D14 AQUATIC INSTRUMENT SYSTEM (AIS)
SITE CHARACTERIZATION REPORT

PREPARED BY	ORGANIZATION	DATE
Ryan Utz	AQU	02/07/2012
Michael Fitzgerald	AQU	02/07/2012
Heather. Powell	AQU	02/07/2012
Charlotte Roehm	AQU	10/25/2013
Charles Bohall	AQU	02/24/2016

APPROVALS (Name)	ORGANIZATION	APPROVAL DATE
Andrea Thorpe	SCI	03/28/2016
Kathy Kirby	PMO	03/07/2016
Tracey Baldwin	AQU	03/07/2016

RELEASED BY (Name)	ORGANIZATION	RELEASE DATE
Jennifer DeNicholas	CM	03/29/2016

See configuration management system for approval history

Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	05/15/2014	ECO-01628	Initial release
B	03/29/2016	ECO-03738	New locations for Sensor Set 1 and Sensor Set 2

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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)/STREON (STR) 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 D14 Aquatic locations: Sycamore Creek (core). 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 D14 AIS SITE CHARACTERIZATION REPORT

3.1 Sycamore Creek

Sycamore Creek is a mid-sized, spatially intermittent, wadable Sonoran desert stream with a watershed area of approximately 500 km^2. As is typical of most Sonoran streams, the hydrologic attributes of Sycamore Creek is highly temporally variable: discharge can remain above zero during the wet season of January-April then typically remain nearly or completely dry from May through December, with episodic very high flow events occurring during the wet season and late summer/early fall. Such hydrologic attributes will prove particularly challenging for maintaining NEON sensor infrastructure, as during some seasons flow may increase several orders of magnitude over a period of hours, while during others zero-flow periods will dominate.

3.1.1 Aquatic Auxiliary and Aquatic Portal Locations for Construction

The estimated location for the Aquatic Auxiliary Portal is:

Figure 1 A Google-Earth-Derived Image of Aquatic Auxiliary Portal for D14 Sycamore Creek

This site is planned for alternate power. Solar is the current target alternate power option, although details are TBD.

Table 1 Aquatic Auxiliary Portal Location

Aquatic Auxiliary Portal	Latitude	Longitude
Location	33.751736°	-111.507222°

Table 2 Aquatic Portal Location

Aquatic Portal	Latitude	Longitude
Location	33.751736°	-111.507222°

3.1.2 Sensor Locations for Construction

The GPS coordinates for S1, S2, Field Device Posts, and the Met Station proposed by AQU, with input from EHS, are presented in Table 3. 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 need to be physically marked prior to construction.

These coordinates are to be used for the input to the AIS design for S1, S2, and the Met station are summarized in Tables 3-5 and Figures 1-5. Sensors associated with discharge measurements may be co-located with either the S1 or S2 sensor stations.

Table 3 Sensor locations for Sycamore Creek.

Sensor	Latitude	Longitude
S1	33.751834°	-111.508653°
S1-FDP	33.751636°	-111.507889°
S2	33.751161°	-111.508389°
S2-FDP	33.751297°	-111.507622°

Table 4 Met station, Secondary Precipitation and NADP location for Sycamore Creek.

Sensor	Latitude	Longitude
Micromet	33.751668°	-111.507840°
Micromet FDP	33.751730°	-111.507760°
Secondary Precipitation	33.751863°	-111.507829°
Precipitation FDP	33.751829°	-111.507829°
NADP	33.751861°	-111.507880°

Figure 2 Map of D14 Sycamore Creek with AQU S1, S2, and micrometeorology station locations.

Figure 3 S1 location at D14 Sycamore Creek. **Note that the benthic substrate consists of sand, thus channel features will likely evolve considerably over time, particularly following high flow events. Shown is the downstream direction. The main channel may be braided at times.**

Figure 4 S2 Location at D14 Sycamore Creek. Shown is the downstream direction. Multiple active channels are very common in Sycamore Creek.

Figure 5 Micrometeorology station location at D14 Sycamore Creek.

Figure 6 Much of the channel in Sycamore Creek consists entirely of sandy reaches, which will shift and evolve during high flow events.

