D17 AQUATIC INSTRUMENT SYSTEM (AIS) SITE CHARACTERIZATION REPORT

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See Configuration Management System for approval history

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A	02/25/2016	ECO-03591	Initial Release

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1 DESCRIPTION

1.1 Purpose

Information collected and described here is used to inform the site design activities for the NEON project Aquatic Instrument System (AIS). This report includes information gathered by the Aquatic (AQU), Facilities and Civil Construction (FCC) and Environmental, Health, & Safety (EHS) teams. The purpose of this report is for the science team to outline what is desired at each site within a domain in order to obtain the best scientific data possible to help answer NEON's Grand Challenge Questions; therefore, this is not a design document, but a report that is an input to the design process.

This report takes precedence over other documents and reports that may repeat the information contained herein.

The Appendices include summary tables for the convenience of the multiple audiences of this report; some of the information in the tables is repeated from the body of this report while other information is exclusive to the summary tables.

1.2 Scope

AQU site characterization information presented in this document is for the D17 aquatic site locations: Teakettle 2 Creek (core) and Upper Big Creek (relocatable). Issues and concerns for each site that need further review are also addressed in this document according to our best knowledge. Unless otherwise noted, the information contained herein takes precedence over the same information repeated elsewhere; thereby, this document contains the official change-controlled information pertinent to these sites.

Disclaimer: All latitude and longitude coordinates are subject to the variation inherent in our GPS equipment and the conditions at the site. Some of the Aquatic sites are in narrow canyons with limited satellite coverage; resulting in coordinates that are not accurate to within 50 cm.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

AD[01]	
AD[02]	
AD[03]	
AD[04]	

2.2 Reference Documents

RD[01]	NEON.NPR.000008 NEON Acronym List
RD[02]	NEON.NPR.000243 NEON Glossary of Terms
RD[03]	[Reference to photos]
RD[04]	[Reference to map(s)]

2.3 Verb Convention

"Shall" is used whenever a specification expresses a provision that is binding. The verbs "should" and "may" express non-mandatory provisions. "Will" is used to express a declaration of purpose on the part of the design activity.

3 D17 AIS SITE CHARACTERIZATION REPORT

3.1 Teakettle 2 Creek

Teakettle 2 Creek site is a wadeable stream on western slope of the Sierra-Nevada Mountains with a watershed size of approximately 302 ha (see TK2 and TK2A in Figure 1). The Teakettle 2 Creek catchment is entirely located within the Teakettle Experimental Area (TEA), which is located in the north part of the Kings River watershed. The TEA is owned and operated by the USFS Pacific Southwest Region. It was established in 1936 for timber management research. TK3 (Figure 1) is currently being monitored and controlled for projects that are currently managed by USFS PSW and the Kings River Experimental Watershed (KREW).

TEA is located in the northern area of the Kings River watershed. TK2 is located at an elevation that spans 2109 m– 2489 m. The average annual precipitation at 2100m is 110 cm and is primarily by snow. The area is representative of a subalpine forest (see Flora section below). The Teakettle 2 Creek watershed is a southeast-facing, second-order with a slope of 8 percent that passes through senescent red fir.

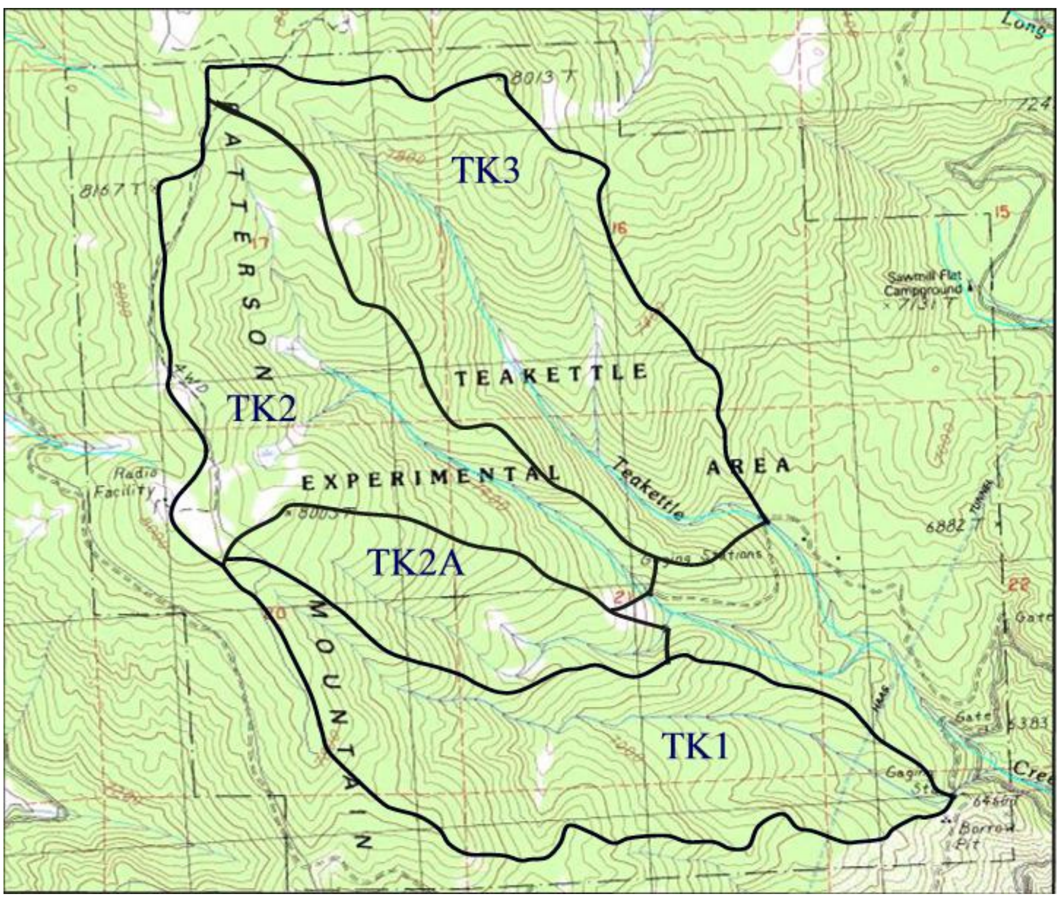

Figure 1. Map of Teakettle Experimental Area and watershed boundaries.

3.1.1 Geology, Flora and Fauna

3.1.1.1 Geology

The Teakettle 2 Creek watershed lies in the Sierra Navada batholith. This batholith is comprised mainly of granite rock and was formed approximately 200 million years ago. The soils in the region are poorly formed due to the climate (cold winters, dry summers), the resistance of the granite to weathering and the removal of eroded material into drainages before further weather and soil formation can occur. Therefore soils in this region have low horizonation, clay content and weak structure. Weathering of granite rocks results in runoff with low dissolved solid content and leads to low nutrient waters.

The proposed aquatic reach for the NEON site lies in the lower extent of TK2 and is the lowest gradient section within the watershed.

3.1.1.2 Flora

The Teakettle Experimental Forest represents a subalpine forest that is dominated by a mix of conifers. Vegetation is characterized by distinct patch conditions of closed-canopy tree clusters, persistent gaps and shrub thickets. The composition of the vegetation follows the elevation gradient with white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), incense cedar (*Calocedrus decurrens*), Jeffry pine (*Pinus jeffreyi*), and red fir at the lower elevations to red fir, lodge pole pine (*Pinus contorta*), and western white pine (*Pinus monticola*) at higher elevations.

The riparian area is extremely dense with shrubs. There are also numerous down trees and debris jams along the reach.

Figure 2 Photo of dense shrubs that are typical the riparian vegetation along Teakettle 2 Creek.

Figure 3 Examples of riparian vegetation along Teakettle 2 Creek.

Figure 4 Example of mixed conifer forest with clusters and patches of thick shrubs typical of the surrounding terrestrial area.

3.1.1.3 Fauna

TBD

3.1.2 Historic Data

The following historic data was captured from web portals and was collected by government agencies.

3.1.2.1 Hydrology

There are two gauging stations upstream of the proposed Teakettle 2 reach, one on TEAK2 and one on TEAK 2A. Data was gathered at these weirs from 1957 – 1983. No more current records have been collected. Data from both gauging stations was downloaded from USGS, synchronized and added together to created a historic hydrograph for the proposed Teakettle 2 site. These gauging stations are located approximately 1000m upstream from the base of the AQU reach. The combined catchments of these two streams and the downstream AQU site is approximately 302 hectares.

The hydrograph shows a mean base flow of 11 LPS in the autumn months. Snow melt begins in March and peaks in June. The graph shows that discharge during the peak flow months of May and June is approximately 18 times greater than base flow. This level of fluctuation in flow will pose many challenges in terms of site deployment and operations. Our infrastructure is designed to accommodate this flow, however, we will have to see what the true impacts are once the sites are constructed. Further sampling protocols may need to be augment to accommodate high flow conditions.

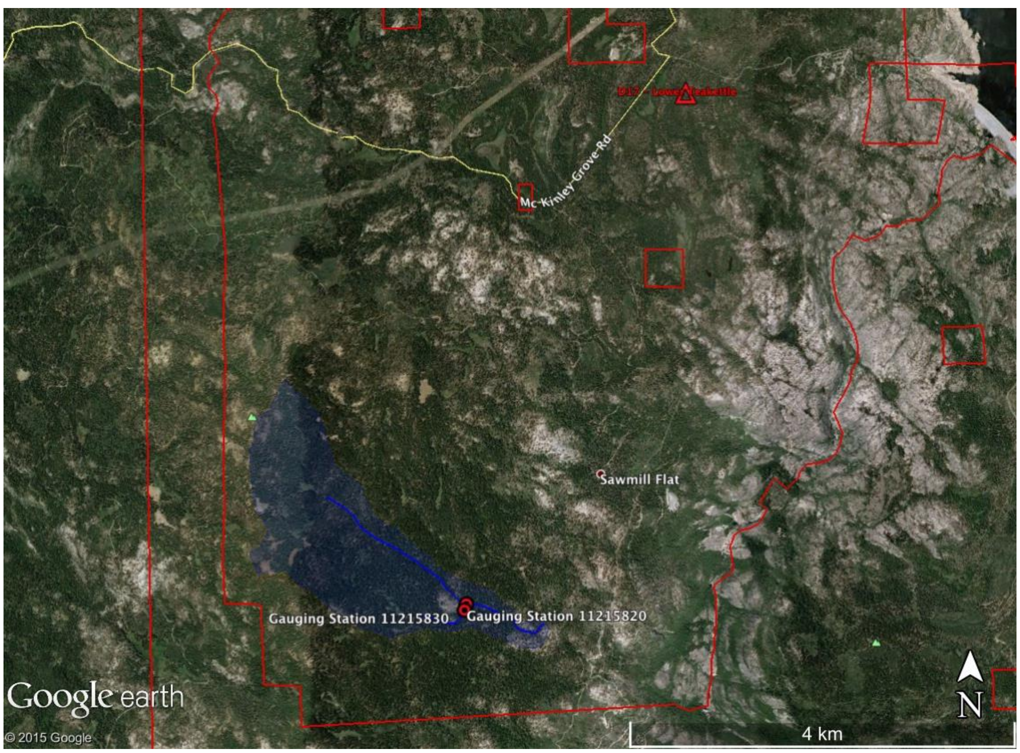

Figure 5 Map showing the (inactive) USGS gauging stations 11215830 and 11215820 located upstream in the Teakettle 2 Creek watershed.

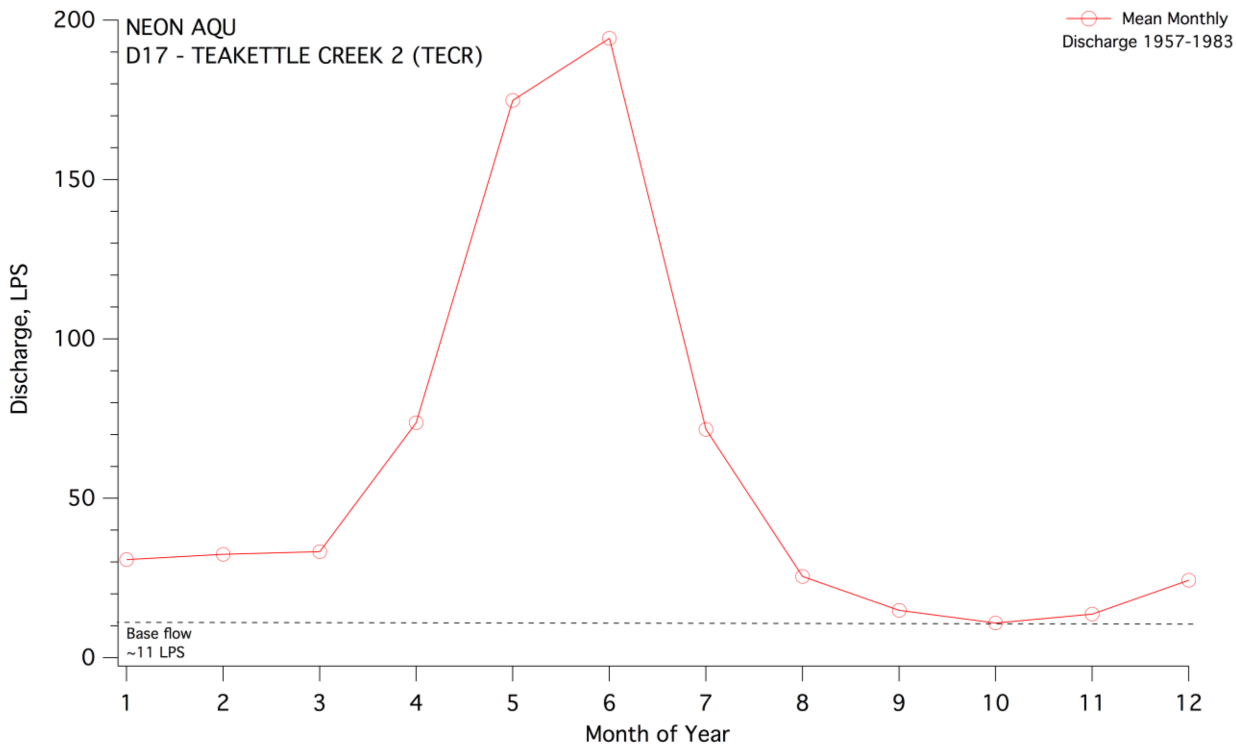

Figure 6 Hydrograph for proposed Teakettle 2 site showing the monthly discharge average over 1957-1983.

3.1.2.2 Climate and Meteorology

The closest weather station that measures both precipitation and air temperature is at the Wishon Dam. It is approximately 7 km away and 10-20m lower in elevation. These data were captured from the California Data Exchange Center hosted by the Dept. of Water Resources. These data are considered provisional.

The data show a mean daily variability in air temperature of approximately 20^{o}C. Precipitation is heaviest through the winter months with summer months being very dry. The bulk of precipitation at this site and elevation falls as snow.

