FIELD METHODS IN HYDROLOGY

Earth 125 Field Report

Introduction to general field techniques used in hydrology including methods to determine river discharge, basic well and spring sampling, well water level measurements, and soil hydraulic characterization. The ~1 week course took place at Sagehen Creek Field Station (north of Truckee, CA) in the eastern Sierra prior to the start of the 2021 Fall quarter under the guidance of Prof. Jordan Clark and teaching assistant Shelby Smith.

Guillermo Romero

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Introduction

Sagehen Field Station is located 20 miles North of Lake Tahoe and 12 miles North of Truckee, CA. The area is characterized as volcanic soils, a Sierran sub-alpine east-side mixed conifer forest with meadows and fens; a 9,000-acre watershed and the headwater stream of the Truckee River. Group field activities were conducted on Sagehen Creek by Guillermo Romero, Ruth Perez, and Lily Partida with the intention of developing field techniques applied in hydrology including methods to determine river discharge, basic well and spring sampling, well water level measurements, and soil hydraulic characterization. Results of group field activities also include a map of a 500-meter reach of Sagehen Creek, cross sections of the creek, and soil sieve analysis. Samples taken from monitoring wells provided conductivity, temperature, pH; Acid titration analysis was performed on samples to determine alkalinity. Independent exercises include an analysis of creek discharge data from Sagehen Field Station and discussion of one of the field stops during the course.

Group Exercises

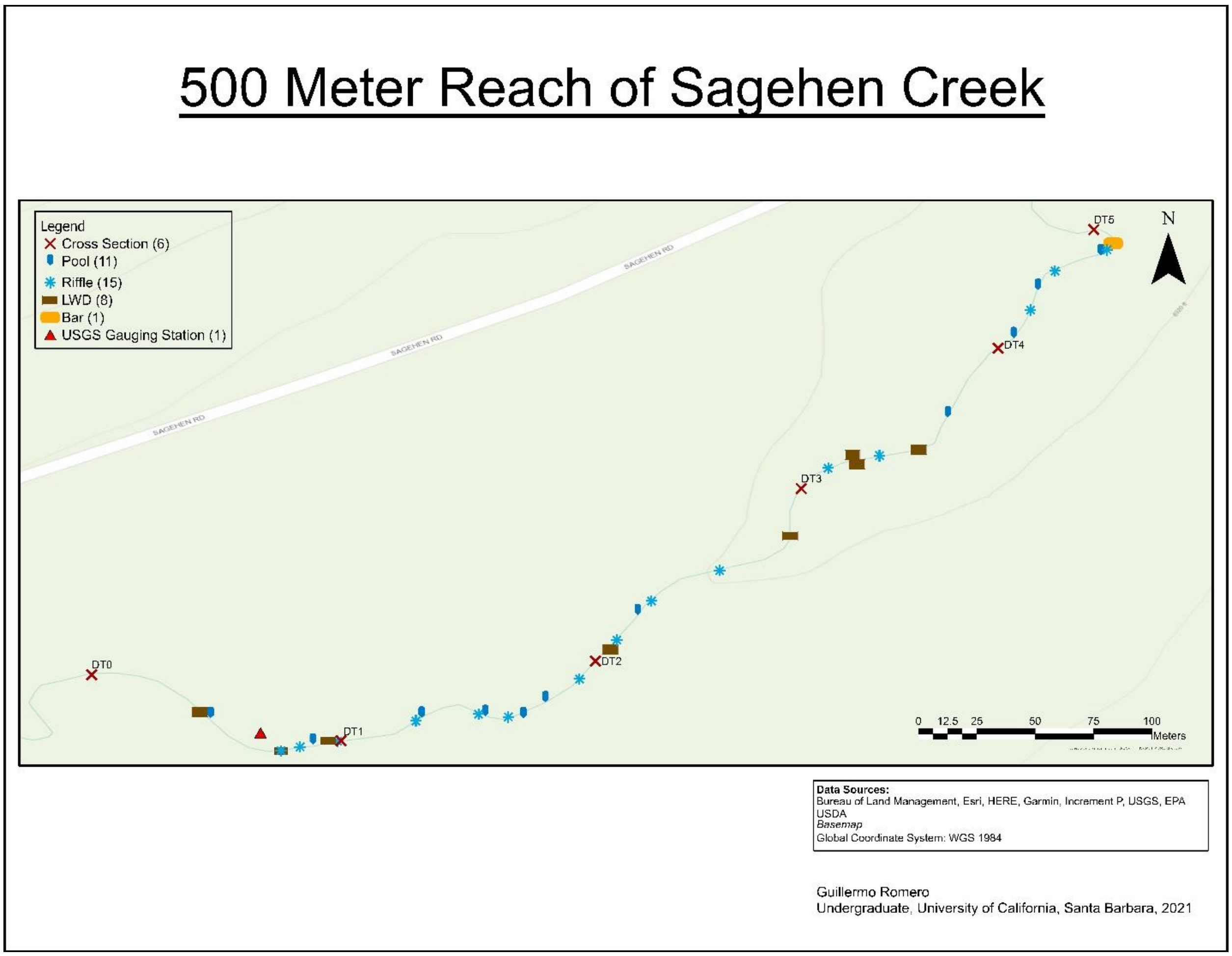
Mapping

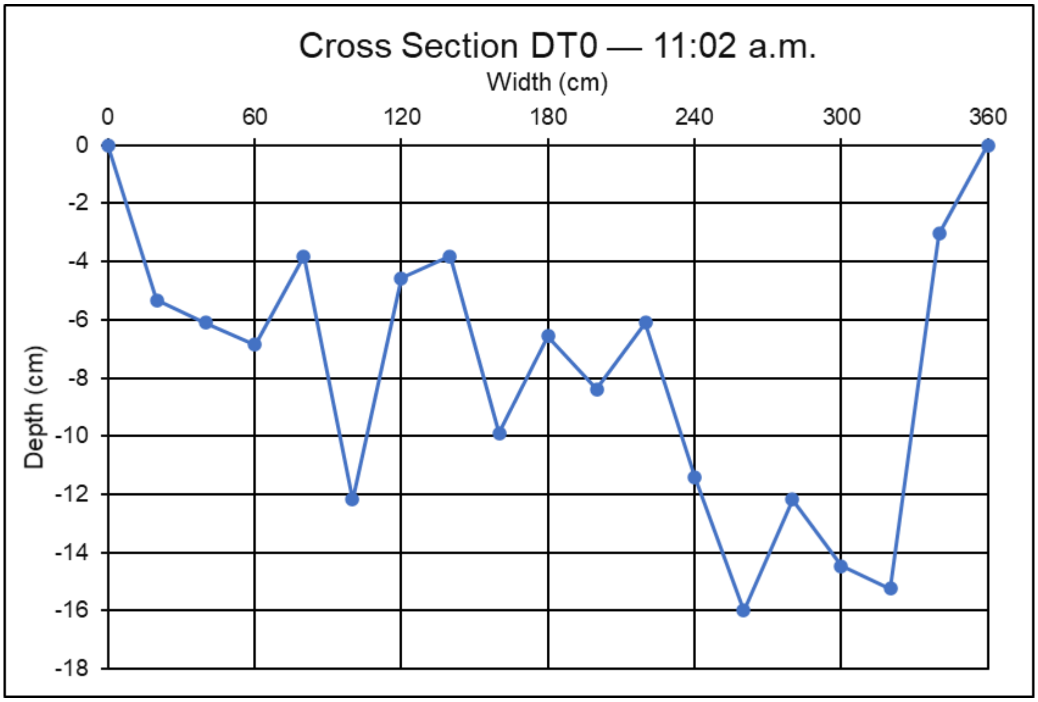
- ***9/14/21 Group Exercise 1****: Map 500 m reach of Sagehen Creek. This should include measuring cross sections every ~100 m and mapping bends, pools, riffles, LWDs, etc*.

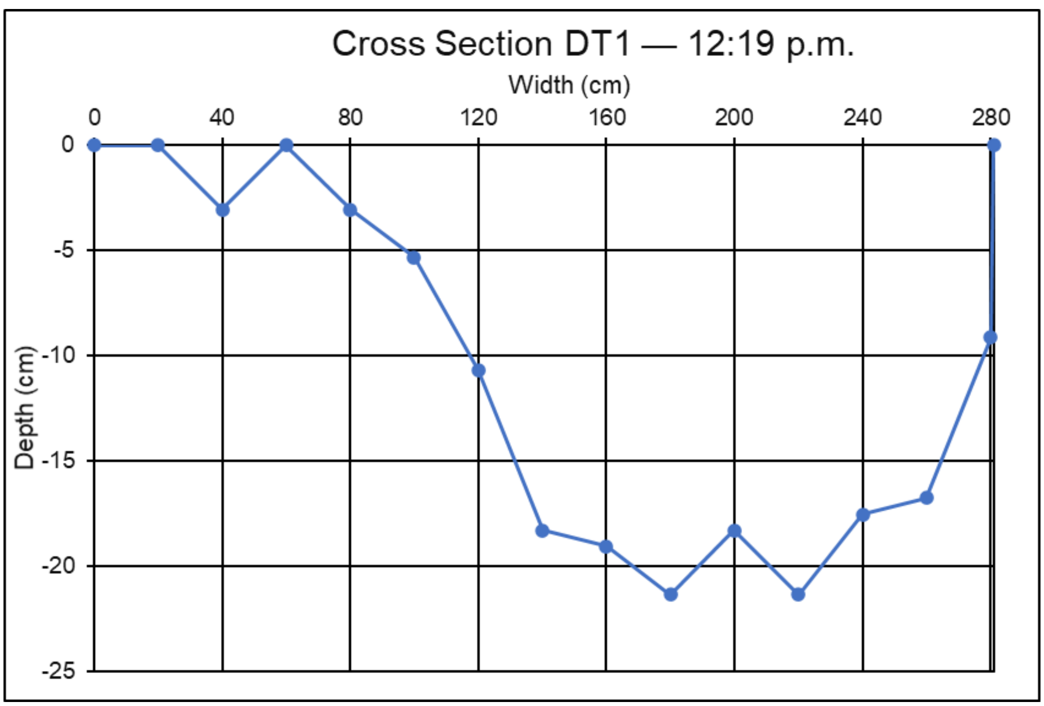
Methods

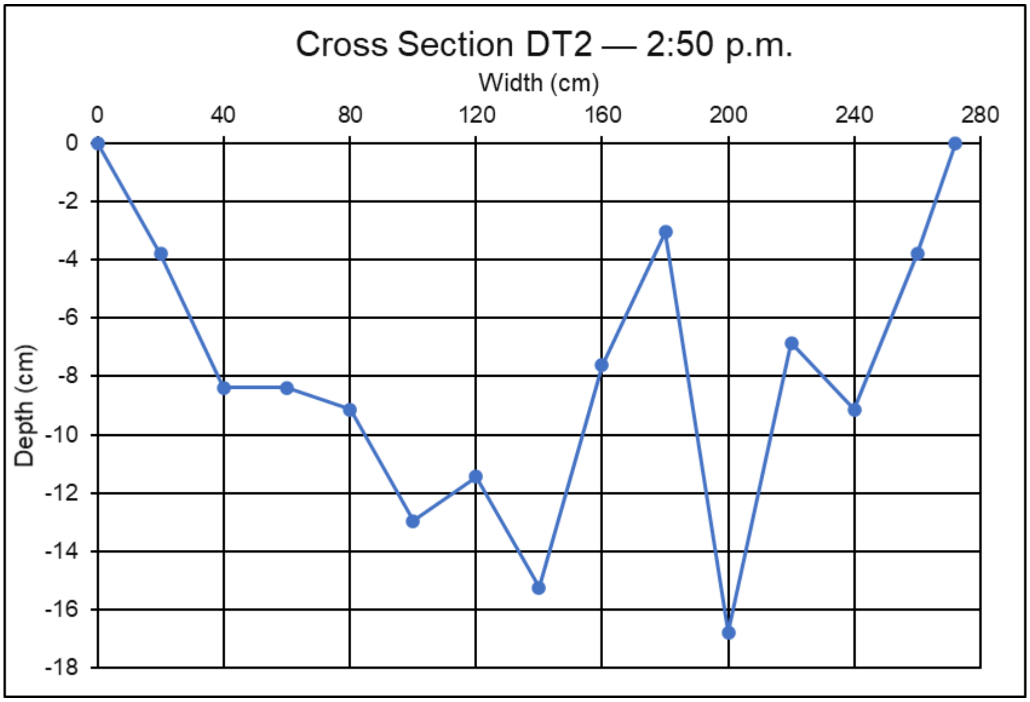
A hand crank spooled tape measure — with units in meter and centimeter — was used to determine the stream's width. Depth of the stream was measured using a Jacob staff with units of feet and subdivided into tenths of a foot at every 20 cm across the width. All measurements were consistently taken from North to South. The initial starting point was chosen not to have an undercut bank providing a more accurate measurement from bank to bank. The following measured cross-section was determined using the spooled tape measure and measuring 100 meters downstream; this was repeated for 500 meters. GPS coordinates were taken using a Gaia GPS phone application***.*** The gpx. file was processed in ArcPro to create a map with GPS points marking all cross-sections, riffles, pools, and large woody debris.