3.1.3 Groundwater Wells

Groundwater monitoring in the hill slopes surrounding the reach will be challenging. The underlain strata consist largely of shallow soils on top of fractured granitic bedrock. Along the western edge of Sycamore Creek the bedrock is exposed and hill slope too steep to operate conventional drilling equipment. The monitoring well network is proposed to be concentrated using a zigzag pattern as shown in Figure 7. GPS coordinates of the wells are summarized in Table 5.

Table 5 Coordinates for Groundwater Monitoring Wells

Well ID	Latitude	Longitude
D14-SYCA-OW-01	33.752086°	-111.508072°
D14-SYCA-OW-02	33.751850°	-111.508258°
D14-SYCA-OW-03	33.751681°	-111.508083°
D14-SYCA-OW-04	33.751503°	-111.508281°
D14-SYCA-OW-05	33.751394°	-111.508064°
D14-SYCA-OW-06	33.751172°	-111.508136°
D14-SYCA-OW-07	33.750900°	-111.507911°

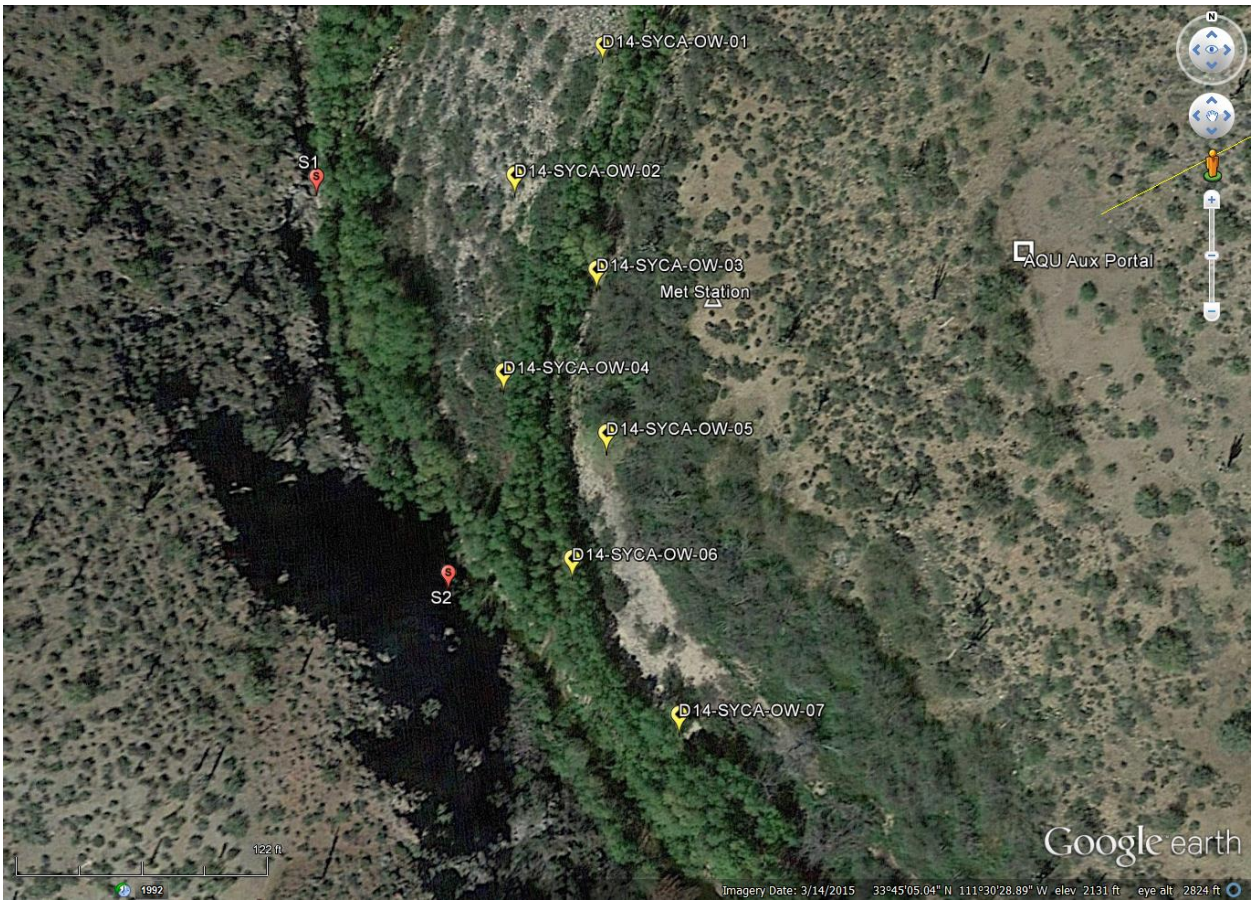

Figure 7 Groundwater monitoring well locations at D14 Sycamore Creek

3.1.4 Riparian Vegetation Cover

During 2010-2011 site visits, the following plant density and type were observed by the AQU team:

Riparian vegetation at Sycamore Creek consists mostly of small trees, shrubs, cactus and grasses. Although some plants grow greater than chest high, and there are taller, mature sycamore and oak trees growing sporadically immediately adjacent to the channel.

Figure 8 Typical riparian vegetation cover at D14 Sycamore Creek

3.1.5 Bank Morphology

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

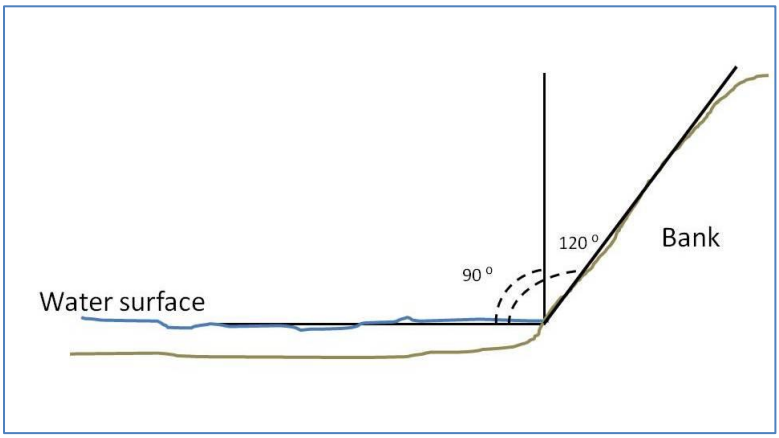

Figure 9 How Bank Angle is Measured