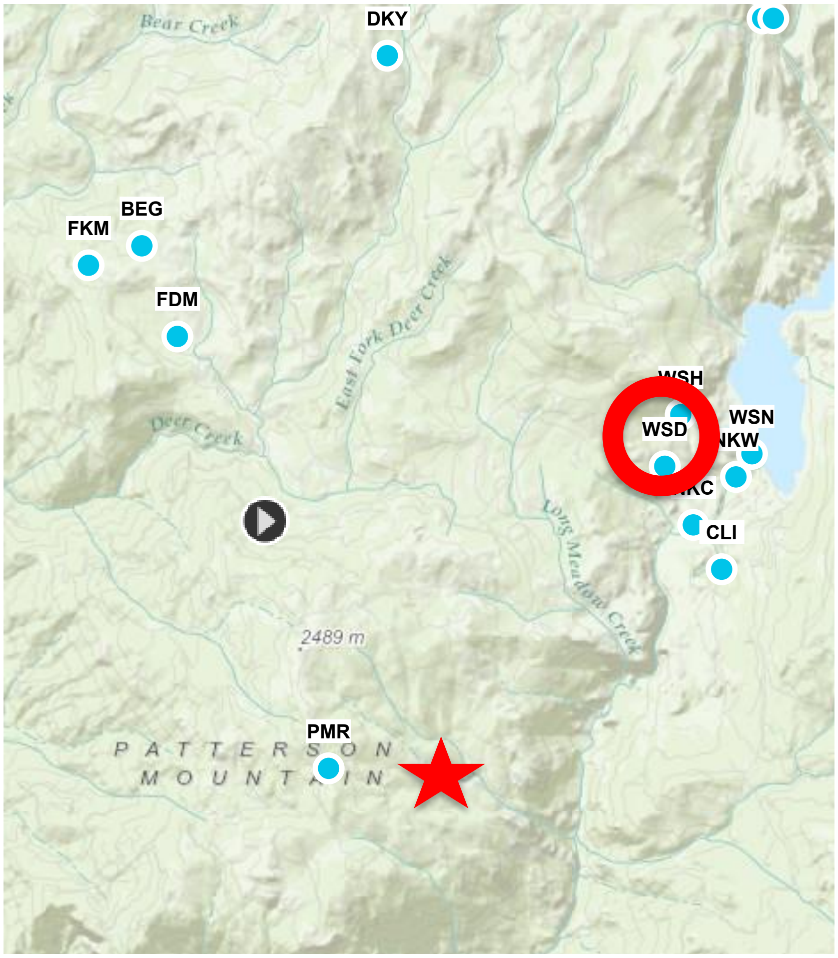

Figure 7 Map showing the location of the nearest weather station measuring both precipitation and temperature (circle) relative to the NEON site (star).

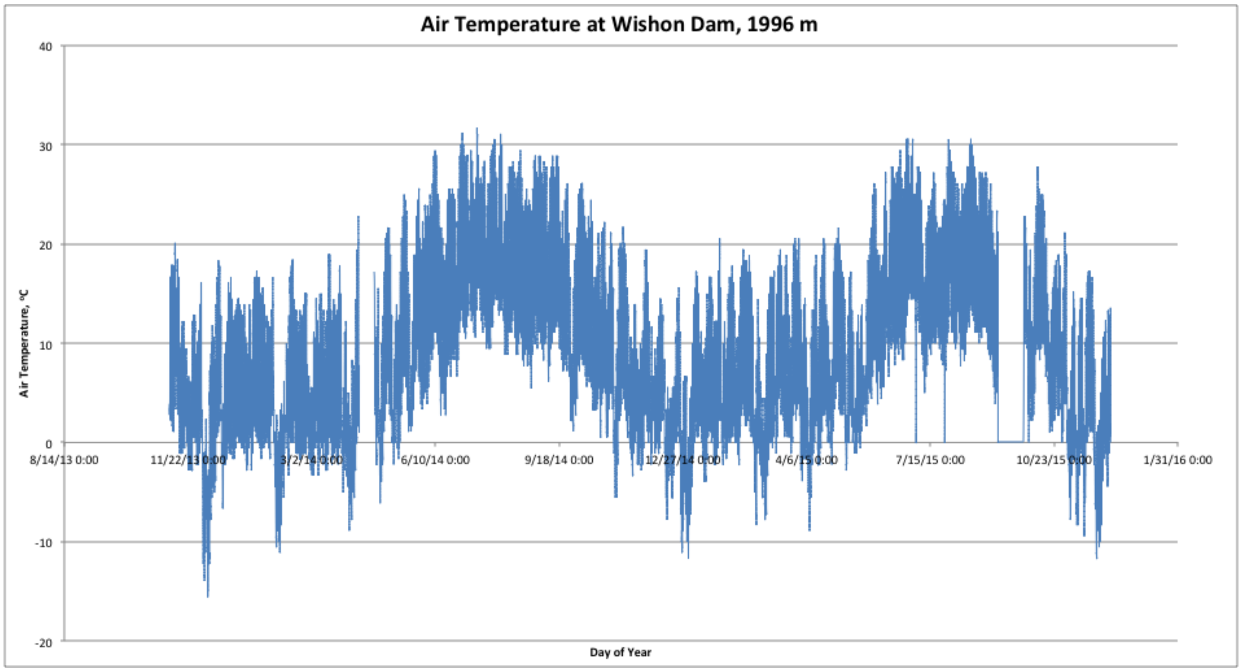

Figure 8 Time series of air temperature measured

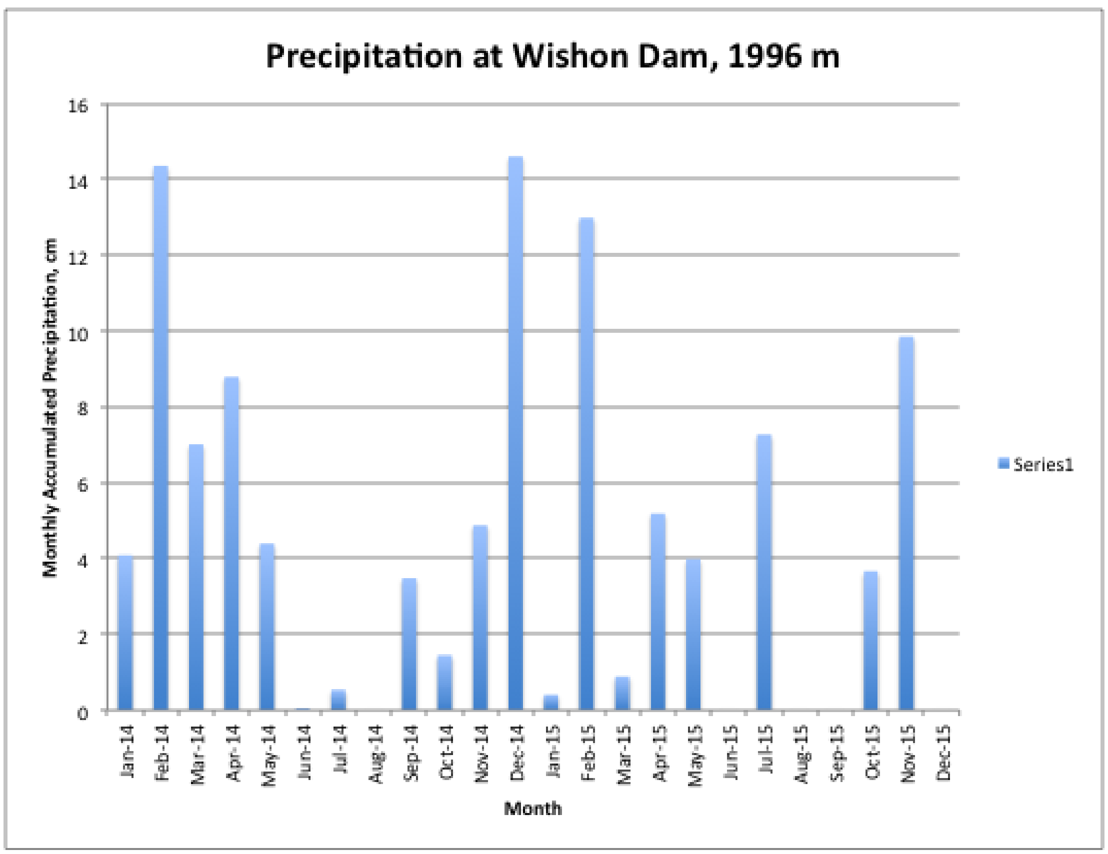

Figure 9 Monthly averaged precipitation data.

3.1.3 Infrastructure and Construction

3.1.3.1 Aquatic Auxiliary and Aquatic Portal Locations for Construction

The initial estimated location for the Aquatic Auxiliary Portal is:

Figure 10 A Google-Earth-Derived Image of Aquatic Auxiliary Portal for D17 Teakettle 2 Creek.

The initial estimated location for the Aquatic Portal is shown in Table 1

Table 1 Aquatic Portal Location

Aquatic Portal	Latitude	Longitude
Location	36.955366°	-119.026147°

3.1.3.2 Sensor Locations for Construction

AQU, with support from EHS, has the following field GPS coordinates for S1 and S2 and met station locations. Many aquatic sites are in narrow canyons or covered by dense canopy, which reduces satellite availability. In these situations, AQU will provide a description of the location and an approximate GPS location (e.g. not accurate to within <1m). This description will suffice for the planning stages, but sites will likely need to be physically marked prior to construction.

Satellite coverage at Teakettle 2 Creek during site characterization was sufficient and produced good estimates of sensor locations as the GPS unit was able to connect to 6+ satellites for all of the measurements. Accuracy of the measurements was reported by the handheld device at sub-meter levels.

These coordinates are to be used for the input to the AIS design:

Table 2 Sensor 1 & Sensor 2 Locations

(Disregard upper table – it cannot be deleted)

	~~**Latitude**~~	~~**Longitude**~~ -
~~S1~~	~~37.614199~~	~~-119.024981°~~
~~S2~~	~~36.955204°~~	~~-119.023544°~~

Sensor	**Latitude**	**Longitude**
S1	36.954756°	-119.024981°
S1 - FDP	36.954853°	-119.025441°
S2	36.955204°	-119.023544°
S2 - FDP	36.955175°	-119.023705°

Table 3 Meteorological Sensor Locations

Sensor	**Latitude**	**Longitude**
Met Station	36.955269°	-119.026122°
Met – FDP	36.955360°	-119.026171°

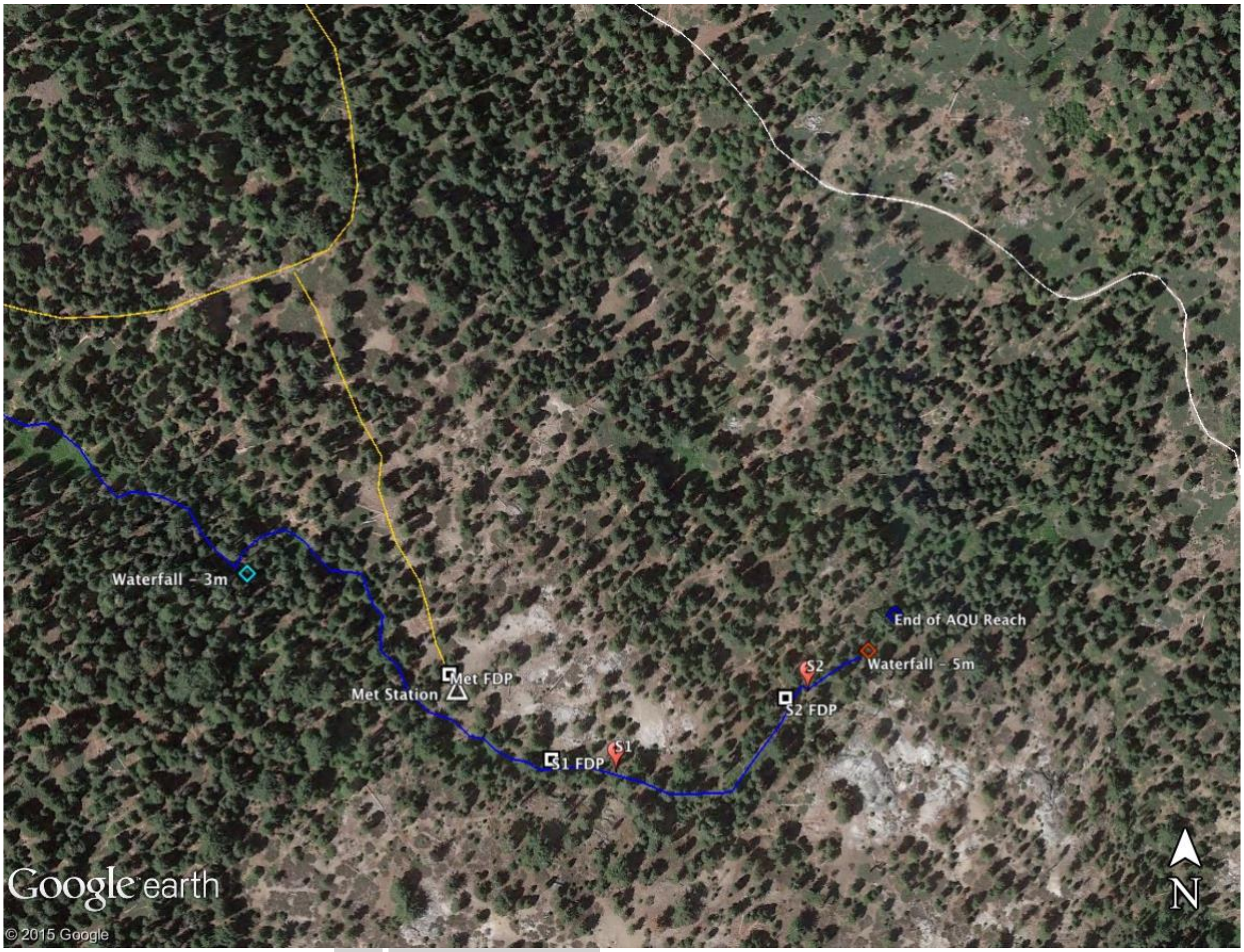

Figure 11 Kmz File of D17 Teakettle 2 Creek Denoting Locations of S1, S2, and Met. Station

Figure 12 Upstream view of the S1 location at D17 Teakettle 2 Creek.

Figure 13 Downstream view of the S1 location at D17 Teakettle 2 Creek.

Figure 14 Upstream view of the S2 location at D17 Teakettle 2 Creek.

Figure 15 Downstream view of the S2 location at D17 Teakettle 2 Creek.