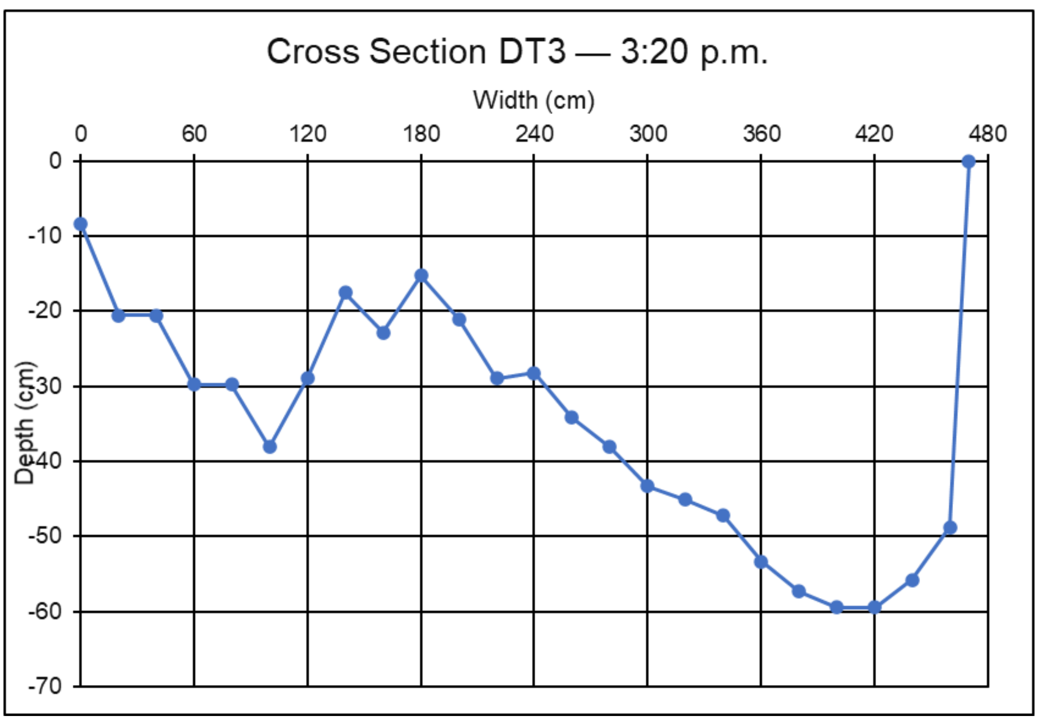
Results

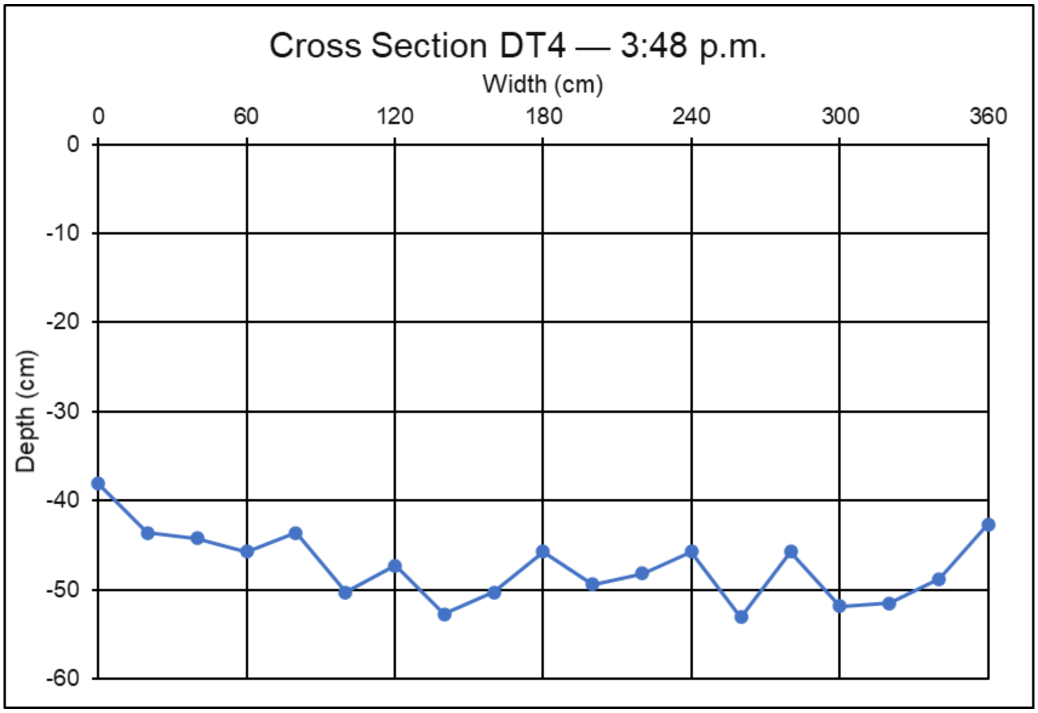

500 Meter Reach of Sagehen Creek
Legend
Cross Section (6)
Pool (11)
Riffle (15)
LWD (8)
Bar (1)
USGS Gauging Station (1)
SAGEHEN RD
N
DT0
DT1
DT2
DT3
DT4
DT5
0 12.5 25 50 75 100
Meters
Data Sources:
Bureau of Land Management, Esri, HERE, Garmin, Increment P, USGS, EPA USDA
Basemap
Global Coordinate System: WGS 1984
Guillermo Romero
Undergraduate, University of California, Santa Barbara, 2021

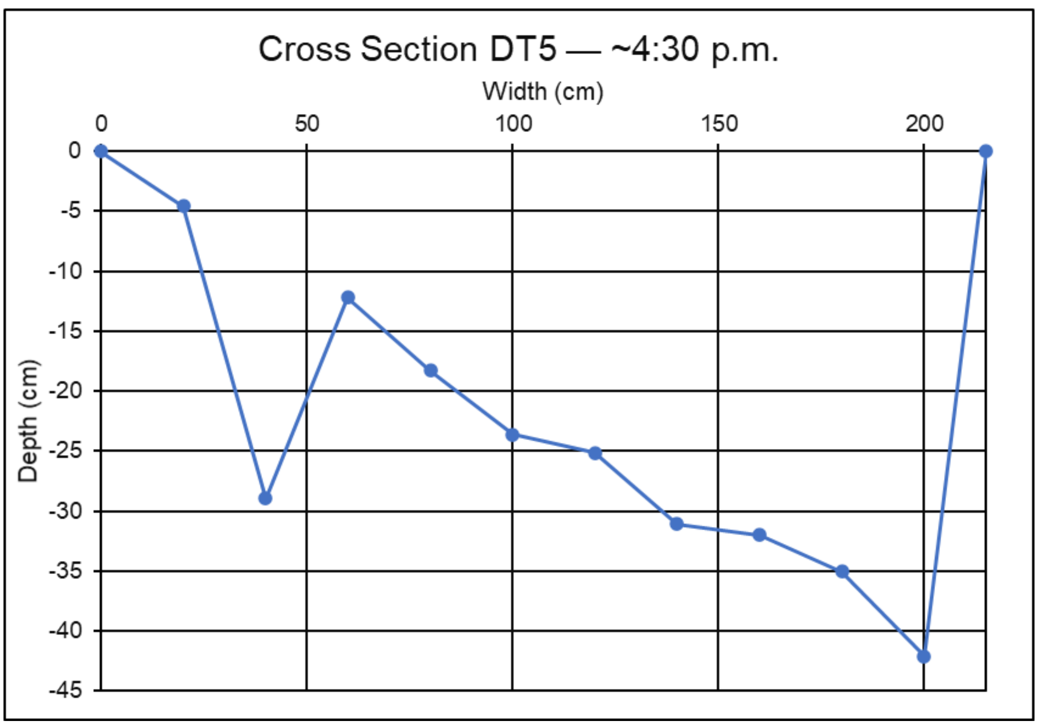

Cross Section DT0 — 11:02 a.m.
Width (cm)
0
60
120
180
240
300
360
0
-2
-4
-6
-8
-10
-12
-14
-16
-18
Depth (cm)


Cross Section DT1 — 12:19 p.m.
Width (cm)
0
40
80
120
160
200
240
280
0
-5
-10
-15
-20
-25
Depth (cm)


Cross Section DT2 — 2:50 p.m.
Width (cm)
0
40
80
120
160
200
240
280
Depth (cm)
0
-2
-4
-6
-8
-10
-12
-14
-16
-18


Cross Section DT3 — 3:20 p.m.
Width (cm)
0
60
120
180
240
300
360
420
480
Depth (cm)
0
-10
-20
-30
-40
-50
-60
-70


Cross Section DT4 — 3:48 p.m.
Width (cm)
0
60
120
180
240
300
360
Depth (cm)
0
-10
-20
-30
-40
-50
-60


Cross Section DT5 — ~4:30 p.m.
Width (cm)
0
50
100
150
200
Depth (cm)
0
-5
-10
-15
-20
-25
-30
-35
-40
-45

Discussion

The characteristics of the measured reach are in line with what would be expected of a mountain stream reach. The meandering pool-riffle channel contains bed substrate size from cobble to boulder though generally more gravel-sized. Sagehen Creek also has forced pool-riffle morphology caused by large woody debris. A few areas along the stream displayed small scour and fill of the banks. Cross-section DT4 reflects the under banks observed in this section of the creek and the observed widening of this section starting from DT3. From DT4 up to the location of the bar within the stream becomes significantly more sinuous. After the bend — where the river changes direction—there is a pronounced narrowing of the stream at DT5. Consistently all cross-sections developed reflect a deeper depth on the south bank of the stream.

In measuring the creek's width, error was introduced in determining the endpoint as the waterline had to be determined using best judgment. At DT4, the undercut banks at both sides made maintaining the tape measure steady while determining the measurement difficult. Depth was challenging to measure with Jacob's staff as estimates were used when a clear water line was not easily distinguished. GPS accuracy is uncertain but is accepted to be within a reasonable approximation of location.

Gauging

- ***Group Exercise 2****: Choose one cross section. Gauge it a number of times, changing the grid resolution to determine the optimal grid for your cross section. Thereafter, gauge it once each day at approximately the same time using your optimal grid.*
- ***Group Exercise 3****: Gauge your cross section at dawn and dusk during one day. Also measure DO and temperature at these times.*

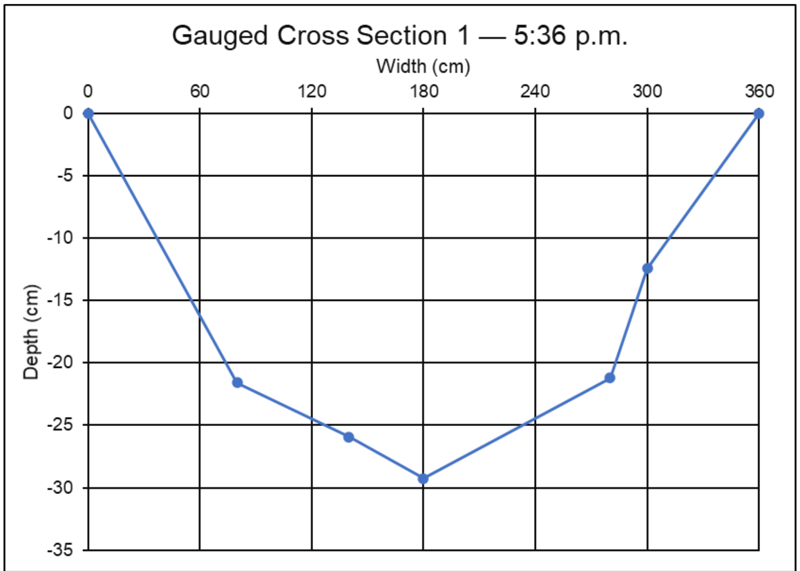
Methods

At the instructor's discretion, this exercise was modified; the choice of the cross-section was to lie at a point in our 500-meter reach that overlaid the 500-meter reach of the secondary group of this course, all other instructions being the same. An appropriate location was determined and used to develop a cross-section and gauge. The spooled tape measure was staked into each side of the banks to maintain consistency in location and width over several days. Gauging of the cross-section occurred on 9/14, 9/15, and twice on 9/16 at dawn and dusk, the resolution was changed on each day with 7, 6, and 9 points used, respectively. Gauging was performed with a flowmeter that counts revolutions of an impeller translated into streamflow velocity(ft/sec) with the equation of the corresponding conversion chart:

$$V = (0.0000854 * COUNTS + 0.05) * 3.28$$

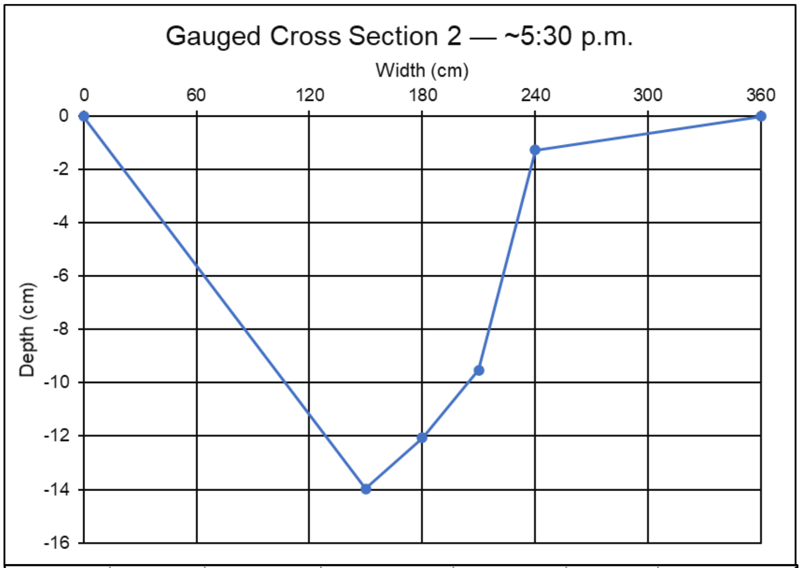
Area was determined graphically using the parallelogram method in conjunction with streamflow velocity to calculate discharge and average discharge. Average discharge was plotted to reflect the variance from day to day, and a rating curve was developed from all calculated discharge values.