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

Table 6 Bank attributes of D14 Sycamore Creek at sensor locations.

Morphology Type	S1	S2
RB* angle	100	95
LB* angle	170	160
Maximum water height	1.3 m (from thalweg to base of canyon)	2.7 m (from thalweg to vegetated floodplain)
Bankfull width†	60 m	30 m
Substrate composition	Sand	Sand

* RB (right bank) and LB (left bank) are determined by facing downstream.
†Note that these distances *do not* correspond to the width between canyon walls- which likely represents the true bankfull width. Distances between canyon walls exceed 50 m in each case.

3.1.6 Site Photos

The following photos of are representative of the site.

Figure 10 Much of D14 Sycamore Creek consists of a sandy channel.

Figure 11 Very high intensity flood events occur in Sycamore Creek. Shown here is debris transported by a recent flood that remained in a riparian tree.

Figure 12 The true channel of Sycamore Creek is very large. Although riparian trees can grow within the channel as shown here, multiple side channels active only during high flow events are located behind these trees. The true channel is typically 50+ meters wide.

Figure 13 More evidence of high-intensity floods that occur in Sycamore Creek. **Floods of the magnitude that deposited the debris likely recur annually.**

Figure 14 The vegetation of the Sycamore Creek basin consists of many plants hazardous to the touch- cactus and thorny shrubs. **Thus a path from the access road will need to be cleared to avoid contact with such vegetation.**