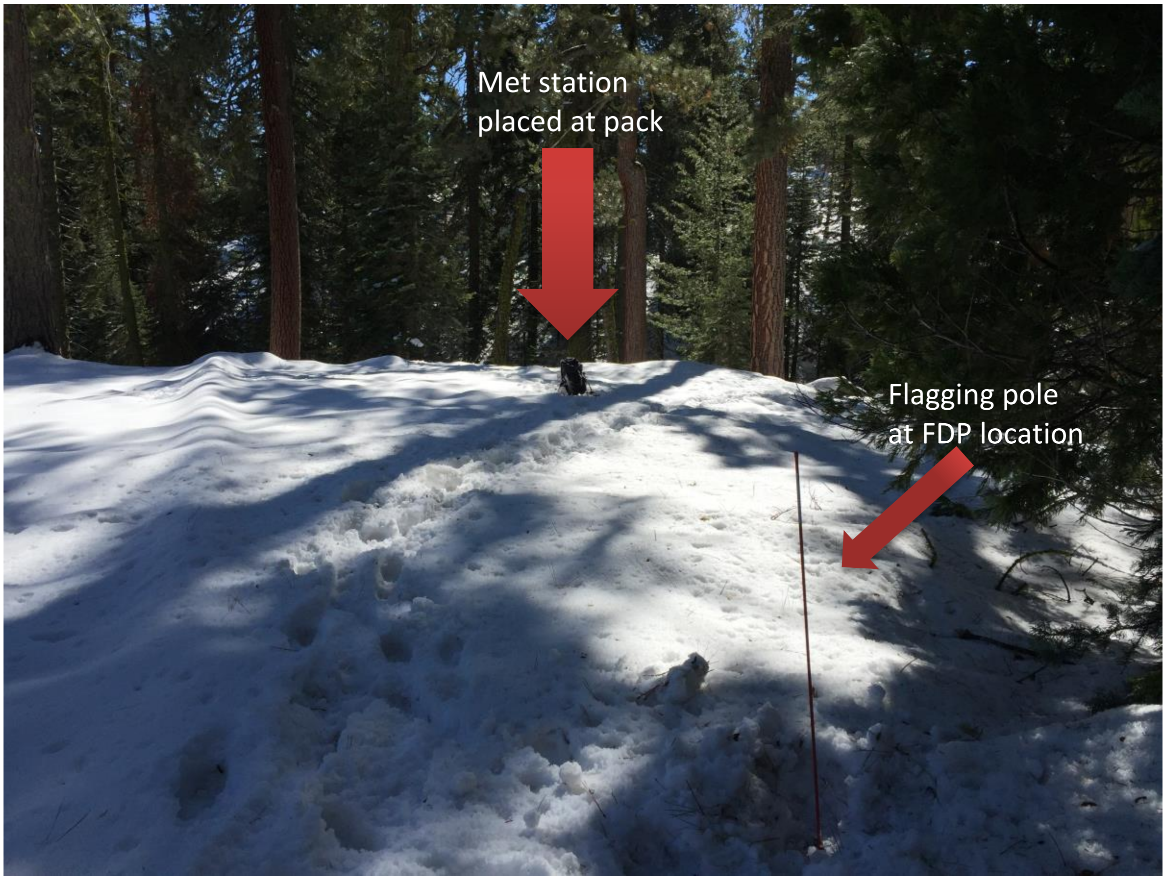

Figure 16 View of met station location from the field device post.

3.1.3.3 Stream Reach Characterization

The standard salt injection for flow measurements and travel time was not permitted for this site at the time of characterization. Additionally the depth of snow and presence of ice made a typical habitat survey unsafe to perform. To overcome these limitations and reasonably estimate the travel time and thus the sensor reach length a smaller survey of habitat and velocity was performed. A 200m section of the lower extent of the reach was surveyed. The average velocity was estimated to be 10 cm/s (see Table 4). Based on this velocity and a target travel time of approximately 30 min for base flow, the sensor reach length would be 180m. Upon investigating the reach for pools at that distance the sensor locations were chosen at distance of 190m. The discharge measured approximately 3m upstream from the S1 location was 6 LPS at the time of characterization.

Table 4 Survey results of 200m subset of reach.

Habitat	Percentage Cover, %	Average Velocity, cm/s
Riffle	33	20
Run	33	6
Pool	33	4
	Mean Reach Velocity	**10**

It should be noted that the difference between base and seasonally high flows is approximately 18 times. Therefore it may result that a 190m reach length it too short to successfully measure stream metabolism at a temporal coverage that meets the observatory requirements. To mediate this risk, we have placed the S1 FDP 30m upstream from the sensor location. There is a pool located approximately 50m upstream of the chosen S1 location to which the sensor may be moved without changing the power/comms installations. This may not be needed and will not be determined until approximately one year into operations of the site.

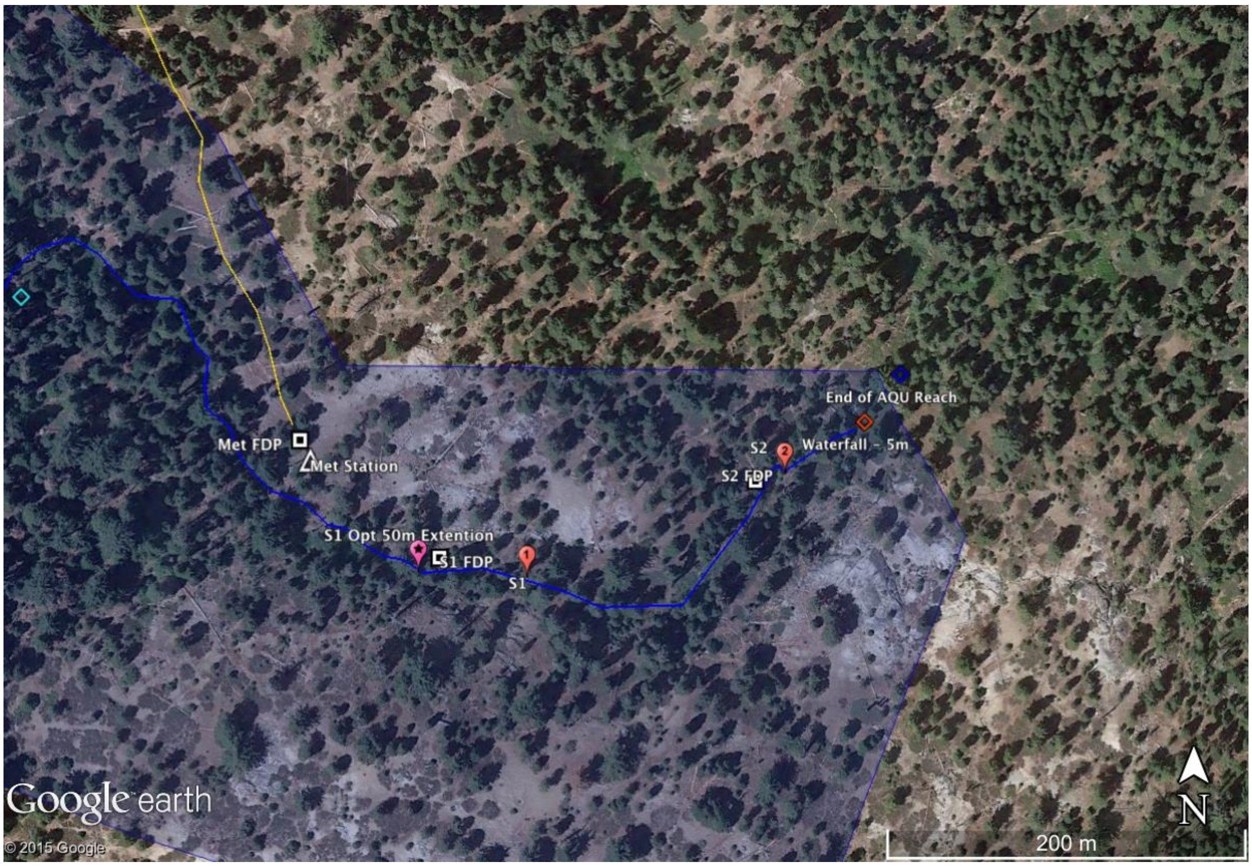

Figure 17 Map showing the location of an optional S1 pool (pink star balloon) if it is found during operations that the current sensor reach is insufficient to capture the data required.

3.1.3.4 Bank Morphology

The bank angle is estimated from the top of the bank, where one might stand to observe the stream/lake, to the top of the water. The estimated angle is from the water to the bank, as illustrated in the figure below.

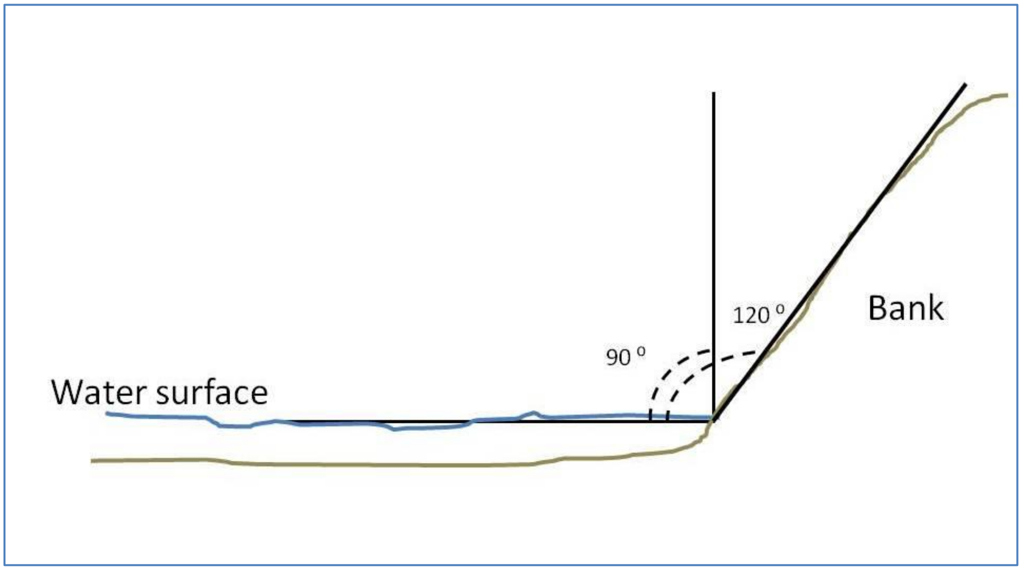

Figure 18 How Bank Angle is Measured

During 2015 site visits, AQU observed the following bank conditions at S1 and S2:

Table 5 Bank attributes of D17 Teakettle 2 Creek sensor locations.

Morphology Type	S1	S2
RB* angle	90	90
LB* angle	113	162
Maximum water height	1.47 m (from channel thalweg to bankful)	2.1 m (rom channel thalweg to bankful)
Bankfull width	4.5 m	6.5 m
Substrate composition	Bedrock, pebbles and sand	Bedrock, pebbles and sand

* RB (right bank) and LB (left bank) are determined by facing downstream.

Figure 9 above shows the steepness of the stream banks and general riparian vegetation along the stream reach.

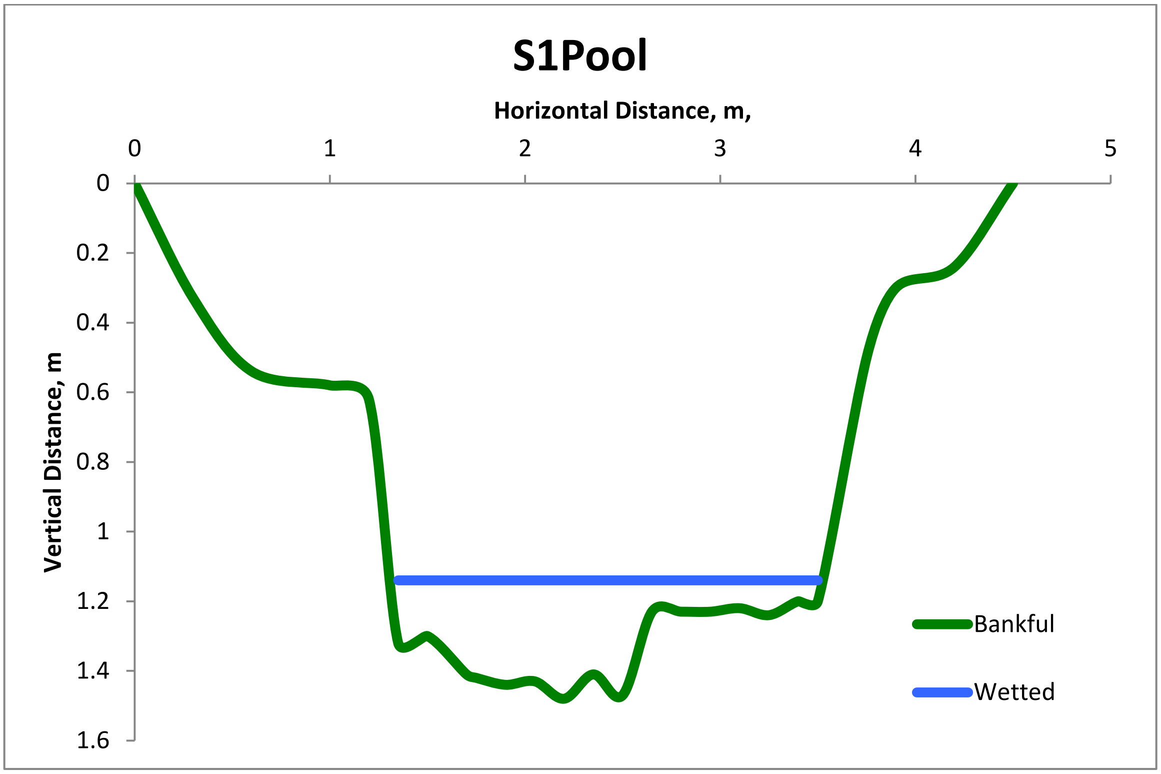

Figure 19 Cross sectional geomorphology survey of S1 pool.

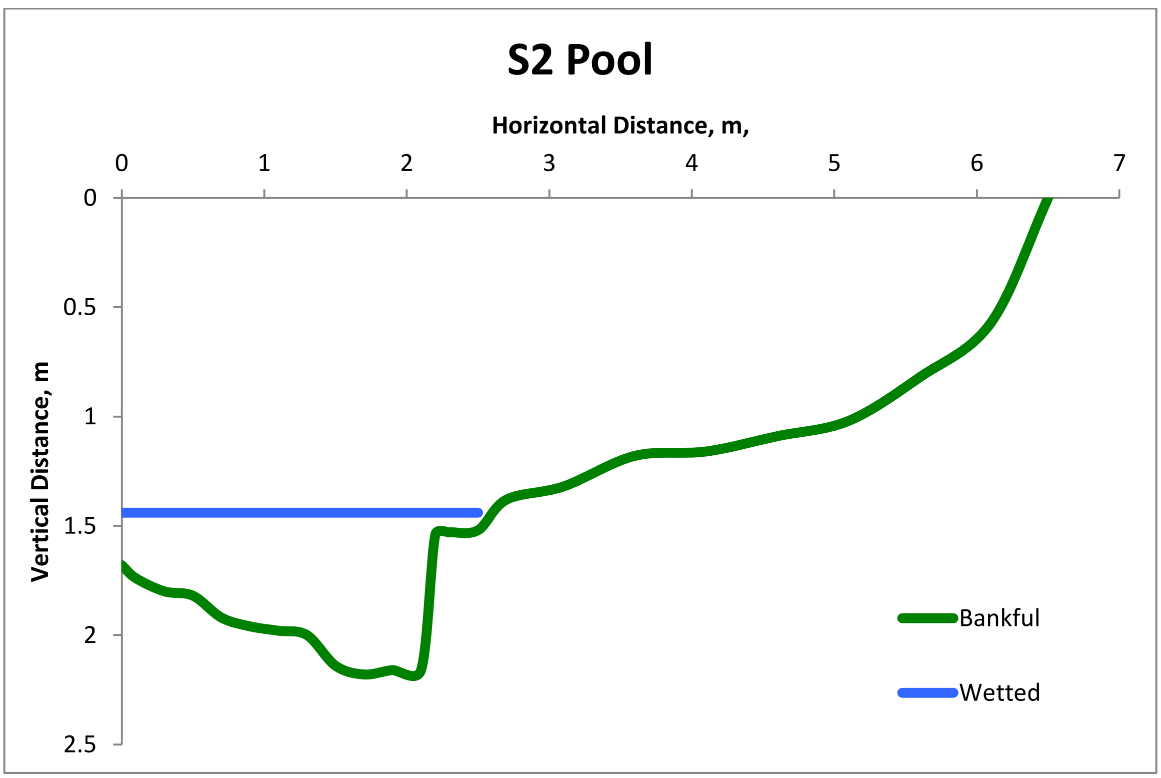

Figure 20 Cross sectional geomorphology survey of S2 pool.

