built. Following the line Taro Nakai has marked with surveyor's tape, the boardwalk should approach the tower site. As the tower has not yet been put into place, the boardwalk construction will end approximately 30 feet from the site. As for the boardwalk, every eight feet the base described in step 1 should be placed on the ground as illustrated in Figure 8. Two parallel 2"x12" pieces of lumber should be placed roughly in parallel on top of the base as shown in Figure 8. For the first and last segments all 5-1/2 inches of the base should be covered but for the middle segments, the edge of the boardwalk lumber should cover only half of the base (2-3/4") as shown in Figure 8.

Side View of the first boardwalk segment



Side View of a middle boardwalk segment

Figure 8 Side views of several boardwalk segments.

Figure 9 Top view of one middle segment of boardwalk

Instrumentation Shed

Overview

The instrumentation shed should be located within 20 feet (6.5m) of the raised tower location, preferably to the west. Taro Nakai will identify the exact location. Siting the shed at some cardinal direction relative to the tower is important because the twelve guy wires for the tower will be secured to the northeast, southeast, southwest, and northwest as shown in Figure 3.

Construction

See the construction guide from Spenard Builder Supply for shed assembly. In addition, several cinder blocks have been purchased to raise the shed off the ground. The cinder blocks serve both to raise the shed and also to make leveling the structure in future years easier after thaw settlement commences.

Electricity

Once the tower and shed are installed, the instrumentation will require a constant power source that can be provided from a grid-connected electrical installation rather than a battery powered remote energy source. Current power estimates are shown in Table 3. Total power draw for the site at peak load is estimated to be 4300 Watts. After accounting for sensors not included on this list and future site expansion the estimated current load is 6500 Watts.

At the site, electrical receptacles will be installed providing power to the instrumentation. Eight to ten power receptacles will be installed inside the shed,

four will be mounted outside to the wall of the shed and another four will be available on the tower. In addition, a light will illuminate the interior of the shed. All electrical work will meet National Electrical Code standards and be performed by a certified electrician.

Table 3 Instrumentation Power Estimate

Instrument	Total Energy (Watts)
Ultrasonic anemometer	1
Infrared gas analyzer	24
Net radiometer (Ventilation)	10
Net radiometer (Heater)	20
Temperature/Humidity probe	0
Cup anemometer	1
Wind vane (power supply)	0
Wind vane (heater)	4
Water Content Reflectometer	5
Present Weather (PWD-100)	65
Soil heat flux plate HFP01SC	3
Sap flow data logger (Probe12)	54
Sap flow probe (TDP-30)	2
Ventilation of temp/humid sensor	53
Computer	100
Monitor	100
Misc. Wall Adapters	150

Known to be added later (PI)	Total Energy (Watts)
Space Heater	2500
Picarro G1301 Gas Analyzer (Y Kim)	600
Geonor Precip Gage (K Sugiura)	15
NK Systems Fiberoptics (K Saito)	15
Total Precipitation Sensor (J Cherry)	600

16 meter Tower

Overview

The principal motivation for all of the other project components is to facilitate construction and then to maintain the ongoing operations of the super-site large tower. Upright Tower of Europe manufactures the tower chosen for installation. The tower is a 16m freestanding model and is to be located precisely at Taro Nakai's surveyed mark. More generally the location is southeast of the warm storage building at PFRR at N65 7' 25.2" W147 29' 15.2", which has the desired slope, aspect, and vegetation composition for the observational site. The rough location of the tower site can also be seen in the cover photo. The tower should be located about 20 feet south of the previously mentioned shed. Tower construction consists of three main components, each of which has its own section in text below. The tower base will be similar to the wood timber base outlined in the included Upright manual. The third tower component is the guy wire anchoring system. The guy wire anchor system is designed to evenly distribute the load of the tower under wind forcing while having small footprint on the ground to minimize vegetative degradation.

Tower Base Installation Overview

The tower base will be similar to the timber foundation shown in the Upright manual (shown on the first page of the second pdf document received from the company). Gravel is reported to be in the subsurface two to three feet below an overlying organic layer. Six pieces of pressure treated timber will be leveled and placed directly on the ground surface. To keep them from moving after installation they will be anchored to the ground surface with 36 inch screed stakes.