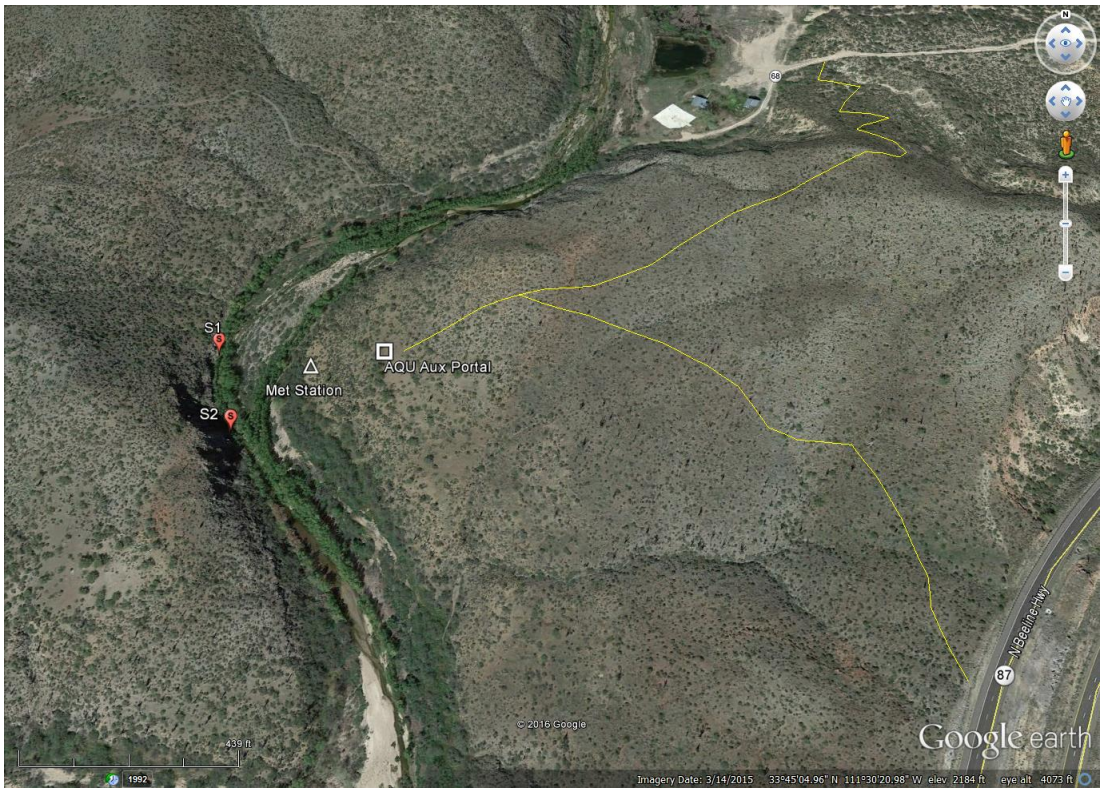

Figure 15 A new 600 m path from highway AZ 87 to the Sycamore Creek channel will need to be developed. The approximate route of this path is shown on the map above. However, the exact route is adjustable. An alternative route is shown from Forest Road 68.

3.1.7 Site Access Needs

For Operations at the site, an access path will be required. There are two main options:

Option 1. A ~600 m path cleared from AZ highway 87 to the stream channel. The approximate route (and areas in the near vicinity) shown in Figure 15 features a moderate gradient and should not require stairs or a ladder. A parking area and secure gate may be needed for site security.

Option 2. Access via the ranch north of the site. This will allow Domain personnel to park a vehicle in a secure area and transport equipment more easily than in Option 1. Option 2 features a severe gradient that may require stairs, ladders, and/or switchbacks.

Both options will need to be pursued simultaneously until a final resolution is in place.

In addition to access to the site, narrow paths along Sycamore Creek may be required to minimize disturbance to vegetation and provide access to NEON infrastructure during regular Operations.

3.1.8 Communications at the Site

- See table in Appendix C for additional IT info.

3.1.9 Power at the Site

There is no local power utility within a 5 mile radius from the site. This site is planned for alternate power.

3.1.10 Site Science Construction Constraints and Limitations

Site-specific issues to consider at D14 Sycamore Creek are:

- The most significant challenge at Sycamore Creek is the hydrologic regime of the stream. Extreme high flow events will very likely threaten sensors and any other *in situ* NEON infrastructure – **designs should take into account the likelihood (~every 5 years) of repeated high stream flow/debris flow events.**
- Personnel working at the site during Construction should be aware of weather in the upstream direction. A localized rainstorm 100s of miles upstream can cause flash flooding at this site – personnel should check weather reports for the local and upstream areas prior to work each day. Once on-site, personnel should pay attention to sudden changes in water levels, or rumbling (e.g. train or landslide) noises from upstream as these are often precursors to large flash floods.
- **The site is subject to damage via theft and vandalism.** Locals have reported that any object that can be seen from the highway will be investigated (e.g. shot at, stolen, or damaged). Thus, any infrastructure or sensors will need to be Objects of value to be located outside of the channel (i.e. solar panels, sensor support equipment) must be kept out of the line of site with route 87 to prevent vandals and thieves from destroying NEON equipment.

