EXPLORING SURFACE WATER-GROUNDWATER INTERACTION IN TWO EAST BAY CREEKS USING GEOCHEMICAL AND ISOTOPIC TRACERS

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CAL STATE EAST BAY

Lawrence Livermore National Laboratory

Study Area: East Bay Plain Subbasin, California

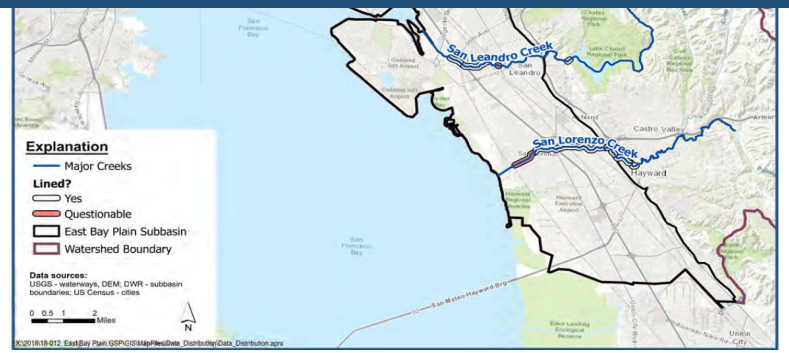
Upper watersheds are effectively separated from lower (urbanized) watersheds

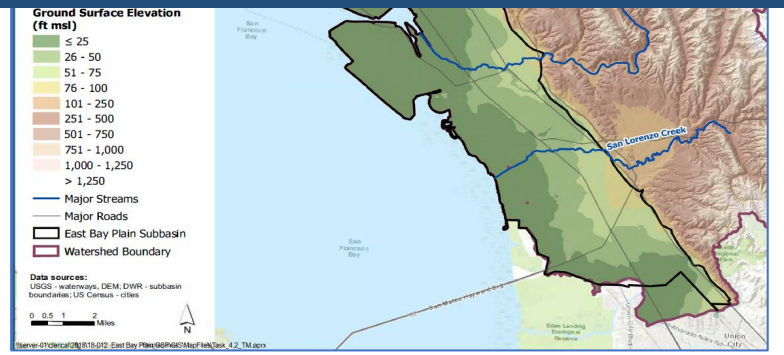
Sufficient annual precipitation

Many streams are perennial

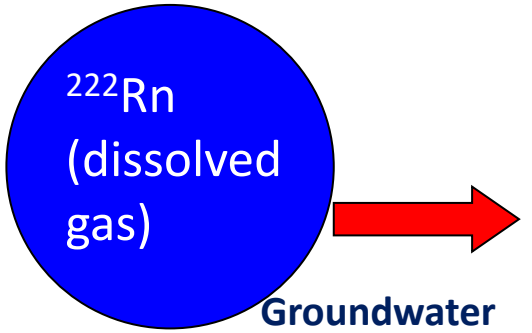
Study Goals:

1. Investigate sources of streamflow
2. Provide metrics for water budget in GSP updates
3. Assess Groundwater Dependent Ecosystems and effects of pumping or other changes in water management on streamflow



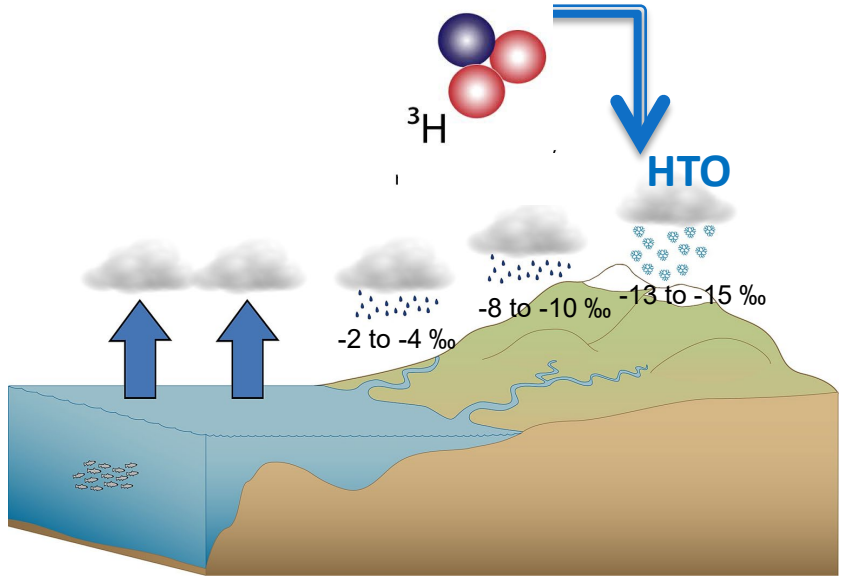


Tracers and Measurements



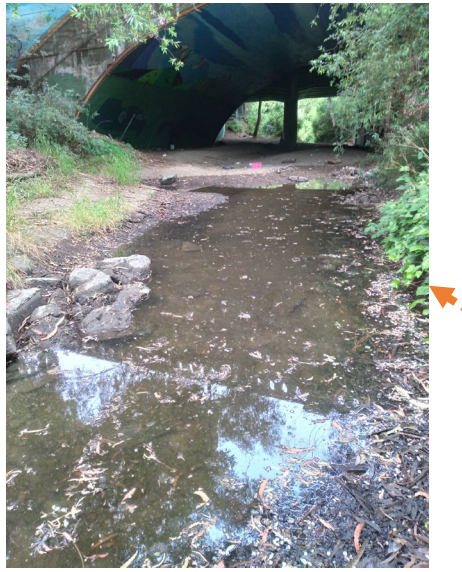
Rocks **Groundwater** **Stream**

Isotope	Purpose	Procedure
Tritium (^{3}H)	"Age" of groundwater in stream	Noble Gas Mass Spectrometry after Helium-3 Accumulation by Tritium Decay
Stable isotopes of the water molecule ($\delta^{18}O$, $\delta^{2}H$)	Source of water (precipitation, ambient groundwater, imported)	Cavity Ring-Down Spectroscopy
Radon-222 (^{222}Rn)	Locations of groundwater influx	RAD7 counting