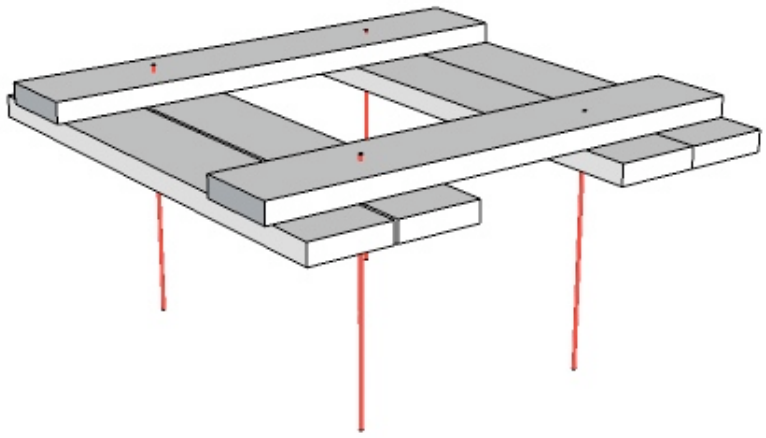


Figure 10 Tower Base

Tower Base Installation Procedure

1) Lay the four lower timbers on the ground surface.

2) Drill two 1-inch diameter holes in each at either end of the timbers.

3) The ground surface may be uneven with moss and vegetation, scrape off this top layer or use a mattock to remove organic material.

4) Pound eight screed stakes into the ground through these holes. Please note only four of the eight screed stakes are shown in Figure 10.

5) Place the two last timbers across these four lower pieces of lumber as shown in Figure 10.

6) Once the tower base top lumber is in position, secure them by nailing them to the lower pieces of wood.

Tower Anchor Installation

Typically, the Upright tower guy wire anchor is a screw type or is cemented into the ground. Due to the frozen conditions at the site and the potential for environmental degradation, which can negatively impact the measurements being made at the super-site, neither of these solutions was deemed practical for the tower. Instead, the load from the guy wire will be spread across the ground using a combination of steel pipe (and corresponding fittings) and screed stakes as illustrated in Figure 11 and Figure 12.

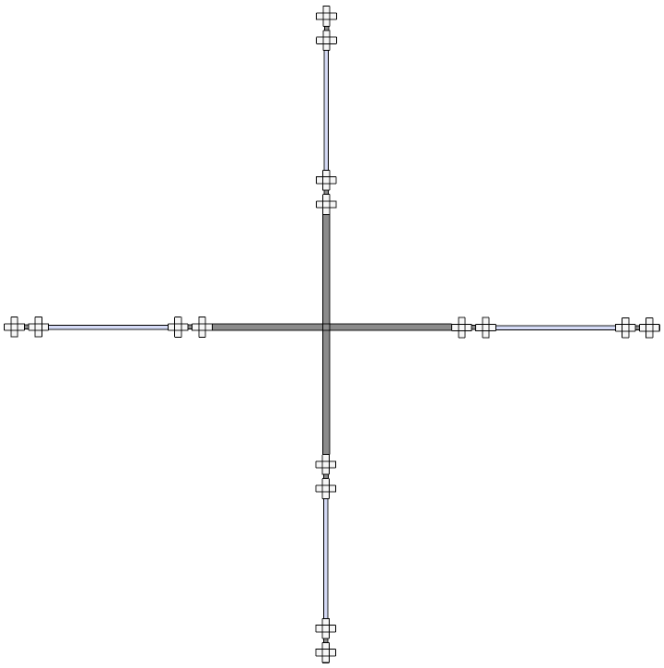


Figure 11 Top view of guy wire anchor (screed stakes and guy wire not shown).

The effect of using a tower anchor in this manner is similar to velcro-ing the anchor to the ground. A list of materials for one anchor is listed in Table 4.

Table 4 Materials list for one guy wire anchor.

Quantity	Item
16	Galvanized Cross, 1” ID Pipe
4	Bell Reducer, 2” to 1”
12	Nipple, 1” ID Pipe x 2” long
4	Galvanized Pipe, 1” ID Pipe x 36” long
2	Galvanized Pipe, 2” ID Pipe x 72” long
16	36” Screed Stake