Driving and access constraints for D14 Sycamore Creek are:

- **A footpath from highway 87 to the Sycamore Creek channel will need to be constructed.** Either the existing pull-off area along the away could be used (which would require a relatively longer footpath) or a new area for vehicles to pull off could be developed.
- **A footpath along the left bank of Sycamore Creek will need to be developed to allow access to all sensor locations and NEON infrastructure**.

3.1.11 Other Issues

No other science issues are identified at this time.

3.2 Sycamore Creek (STR)

Sycamore Creek (STR) is a mid-sized, spatially intermittent, wadable Sonoran desert stream with a watershed area of approximately 500 km^2. As is typical of most Sonoran streams, the hydrologic attributes of Sycamore Creek (STR) is highly temporally variable: discharge can remain above zero during the wet season of January-April then typically remain nearly or completely dry from May through December, with episodic very high flow events occurring during the wet season and late summer/early fall. Such hydrologic attributes will prove particularly challenging for maintaining NEON sensor infrastructure, as during some seasons flow may increase several orders of magnitude over a period of hours, while during others zero-flow periods will dominate.

3.2.1 Aquatic Auxiliary and Aquatic Portal Locations for Construction

Refer to section 3.1.1. for information on the Aquatic Auxillary Portal and Aquatic Portal Locations at this site. The STREON portal will be at 33.748630°, -111.506540°

3.2.2 Sensor Locations for Construction

The GPS coordinates for STR S1, STR S2 and the STREON nutrient addition station obtained by AQU, with input from EHS, are presented in Tables 7 and 8. 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.

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

Table 7 STREON Sensor 1 & Sensor 2 Locations

Sensor	Latitude	Longitude
STR S1	33.748579480	-111.506655652
STR S2	33.748298902	-111.507439941

Sensors supporting discharge measurements would best be co-located with the STR *S2* location.

A flat, vegetated area located on the right bank near the S1 sensor appears suitable for installing sensor supporting equipment. However, the flat area very likely becomes inundated during high flow events. The valley slope (that does not flood) is located nearby. Only one nutrient addition station is required for Sycamore Creek (STR).Table 8 lists suggested coordinates for installing the STREON nutrient drip. However, any location may be selected so long as the nutrient addition station is deployed within 20 m of the STREON S1 sensor set. The nutrient addition station may need to be deployed on an elevated platform to prevent flood damage if deployed very near the channel.

Table 8 STREON hut location. The coordinates provided correspond to the slope immediately adjacent to the terraced, vegetated area that may also prove suitable for a hut location. These coordinates are suggestions and need not be rigidly adhered to.

Hut	Latitude	Longitude

Nutrient drip Location	33.748603	--111.506521

Figure 16 Map of D14 Sycamore Creek (STR) showing STR S1, STR S2, and nutrient station locations.

Figure 17 STR S1 location at D14 Sycamore Creek (STR). A flat, vegetated area is located on the right bank and appears suitable for installing sensor supporting equipment. However, the flat area very likely becomes inundated during high flow events. The valley slope (that does not flood) is located nearby.

Figure 18 STR S2 location at D14 Sycamore Creek (STR), facing upstream. Note that the left bank is a bedrock outcrop and the beginning of a sheer cliff. Despite this feature, one may access the sensor location on foot (except during very high flows).