Results



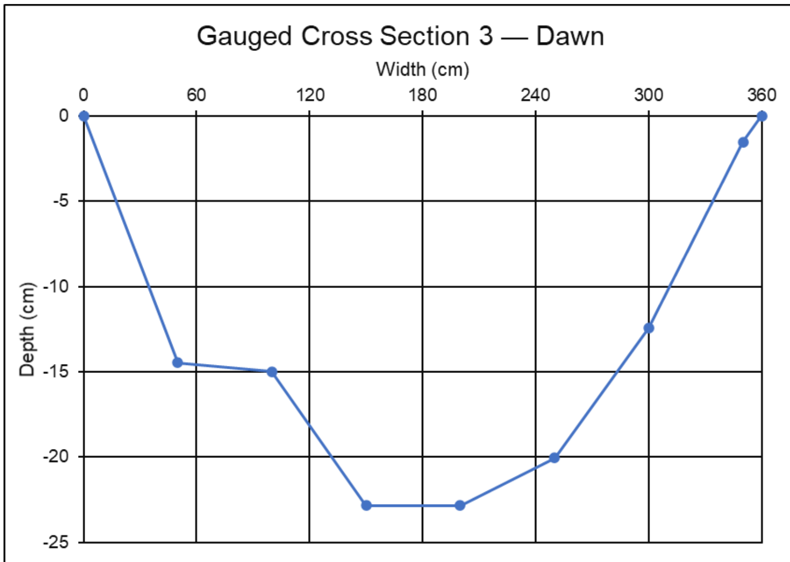
Distance (cm)	Distance (ft.)	Depth(ft)	Flow (counts/sec)	Velocity(ft/sec)	Area(Sq. ft.)	Discharge (ft^3/sec)
0	0.00	0.00	0	0.00	0.93	0.00
80	2.62	-0.71	5	0.18	6.20	1.10
140	4.59	-0.85	7	0.18	9.94	1.82
180	5.91	-0.96	19	0.22	13.51	2.93
280	9.19	-0.70	17	0.21	14.62	3.09
300	9.84	-0.41	4	0.18	12.25	2.15
360	11.81	0.00	0	0.00	11.81	0.00

Total Average Discharge (ft^3/sec)	Total Average Discharge (m^3/sec)
1.59	56.02



Distance (cm)	Distance (ft.)	Depth(ft)	Flow (counts/sec)	Velocity(ft/sec)	Area(Sq. ft.)	Discharge(ft^3/sec)
0	0.00	0.00	0	0.00	1.13	0.00
150	4.92	-0.46	3	0.17	7.44	1.28
180	5.91	-0.40	3	0.17	8.35	1.44
210	6.89	-0.31	2	0.17	8.28	1.41
240	7.87	-0.04	28	0.24	8.12	1.97
360	11.81	0.00	0	0.00	11.81	0.00

Total Average Discharge (ft^3/sec)	Total Average Discharge (m^3/sec)
1.02	35.88

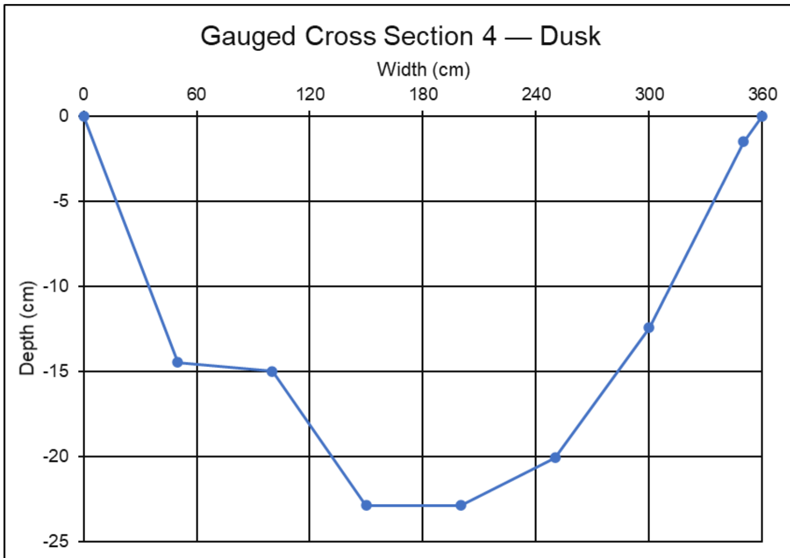


D.O. > 12

Tempearature = 6°C

Distance (cm)	Distance (ft.)	Depth(ft)	Flow (counts/sec)	Velocity(ft/sec)	Area(Sq. ft.)	Discharge(ft^3/sec)
0	0.00	0.00	0	0.00	0.39	0.00
50	1.64	-0.47	0	0.05	3.23	0.16
100	3.28	-0.49	3	0.17	6.34	1.09
150	4.92	-0.75	16	0.21	9.84	2.06
200	6.56	-0.75	20	0.22	12.34	2.71
250	8.20	-0.66	13	0.20	13.45	2.70
300	9.84	-0.41	3	0.17	12.47	2.15
350	11.48	-0.05	0	0.05	11.78	0.59
360	11.81	0.00	0	0.00	11.81	0.00

Total Average Discharge (ft^3/sec)	Total Average Discharge (m^3/sec)
1.27	44.96

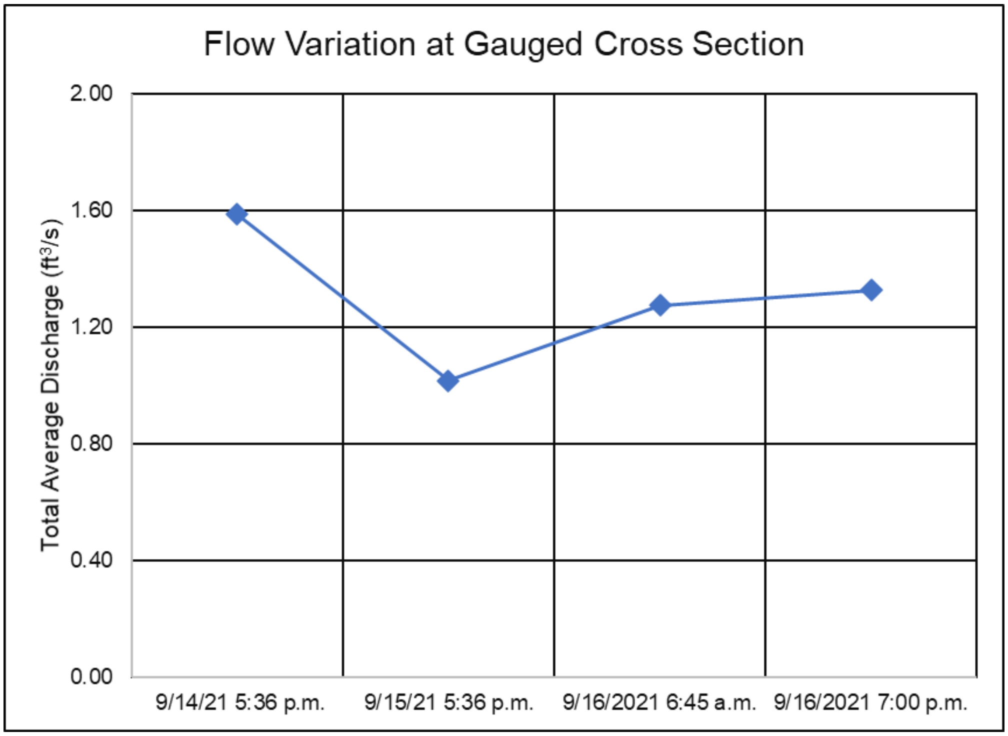


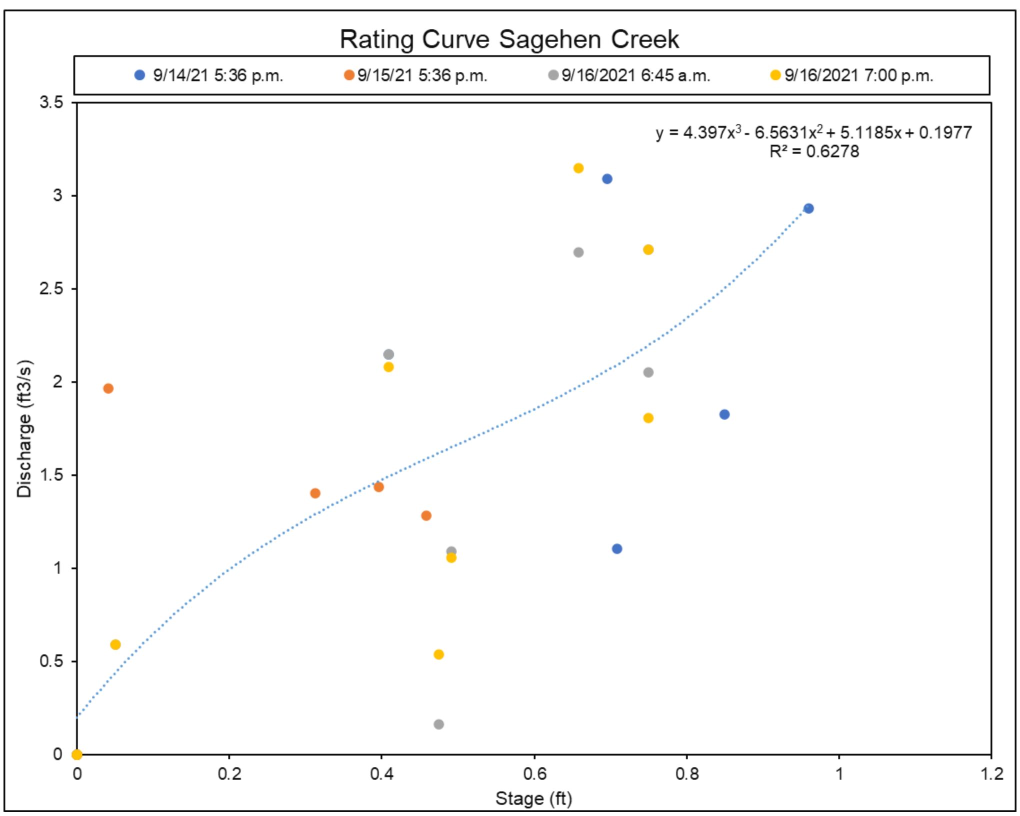
D.O. = 8

Temperature = 11.5 °C

Distance (cm)	Distance (ft.)	Depth(ft)	Flow (counts/sec)	Velocity(ft/sec)	Area(Sq. ft.)	Discharge(ft^3/sec)
0	0.00	0.00	0	0.0	0.39	0.00
50	1.64	-0.47	1	0.17	3.23	0.54
100	3.28	-0.49	1	0.17	6.34	1.06
150	4.92	-0.75	7	0.18	9.84	1.81
200	6.56	-0.75	20	0.22	12.34	2.71
250	8.20	-0.66	25	0.23	13.45	3.15
300	9.84	-0.41	1	0.17	12.47	2.08
350	11.48	-0.05	0	0.1	11.78	0.59
360	11.81	0.00	0	0.0	11.81	0.00

Total Average Discharge (ft^3/sec)	Total Average Discharge (m^3/sec)
1.33	46.83


Flow Variation at Gauged Cross Section
Total Average Discharge (ft³/s)
2.00
1.60
1.20
0.80
0.40
0.00
9/14/21 5:36 p.m.
9/15/21 5:36 p.m.
9/16/2021 6:45 a.m.
9/16/2021 7:00 p.m.


Rating Curve Sagehen Creek
9/14/21 5:36 p.m.
9/15/21 5:36 p.m.
9/16/2021 6:45 a.m.
9/16/2021 7:00 p.m.
y = 4.397x³ - 6.5631x² + 5.1185x + 0.1977
R² = 0.6278
Discharge (ft3/s)
Stage (ft)
3.5
3
2.5
2
1.5
1
0.5
0
0
0.2
0.4
0.6
0.8
1
1.2

Discussion

A very consequential error was made impacting the analysis of the gauged cross-section and the calculated discharge. The resolution was supposed to be determined on the first day of gauging to find the optimal resolution, but instead was changed on the three separate days gauging was performed. The error is reflected in the flow variation graph as the consistency of discharge is more evident on the last day, where the same resolution was used for both dawn and dusk. In section 1, the lack of points captured on the lower end of the width values increases the average discharge as it is not brought down by the lower values of velocity seen at this end. Section 2 captures the deepest part of the stream and higher discharge calculated at this point, but the spread of area between measurements significantly reduced the average discharge. Sections 4 and 5 have a subjective optimal resolution; the depth and calculated discharge reflect the cross section more accurately. The error impacts the rating curve as the inconsistency of all points combined lowers the R^2 value, indicating minimal relation between stage and discharge. From the flow variation and rating curve, an expected value of ~1.3 ft^3/s for each cross-section may have been what would have been expected from all days gauged. Though the resolution error impacts the analysis, value is still taken from the exercise as learning field techniques in gauging a stream include recognizing and eliminating errors in further application in the methods.

Other sources of error include the operation of the flowmeter, which may have impacted the flow variation when comparing dawn and dusk values. The expectation was that discharge would be higher at dawn and lower at dusk from increased vegetation activity. Increased vegetation activity is supported by the values of dissolved oxygen reported with a higher value at dawn and a lower value at dusk, 8, and 12, respectively. The incongruity of the average discharge and dissolved oxygen is more likely attributable to human error rather than some natural cause for increased discharge in the evening during drought conditions.

Soil Properties

- ***9/15/21 Group Exercise 4***: *Dig a soil pit at least 1 meter deep. Collect sufficient sediment to characterize its hydrologic properties (i.e., grain size distribution, porosity, specific yield, and hydraulic conductivity) for each layer you identify. Compare the hydraulic conductivity your group determined to one calculated using the sediment size distribution [hint: look at Fetter (1994)1 chapter 4 for the relationships of Shepherd (Ground Water, 27, 633-683, 1989)]. Using an infiltrometer, determine the infiltration rate next to the soil pit and at its bottom.*

Methods

This exercise was modified at the instructor's discretion; To distinguish from previous course offerings, a soil pit site was chosen south of the field station. Proximity to the secondary group was ~28 meters due to the limited availability of tools. On the southern side of the field station, there are two geologic units, Tpap and Qc, according to a geologic map of the area (Sylvester, 2017). A 1-meter-deep soil pit was excavated at 120 °W 39°N, in a Qc unit, visual characterization was noted, and soil samples were taken from distinct horizons. In situ infiltrometer measurements were taken to determine hydraulic conductivity at the top and bottom of the soil pit.

Particle size distribution of collected soil samples was determined using U.S. standard sieves and plotted on a unified soil classification distribution plot. To apply Hazen and Sheperd methods of determining hydraulic conductivity, mm sieve openings corresponding to 10, 30, 50, and 60 percent finer by mass (d_{10}, d_{30}, d_{50}, d_{60}) were determined with the use of the soil distribution plot. Percent adjusted fraction samples were calculated and plotted on a soil textural triangle classification. With the use of a Darcy apparatus, hydraulic conductivity, porosity, and specific storage was calculated. For comparison, calculations of hydraulic conductivity were made as a falling head permeameter and constant head permeameter.