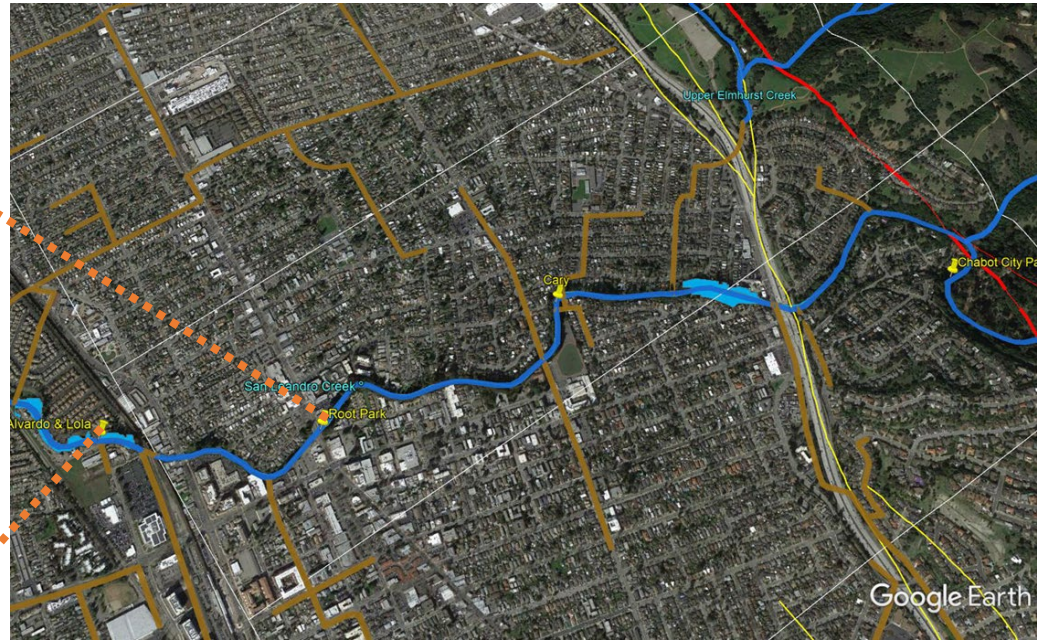


San Leandro Creek May 12, 2021

below Lake Chabot



Root Park



Sampling locations on San Leandro Creek

X-section at Cary

Alvarado & Lola

San Pablo Creek May 12, 2021

Kennedy Grove

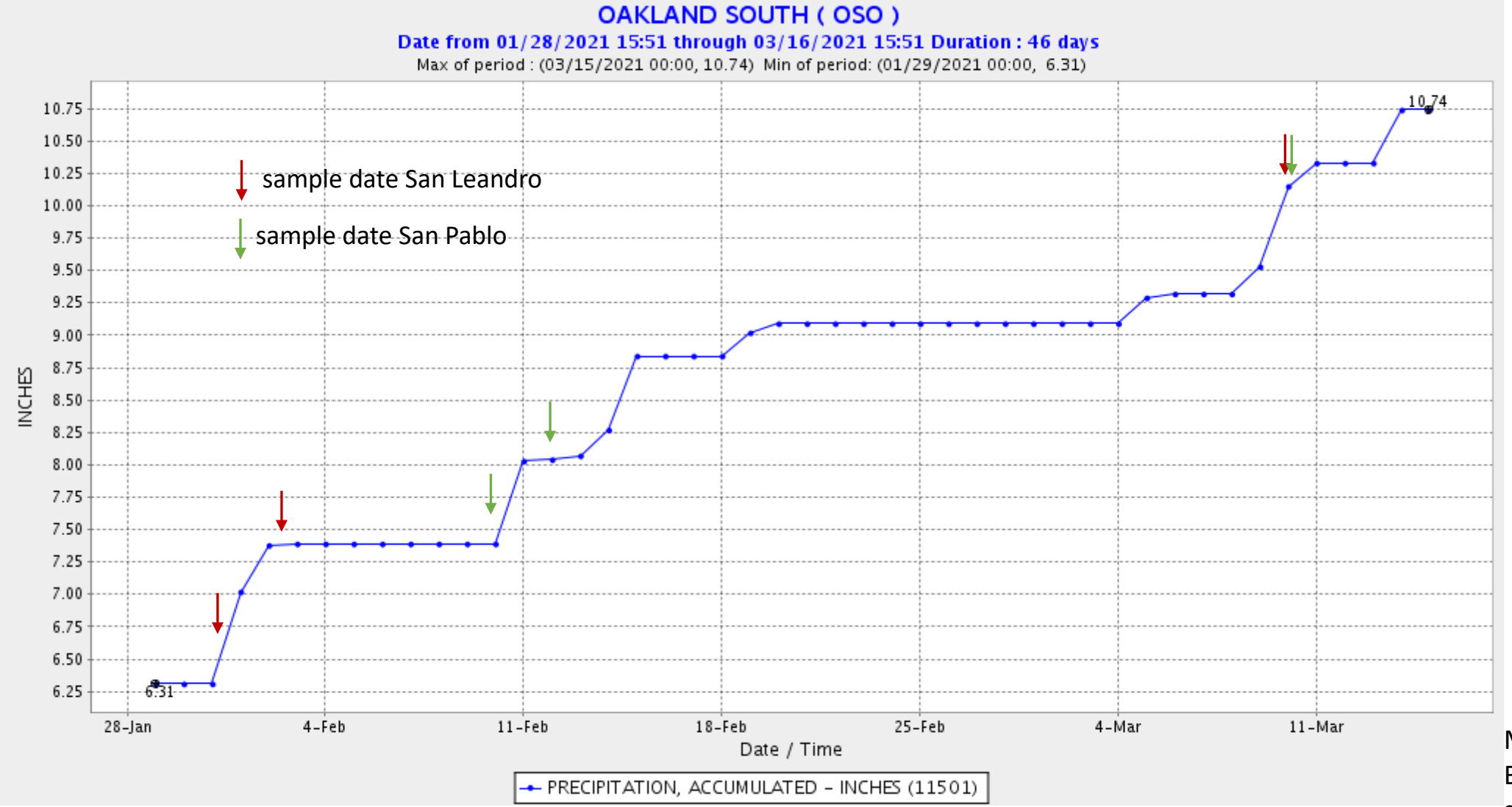