Figure 19 Meteorology station, STREON hut and STREON nutrient drip apparatus location at D14 Sycamore Creek (STR). A flat, grassy terrace immediately adjacent to the channel provides a suitable location for installing such facilities. **However, this terrace is very likely inundated during high flow events. Therefore, positioning infrastructure on the slope shown in the right-hand edge of this figure may prove the best option. Alternatively, facilities may be anchored and/or raised to help withstand high flow events.**

Figure 20 The flat, vegetated area in between the AQU and Sycamore Creek (STR) reaches appears for installing various NEON infrastructure, though the terrace likely floods during high flow events. However, the water velocity during such events is not likely very high (as suggested by the vegetation) and **a raised STREON hut on this terrace may prove to be the best option.**

3.2.3 Groundwater Wells

A network of 8 shallow groundwater monitoring wells will be installed on the eastern side of Sycamore Creek. The monitoring well network will begin in the Aquatic reach and will terminate before the STREON reach. Details and a summary of monitoring well locations is contained in Section 3.1.3.

3.2.4 Riparian Vegetation Cover

During 2010-2011 site visits, the following plant density and type were observed by the AQU team:

Riparian vegetation consists at Sycamore Creek (STR) consists mostly of small trees, shrubs, cactus and grasses. Although very few plants grow greater than chest high, mature sycamore and oak trees sporadically grown immediately adjacent to the channel. The majority of the canopy along the Sycamore Creek (STR) channel is entirely open.

Figure 21 Typical riparian vegetation along the channel of D14 Sycamore Creek (STR).

3.2.5 Bank Morphology

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

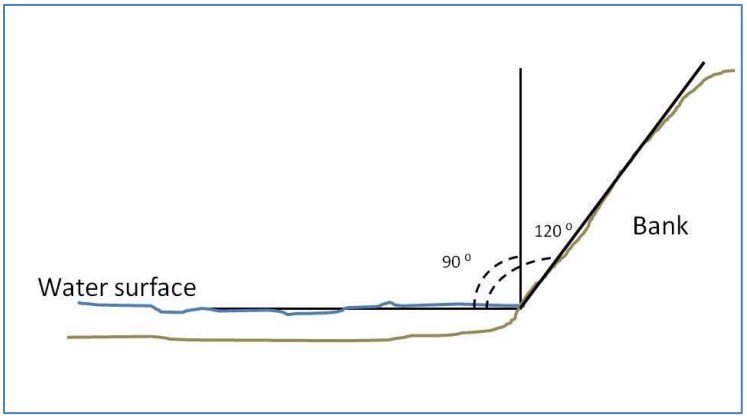

Figure 22 How Bank Angle is Measured

During 2011 site visits, AQU observed the following bank conditions at STR S1 and S2:

Table 9 Bank attributes at D14 Sycamore Creek (STR).

Morphology Type	STR S1	STR S2
RB* angle	170	90
LB* angle	145	130
Maximum water height	2.0 m (from thalweg to terraced floodplain, not canyon wall)	2.3 m (from thalweg to terraced floodplain, not canyon wall)

Bankfull width	23.5 m (terraced floodplain, not canyon wall)	13.6 m (terraced floodplain, not canyon wall)
Substrate composition	Boulder and sand	Sand and boulder

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

3.2.6 Site Photos

The following photos of are representative of the site.

Figure 23 In many places within Sycamore Creek (STR), thick mats of filamentous algae cover the stream bottom.

Figure 24 Large boulders characterize high-gradient short reaches of Sycamore Creek (STR).

Figure 25 In other places, sand entirely dominates the benthic substrate of Sycamore Creek (STR).

Figure 26 The channel of Sycamore Creek (STR) during low or baseflow conditions consists of multiple inactive sub-channels such as this one.

Figure 27 Emergent macrophytes such as the cattails shown here are commonly encountered along the active channel of Sycamore Creek (STR).

Figure 28 Old barbed wire fencing from defunct ranching operations may require removal during construction of access paths.

3.2.7 Site Access Needs

Access at Sycamore Creek (STR) will require a ~400 m path cleared from AZ highway 87 to the stream channel. The approximate route (and areas in the near vicinity) shown in Figure 15 features a moderate gradient and should not require stairs or a ladder. A gravel area where several cars may pull off the highway is already developed along route 87 just south of the area shown in Figure 15.

Additionally, paths along the Sycamore Creek (STR) channel will be required to minimize disturbance to vegetation and provide access to NEON infrastructure. Near the bottom of the STREON reach (the southern end of the blue line shown in Figure 15) is a sheer cliff on the left bank. Although the sensor location is at the edge of the sheer face, the cliff may complicate access and/or solar power installations.