Tower Anchor Installation Procedure

1) Connect pipe and fittings for each 1/2 of an anchor. The connections should be put together in the following order:
a) 1" Cross pipe fitting

b) 1" x 2" long nipple
c) 1" Cross pipe fitting. This fitting should be twisted to 90 degrees clockwise relative to the first.
d) 1" x 36" long pipe.
e) 1" Cross pipe fitting. This fitting should be oriented the same as the first pipe fitting.
f) 1" x 2" long nipple.
g) 1" Cross pipe fitting. This fitting should be twisted to 90 degree clockwise relative to the previous cross.
h) 1" x 2" long nipple.
i) 1" to 2" bell reducer.
j) 2" x 72" long pipe.
k) 1" to 2" bell reducer.
l) 1" x 2" long nipple.
m) 1" Cross pipe fitting. This fitting should be oriented the same as the first pipe fitting.
n) 1" x 2" long nipple
o) 1" Cross pipe fitting. This fitting should be twisted to 90 degrees clockwise relative to the first.
p) 1" x 36" long pipe.
q) 1" Cross pipe fitting. This fitting should be oriented the same as the first pipe fitting.
r) 1" x 2" long nipple.
s) 1" Cross pipe fitting. This fitting should be twisted to 90 degree clockwise relative to the previous cross.
Use pipe wrenches to tighten and remember that each cross should be rotated 90 degrees relative to the one on either side of it as shown in Figure 12.

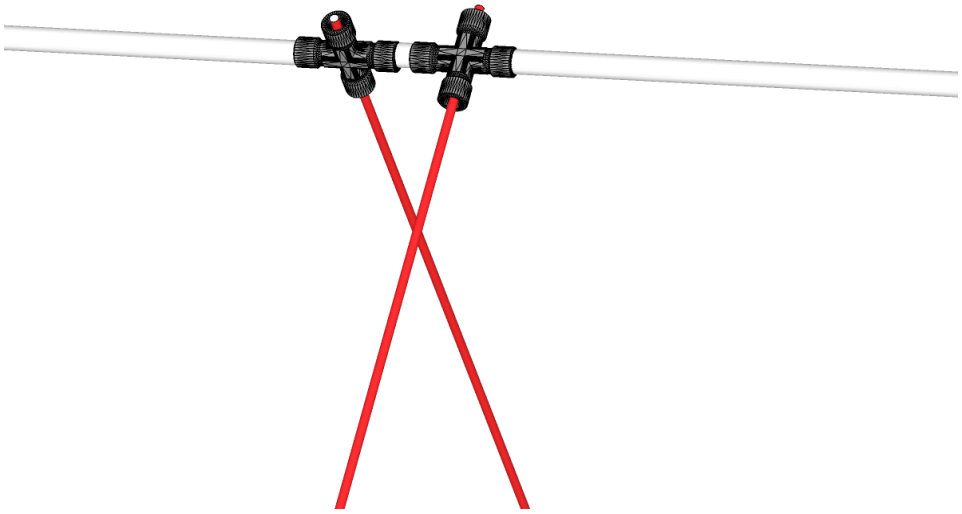


Figure 12 Close-up view of one the anchor to soil interface. Screed stakes are driven through the 1" crosses to secure the anchor to the ground.

2) Repeat for each 1/2 of an anchor (8 total).

3) Taro Nakai will mark the anchor positions. The positions, as shown in the Guy Layout Specification table (on page 8 of the second manual pdf and in Figure 13) should be 42 feet from the tower base. If the tower has the two main faces in the North and South directions then the guy wires should be place to the NE, the NW, the SW, and the SE.

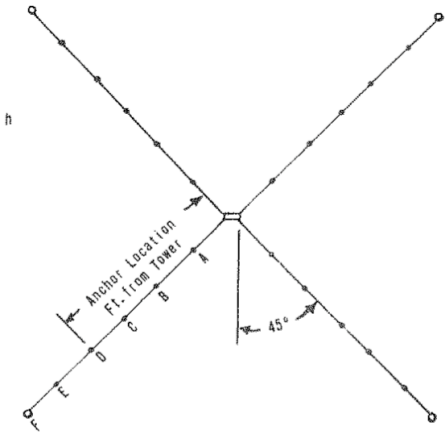


Figure 13 Tower and guy wires. Guy wire anchors should be located 42 feet from the tower.

4) After the anchors are in position, drive screed stakes through the crosses into the ground to secure the anchor to the ground.

Tower Construction

See the Upright Tower Instruction Manual for precise direction on proper assembly. Figure 14 shows a photo of the tower. A person is included for scale.

Figure 14 Installed Upright tower in Siberia. Photo shows the scale of the tower.

3 meter Tripod

Overview

Near the tall freestanding platform tower, a second tower will be placed. This three meter high tripod is intended for additional radiation sensors, snow sensors, and surface temperature sensors.

Tripod Construction Procedure

Campbell Scientific manufactures the three-meter tripod; use their manual as an installation reference.