Via Verdi

Bell Park

D’Avila

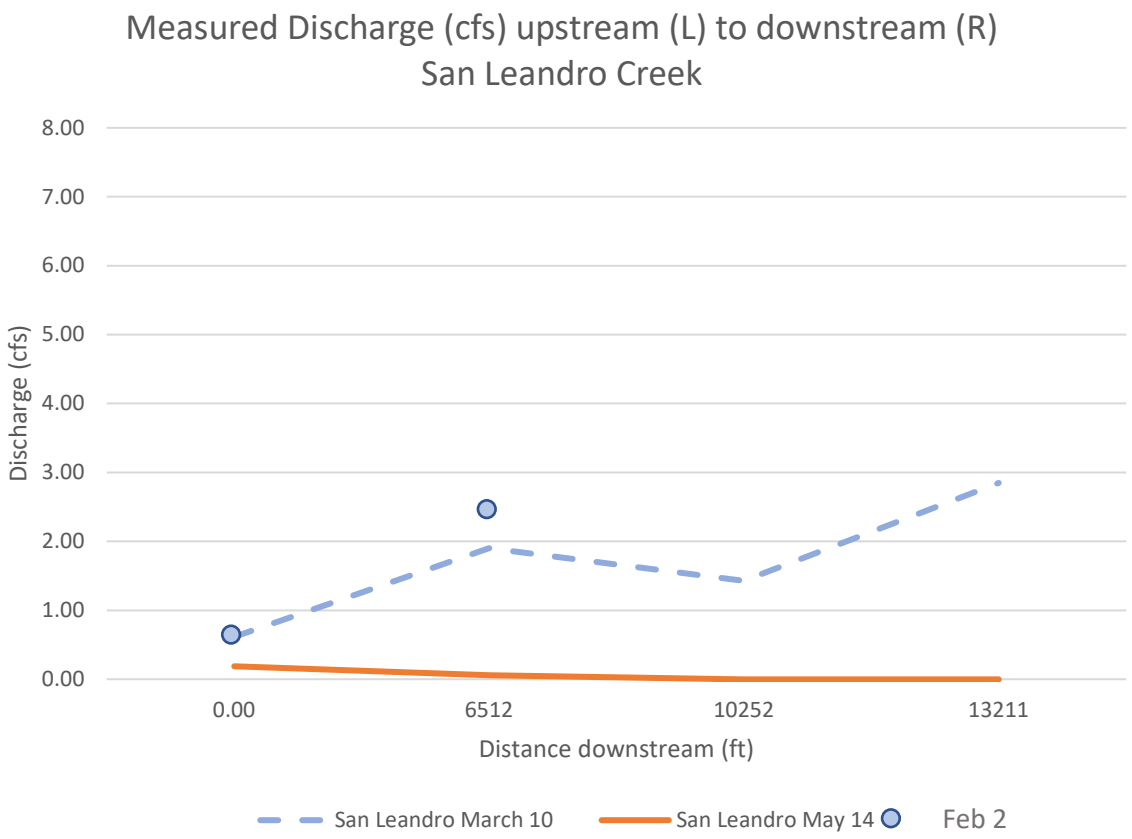
St. Joseph’s Cemetery

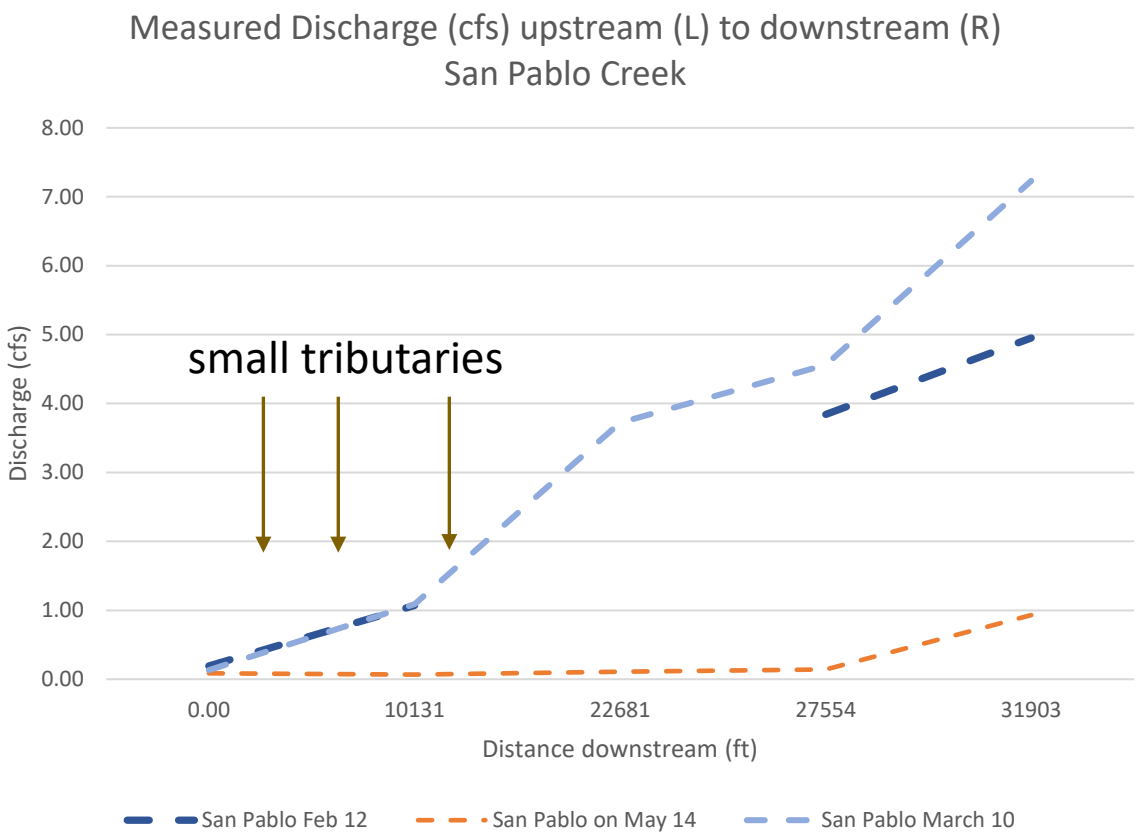
Event Sampling



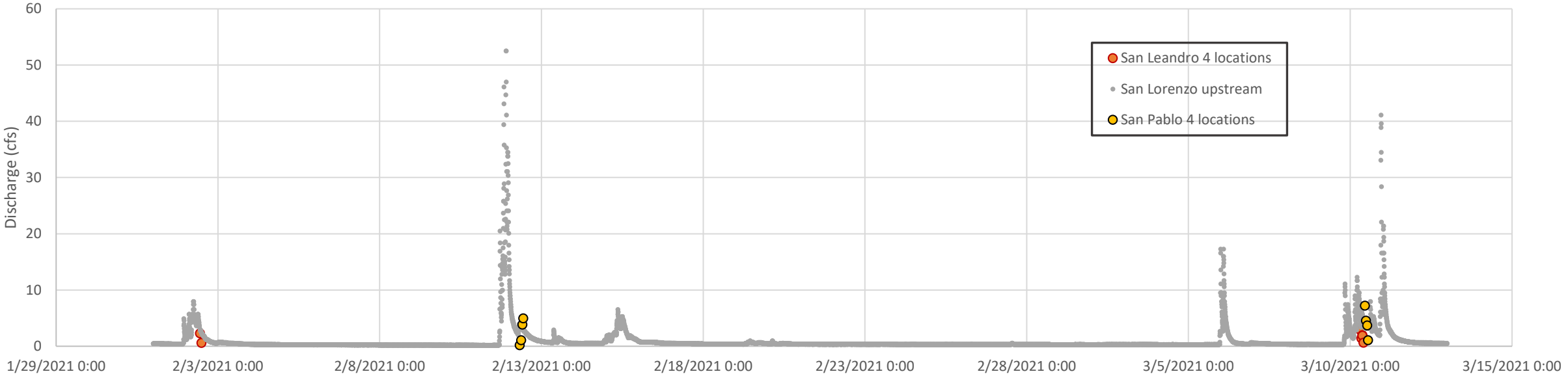
May 12, 2021 Baseflow samples collected at all locations