3.1.3.4.1 Groundwater Wells

This section will be revised once the NEON hydrologist has had a chance to visit the site and determine well locations and installation method. Shown in Figure 21 is an idealized well layout for the site. This figure will be updated following a visit during the late spring/summer 2016, and the coordinates will be supplied in Table 5.

The groundwater observation wells network at the site (Figure 21, Table 6 will consist of 8 wells installed using either a powered hand auger or a direct-push rig (i.e. Geoprobe). Due to the geology of the site, well drilling may be difficult and groundwater may be limited. Topography at the site is predominately high gradient granite with subalpine forest spread throughout the site.

Generally the site is accessible for the rig and installation but is anticipated to be difficult because of the high gradient geology. The estimated drilling depth is about 30 feet for all wells. The exact location of the wells may need to change slightly if the rig is unable to reach the desired locations due to the presence of downed trees, thick underbrush, or seasonal boggy regions. The presence of obstructions in the subsurface (e.g. glacial erratics) does not appear to be an issue for this site and minimal issues are anticipated with the installation of the well network.

AQU prefers the surface completion of the wells to include an above-grade stick-up protective cover and be minimally invasive. The State of California has several requirements for construction of groundwater monitoring wells that NEON will either need to meet or apply for a waiver. Chief among the State requirements are 1) an acceptable grout to fill the annular space such as neat cement, bentonite chips, or a bentonite / cement mixture; 2) surface seal of the well requires a poured concrete or cement slab poured around a steel outer casing with a locking cap from a depth of 2 feet below land surface to the top of land surface.

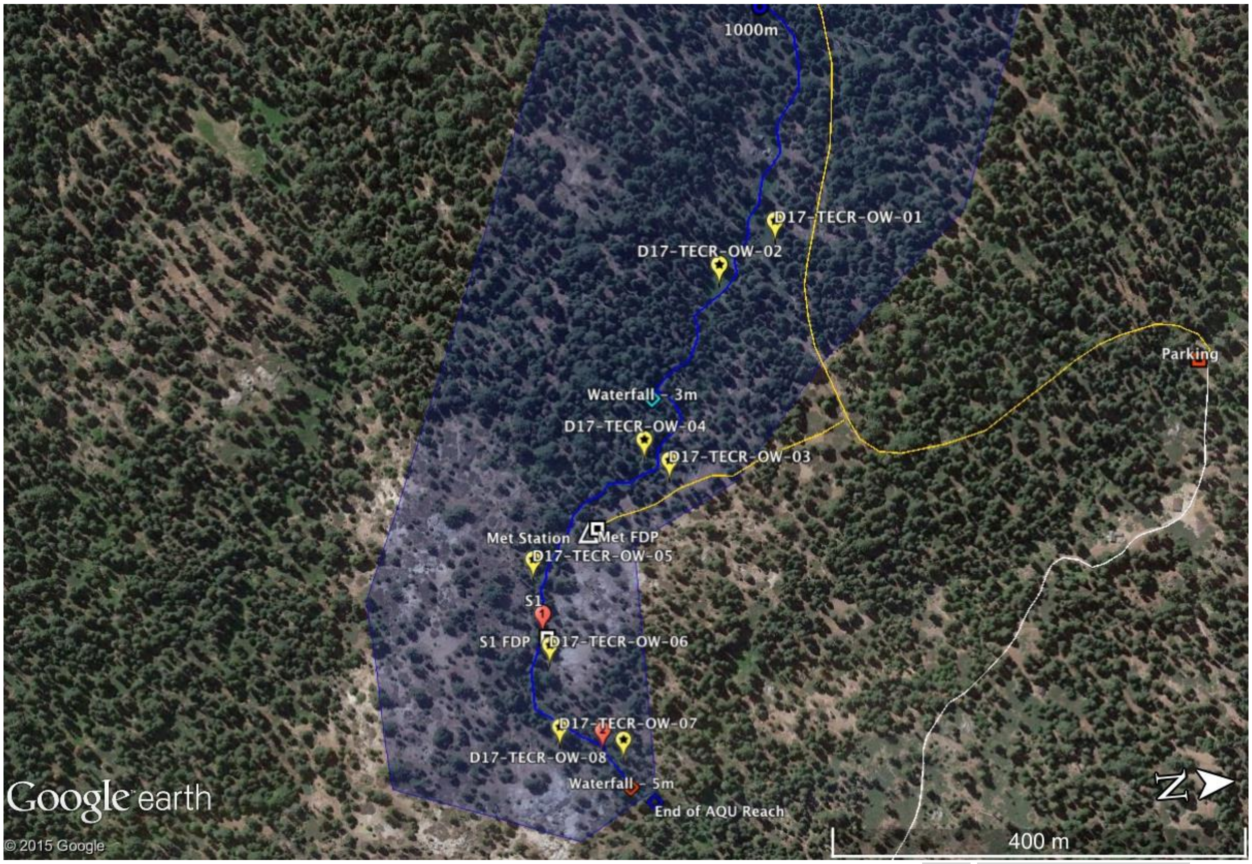

Figure 21 Initial Groundwater Well Locations Based on EMS kmz File at D17 Teakettle 2 Creek.

Table 6 Groundwater well locations at D17 Teakettle 2 Creek.

Well ID	Latitude	Longitude
D17-TECR-OW-01		
D17-TECR-OW-02		
D17-TECR-OW-03		
D17-TECR-OW-04		
D17-TECR-OW-05		
D17-TECR-OW-06		
D17-TECR-OW-07		
D17-TECR-OW-08		

3.1.4 Site Access Needs

Teakettle 2 Creek is located in the Teakettle Experimental Area, which is 122 km ENE of Fresno, C. It is reachable via Highway 168 to Shaver Lake and then south on Dinky Road to McKinley Grove to Blackrock Rd. Travel in the area is via maintained paved roads up to the lower portion of McKinley Grove and Blackrock which become gravel roads. The final 7-8km are unmaintained roads, which will require snow chains and four wheel drive vehicles to access during winter months. There is a gate with a coded lock at the access from Blackrock road (Figure 17 below). The parking is suitable for one vehicle with a turn-around area near weir on Teakettle 3.

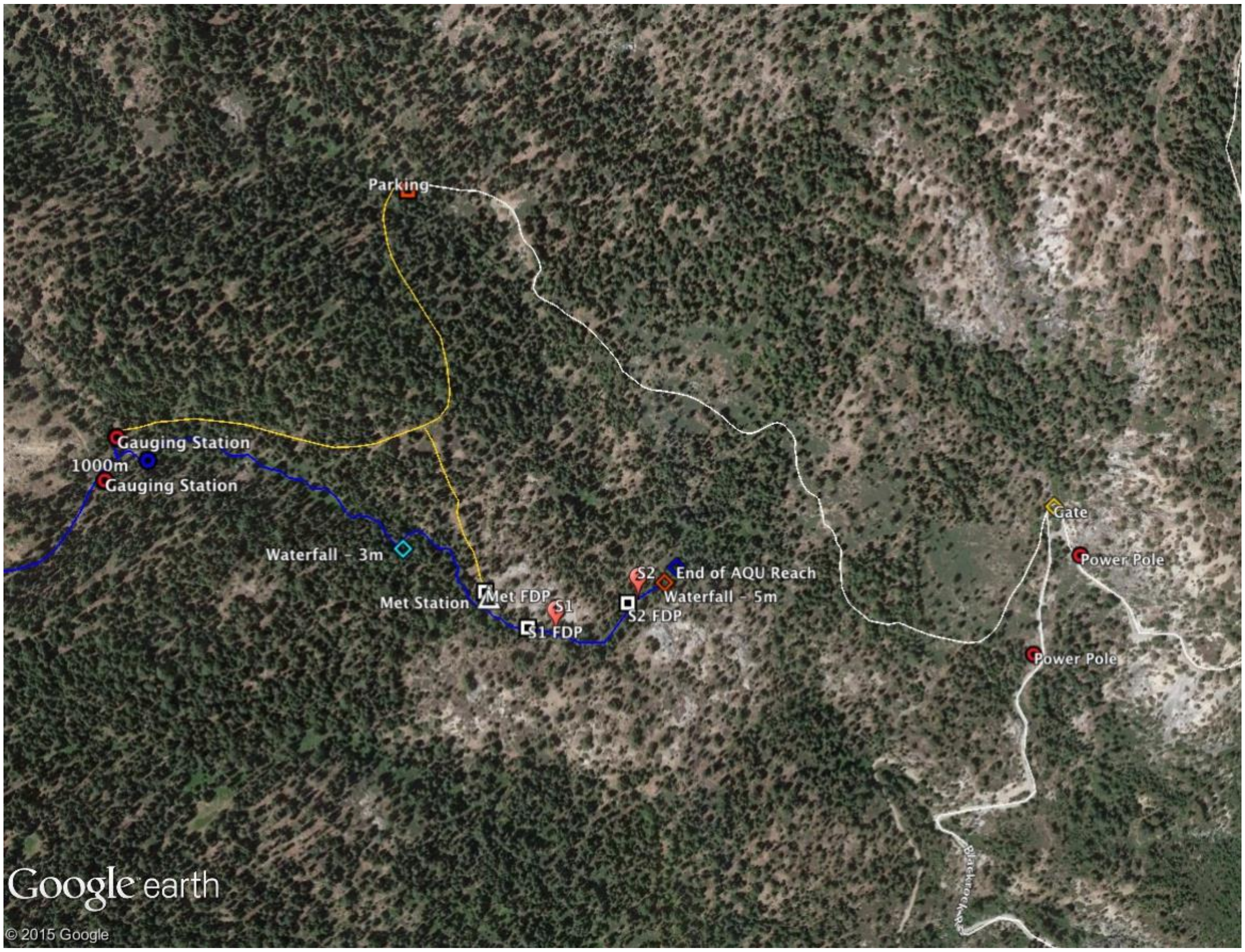

Figure 22 Map of site location showing the access roads (white) and pathways (yellow) , location of the access gate and parking area.

There is an existing path leading from the parking area to the gauging stations on Teakettle 2 and Teakettle 2A. This path is an abandon road. Currently it has many downed trees, many of substantial size (Figure 17). We request that the trees in this path be cut to allow a small track vehicle to be driven into the site during winter months. Snowshoes will be necessary for accessing the sensors and stream during winter months; however a track vehicle for the snow will be necessary to transport equipment to execute sampling and maintenance protocols. Figure XX shows photos of the trail and downed trees for reference.

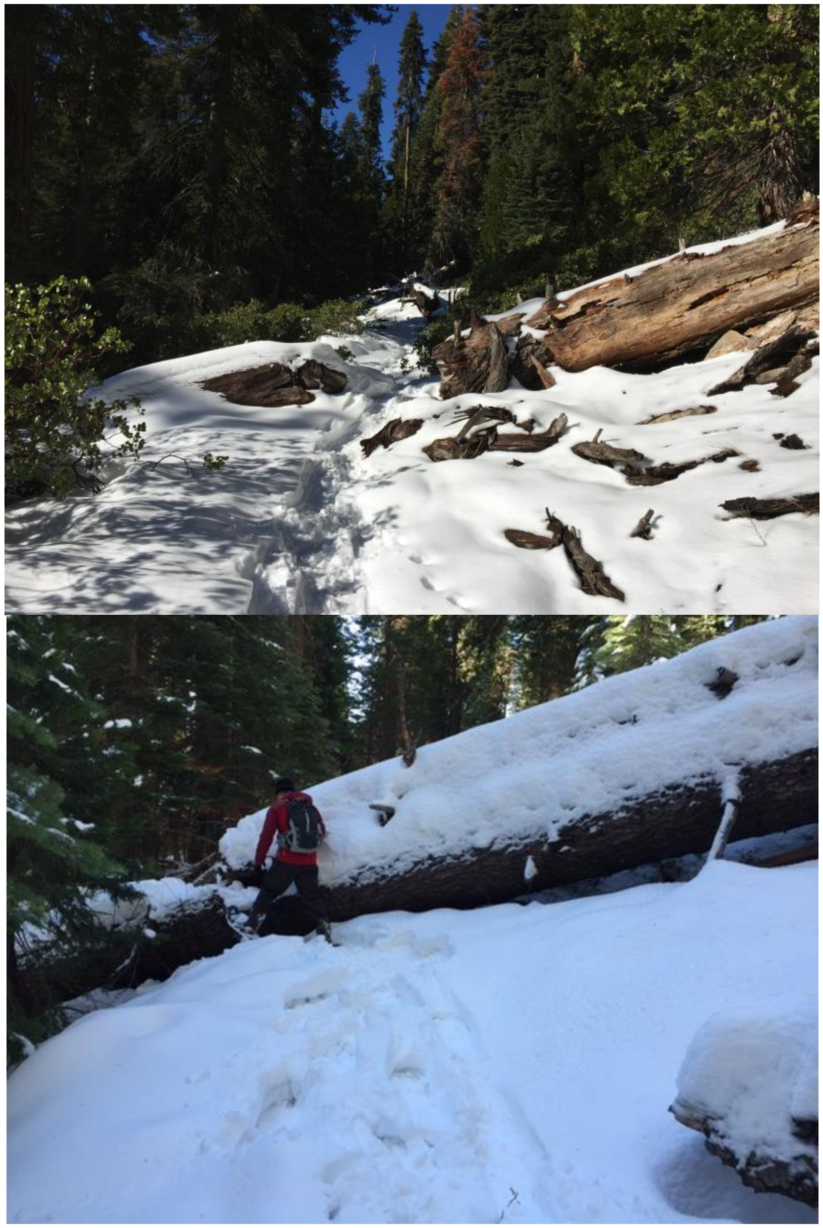

Figure 23 Photos of the access path and examples of downed trees that require removal.

Figure 24 Photo of parking area where road terminates at existing bridge and gauging station on TEAK3.

3.1.4.1 Science Perspective on Access Needs (Pathways, Stairs, Etc.) to Reduce Site Erosion/Impact

No stairs or new pathways will be required for construction or operation at the site.

3.1.5 Communications at the Site

See TIS Soaproot site plan.

3.1.6 Power at the Site

The local power utility company is PG&E.

3.1.7 Site Science Construction Constraints and Limitations

No stairs or new pathways will be required for construction or operation at the site. However, construction activities will needed to be coordinated with the Teakettle Experimental Area management and UC Merced faculty to ensure there are no impacts to ongoing studies in the area (TEAK3).

Site-specific issues to consider at D17 Teakettle 2 Creek are:

Driving and access constraints for D17 Teakettle 2 Creek are:

- Access to sensor locations at Teakettle 2 Creek is via existing trails and should not require the installation of additional trails.
- Some minor trimming of trees along the stream reach may be required to support monitoring and observational sampling activities in the reach.

3.1.8 Other Issues

No other science issues are identified at this time.

3.2 Upper Big Creek

The Upper Big Creek site is a wadable stream on the western slope of the Sierra-Nevada Mountains with a watershed size of approximately 34 km^2. The Upper Big Creek catchment is entirely located in the Sierra National Forest, which consists of mixed mature cottonwood trees, short grasses, and shrubs. The flow regime of Upper Big Creek is typical of snowmelt dominated mountainous streams in the west. Base flows are lowest in the winter (November - March) and highest in the late spring (April – June).