Falling Head Permeameter	Constant Head Permeameter	Hazen Method	Sheperd Method	Coefficient of Uniformity
$K = \frac{aL}{At} * \ln\left(\frac{h_0}{h_f}\right)$	$K = \frac{VL}{t\Delta hA}$	$K = 80 * d^2$	$K = 100 * d_{50}^{1.5}$	$C_u = \frac{d_{60}}{d_{10}}$

Results

Volume (V)(cm^3)	Area (A)(a)(cm^3)	Length (L) (cm)
152.053	15.2	10

Soil A				
Measured Volume of water through Darcy apparatus (mL)	h_0 (cm)	h_f (cm)	Time (t) (s)	Δh (cm)
50	30	27	855	3

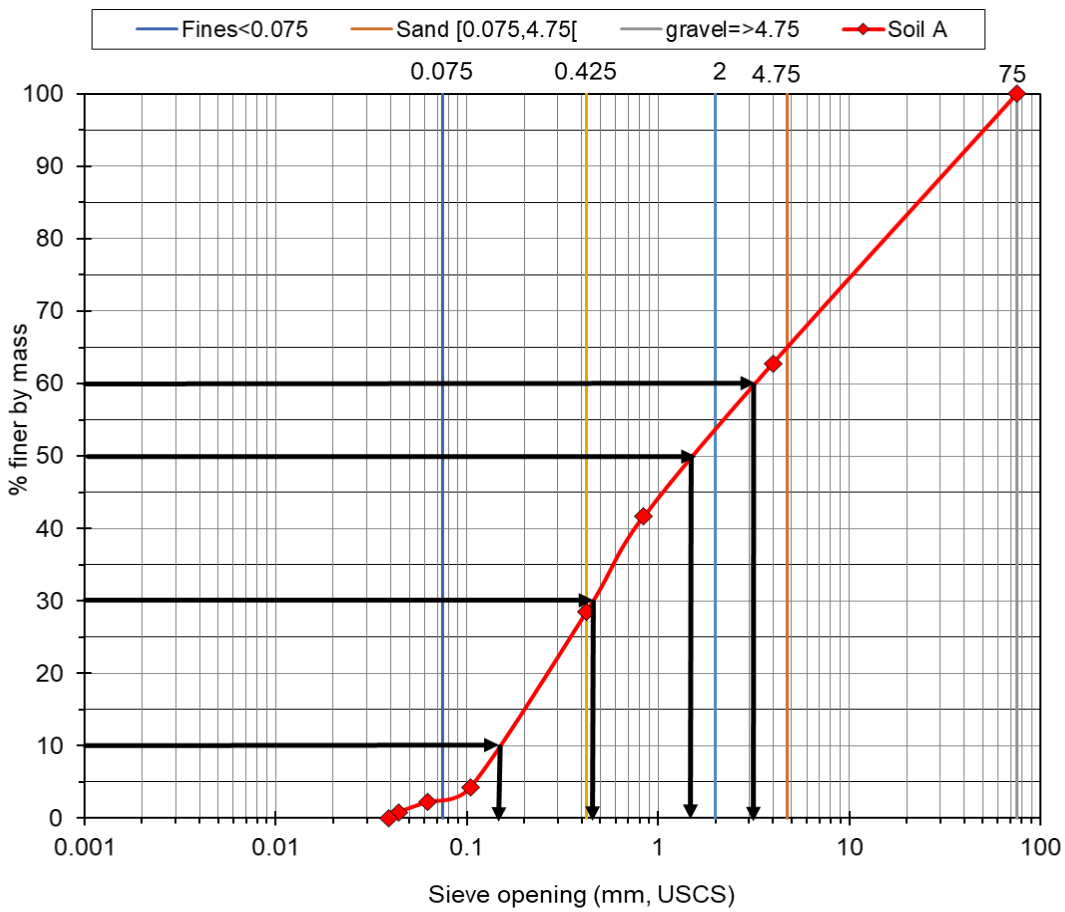
Total Sample Weight (g)
82.15

Soil B				
Measured Volume of water through Darcy apparatus (mL)	h_0 (cm)	$h_{f\,(cm)}$	Time (t) (s)	Δh (cm)
50	30	27	182	3
100	30	24	433	6

Total Sample Weight (g)
107.13

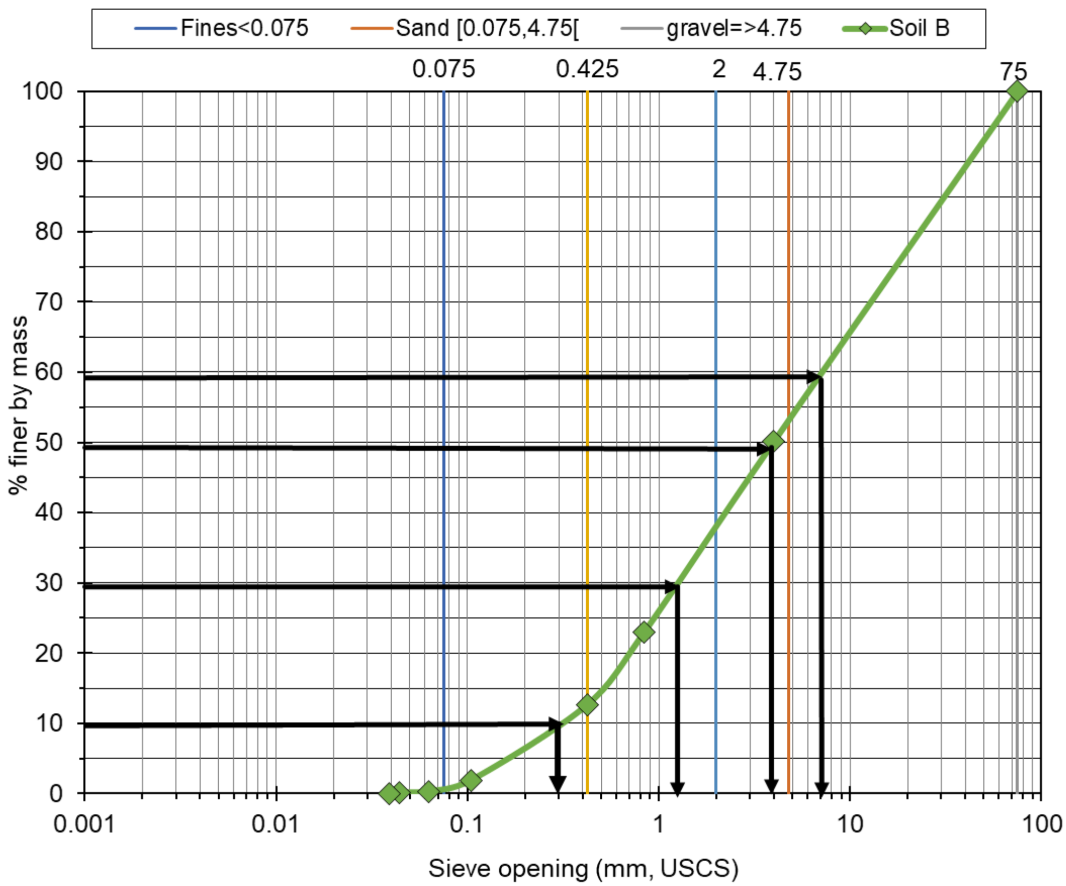
Infiltrometer Soil A			
Measured Drop (cm)	Elapsed Time (s)	Rate (cm/s)	Average Rate (cm/s)
40	106	0.38	0.32
50	155	0.32	
60	196	0.31	
70	260	0.27	

Infiltrometer Soil B			
Measured Drop (cm)	Elapsed Time (s)	Rate (cm/s)	Average Rate (cm/s)
10	21	0.48	0.29
20	80	0.25	
30	200	0.15	



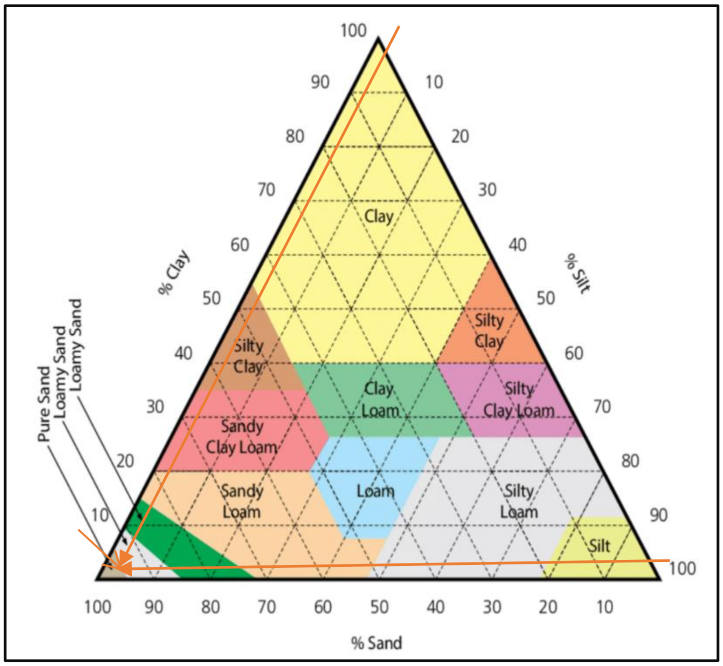
Soil A					
US Standard Sieve	particle size (mm)	Weight (g)	Weight percent	% finer dry mass	Soil A % adjusted fraction
					clay = 1.32
	75			100	silt =1.02
5	4	30.15	37.20	62.80	sand =97.66
20	0.84	17.15	21.16	41.64	
40	0.425	10.65	13.14	28.50	
140	0.105	19.65	24.24	4.26	
230	0.0625	1.65	2.04	2.22	
325	0.044	1.15	1.42	0.80	
<325	<0.044	0.65	0.80		

K (cm/s)		
Falling head permeameter(50 mL) = 0.0012	d_{10}= 0.15	K Hazen method = 0.018
Constant head permeameter(50mL) = 0.013	d_{30} =0.45	K Sheperd method = 0.078
	d_{50} = 1.7	
	d_{60} =3.2	
	C_u = 21.3 poorly sorted	n = 0.32
	C_c = 0.42	specific yield = 18.97% fine sand



soil B					
US Standard Sieve	particle size (mm)	Weight (g)	Weight percent	% finer dry mass	Soil B % adjusted fraction
					clay = .28
	75			100	silt = 0.28
5	4	51.65	49.88	50.12	sand = 99.44
20	0.84	28.15	27.18	22.94	
40	0.425	10.65	10.28	12.65	
140	0.105	11.15	10.77	1.88	
230	0.0625	1.65	1.59	0.29	
325	0.044	0.15	0.14	0.14	
<325	<0.044	0.15	0.14		

K (cm/s)		
Falling head permeameter(50ml) = 0.0058	d_{10}=0.3	K Hazen method = 0.072
Falling head permeameter(100ml) = 0.0052	d_{30}=1.5	K Sheperd method = 0.27
Constant head permeameter(50 mL) = 0.060	d_{50}=3.9	
Constant head permeameter(100 mL) = 0.025	d_{60}=4.2	
	C_u = 14 poorly sorted	n = 0.63
	C_c = 1.79	specific yield = 12.65% fine sand



Discussion

Two horizons were observed, soil sample A and soil sample B, both being very loose sediments. Soil sample A was surrounded by dried organic matter and ~1/2 m deep. Soil sample B was the only other horizon and the most significant portion of the pit. Roots, cobbles, and one small boulder were observed in the second horizon. Qc was chosen as the characterization indicated more conducive soil conditions for digging a pit. Sylvester (2017) characterizes Qc as from the Holocene period, unsorted, poorly consolidated, granitic colluvium decomposed granite, soil matrix-supported debris flow material, sand and cobble to boulder gravel. Support for the Qc characterization was observed within the two horizons and from the soil classifications applied. Percent adjusted fractions plotted on the soil texture triangle classify both samples as pure sand. Specific yields of both A and B indicate a fine sand classification. Calculated porosity for soil sample A does support a sand classification, but soil sample B indicates silt. Soil distribution of sieved soil indicates that ~60% for both soil samples is finer than sand. Hydraulic conductivity presents a challenge as there is very little agreement in the calculated values. For Sample A, the Hazen method and constant head permeameter calculated values of .018 cm/s and .013 cm/s are more closely related, but these are not the methods that were instructed to be applied. Instructions were to apply falling head permeameter and Sheperd method, which do not agree for either sample. The range for hydraulic conductivity for silty sands is 10^{-5} – 10^{-3} cm/s; falling head permeameter values for both samples lie in this range and would be the most appropriate values to report. The Sheperd method seems to be grossly inaccurate when compared to all other values. Regarding the Sheperd method, it seems that error lies in either the sieve analysis and derived mean grain size (d_{50}) or that the soil is texturally immature, and the 100-shape factor applied is not appropriate, the latter a more probable cause for the discrepancies in values.

Monitoring wells

- ***9/16/21 Group Exercise 5****: As a class we will conduct an aquifer pump and slug test at MW1S. The data from the pressure loggers will be email to you after we return to UCSB*.