Discharge Results





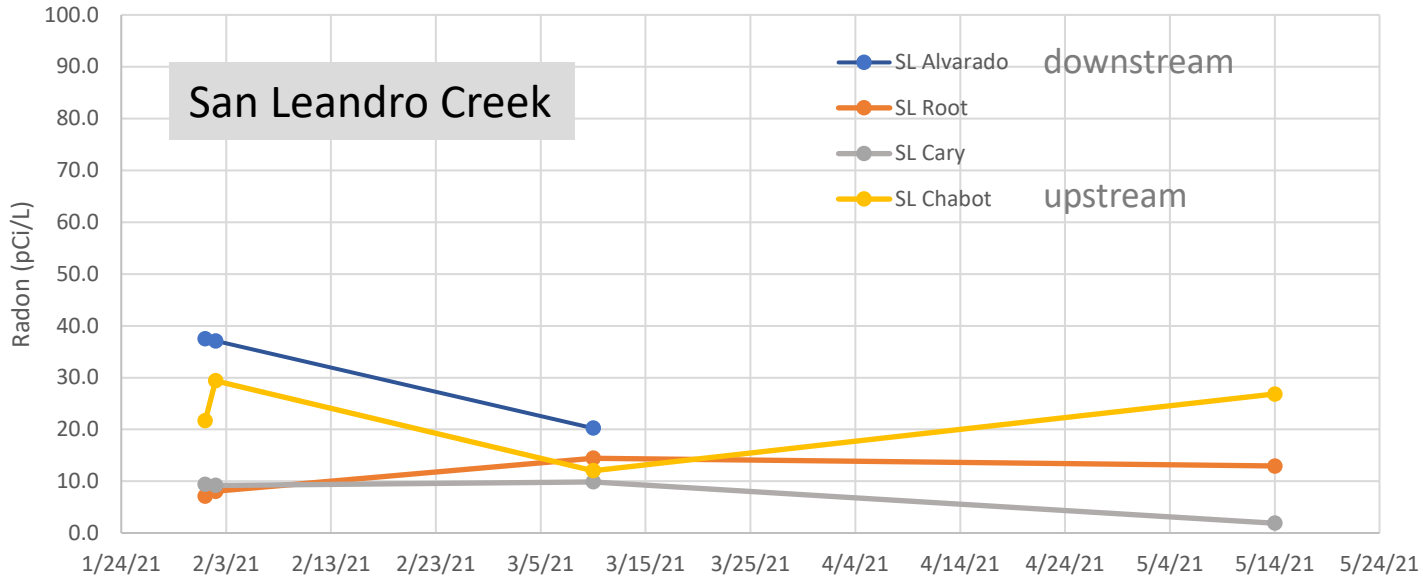
Comparison with a San Lorenzo Creek gage

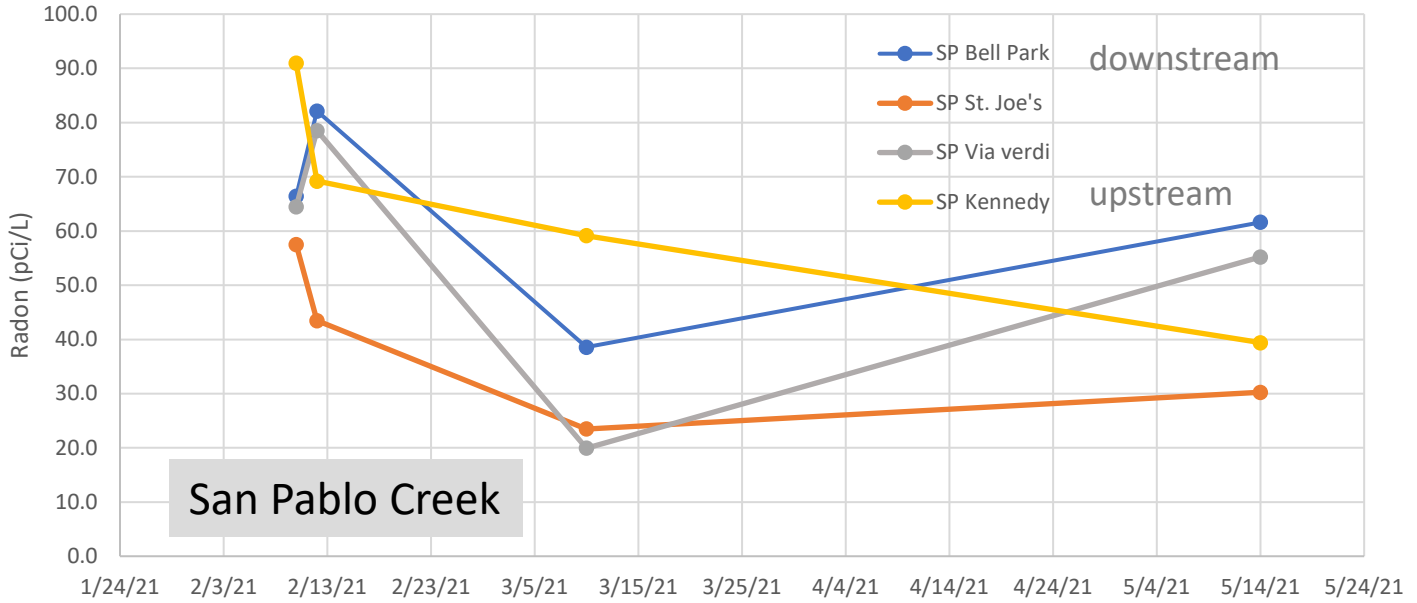


- Installation of gages is expected during continuing GSP work
- Continuous discharge would allow quantification of key components of the water budget
- Continuous discharge would allow quantification of the flux of the different water components to the bay

Radon Results

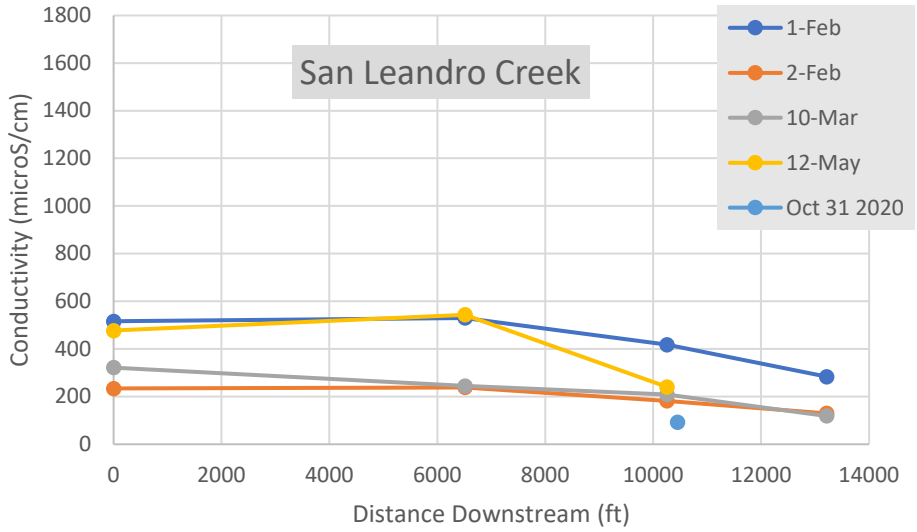
- Radon activity is more than 2X higher in San Pablo Creek than in San Leandro Creek
- San Leandro Creek is losing or neutral, except perhaps at most downstream site
- San Pablo Creek gaining, at all locations and nearly all times
- Lower radon in San Pablo Creek during March event indicates more overland flow, or loss of Radon with higher turbulence