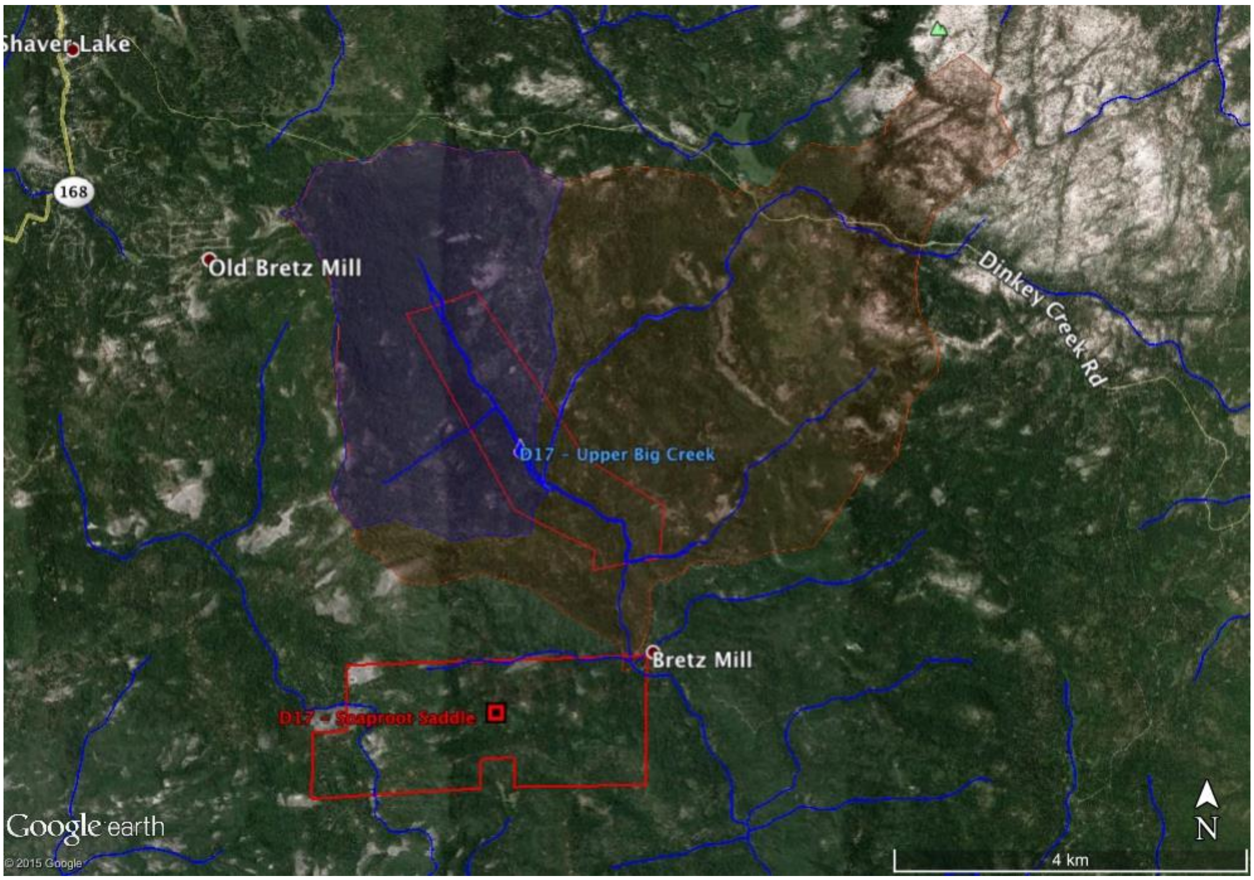

Figure 25 Map of Upper Big Creek catchments for NEON AQU site (blue) and expanded permitted area (orange).

3.2.1 Geology, Flora and Fauna

3.2.1.1 Geology

The Big Creek Basin lies in the Sierra Nevada batholith within the southern extent of the Sierra Nevada mountain range. This batholith is comprised mainly of granite rock and was formed approximately 200 million years ago. The soils in the region are poorly formed due to the climate (cold winters, dry summers), the resistance of the granite to weathering and the removal of eroded material into drainages before further weather and soil formation can occur. Therefore soils in this region have low horizonation, clay content and weak structure. Weathering of granite rocks results in runoff with low dissolved solid content and leads to low nutrient waters.

The NEON FIU site characterization of the proposed Soaproot site found the following characteristics:

Soils: Dominant soil series at the site: Holland Family, 35 to 65 percent slopes. The taxonomy of this soil is shown below:

Order: Alfisols
Suborder: Xeralfs
Great group: Haploxeralfs
Subgroup: Ultic Haploxeralfs
Family: Fine-loamy, mixed, semiactive, mesic Ultic Haploxeralfs
Series: Holland Family, 35 to 65 percent slopes

Additional Site Aspects:

Watershed: (Upper) 7.37 km^2 (Whole - 33 km^2)
Elevation range over catchment: 1003m - 1700m
Elevation Range over suggested reach area: 1132m-1153m
Suggested Reach length: 1130m
Mean annual flow volume: 5 cfs
Mean annual flow velocity: 1.1 fps
Stream order: 1

2011 National Land Cover Dataset:

Deciduous Forest (41): 0.4%
Evergreen Forest (42): 88.3%
Mixed Forest (43): 0.7%
Other: 10.6%

3.2.1.2 Flora

The Upper Big Creek Basin ecosystem is dominated by coniferous (ponderosa and sugar pines, cedar, sequoia, redwood, white fire) forest with a mean canopy height of 32m. The understory is primarily scrub-shrub.

The riparian forest is dominated by cedars, pines and firs with a small percentage (<1%) of black oak, white alder, Oregon ash and cottonwood. The understory is scrub-shrub with ferns and grasses. The riparian forest floor contains much higher amounts of organic matter due to dead-fall, shading and higher humidity.

Figure 26 Photo of vegetation characteristic of watershed.

Figure 27 Photo of vegetation characteristic of watershed.

3.2.1.3 Fauna

The aquatic flora includes aquatic plants and algae with moss also present on large woody debris and rocks.

Brook trout have been seen during NEON site visits to Big Creek. Brown and rainbow trout may also be present. Amphibians have not been seen but also have not been surveyed for and therefore their presence is unknown at this time.

Federally listed species in the SNF that may be impeached by NEON AQU include cutthroat trout (Lahontan and Paiute), the Yosemite toad, Sierra Nevada yellow-legged frog and California red-legged frog.

Figure 28 Photo of crayfish.

3.2.2 Historic Data

The following historic data was captured from web portals and was collected by government agencies.

3.2.2.1 Hydrology

There was a previous USGS gauging station (11219000) approximately 4 km downstream from the proposed NEON site. The record from this station is severely limited with the only records being collected between 1912 – 1914. No more current records have been collected. Data from 1912 shows a remarkably higher flow pattern than in subsequent years indicating a dramatic change in watershed management. Therefore only the data from 1913-1914 was considered in analyzing the flow patterns in the reach. The gauging station is located approximately 4 km downstream from the base of the AQU reach. The catchment area where the gauging station is located is 50.8km. The ratio of catchments between the AQU reach and the gauging station was used to scale the historical data to estimate the hydrograph for the AQU site (Figure 25).

The hydrograph shows a mean base flow of 10 LPS in the autumn months. Snow melt begins in March and peaks in April. The graph shows that discharge during the peak flow month of April is approximately 21 times greater than base flow. This level of fluctuation in flow will pose many challenges in terms of site deployment and operations. Our infrastructure is designed to accommodate this flow, however, we will have to see what the true impacts are once the sites are constructed. Further sampling protocols may need to be augment to accommodate high flow conditions.

There is some indication that Big Creek may be spring fed since it has had consistently flowing water during late season site visits in October 2014 and September and November of 2015. During these visits the primarily snow fed stream of Summit Creek was either dry or flow was extremely low. Providence Creek which is also primarily snow fed has been completely dry during both visits.

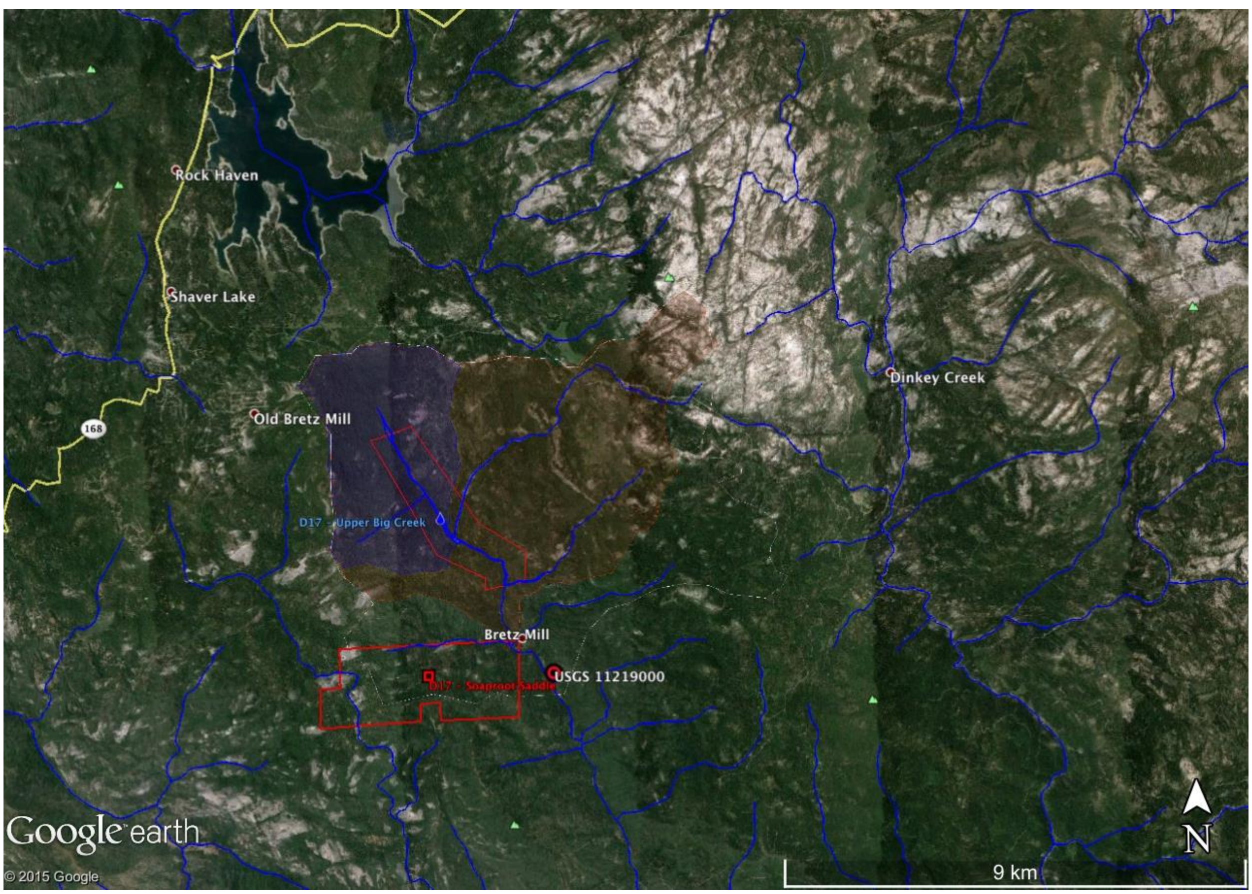

Figure 29 Map of inactive USGS gauging statino 11219000.

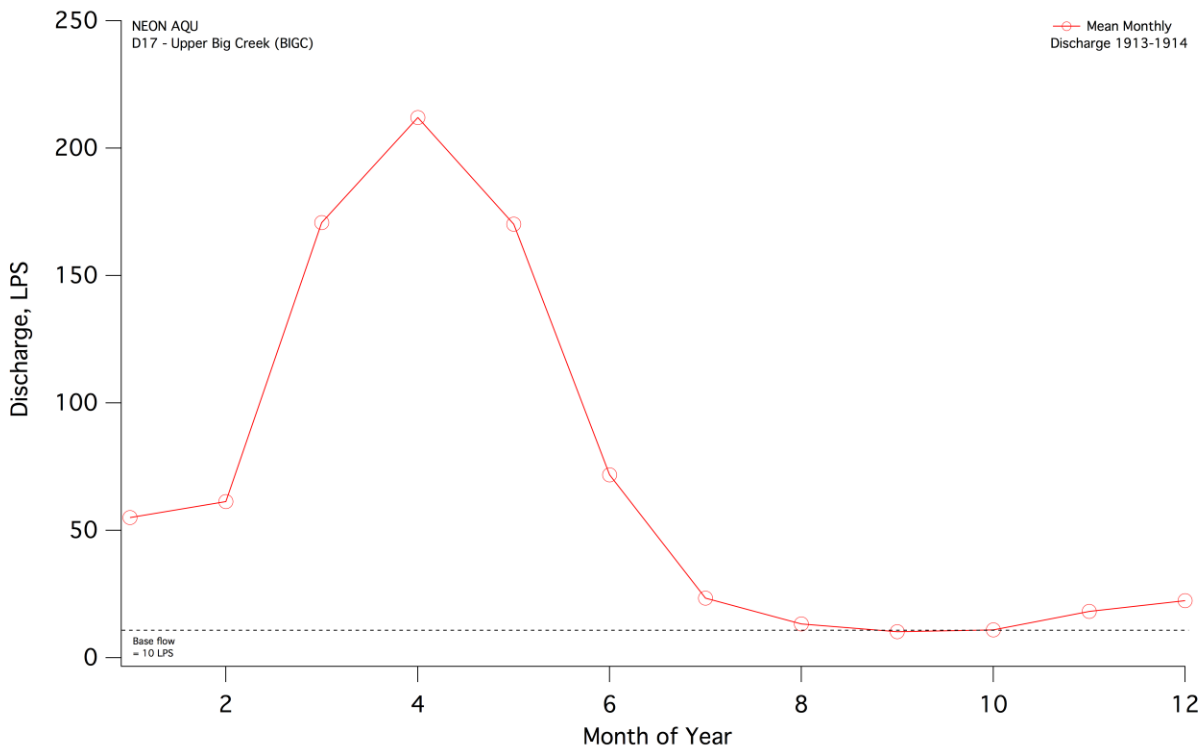

Figure 30 Hydrograph of mean monthly discharge based on historic data and catchment scaling.

3.2.2.2 Climate and Meteorology

The climate in the Big Creek watershed is considered Mediterranean with warm dry summers with temperatures ranging from 14-20^{o}C and mild to moderate wet winters with temperatures ranging from 0-9^{o}C. The annual mean temperature is 11.52 ^{o}C. It represents moist sites of the Sierra Nevada, with annual precipitation averaging 904.8mm. It is below the snow-dominated transition elevation, with recently decreasing proportions of precipitation falling as snow between December and March.

The closest weather station that measures both precipitation and air temperature is at the Fence Meadow Lookout. It is approximately 10 km away and 400m higher in elevation. These data were captured from the California Data Exchange Center hosted by the Dept. of Water Resources. These data are considered provisional.

The data show a mean daily variability in air temperature of approximately 20^{o}C. Precipitation is heaviest through the winter months and early spring with summer months being very dry. The bulk of precipitation at this site and elevation falls as rain. The data from this weather station show an recent average of approximately 40cm of precipitation annually. This is about half of what is historically reported for the site; however this is likely due to the change in location and elevation of the station relative to the site. The same discrepancies in temperature are accounted for by differences in station location.