Methods

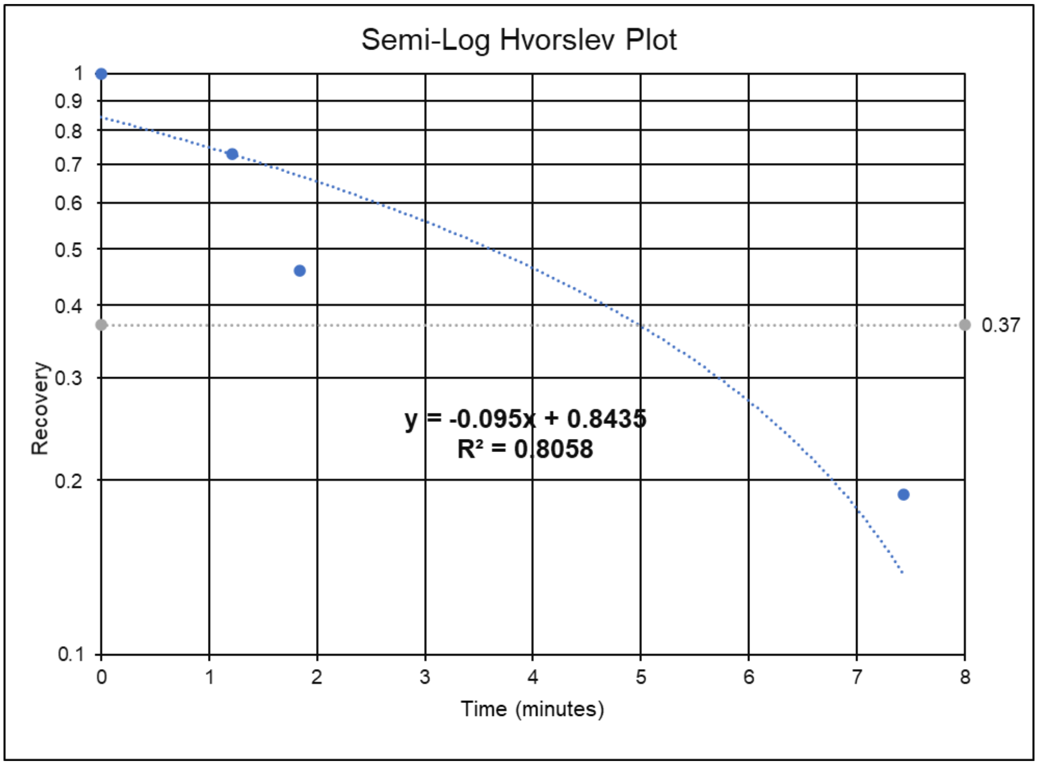
Pressure logger data is averaged for each year available and graphed for comparison. Using a submersible pump and an electric sounder depth probe, several measurements of MW1S and MW1D were taken to determine drawdown and subsequently well recovery. In calculating drawdown, an initial volume multiplier was determined of 0.16 to be applied to the measured 2-in. casing diameter of the well. The electric sounder was lowered into the wells to measure total depth and static water depth values. Total depth minus static water depth provides the depth of the water column in the well. The calculated volume multiplier is used with the depth of the water column to convert to a single casing volume in gallons. Industry standards were applied of three casing volumes purged out of the wells. Measurements were taken after purging to determine drawdown, temperature, conductivity, and pH. To estimate hydraulic conductivity, the Hvorslev Slug Test method was applied to the wells. An initial starting static water level depth was chosen to determine recovery with measurements of time taken every 1 foot of water level rise. Data points were plotted on a semi-log graph to determine the time at when dimensionless recovery is equal to 0.37. Well log data containing values for the radius of wellbore and length of the screen is required for the equation of hydraulic conductivity:

$$K = \frac{r_c^2 * \ln\left(\frac{L}{r_w}\right)}{2 * L * T_0}$$

Results

MW - 1 (Shallow)											
Total Depth (ft)	Static Water Depth (ft)	Depth of Water Column (ft)	Volume Multiplier (gal/ft)	Casing Volume (gal)	Three casing volumes (gal)	Purge, Time Start	Purge, Time Stop	Total Purge Time	Purge Rate (gal/min)	Drawdown (ft)	DTW @ 80% Recharge (ft)
11.8	4.5	7.3	0.16	1.17	3.51	10:15 AM	10:18 AM	3 min 6 sec	1.13	2.8	5.96
Time	Change in time (min)	Transient water level (ft)	Drawdown	Recovery	Time	Temperature (°C)	pH	Conductivity (mS)			
10:25 AM	0	8.2	-3.7	1.0	11:23 AM	10.96	6.84				
10:26 AM	1.21	7.2	-2.7	0.7	11:28 AM	10.8	7.07				
10:29 AM	1.84	6.2	-1.7	0.5	11:33 AM	11	7.07	33.6			
10:36 AM	7.43	5.2	-0.7	0.2							

MW - 1 (Deep)											
Total Depth (ft)	Static Water Depth (ft)	Depth of Water Column (ft)	Volume Multiplier (gal/ft)	Casing Volume (gal)	Three casing volumes (gal)	Purge, Time Start	Purge, Time Stop	Total Purge Time	Purge Rate (gal/min)	Drawdown (ft)	DTW @ 80% Recharge (ft)
37.3	1.3	36	0.16	5.76	17.3	1:46 PM	2:02 PM	16 min	1.08	0.5	8.5
Time	Temperature (°C)	pH	Conductivity (mS)								
2:13	17.1	7.88	325								
2:38	10.3	7.9	372								



h_0 (ft)	H_0 (ft)	H_t (ft)	r_c (in)	r_w (ft)	L (ft)	T_0 (min)	K (ft/min)
4.5	2.8	-3.7	2	0.5	0.75	4.98	0.22
h_0 (cm)	**H_0 (cm)**	**H_t (cm)**	**r_c (cm)**	**r_w (cm)**	**L (cm)**	**T_0 (sec)**	**K (cm/s)**
137.1	85.3	-112.8	5.1	15.24	22.86	298.8	0.00077

Discussion

Well log data from Sagehen Creek Field Station was unavailable as an Error 404 indicated the page no longer exists. Since the radius of the casing was measured on site, but the radius of the wellbore and the length of the screen were not available, reasonable values were used from previous coursework for MW1S. Determining recovery of MW1D was attempted, but the rate of recharge was approximately equal to the discharge, and accurate measurements could not be obtained. In Contrasting the two wells, it can be surmised that each reaches two distinct aquifers. The depth of MW1D and fast recharge indicate an aquifer with high hydraulic conductivity and porous material. Given local geology, the porous material likely ranges from well-sorted sands, glacial outwash, or well-sorted gravel. The calculated hydraulic conductivity of MW1S is very low; this is most likely due to an overestimation of the radius of the wellbore and length of the screen. Despite the very low value derived for K, the observed slow recharge rate while determining recovery supports a low hydraulic conductivity and aquifer of clay, silt, and sand sediments..

Sampling

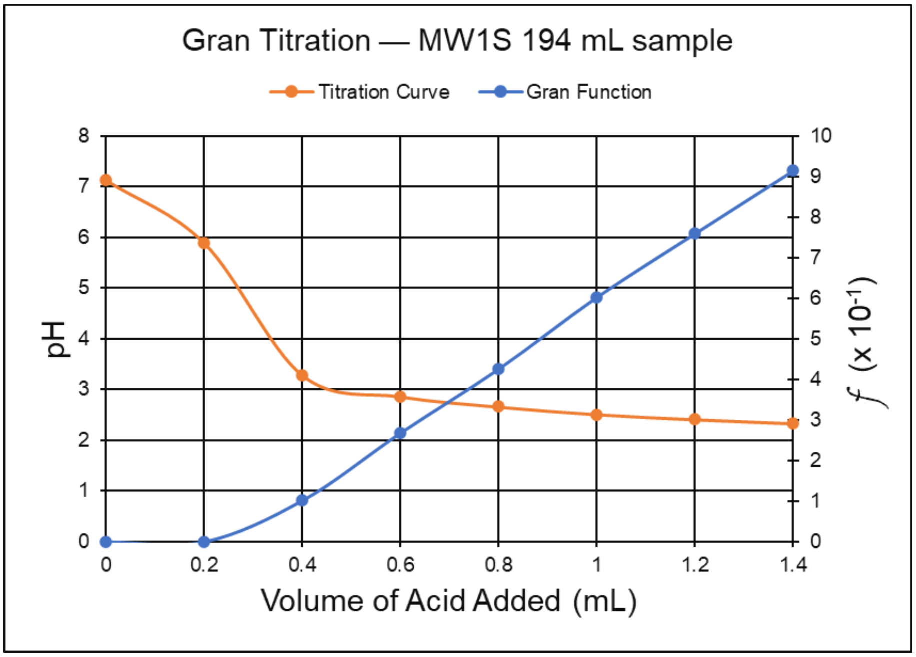
- ***9/16/21 Group Exercise 6****: Find and sample one of the springs for Conductivity, Temperature, and Alkalinity (Alk). Collect samples for stable isotopes of water, VOAs, anions, and cations. Remember to filter the ion samples. Compare your measurement of Conductivity, Temperature, and Alk to past surveys.*

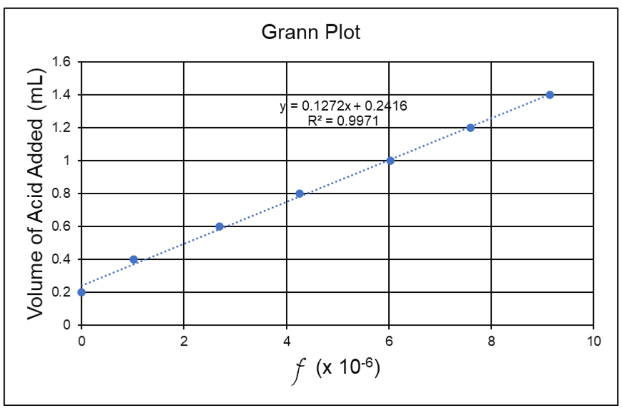
Methods

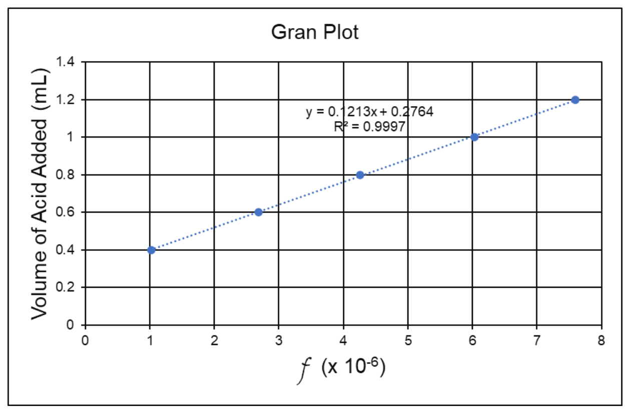
This exercise was modified at the instructor's discretion; Due to the closure of National Parks to prevent wildfires, the springs located around Sagehen Creek Field Station were out of bounds. Sampling was performed after purging of the wells and measured for pH, conductivity, temperature. VOA sampling was performed with techniques of rinsing sample bottles and observing no air bubbles trapped within the sample. Anion and cation samples were obtained with the requisite flushing of filters and capture with filters. The anion and cation and sample bottles were filled to overflow one and half times before being sealed. All samples were labeled with sample number, date, time, and location. Acid titration was performed on samples from MW1S and MW1D approximately a week after returning to UC Santa Barbara atop of Webb Hall. The Gran Titration Method of analysis and Gran function was applied to determine the alkalinity of three samples from well sample bottles.

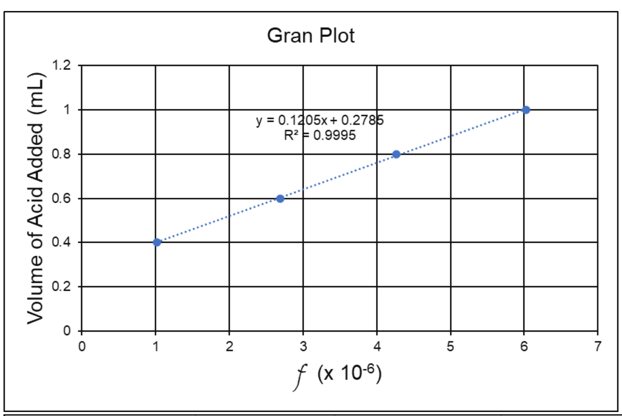
Results

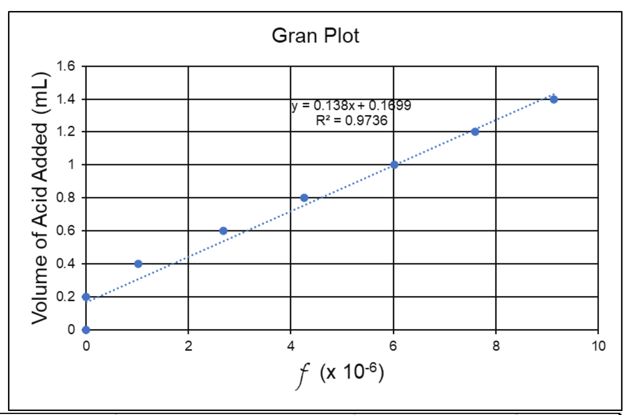
MW - 1 (Shallow)				MW - 1 (Deep)			
Time	**Temperature (°C)**	**pH**	**Conductivity (mS)**	**Time**	**Temperature (°C)**	**pH**	**Conductivity (mS)**
11:23 AM	10.96	6.84		2:13	17.1	7.88	325
11:28 AM	10.8	7.07		2:38	10.3	7.9	372
11:33 AM	11	7.07	33.6				