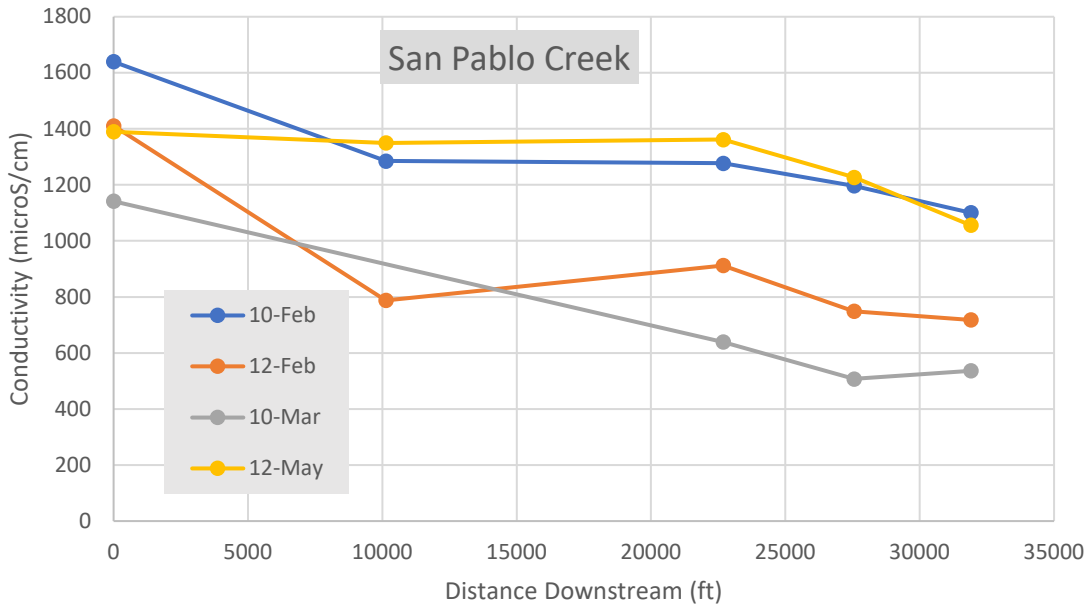




Conductivity/TDS Results

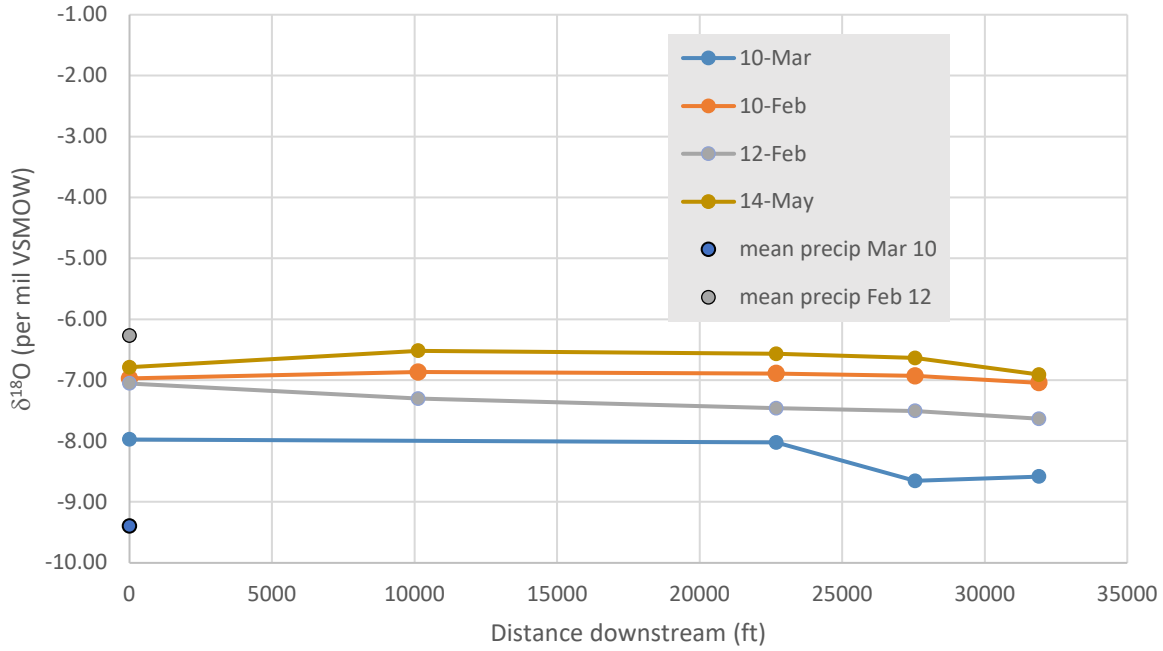
- San Leandro Creek is significantly lower in TDS than San Pablo Creek
- Rain events decrease conductivity at all locations, as expected
- Conductivity decreases with distance downstream, due to influence of imported water