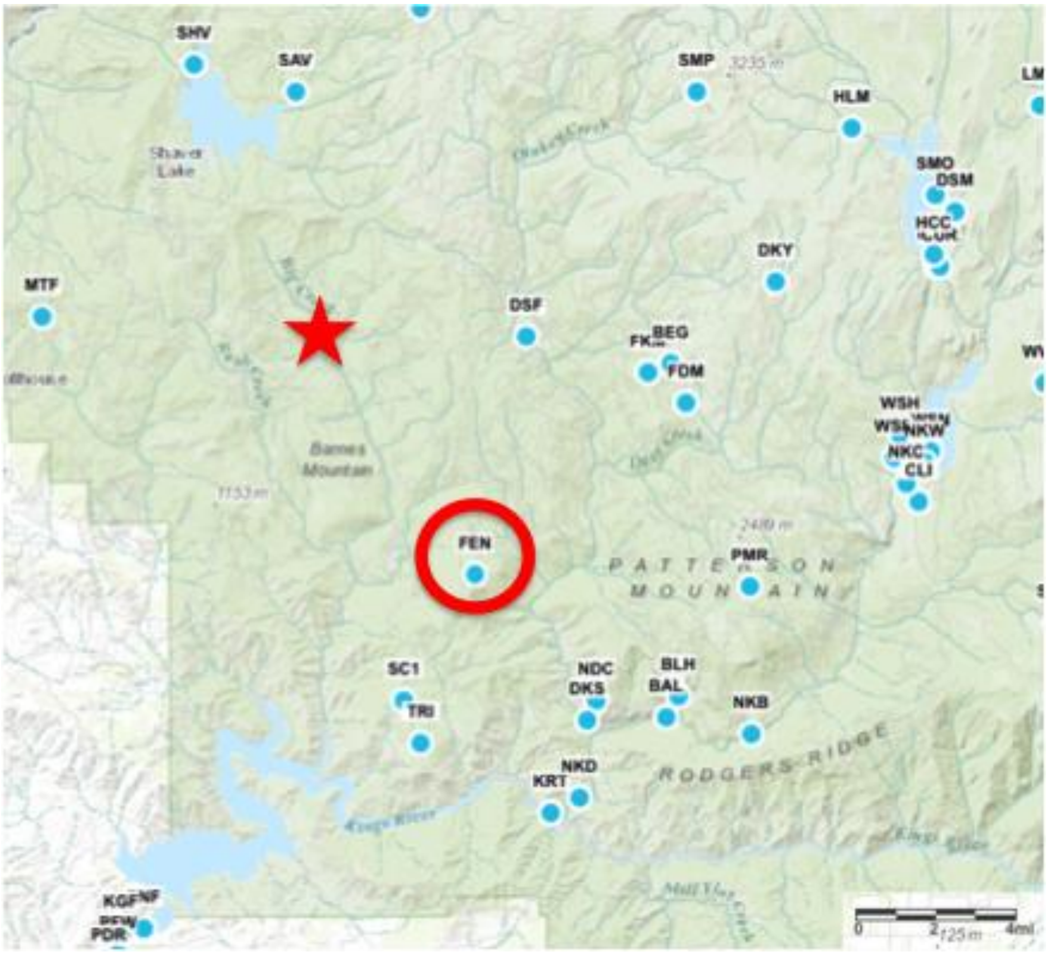

Figure 31 Map showing the nearest weather station for which historic meteorological data was captured.

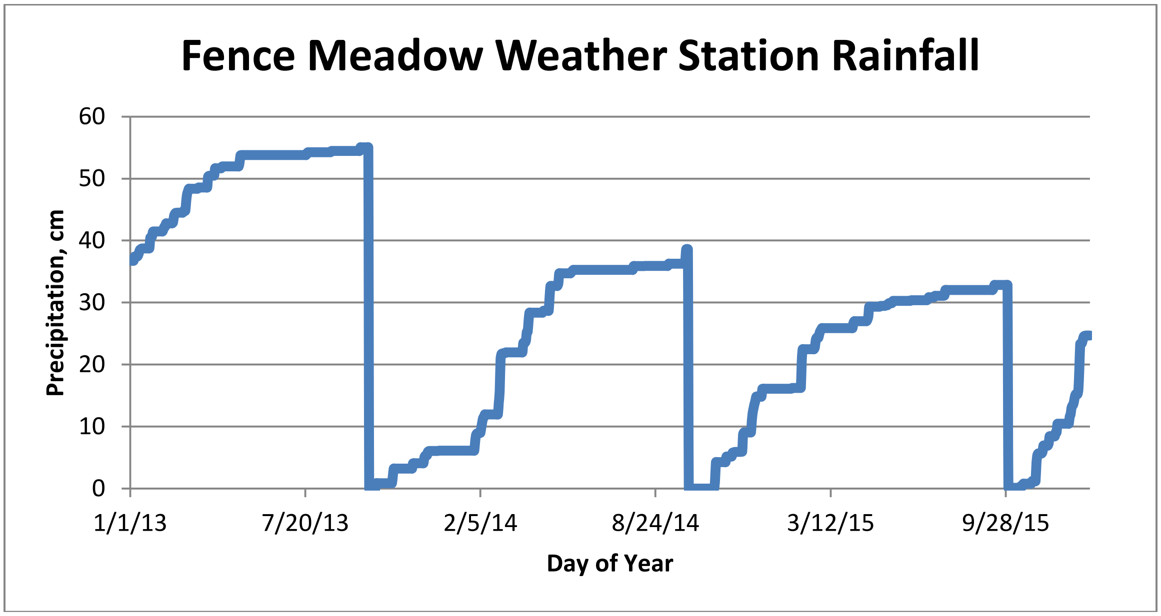

Figure 32 Time series of the accummulated daily precipitation for 2013-2015.

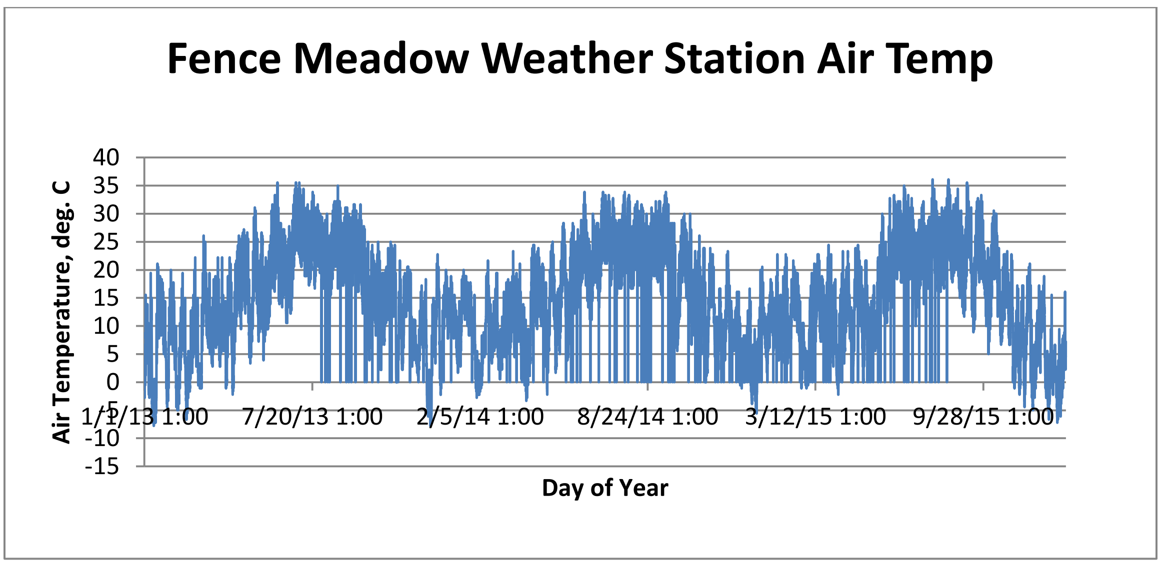

Figure 33 Time series for the air temperature for 2013-2015.

3.2.3 Infrastructure and Construction

3.2.3.1 Aquatic Auxiliary and Aquatic Portal Locations for Construction

The initial estimated location for the Aquatic Auxiliary Portal is:

The initial estimated location for the Aquatic Portal is:

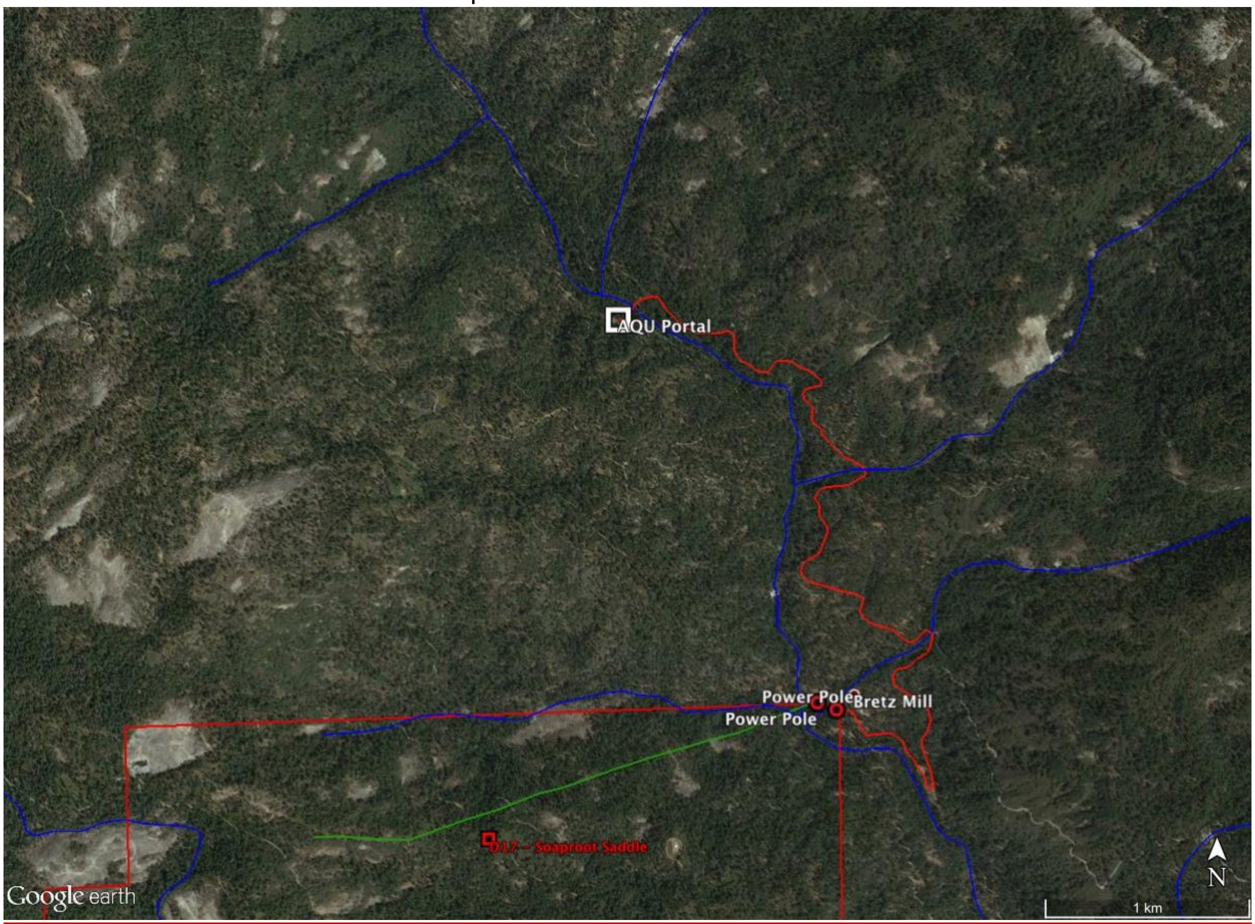

Figure 34 A Google-Earth-Derived Image of Aquatic Auxiliary Portal for D17 Upper Big Creek

Table 7 Aquatic Auxiliary Portal Location

Aquatic Auxiliary Portal	Latitude	Longitude
Location	37.057186°	-119.254828°

Table 8 Aquatic Portal Location

Aquatic Portal	Latitude	Longitude
Location	37.057186°	-119.254828°

3.2.3.2 Sensor Locations for Construction

AQU, with support from EHS, has the following field GPS coordinates for S1 and S2 and met station locations. Many aquatic sites are in narrow canyons or covered by dense canopy, which reduces satellite availability. In these situations, AQU will provide a description of the location and an approximate GPS location (e.g. not accurate to within <1m). This description will suffice for the planning stages, but sites will likely need to be physically marked prior to construction.

Satellite coverage at Upper Big Creek during site characterization was sufficient and produced good estimates of sensor locations as the GPS unit was able to connect to 6+ satellites for all of the measurements. Accuracy of the measurements was reported by the handheld device at sub-meter levels.

These coordinates are to be used for the input to the AIS design:

Table 9 Sensor 1 & Sensor 2 Locations

Sensor	Latitude	Longitude
S1	37.058728°	-119.256475°
S1 - FDP	37.058636°	-119.256523°
S2	37.057549°	-119.255451°
S2 - FDP	37.057602°	-119.255534°

Table 10 Met Station and STREON nutrient addition station Locations

Infrastructure	Latitude	Longitude
Met Station	37.057161°	-119.254937°
Secondary Precipitation Gauge	37.057164°	-119.255075°
Met/Precip - FDP	37.057154°	-119.255098°

Figure 35 Locations of S1, S2, Met Station and Secondary Precipitation for D17 Upper Big Creek.

Figure 36 Downstream of S1 location at D17 Upper Big Creek.

Figure 37 Upstream view of S1 location at D17 Upper Big Creek.

Figure 38 Upstream view of S2 location at D17 Upper Big Creek.

Figure 39 Downstream view of S2 location at D17 Upper Big Creek.

Figure 40 Photo of met station and secondary precipitation gauge location at D17 Upper Big Creek.

3.2.3.2.1 Stream Reach Characterization

The standard salt injection for flow measurements and travel time was not permitted for this site at the time of characterization. However, an exhaustive habitat survey was performed of the 1000m AQU reach. The velocity was measured in a subset of habitat features in order to best estimate the average reach velocity.

Table 11 Average velocities measured in a subset of habitat survey throughout the AQU reach.

Habitat Type	Average Velocity, cm/s	Samples, n
Pool	3.575	4
Run	7.05	1
Riffle	38.10	4
Run/Riffle Complex	19.60	3

These averages were then applied to each of the features at their recorded lengths throughout the reach. This then provided an average reach velocity of 6.77 cm/s. At this rate the distance between the pools should be on the order of 120-180m. With the extensively detailed habitat survey we were able to identify the ideal pools, low in the watershed just upstream from the confluence with Summit Creek, with directly calculated travel times based on the habitat features along that particular extent. The result was a sensor reach length of 182 m with a calculated travel time of 39 minutes near base flow conditions.

The difference in base and seasonally high flows is about 20 times. The geomorphology and substrate material of the stream channel and banks throughout the reach will effect the change in velocity with discharge. The change in velocity will be smaller than the change in discharge because of the geometry of the channel, substrate and vegetation. It is therefore likely that the distance of 182 m that was initially chosen for the sensor reach will be sufficient to measure metabolism across the annual variation in flow.