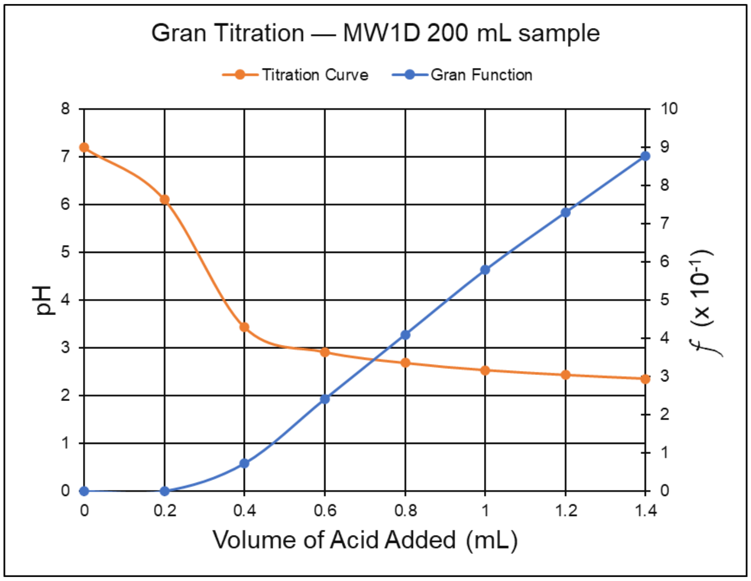


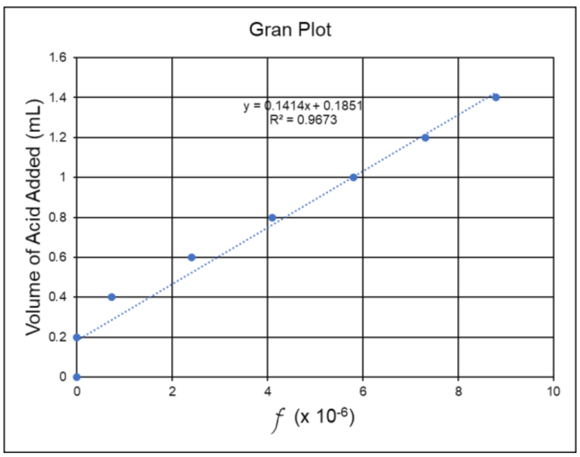


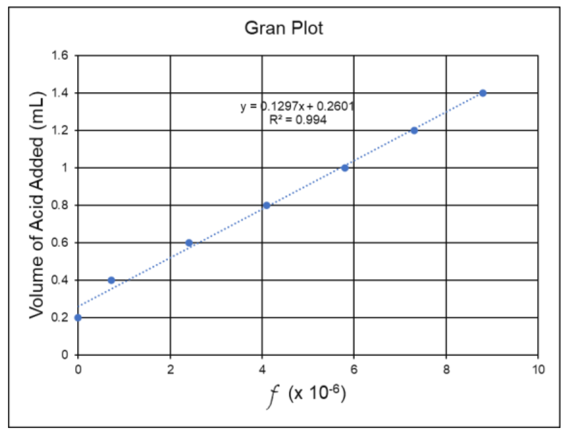


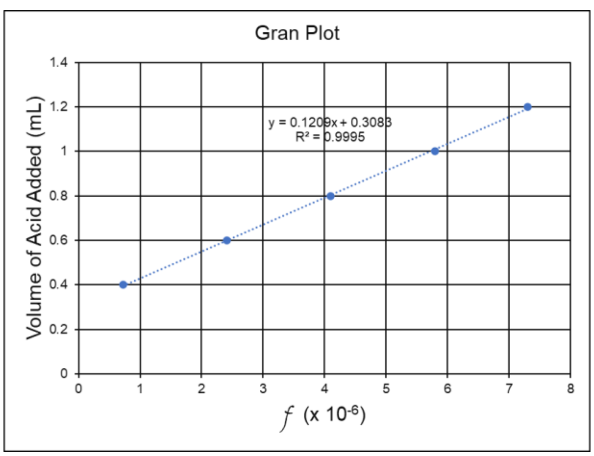


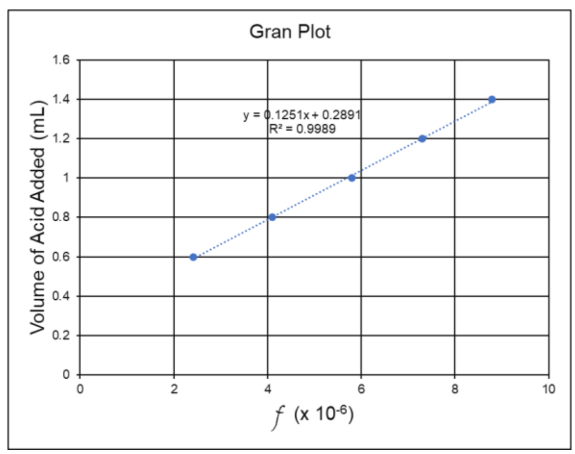
# of Points	R^2	Acid Added	Volume of Sample	Gran intercept	H^+ added	[Alk]
8	0.9736	1.4	195.4			
7	0.9971	1.2	195.2			
5	0.9997	0.8	194.8			
4	0.9995	0.6	194.6	0.2785	0.2785	0.0014



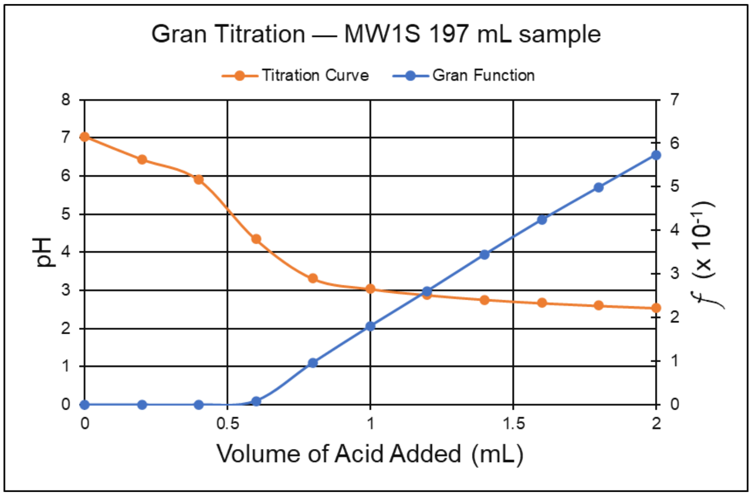


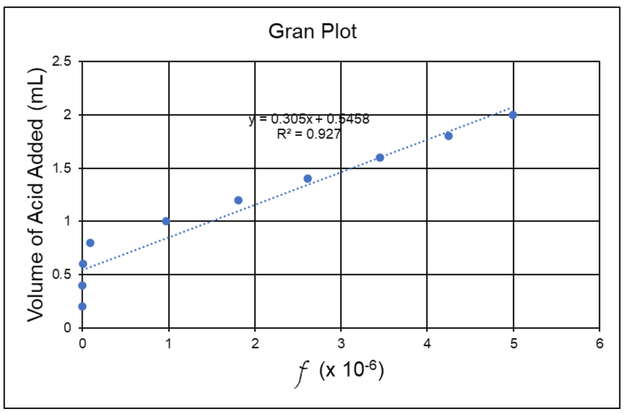


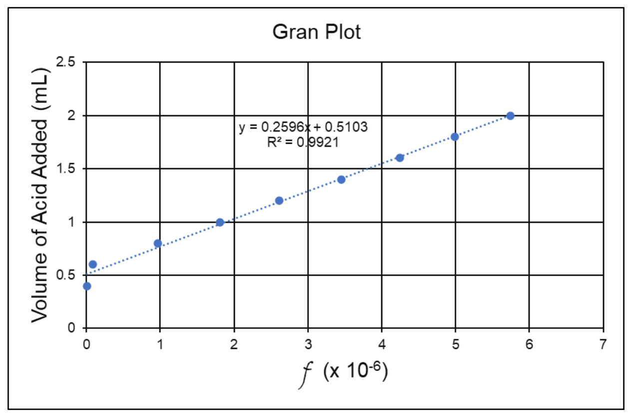


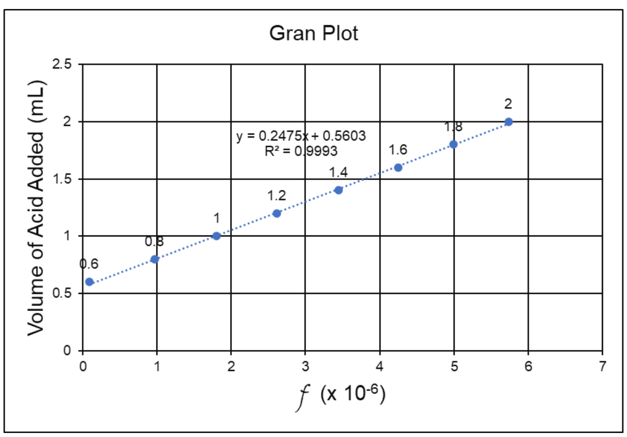


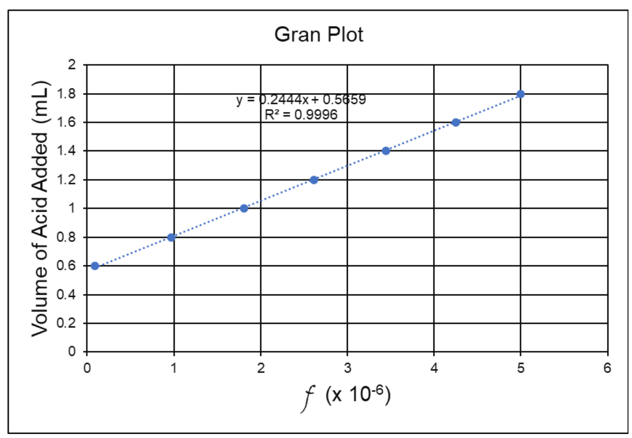
# of Points	R^2	Acid Added	Volume of Sample	Gran intercept	H^+ added	[Alk]
8	0.9673	1.4	201.4			
7	0.994	1.2	201.2			
5	0.9989	0.8	200.8			
4	0.9995	0.8	200.8	0.3083	0.3083	0.0015











# of Points	R^2	Acid Added	Volume of Sample	Gran intercept	H^+ added	[Alk]
8	0.927	2	199			[Alk]
7	0.9921	1.6	198.6			
5	0.9993	1.4	198.4			
4	0.9996	1.2	198.2	0.5659	0.5659	0.0029

Discussion

Repeat titration of MW1S produced a significant disparity between the two values of alkalinity reported with a 69.8% difference. Alkalinity between MW1D and MW1S is almost identical, so there was an error introduced into the process at some point. The volume measured may have been measured of both the sample and the added acid. The gran intercept chosen from the Gran plot may be incorrect due to many points, but from the Gran titration graph, a line from where f = 0 to the acid needed is very close to the value chosen. Contamination of the sample is also possible from repeated sampling.

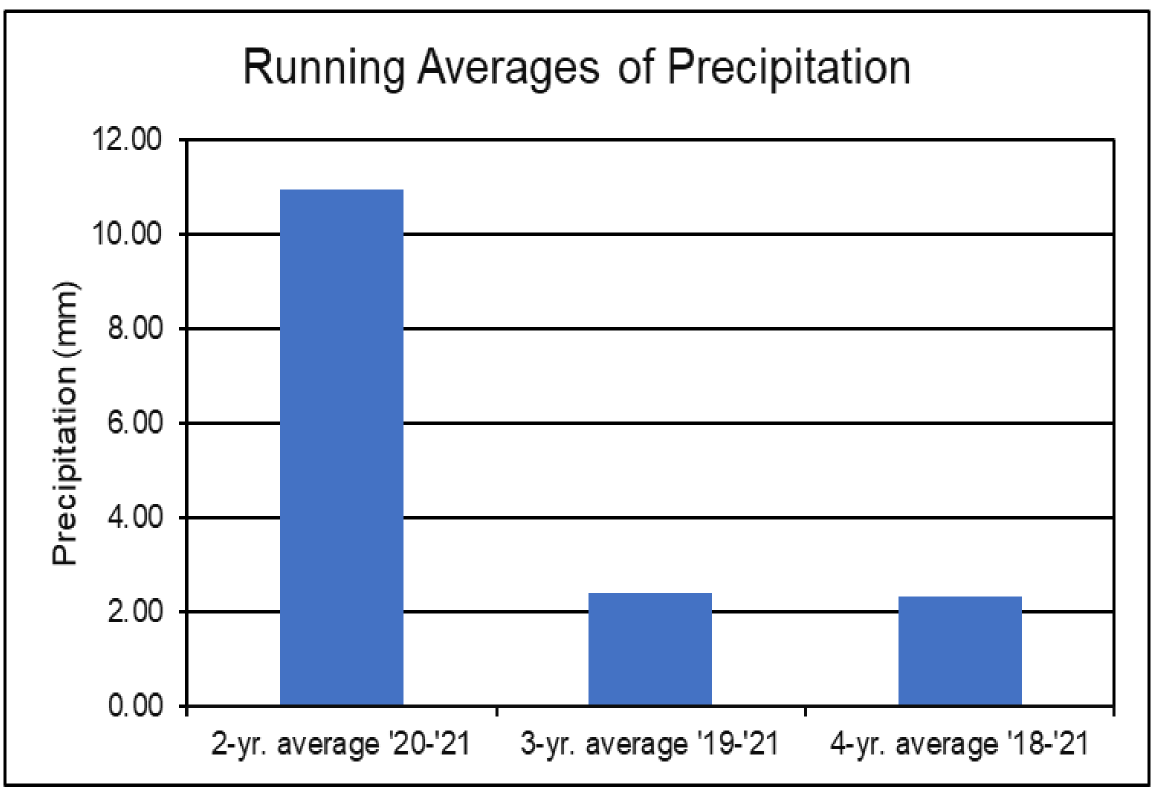
Independent Exercises

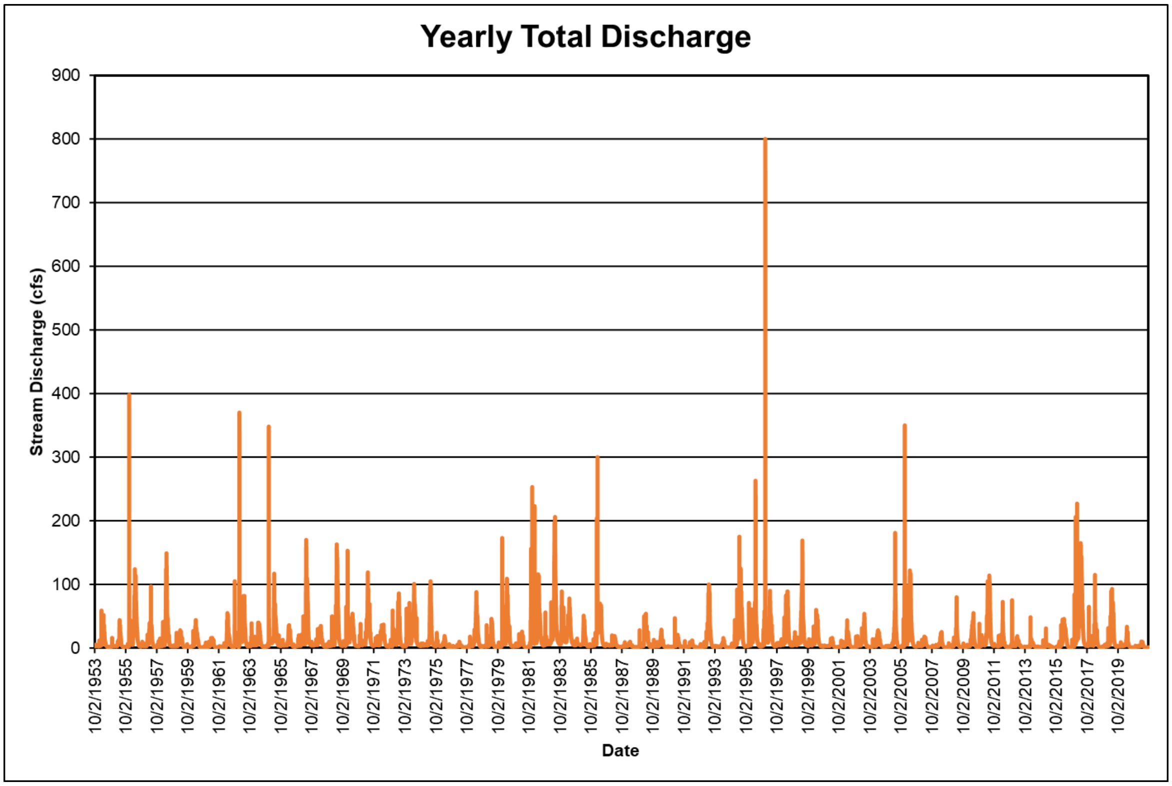
Long Term Data Analysis

- ***Individual Exercise 1***: *Download the precipitation and creek discharge data from the Sagehen Field Station web site (http://sagehen.ucnrs.org/research/resources-data/#water). How well does the annual precipitation predict annual discharge? Does the prediction of discharge improve when considering long-term mean annual precipitation (i.e., the mean of the previous 2-, 3-, 4-, etc. years)?*

Methods

This exercise was modified at the instructor's discretion; Sagehen Field station precipitation and discharge was provided through the course website. USGS data of precipitation and discharge were plotted to determine if predictions of annual discharge can be determined from annual precipitation. Further analysis involving long term mean annual precipitation and how it relates to precipitation and discharge.