Site Instrumentation

Overview

Sensors for the super site are listed in the Appendix, a subset are displayed in Figure 15. See the project webpage (**http://research.iarc.uaf.edu/pfrr_super-site/**) or the Appendix for precise metadata such as sampling frequency but generally, most meteorological sensors are sampled every ten seconds, and subsurface sensors are measured less frequently, once every five minutes. Means are stored every thirty minutes. Net radiation and eddy covariance sensors are installed at the ground surface as well as above the tree canopy. Several air, humidity, and wind sensors measure those parameters in a vertical profile from the ground surface to the top of the tower at 16 meters.

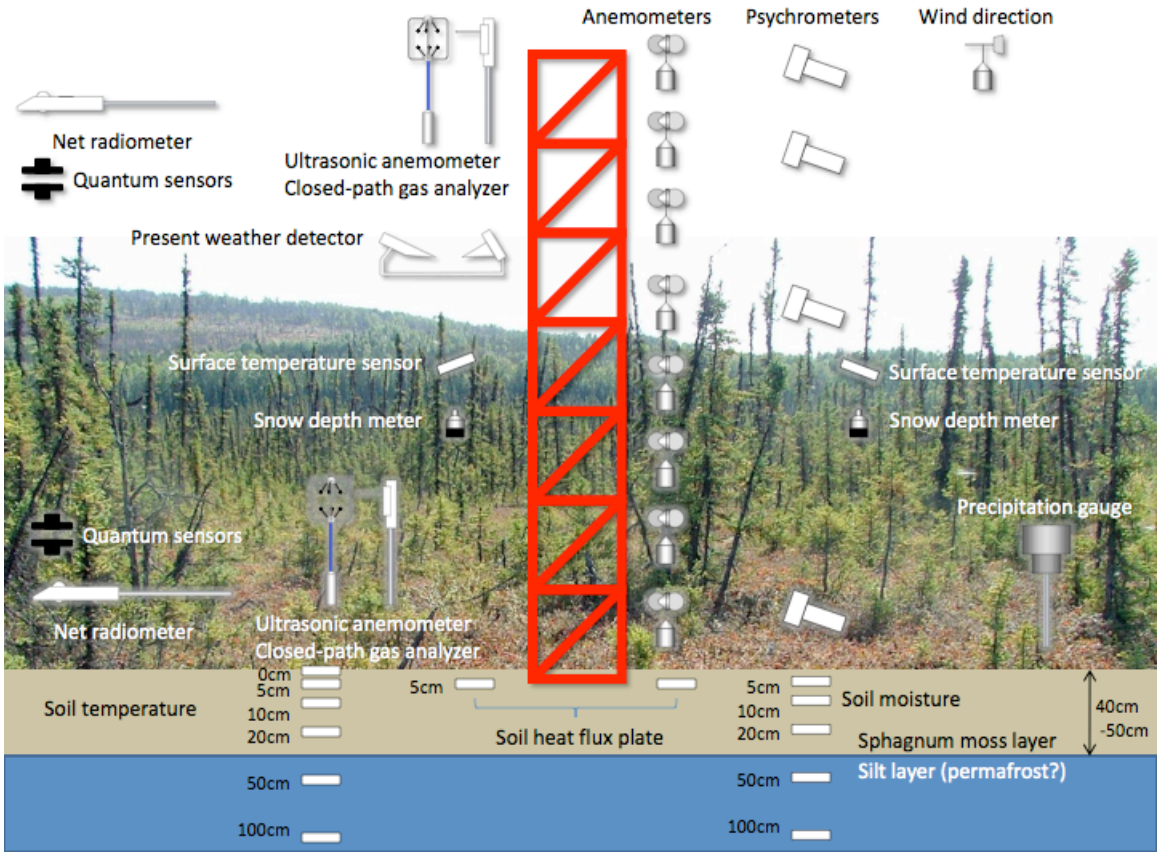


Figure 15 approximate locations of sensors to be installed at the super-site

Each sensor comes with a manual from the factory. These manuals list best practices for installing and operation and should be used as a guide during site set up. Many sensors also include mounting or other special hardware such as cross arms for wind speed to position the sensor away from the tower, lessening tower interference or aspirated radiation shields for the temperature / humidity measurements.

Several Campbell Scientific CR-1000 data loggers will be used to collect the majority of the measurements made. However, eddy covariance, sap flow, and imaging sensors will be logged separately. A computer in the shed will retrieve and store data from these units.