3.2.3.2.2 Bank Morphology

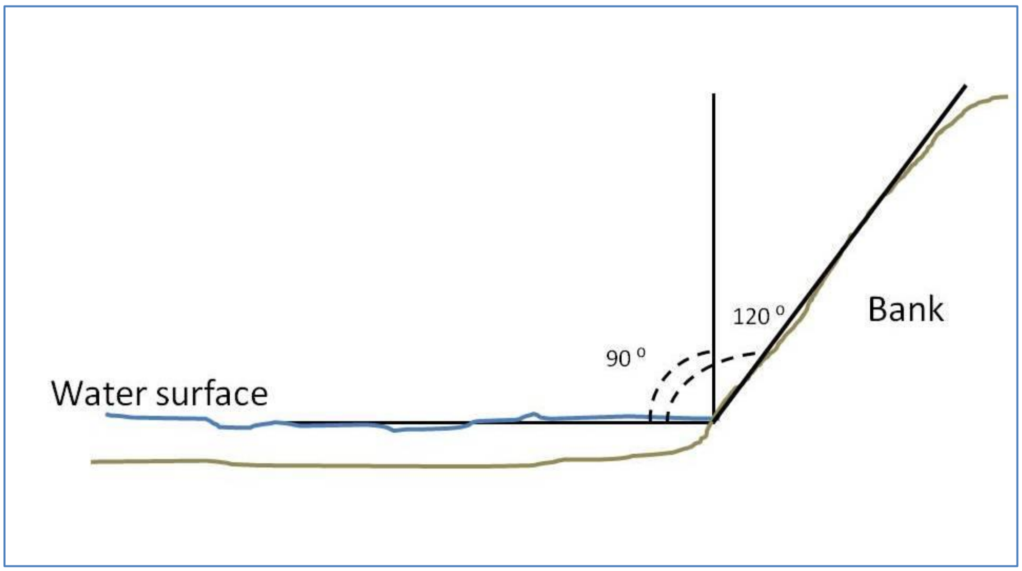

Figure 41 How Bank Angle is Measured

During 2015 site visits, AQU observed the following bank conditions at S1 and S2:

Table 12 Bank Conditions At D17 Upper Big Creek In 2012

Morphology Type	S1	S2
RB* angle	90	140
LB* angle	130	90
Maximum water height	1.80 m	2.58 m
Bankfull width	4.2 m	11.5 m
Substrate composition	Sand, pebbles and cobbles	Sand, pebbles, cobbles and boulders

* RB (right bank) and LB (left bank) are determined by facing downstream.

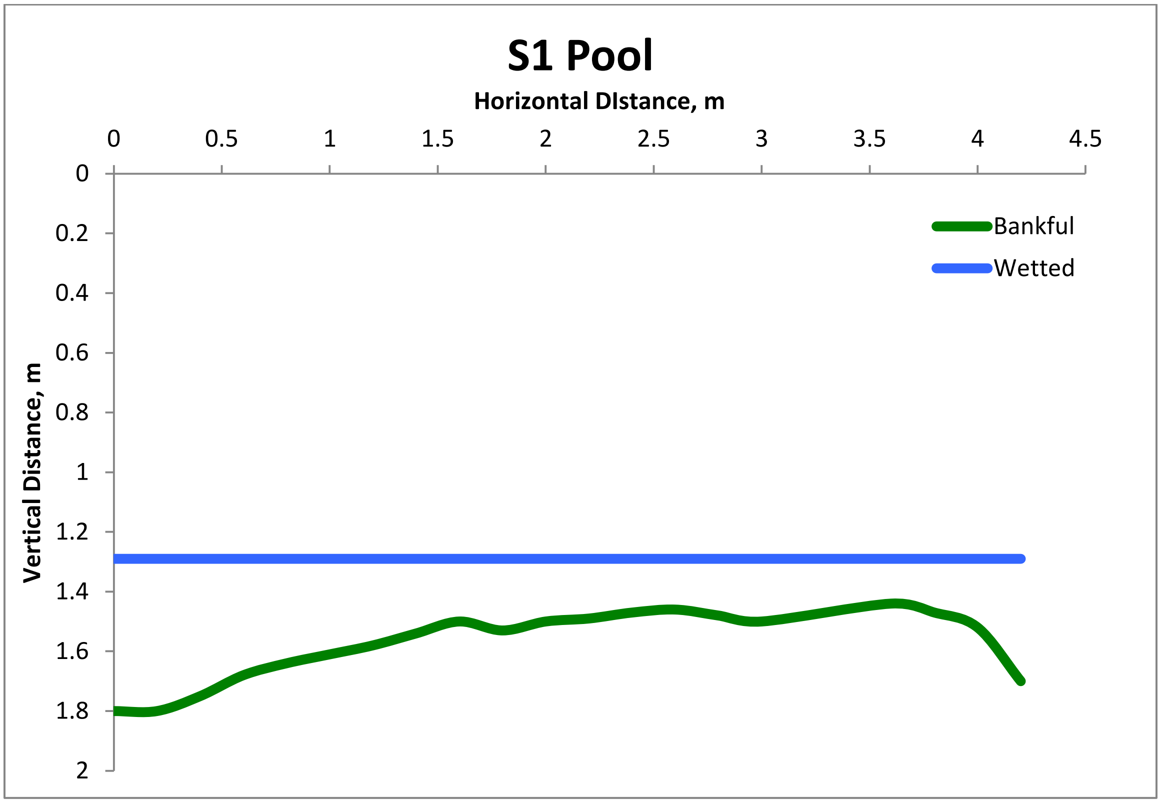

Figure 42 Cross sectional survey at S1 location.

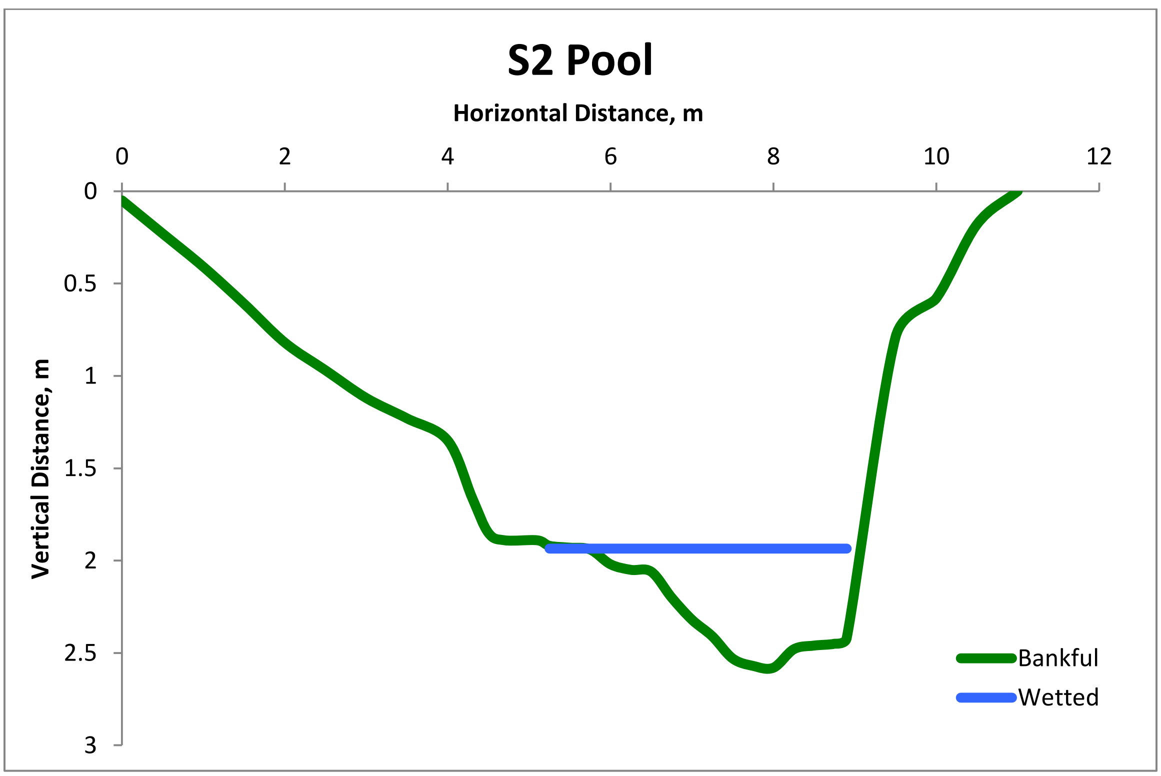

Figure 43 Cross sectional survey at S2 location.

3.2.3.3 Groundwater Wells

This section will be revised once the NEON hydrologist has had a chance to visit the site and determine well locations and installation method. Shown in Figure 44 is an idealized well layout for the site. This figure will be updated following a visit during the late spring/summer 2016, and the coordinates will be supplied in Table 13.

The groundwater observation wells network at the site (Figure 34, Table 13) will consist of 8 wells installed using either a powered hand auger or a direct-push rig (i.e. Geoprobe). While there are areas of shallow bedrock, the majority of drilling at this site should be more straight forward.

Generally the site is accessible for the rig and installation. The estimated drilling depth is approximately 30 feet for all wells. The exact location of the wells may need to change slightly if the rig is unable to reach the desired locations due to the presence of downed trees, thick underbrush, or seasonal boggy regions. The presence of obstructions in the subsurface (e.g. glacial erratics) does not appear to be an issue for this site and minimal issues are anticipated with the installation of the well network.

AQU prefers the surface completion of the wells to include an above-grade stick-up protective cover and be minimally invasive. The State of California has several requirements for construction of groundwater monitoring wells that NEON will either need to meet or apply for a waiver. Chief among the State requirements are 1) an acceptable grout to fill the annular space such as neat cement, bentonite chips, or a bentonite / cement mixture; 2) surface seal of the well requires a poured concrete or cement slab poured around a steel outer casing with a locking cap from a depth of 2 feet below land surface to the top of land surface.

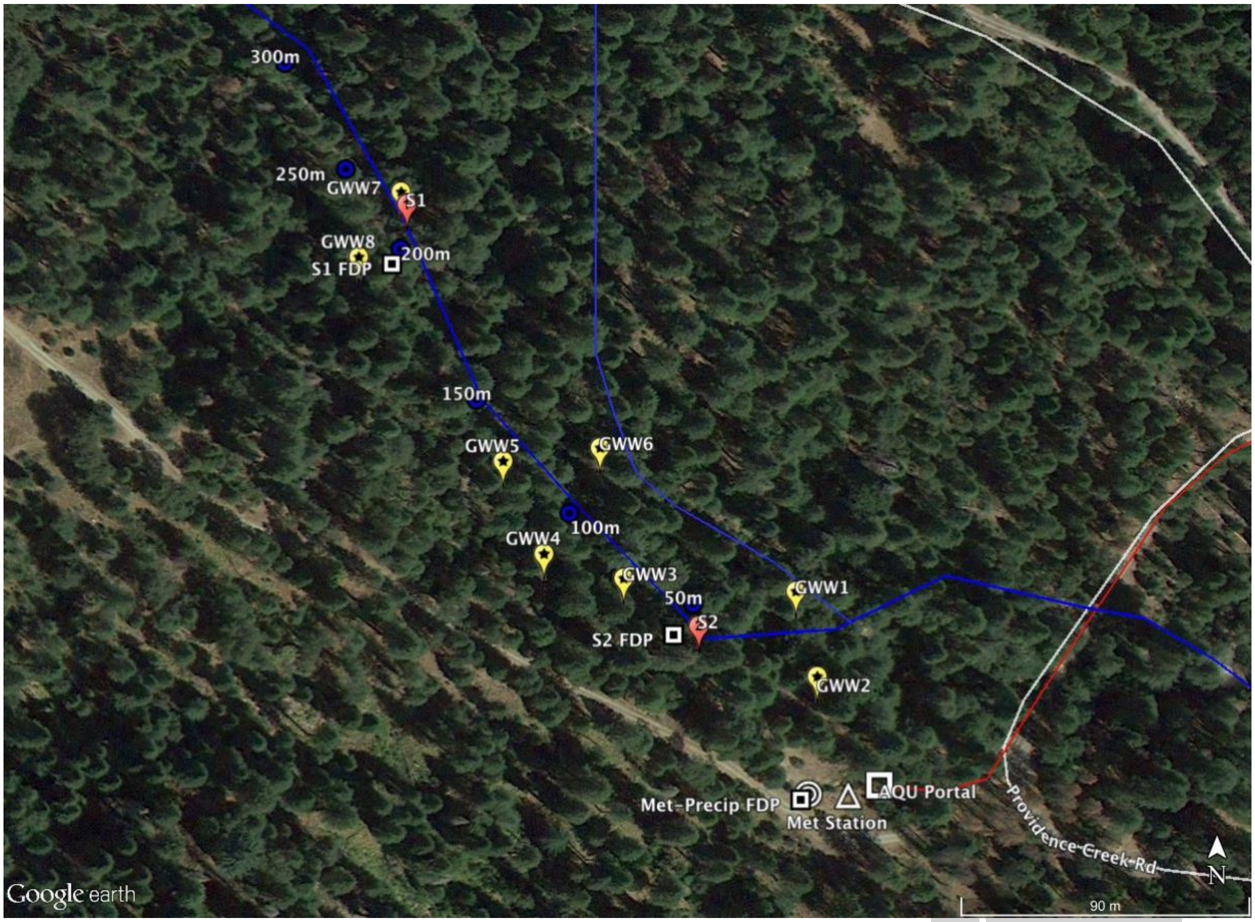

Figure 44 Initial Groundwater Well Locations Based on EMS kmz File at D17 Upper Big Creek.

Table 13 Groundwater well locations at D17 Upper Big Creek.

Well ID	Latitude	Longitude
D17-BIGC-OW-01		
D17- BIGC-OW-02		
D17- BIGC-OW-03		
D17- BIGC-OW-04		
D17- BIGC-OW-05		
D17- BIGC-OW-06		
D17- BIGC-OW-07		
D17- BIGC-OW-08		

3.2.4 Site Access Needs

Upper Big Creek is located in the Sierra National Forrest approximately 92 km ENE of Fresno, CA. It is reachable via Highway 168. From Highway 168 turn south onto Cressman Rd, then turn left onto Peterson Rd. From Peterson Rd, continue onto Big Creek Rd past Bretz Mill camp and then staying left to reach the site. Travel in the area is via maintained paved roads to the parking area. The parking is suitable for two vehicles and there are turn-around areas at the intersecting roads near the bridge.

Figure 45 Photo of parking area at bridge at the base of the AQU reach.

There are existing gravel roads that extend up both sides of the AQU reach (see Figure 35). These may be used to access the stream for sampling and maintenance activities. Therefore no pathway construction or improvements will be needed fro this site.