Yearly Total Discharge
Stream Discharge (cfs)
900
800
700
600
500
400
300
200
100
0
10/2/1953
10/2/1955
10/2/1957
10/2/1959
10/2/1961
10/2/1963
10/2/1965
10/2/1967
10/2/1969
10/2/1971
10/2/1973
10/2/1975
10/2/1977
10/2/1979
10/2/1981
10/2/1983
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10/2/1987
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10/2/1991
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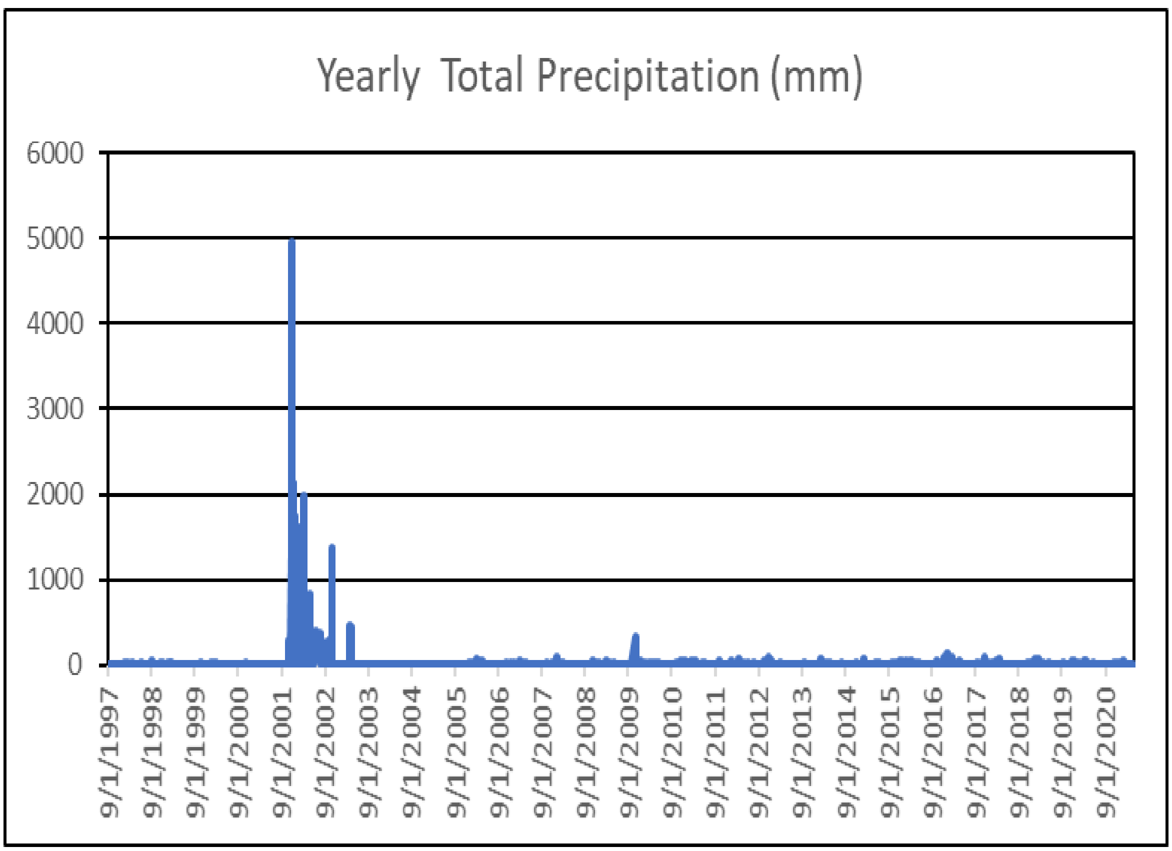
10/2/1995
10/2/1997
10/2/1999
10/2/2001
10/2/2003
10/2/2005
10/2/2007
10/2/2009
10/2/2011
10/2/2013
10/2/2015
10/2/2017
10/2/2019
Date


Yearly Total Precipitation (mm)
6000
5000
4000
3000
2000
1000
0
9/1/1997
9/1/1998
9/1/1999
9/1/2000
9/1/2001
9/1/2002
9/1/2003
9/1/2004
9/1/2005
9/1/2006
9/1/2007
9/1/2008
9/1/2009
9/1/2010
9/1/2011
9/1/2012
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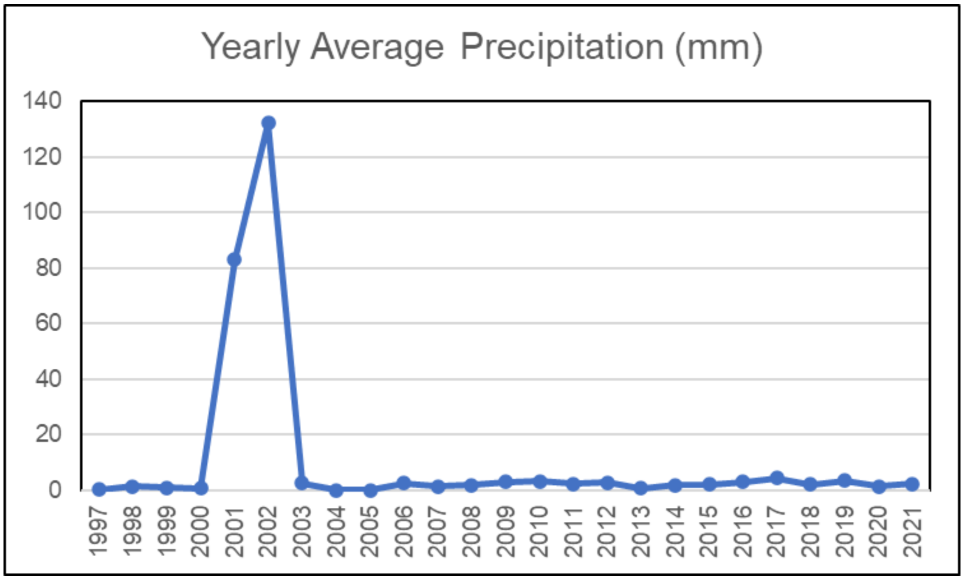
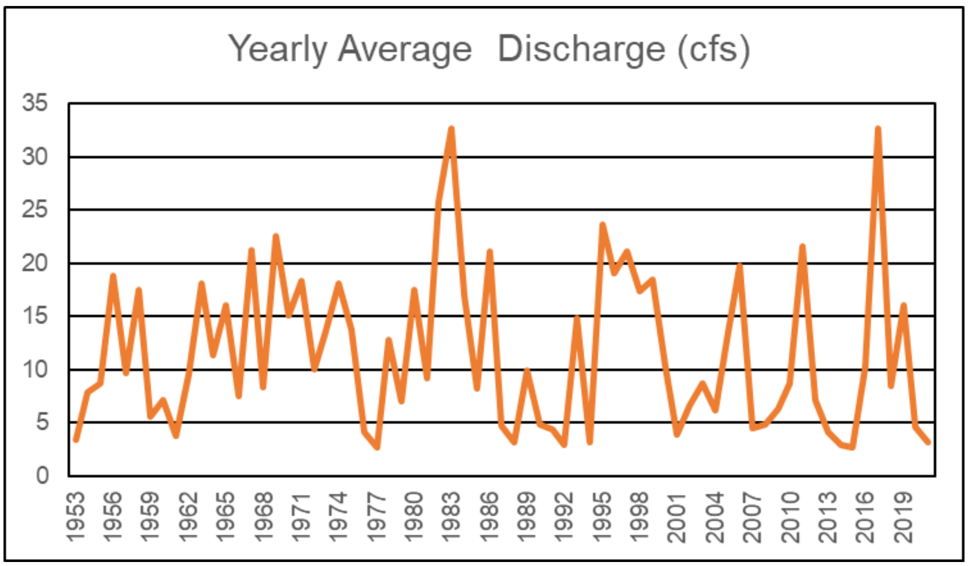
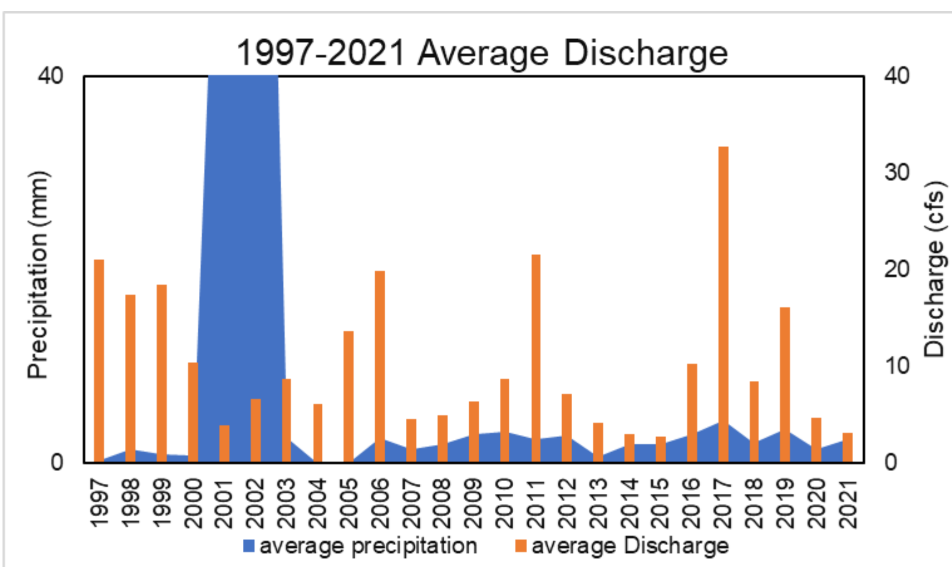
9/1/2018
9/1/2019
9/1/2020


Yearly Average Precipitation (mm)
140
120
100
80
60
40
20
0
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021


Yearly Average Discharge (cfs)
35
30
25
20
15
10
5
0
1953 1956 1959 1962 1965 1968 1971 1974 1977 1980 1983 1986 1989 1992 1995 1998 2001 2004 2007 2010 2013 2016 2019


1997-2021 Average Discharge
Precipitation (mm)
Discharge (cfs)
40
0
40
30
20
10
0
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
average precipitation
average Discharge

Discussion

The total sum of values for precipitation is not a good indicator for annual discharge. This is most prominently reflected in 2001 and 20002, where total precipitation sees a significant jump, yet discharge does not reflect the exact change. It can be seen that there is not much change in values over the same 20-year period for precipitation, but discharge swings with some sense of consistency. Two separate plots of average annual discharge for both precipitation and discharge were developed. No relationship is apparent when the two are isolated, and the limitations of 20-year precipitation data instead of almost seventy years of discharge data skew the scaling. When the two data sets are overlain and limited to available data of 20 years of precipitation data, the data sets' boundaries can be adjusted to compensate for differing units and an outlier of 2001-2002 data. At this resolution, it can be predicted that a rise in discharge will soon follow as precipitation increases. The predictiveness of this cycle is improved with the use of long-term averages of precipitation data. The same general slope of the running average graph can be seen in both average discharge plots supporting a predictive power to analysis.

Description of Field Stop

- **9/17/21 Individual Exercise 2**: Choose one field stop along the tour starting with the San Luis Reservoir continuing through Mono Lake and ending with the St. Francis dam. Write a brief description of the site, why you decided to focus on it, and how it relates to the general field of hydrology. If you have taken Earth 104A, you cannot write about the St. Francis dam. Please include a photo or other figure in your piece. The target length of your description and impression is 750 words.

Truckee Donner public utility district operates 13 wells plus wells providing raw water to golf courses in the area. During the course of the trip, a stop was made at one of the public utility water wells. The water level in the well is at a depth of 240 feet, and water tanks are maintained full for if and when the power goes out in the area, the utility companies' systems can remain running for up to 12-24 hours. Initially powered on by 400-500 amps and maintained running with ~215 amps, the well pumps 5-6 million gallons a day during the summer, with maintenance occurring every 2-5 years. The well itself is a point of information gathering that is then delivered to those making decisions on the water. Any new subdivision in the area is required to determine their source of water supply and building of wells. At the public supply well, raw water samples are taken through an outlet from the well to test for arsenic, dissolved organic carbon, and other contaminant testing. The amount of chlorine used in the water is monitored as meter measurements, chlorine levels, and other water treatments are required by California Law to be logged in state reports.