3.2.8 Communications at the Site

Refer to section 3.1.8 for information on communication at the site.

3.2.9 Power at the Site

Refer to section 3.1.8 for information on communication at the site.

3.2.10 Site Science Construction Constraints and Limitations

Site-specific issues to consider at D14 Sycamore Creek (STR) are:

- The most significant challenge for operations at Sycamore Creek (STR) is the hydrologic regime of the stream. Extreme high flow events will very likely threaten sensors and any other *in situ* NEON infrastructure.

- Objects of value to be located outside of the channel (i.e. solar panels, sensor support equipment) must be kept out of the line of site with route 87 to prevent vandals and thieves from destroying NEON equipment.

Driving and access constraints for D14 Sycamore Creek (STR) are:

- A footpath from highway 87 to the Sycamore Creek (STR) channel will need to be constructed. Either the existing pulloff area along the away could be used (which would require a relatively longer footpath) or a new area for vehicles to pull off could be developed.
- A footpath along the left bank of Sycamore Creek (STR) will need to be developed to allow access to all sensor locations and NEON infrastructure.

3.2.11 Other Issues

No other science issues are identified at this time.

4 APPENDIX A. FCC SUMMARY TABLES FOR AIS SITE COMPONENTS AT D14

4.1 Sycamore Creek FCC Summary Table

Site Component	Latitude	Longitude	Units
Stream, Lake			Description
Aquatic Auxiliary Power Portal location	33.751736°	-111.507222°	Lat, Long in degrees
Aquatic Portal location	33.751736°, -111.507222°		m away from bank, direction
Pathway needed? What is length?			Yes/no, description w/ length
Pathway start location	Site1-PathStartLat	Site1-PathStartLong	Lat, Long in degrees
Pathway end location	Site1-PathEndLat	Site1-PathEndLong	Lat, Long in degrees
Stairs or ladder needed?			Yes/no, description
Stairs top location	Site1-StairsTopLat	Site1-StairsTopLong	Lat, Long in degrees
Stairs length	Site2-StairsLength		Meters
Ladder top location	Site1-LadderTopLat	Site1-LadderTopLong	Lat, Long in degrees
Ladder length	Site1-LadderLength		Meters
Boardwalk needed? What is length?			Yes/no, description w/ length
Boardwalk start location	Site1-BrdwlkStartLat	Site1-BrdwlkStartLong	Lat, Long in degrees
Boardwalk end location	Site1-BrdwlkEndLat	Site1-BrdwlkEndLong	Lat, Long in degrees
Shall stairs, boardwalk be installed during construction?			Yes/no, description
Fencing needs			Description
Site management			Description
Any additional site specific information			Description

4.2 Sycamore Creek (STR) FCC Summary Table

Site Component	Latitude	Longitude	Units
Stream, Lake, or Stream+STREON			Description
Aquatic Auxiliary Power Portal location	33.748630°	-111.506540	Lat, Long in degrees
Aquatic Portal location	33.748630, -111.506540		m away from bank, direction
STREON Hut location			m away from bank, direction
Pathway needed? What is length?			Yes/no, description w/ length
Pathway start location	STR-PathStartLat	STR-PathStartLong	Lat, Long in degrees
Pathway end location	STR-PathEndLat	STR-PathEndLong	Lat, Long in degrees
Stairs or ladder needed?			Yes/no, description
Stairs top location	STR-StairsTopLat	STR-StairsTopLong	Lat, Long in degrees
Stairs length	STR-StairsLength		Meters
Ladder top location	STR-LadderTopLat	STR-LadderTopLong	Lat, Long in degrees
Ladder length	STR-LadderLength		Meters
Boardwalk needed? What is length?			Yes/no, description w/ length
Boardwalk start location	STR-BrdwlkStartLat	STR-BrdwlkStartLong	Lat, Long in degrees
Boardwalk end location	STR-BrdwlkEndLat	STR-BrdwlkEndLong	Lat, Long in degrees
Shall stairs, boardwalk be installed during construction?			Yes/no, description
Fencing needs			Description
Site management			Description
Any additional site specific information			Description