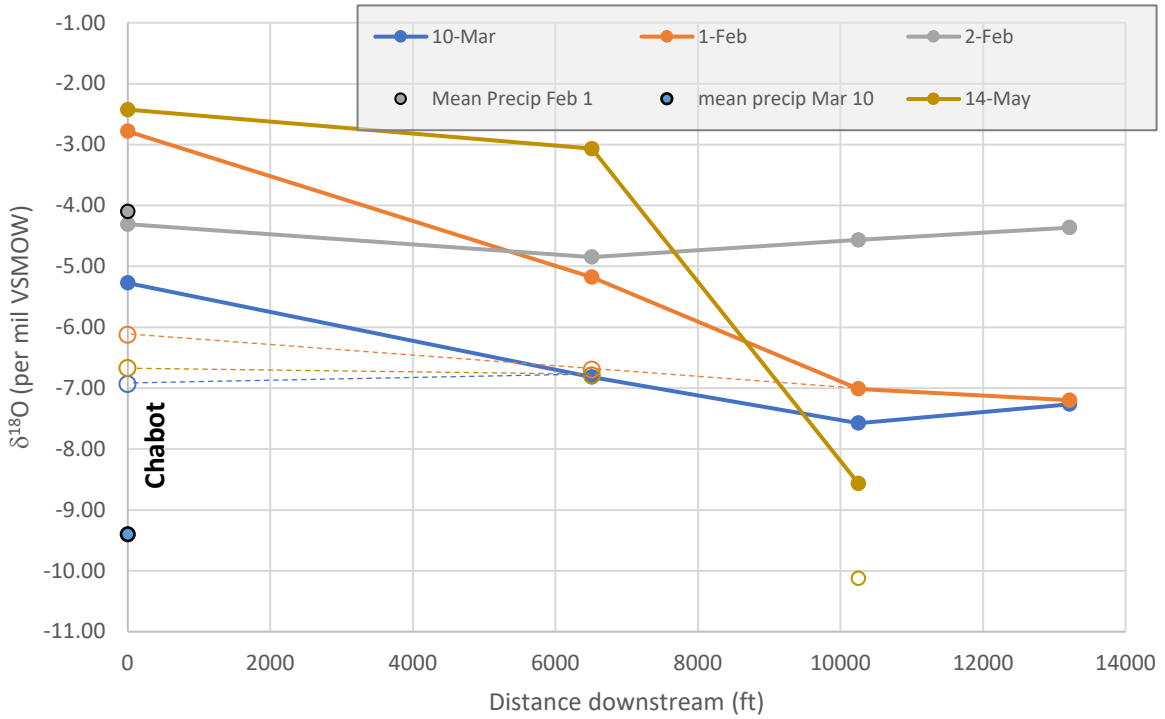


Stable isotope results

San Pablo Creek



San Leandro Creek



- San Leandro Creek
  - Upstream samples are evaporated (corrected values shown with open symbols)
  - During the Feb 1-2 event, the stream takes on the isotopic signature of the precipitation entirely
- San Pablo Creek
  - Slightly isotopically lighter going downstream
  - During events, the stream shows some response to precipitation but is likely buffered by groundwater inflow

Results of mixing calculations

- End Members
  - Pre-event water (-6.8‰)
  - Event water (from volume-weighted precipitation)
  - Imported water (very light, -11.6‰)
  - Releases from reservoir (evaporated, -3.0‰)
- Two tracers
  - Stable isotopes
  - TDS (Chloride)

- Results

Date	Location	%Event Water	% Pre-event	% Imported	$\delta^{18}O$ value measured in stream
10 Feb	Below SP dam		100		-6.87
10 Feb	downstream			5	-7.04
10 Mar	Below SP dam	48	52		-7.95
10 Mar	downstream			17	-8.58

Date	Location	%Event Water	% Pre-event	% Imported	$\delta^{18}O$ value measured in stream
1 Feb	Below Lake Chabot		100		-2.78
1 Feb	downstream			4	-7.01
2 Feb	Below Lake Chabot	100			-4.31
2 Feb	downstream			6	-4.57
14 May	Below Lake Chabot		100		-2.73
14 May	downstream			83	-10.1

Tritium (^3H) results

Location	Tritium concentration on Mar 10, 2021 (pCi/L)	Uncertainty (pCi/L)
San Pablo Creek at SP dam	7.09	0.51
San Pablo Creek downstream	8.31	1.20
San Leandro Creek at Chabot Lake	11.36	1.41
San Leandro Creek downstream	12.04	0.60

- Confirms very recent water/runoff in San Leandro Creek during events
- On San Pablo Creek, the groundwater end-member in the mixture (52%) on March 10 would have a tritium value of approximately 3 pCi/L to result in a sample value of 7.1 pCi/L, corresponding to a water age of approximately 20 years

We learned a lot about the hydrology of these urban watersheds for about $35K

Key Takeaways from this study:

- Stream generation on San Leandro Creek
  - small releases (recharge by 8,000 ft downstream of dam)
  - event runoff (recharges + some to bay during larger events)
  - imported water (from leaky infrastructure?) during dry periods (spatially limited)
- Stream generation on San Pablo Creek
  - in large part from groundwater inflow
  - imported water becomes a detectable component downstream in urbanized area
  - imported water may be necessary to maintain GDEs