The public utility well is an interesting choice to focus on because it lies at an intersection of science, academic understanding of water management, and practical applications in maintaining the water supply for the people of Truckee. The ability to clearly outline the impact of the excellent work done by the public utility workers is not something that a great many can say of their work. In California, water is not to be taken for granted as the ongoing drought drives that message in. Nevertheless, during the last drought, so much water was over-pumped from the ground that the earth collapsed in the San Joaquin Valley. An overabundance of wells went dry during the last drought, and the trend seems to look worse for the ongoing drought. The Sustainable Groundwater Management Act (SGMA) was passed as a reaction to the last drought, but the behavior has not changed, with ~2700 projected to go dry this year.

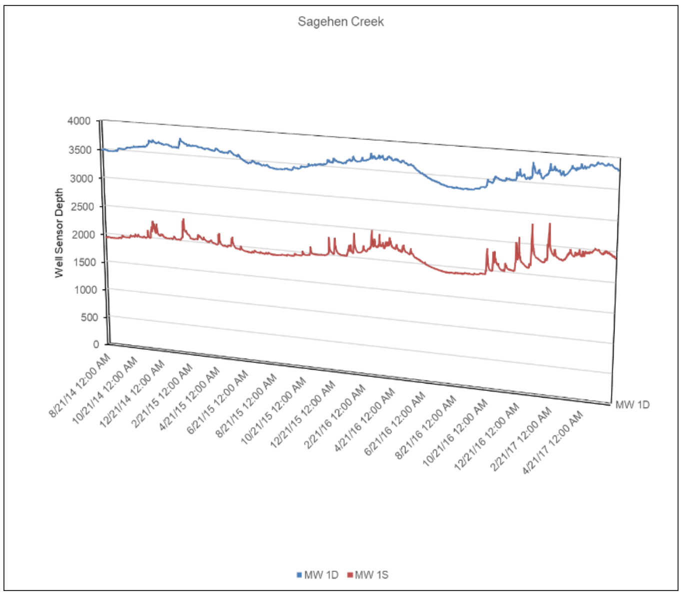
The climate is changing, and the expectation is that more drought events will occur and impact the state of California. A public utility well is a great place to understand how these coming changes can impact the state's hydrology. At points like the well, decisions are made that can have a great deal of impact on managing California's groundwater. A part of the study of hydrology concerns understanding how water moves, is stored, and ultimately managed to benefit both the environment and our societies. The Truckee public utility is not a glamorous or beautiful spot, but it directly deals and intersects with the concerns of hydrologic study, making it a worthwhile visit.

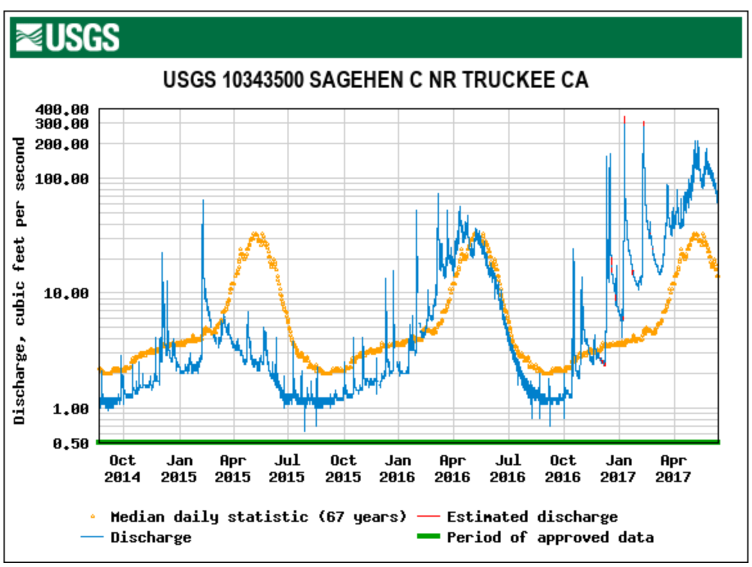
Examination of Groundwater Level Record

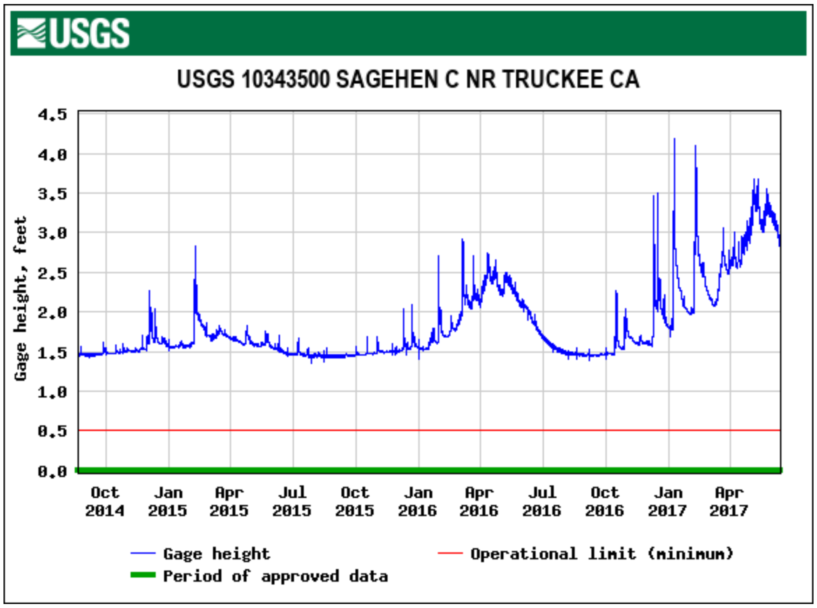
- **Individual Exercise 3**: Please examine the record of groundwater water level in MW1S and MW1D. The data is in an excel file and can be found on the Earth 125 GauchoSpace page. Discuss both long-term and short-term changes. You should compare and contrast the well records. It will be helpful to also compare the water levels to Sagehen Creek discharge, basin temperature, and precipitation.

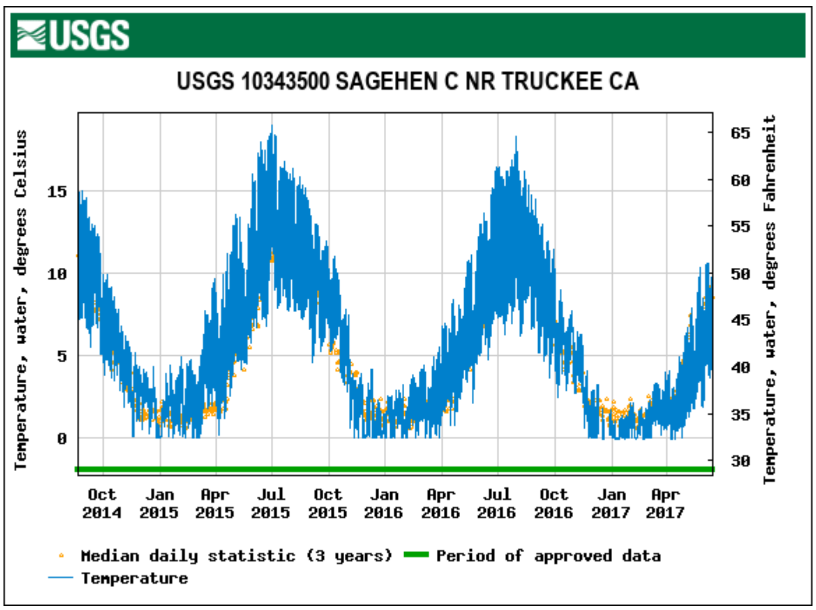
Methods

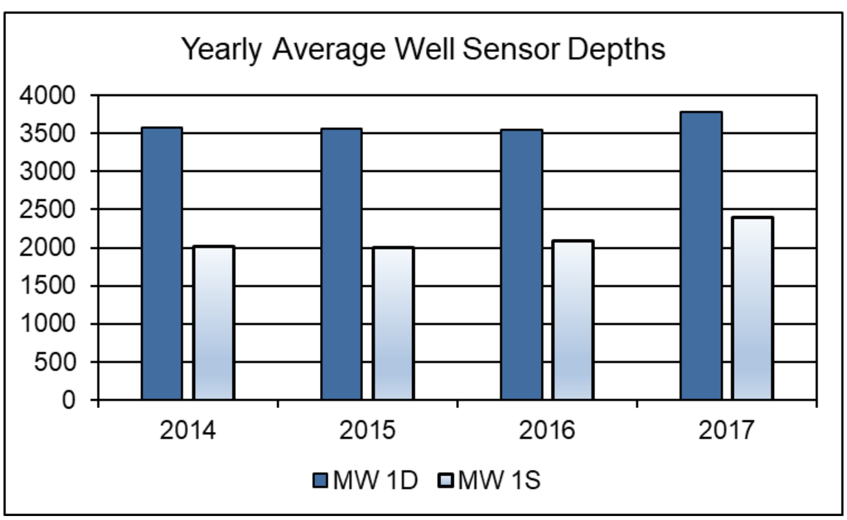
Data points sensor depth were processed in Excel to produce several graphs to compare differences in MW1S and MW1D visually. USGS data was accessed of the gauge next to Sagehen Creek to further contrast long-term and short-term changes

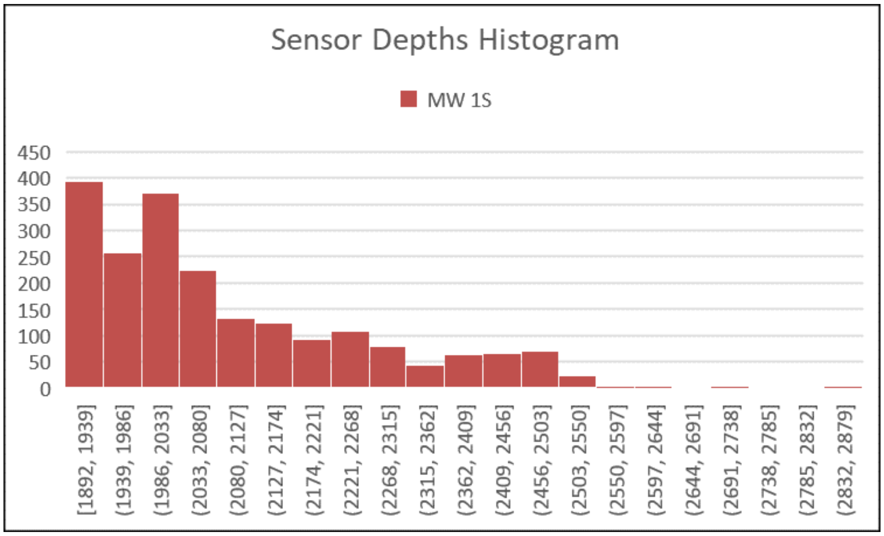


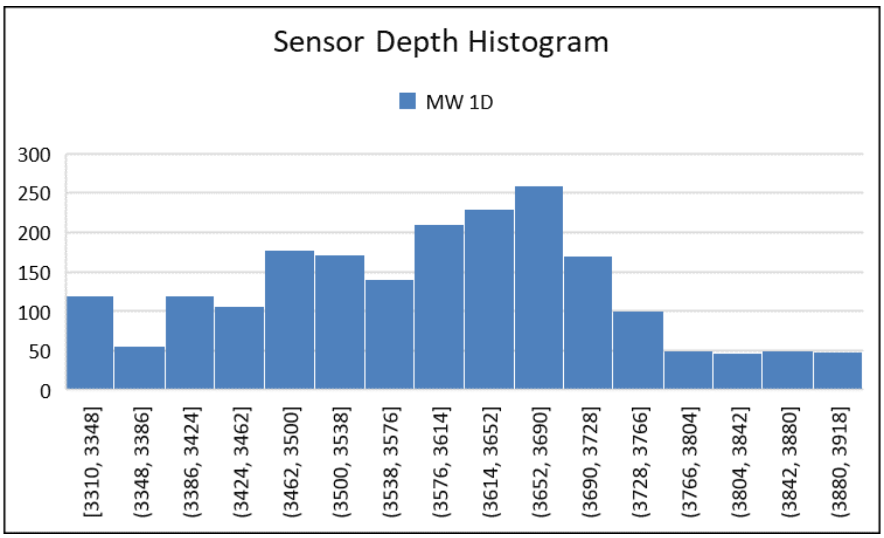



USGS
USGS 10343500 SAGEHEN C NR TRUCKEE CA
Gage height, feet
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Oct 2014
Jan 2015
Apr 2015
Jul 2015
Oct 2015
Jan 2016
Apr 2016
Jul 2016
Oct 2016
Jan 2017
Apr 2017
Gage height
Operational limit (minimum)
Period of approved data


USGS
USGS 10343500 SAGEHEN C NR TRUCKEE CA
Temperature, water, degrees Celsius
15
10
5
0
Temperature, water, degrees Fahrenheit
65
60
55
50
45
40
35
30
Oct 2014
Jan 2015
Apr 2015
Jul 2015
Oct 2015
Jan 2016
Apr 2016
Jul 2016
Oct 2016
Jan 2017
Apr 2017
Median daily statistic (3 years)
Period of approved data
Temperature


Yearly Average Well Sensor Depths
4000
3500
3000
2500
2000
1500
1000
500
0
2014
2015
2016
2017
MW 1D
MW 1S





Results

Seasonal flux is evident in the graphs with peak discharge, gauge height, and sensor depth occurring during the winter, with sharp visible wavelength peaks in January. The sinuosity is also observed in the temperature graph but reflecting a trough during the winter months cold weather. This undulation is reflective of the close relationship between precipitation, discharge, and gauge height. When looking at groundwater level in-between years, there seems to be an erratic rise and fall. However, these short-term changes are reflective of the variability that can occur in short periods. The wavelength form of seasonal changes is consistent, but single years are much more sensitive to changes. The consistent average over the years is an interesting point as fluctuations may have short-term impacts but do not change the mean. The histograms of each well indicate that MW1S water is generally not too depleted but can see periods of low quantities of groundwater. The MW1D sensor depth histogram displays a somewhat normal distribution, likely because it has a consistently fast recharge rate maintaining water level at a shorter depth.

References

Sylvester, A.G. (2017). *Geology of the Independence Lake and Hobart Mills 7.5' Quadrangles, Nevada and Sierra Counties, California*.