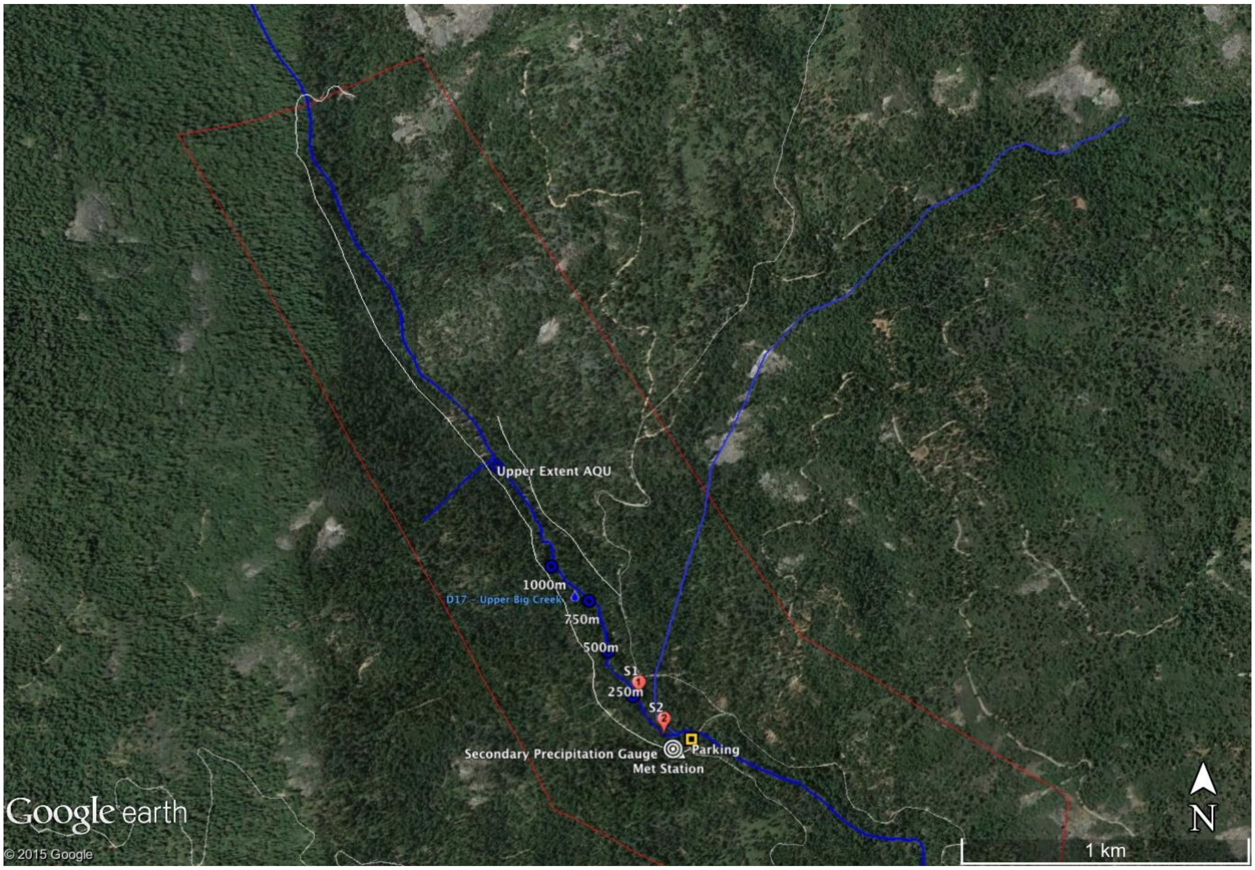

Figure 46 Map of site access roads.

3.2.5 Communications at the Site

See TIS Soaproot site plan.

3.2.6 Power at the Site

The local power utility company is PG&E.

3.2.7 Site Science Construction Constraints and Limitations

At present there are no known site-specific issues to consider at D17 Upper Big Creek.
However, special consideration may be identified during the environmental assessment conducted by the USFWS and USFS regional offices.

3.2.8 Other Issues

No other science issues are identified at this time.

4 APPENDIX A. FCC SUMMARY TABLES FOR AIS SITE COMPONENTS AT D17

4.1 Teakettle 2 Creek FCC Summary Table

Site Component	**Latitude**	**Longitude**	**Units**
Stream, Lake, or River	Stream		Description
Aquatic Auxiliary Power Portal location	36.955366°	-119.026147°	Lat, Long in degrees
Aquatic Portal location	36.955366°	-119.026147°	Lat, Long in degrees
Access Gates needed? Where	No		
Pathway needed? What is length?	Remove down trees from existing path (old road) from parking area to existing gauging stations.		Yes/no, description w/ length
Pathway start location			Lat, Long in degrees
Pathway end location			Lat, Long in degrees
Stairs or ladder needed?	No		Yes/no, description
Boardwalk needed? What is length?	No		Yes/no, description w/ length
Shall stairs, boardwalk be installed during construction?	No		Yes/no, description
Fencing needs	None		Description
Site management			Description
Any additional site specific information			Description

4.2 Upper Big Creek FCC Summary Table

Site Component	Latitude	Longitude	Units
Stream, Lake, or River	Stream		Description
Aquatic Auxiliary Power Portal location	37.057186°	-119.254828°	Lat, Long in degrees
Aquatic Portal location	37.057186°	-119.254828°	Lat, Long in degrees
Access Gates needed? Where	No		
Pathway needed? What is length?	No		Yes/no, description w/ length
Pathway start location			Lat, Long in degrees
Pathway end location			Lat, Long in degrees
Stairs or ladder needed?	No		Yes/no, description
Boardwalk needed? What is length?	No		Yes/no, description w/ length
Shall stairs, boardwalk be installed during construction?	No		Yes/no, description
Fencing needs	None		Description
Site management			Description
Any additional site specific information			Description

5 APPENDIX B. EHS SUMMARY TABLES FOR AIS SITE COMPONENTS AT D17

5.1 Teakettle 2 Creek EHS Summary Table

Site Component	Latitude	Longitude	Units
Sensor 1 (S1) location	36.954756°	-119.024981°	Lat, Long in degrees
S1 Field Device Post	36.954853°	-119.025441°	Meters from S2
Sensor 2 (S2) location	36.955204°	-119.023544°	Lat, Long in degrees
S2 Field Device Post	36.955175°	-119.023705°	Meters from S2
Met Station location	36.955269°	-119.026122°	Lat, Long in degrees
Met Field Device Post	36.955360°	-119.026171°	Lat, Long in degrees
Aquatic Auxiliary Power Portal location	36.955366°	-119.026147°	Lat, Long in degrees
Aquatic Portal location	36.955366°	-119.026147°	Lat, Long in degrees

5.2 Upper Big Creek EHS Summary Table

Site Component	Latitude	Longitude	Units
Sensor 1 (S1) location	37.058728°	-119.256475°	Lat, Long in degrees
S1 Field Device Post	37.058636°	-119.256523°	Meters from S2
Sensor 2 (S2) location	37.057549°	-119.255451°	Lat, Long in degrees
S2 Field Device Post	37.057602°	-119.255534°	Meters from S2
Met Station location	37.057161°	-119.254937°	Lat, Long in degrees
Met-Precipitation Field Device Post	37.057154°	-119.255098°	Lat, Long in degrees
Precipitation Gauge (tipping bucket)	37.057164°	-119.255075°	Lat, Long in degrees
Aquatic Auxiliary Power Portal location	37.057186°	-119.254828°	Lat, Long in degrees
Aquatic Portal location	37.057186°	-119.254828°	Lat, Long in degrees

6 APPENDIX C. IT SUMMARY TABLES FOR AIS SITE COMPONENTS AT D17

6.1 Teakettle 2 Creek IT Summary Table

Site Component	Latitude	Longitude	Units
REQUIRED			
Aquatic Auxiliary Power Portal location	36.955366°	-119.026147°	Lat, Long in degrees
Aquatic Portal location	36.955366°	-119.026147°	Lat, Long in degrees
DESIRED			
Cell tower visible from site			Yes/no
Cell phone signal at site			Yes/no, which carrier?
Strength of cell phone signal			Description
Facility on property			Yes/no
Internet connectivity at facility			Yes/no, description
Phone number at facility location			Area code & first 3 needed

6.2 Upper Big Creek IT Summary Table

Site Component	Latitude	Longitude	Units
REQUIRED			
Aquatic Auxiliary Power Portal location	37.057186°	-119.254828°	Lat, Long in degrees
Aquatic Portal location	37.057186°	-119.254828°	Lat, Long in degrees
DESIRED			
Cell tower visible from site			Yes/no
Cell phone signal at site			Yes/no, which carrier?
Strength of cell phone signal			Description
Facility on property			Yes/no
Internet connectivity at facility			Yes/no, description
Phone number at facility location			Area code & first 3 needed

7 APPENDIX D. HABITAT SURVEYS FOR AIS SITES AT D17

7.1 Teakettle 2 Creek Habitat Survey (subset velocity survey)

Habitat Type	Velocity, cm/s	Depth, cm
Pool - head	3.98	
Pool - tail	4.28	
Pool - mid	0.66	
Riffle	29.3	4
Run/Riffle Complex	11.05	6
Run	4.82	12
Run	6.16	4
Pool	4.1/2.2	
Run	5.4	4
Step Complex	4.87	
Riffle	9.49	
Pool	3.36	20
Pool	3.95	26
Run	6.38	22
Pool	3.2	

7.2 Upper Big Creek Habitat Survey

Habitat feature	Length (m)	Location In Stream from bottom (m)	Wetted width (m)	Depth (cm)	CWD (%)	Substratum (%)
Run						
Pool -S2	2.4	52.4	2.4	32	5	10 Boulder, 90 Sand
Run	6.4	58.8	3.6	26	0-5	15 Boulder, 85 Sand
Riffle	6.4	65.2	3	8	0-5	65 Boulder, 35 Sand
Run	15	80.2	4	18	20	10 Boulder, 90 Sand
Pool	7.4	87.6	2	42	5	5 Boulder, 95 Sand Gravel Mix
Run	12	99.6	4	12	5	5 Boulder, 95 Sand
Pool	4.3	103.9	6	40	15	100 Sand
Run	12	115.9	1.5	14	50	5 Boulder, 95 Sand
Riffle	13.5	129.4	3	8	5-10	90 Boulder, 10 Sand
Run	10	139.4	2.5	20	0-5	60 Boulder, 40 Sand Gravel Mix
Riffle/Run Complex	27	166.4	3	10	0-5	90 Boulder, 10 Sand Gravel Mix
Pool	15	181.4	4.5	56	50	5 Boulder, 95 Sand Gravel Mix
Riffle/Run Complex	22.5	203.9	3	14	40	35 Boulder, 65 Sand Gravel Mix
POOL	5.5	209.4	3.5	32	50	5 Boulder, 95 Sand Gravel Mix
Riffle/Run Complex	18	227.4	4	10	40	35 Boulder, 65 Sand Gravel Mix
Pool - S1	7.5	234.9	4	50	15	5 Boulder, 95 Sand Gravel Mix
Run	50	284.9	3	20	60	5 Boulder, 95 Sand Gravel Mix
Run	12	296.9	1.5	10	30	100 Sand
Pool	6	302.9	3	50	20	100 Sand
Riffle/Run Complex	16.5	319.4	3	10	10	65 Boulder, 35 Sand Gravel Mix
Pool	16.5	335.9	4	35	80	100 Sand
Run	35.5	371.4	2	12	10	100 Sand Gravel Mix
Pool	7	378.4	2	45	0-5	100 Sand
Run	8	386.4	3	6	5-10	100 Sand Gravel Mix
Pool	10.5	396.9	4	25	20	100 Sand
Run	50	446.9	2.5	20	35	100 Sand Gravel Mix
Riffle/Run	27	473.9	2.5	16	0-5	50 Sand, 50 Cobble

Complex						
Pool	7	480.9	3	36	60	100 Sand Gravel Mix
Run	21	501.9	3	16	30	100 Sand Gravel Mix
Run	8	509.9	3	12	5	100 Sand Gravel Mix
Pool	5	514.9	2.5	38	15	mix 100
Run	16	530.9	2	14	15	mix 100
Pool	3.5	534.4	4	36	10	mix 100
Run	17.5	551.9	2	10	15	mix 100
Run	38	589.9	2	16	10	mix 100
Pool	9	598.9	5	24	70	mix 100
Run	3	601.9	1	4	15	mix 100
Run	17	618.9	1	6	5	mix 100
Pool	7	625.9	2.5	16	20	mix 100
Run	11	636.9	4	10	5	mix 100
Pool	5	641.9	2	40	0-5	mix 100
Run	10	651.9	2	20	0-5	mix 100
Pool	15	666.9	4	58	10	mix 100
Run	4	670.9	3	10	10	
Riffle	4	674.9	3	6	5	cobble 65, sand/gravel 35
Run	8.5	683.4	3	12	0-5	cobble 5, sand/gravel l95
Pool	6.5	689.9	3	46	20	100 Sand Gravel Mix
Run	12	701.9	3	14	15	100 Sand Gravel Mix
Run	19	720.9	2.5	16	5	5 Cobble, 95 Sand Gravel Mix
Pool	7	727.9	2.5	30	25	100 Sand Gravel Mix
Riffle/Run Complex	22	749.9	2	16	20	5 Cobble, 95 Sand Gravel Mix
Pool	2	751.9	2	26	5	100 Sand Gravel Mix
Pool	4	755.9	5	52	50	100 Sand Gravel Mix
Run	19	774.9	2.5	10	0-5	100 Sand Gravel Mix
Pool	4	778.9	5	50	5	2 Boulder, 5 Cobble, 93 Sand Gravel Mix
Riffle	4	782.9	1	6	0	90 Cobble, 10 Pebble
Run	9	791.9	3	12	5	40 Cobble, 60 Sand Gravel Mix
Riffle	5	796.9	4	4	0	90 Cobble, 10 Sand Gravel Mix
Pool	5	801.9	2.5	36	5	30 Cobble, 70 Sand Gravel Mix
Pool	11	812.9	3	32	10	10 Cobble, 90 Sand Gravel Mix
Run	15	827.9	1.5	27	5	85 Cobble, 15 Sand Gravel Mix
Pool	8	835.9	4	50	30	20 Cobble, 80 Sand Gravel Mix
Run	20	855.9	4	18	0-5	25 Cobble, 75 Sand Gravel Mix
Pool	2	857.9	4	32	10	100 Sand Gravel Mix
Run	4	861.9	4	18	5	100 Sand Gravel Mix

Run	18	879.9	3.5	14	10	5 Cobble, 95 Sand Gravel Mix
Riffle	4.5	884.4	5	6	0-5	95 Cobble, 5 Gravel
Pool	7.5	891.9	5	10	15	100 Sand
Run	1	892.9	3	24	20	100 Sand Gravel Mix
Pool	3	895.9	5	35	50	100 Sand Gravel Mix
Run	4	899.9	3.5	12	10	2 Cobble, 98 Sand Gravel Mix
Pool	4	903.9	3	32	5	5 Cobble, 95 Sand Gravel Mix
Riffle	2.5	906.4	3	6	0-5	75 Cobble, 25 Sand Mxi
Run	1.5	907.9	2	14	0-5	45 Cobble, 55 Sand Gravel Mix
Run	9	916.9	3	14	0-5	15 Cobble, 5 Boulder, 80 Sand Gravel Mix
Pool	4	920.9	2	54	10	5 Boulder, 5 Cobble, 90 Sand Gravel Mix
Riffle/Run Complex	6	926.9	1	8	5	100 Sand Gravel Mix
Pool	9	935.9	5	70	65	100 Sand Gravel Mix
Riffle/Run Complex	12	947.9	2	10	5	5 Cobble, 95 Sand Gravel Mix
Pool	10	957.9	4	60	25	100 Sand Gravel Mix
Pool	3	960.9	5	74	5	10 Cobble, 90 Sand Gravel Mix
Riffle	4	964.9	5	4	0	90 Cobble, 5 Boulder, 5 Sand Gravel Mix
Pool	21	985.9	4	34	15	10 Cobble, 90 Sand Gravel Mix
Riffle/Run Complex	22	1007.9	2	16	10	50 Cobble, 50 Sand Gravel Mix