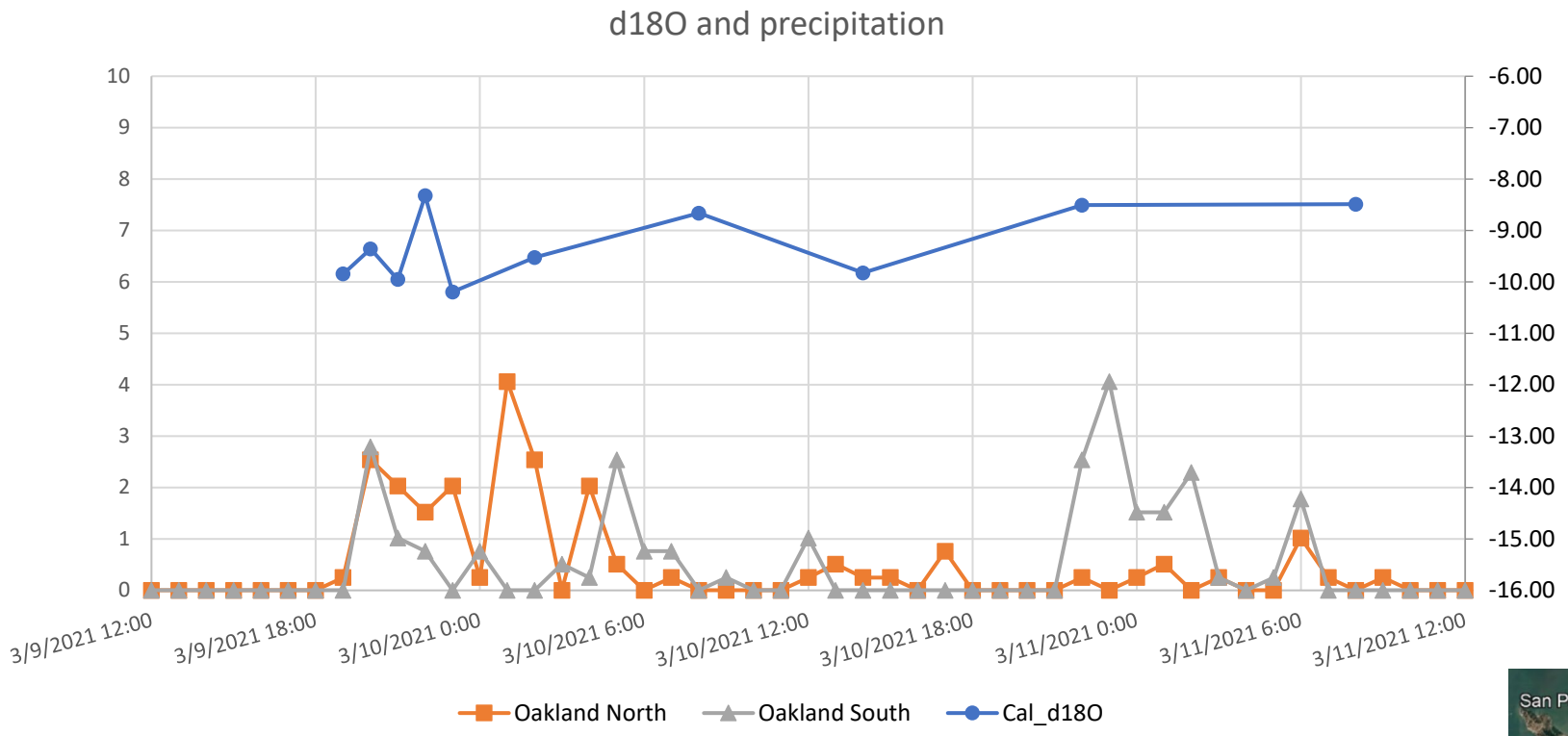
Limitations

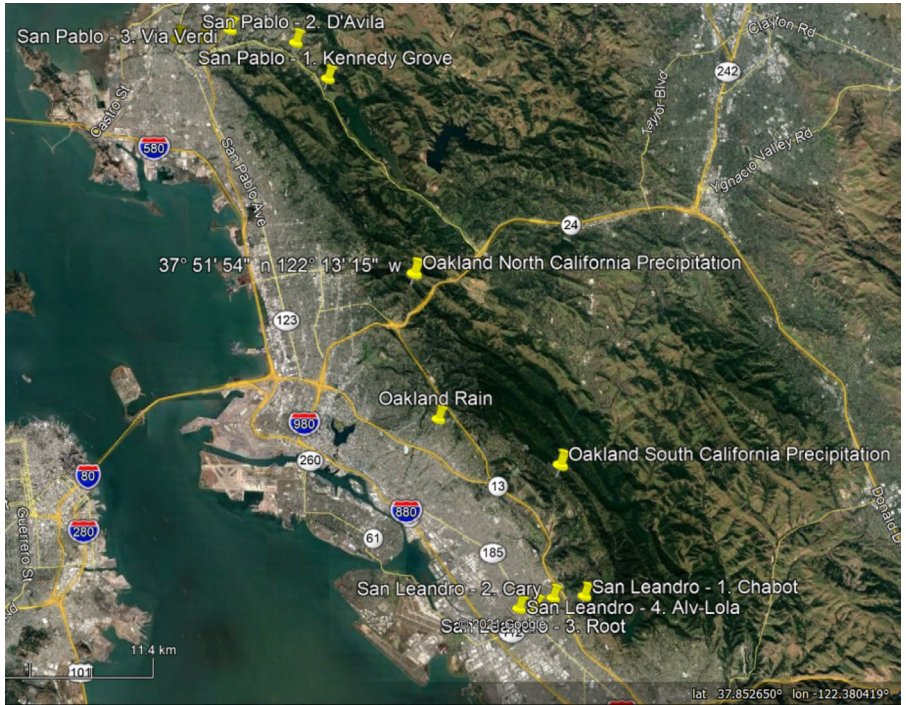
- Sampling is synoptic – surface water-groundwater exchange varies with hydrologic conditions
- Lack of continuous discharge (stream gage) data precludes quantifying fluxes
- End member characterization is limited by the small number of samples

Future Work

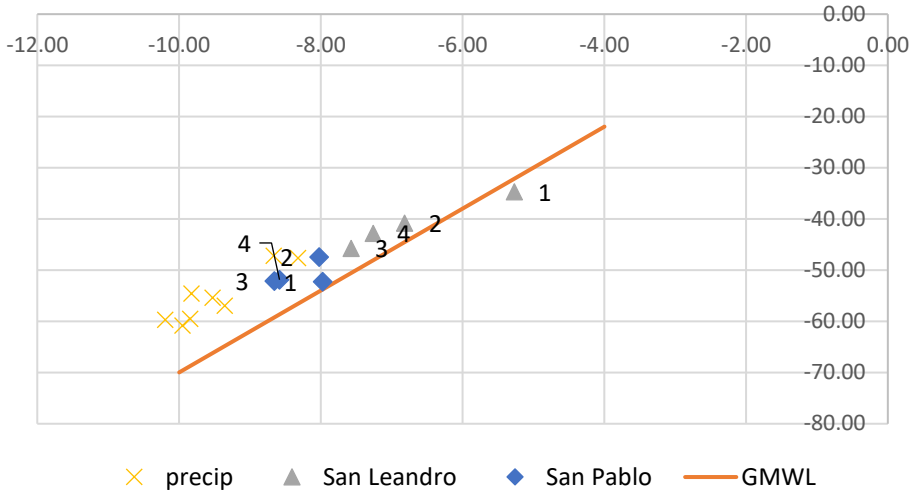
- More comprehensive sampling (in space and time) for the tracers discussed here and for additional constituents (nutrients, metals, etc.)
- Installation of gages under GSP implementation
- Integration of these data with other types of monitoring data and with model output
- Installation of shallow wells adjacent to streams

Extra slides

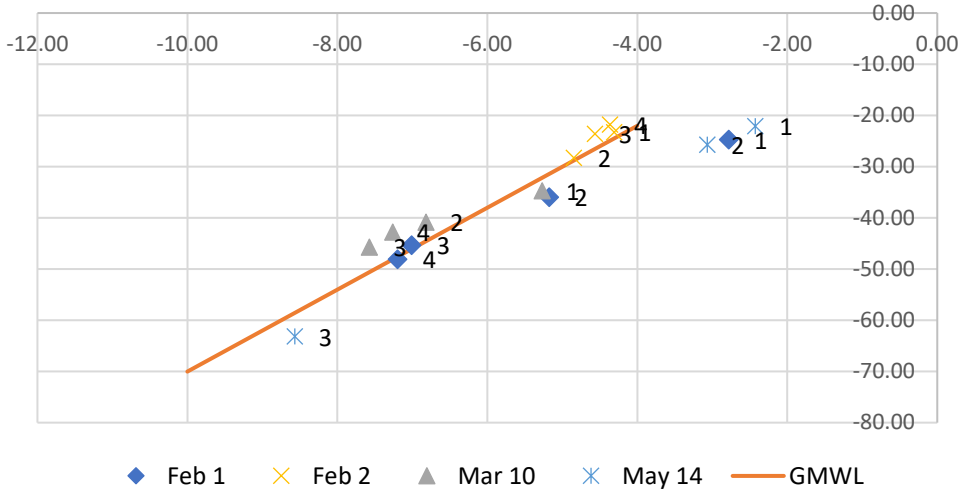

d18O and precipitation
10
9
8
7
6
5
4
3
2
1
0
-6.00
-7.00
-8.00
-9.00
-10.00
-11.00
-12.00
-13.00
-14.00
-15.00
-16.00
3/9/2021 12:00
3/9/2021 18:00
3/10/2021 0:00
3/10/2021 6:00
3/10/2021 12:00
3/10/2021 18:00
3/11/2021 0:00
3/11/2021 6:00
3/11/2021 12:00
Oakland North
Oakland South
Cal_d18O


San Pablo - 2. D'Avila
San Pablo - 3. Via Verdi
San Pablo - 1. Kennedy Grove
37° 51' 54" n 122° 13' 15" w
Oakland North California Precipitation
Oakland Rain
Oakland South California Precipitation
San Leandro - 2. Cary
San Leandro - 1. Chabot
San Leandro - 4. Alv-Lola
San Leandro - 3. Root
11.4 km

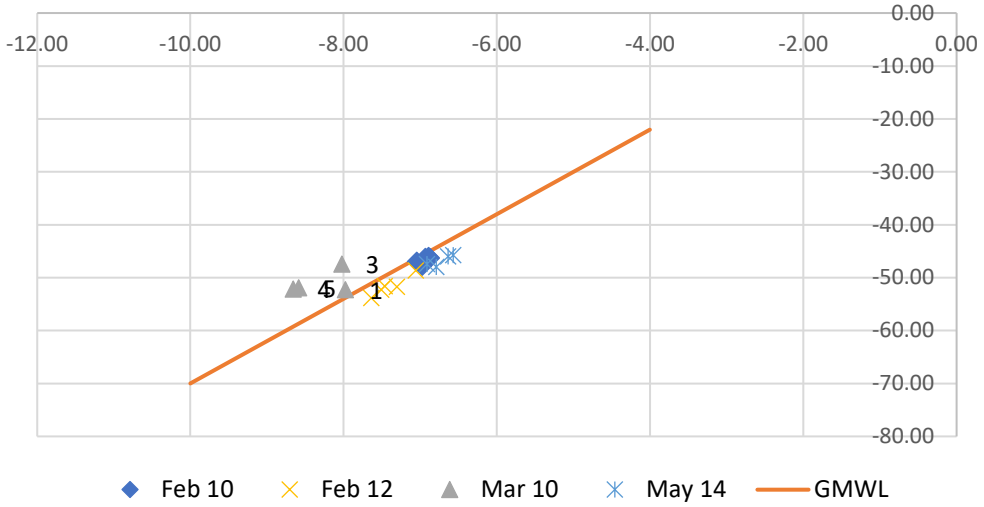
High Flow Event (3/10/2021)

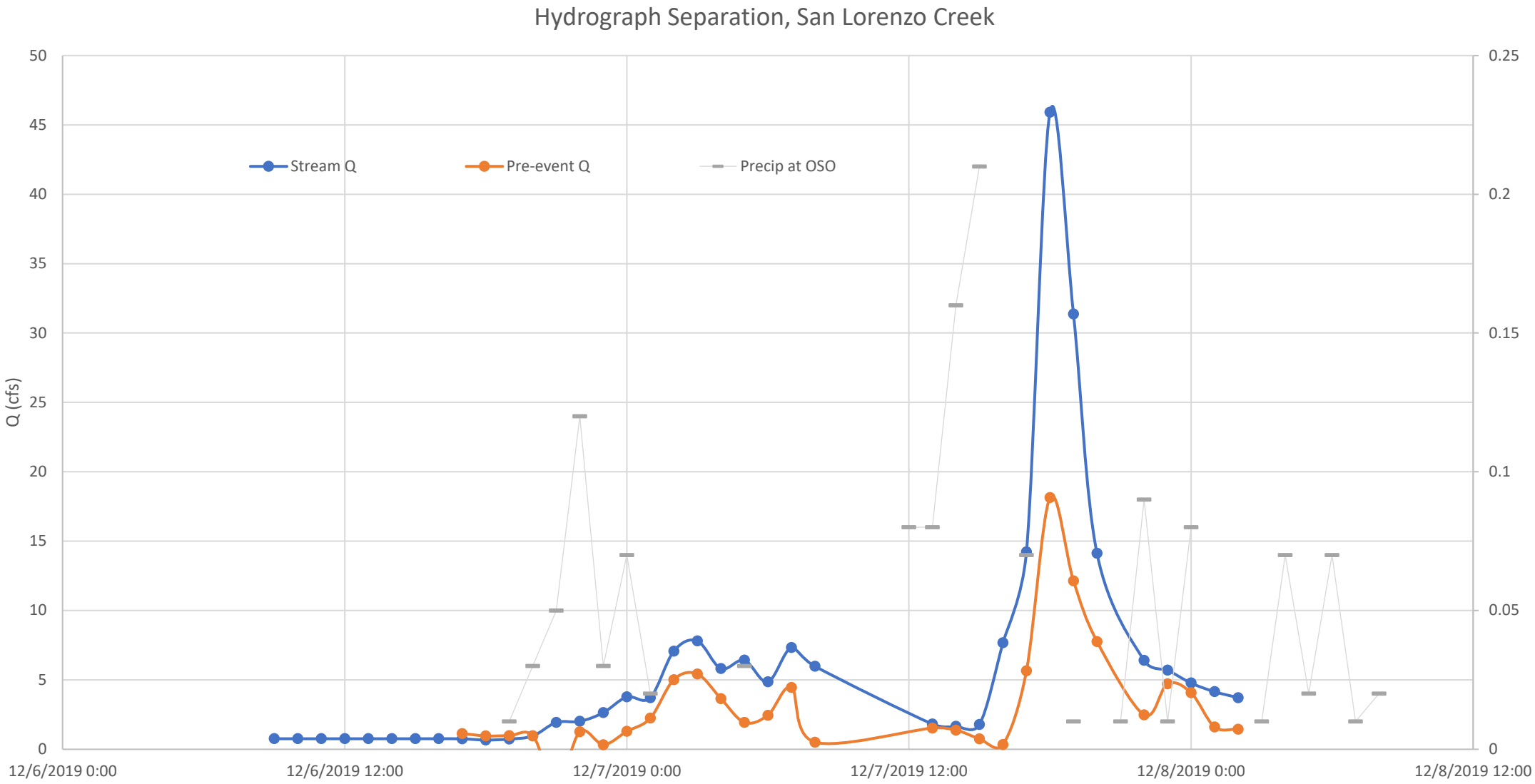


San Leandro, all dates



San Pablo, all dates




Hydrograph Separation, San Lorenzo Creek
Stream Q
Pre-event Q
Precip at OSO
Q (cfs)
50
45
40
35
30
25
20
15
10
5
0
0.25
0.2
0.15
0.1
0.05
0
12/6/2019 0:00
12/6/2019 12:00
12/7/2019 0:00
12/7/2019 12:00
12/8/2019 0:00
12/8/2019 12:00

Stable isotope Results

- Stable isotopes in precipitation vary over a wide range for different storm events
  - Precipitation during the Feb 1, 2021 event was significantly isotopically heavier than pre-event stream flow
  - Precipitation during the March 10 event was somewhat isotopically lighter than pre-event stream flow
- All results fall near the Global Meteoric Water Line; the Local Meteoric Water Line is above the GMWL with the same slope and a higher y-intercept