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MEMORANDUM

TO: Kristina Handt, Administrator, City of Scandia

FROM: Erik Anderson, Water Resource Specialist

DATE: January 15, 2014

RE: **Zavoral Mining and Reclamation Project – Annual Surface Water Monitoring Report**

As per the contract (13-01) between the Washington Conservation District (WCD) and the City of Scandia, WCD staff performed surface water monitoring tasks pertaining to Technical Service 1 of Exhibit B. This memorandum serves as a summary of those activities.

The Washington Conservation District installed stream monitoring equipment at two locations on Zavoral Creek in 2013. One site is located at the monitoring point that was installed for the EIS pump test near the creek mouth (referred to simply as Zavoral Creek), the other site is located upstream of all groundwater inputs to the creek (Crystal Springs). This paired monitoring setup can be used to help determine sources of impacts to Zavoral Creek by potentially either eliminating or supporting the mine as a source. Continuous turbidity, dissolved oxygen, temperature, specific conductivity, stage, velocity, and discharge data were collected at both locations. Water quality samples were collected during base and storm flow at Zavoral Creek and analyzed for total & volatile suspended sediments. No samples were collected at Crystal Springs. Equipment at both locations was installed on 6/12/13 with the intention of gathering baseline data previous to the commencement of mining activities. Due to the harsh winter weather, all equipment was removed at Crystal Springs on 10/31/13 and the stage/flow recorder was removed at Zavoral Creek on 11/14/13. At the time of this report, all other parameters are still being recorded. Macroinvertebrate samples were collected in June and September to be used as baseline data for comparisons to future data collection.

Results/Conclusions/Recommendations

Surface water data collected at Zavoral Creek and Crystal Springs from 6/12/13 – 12/31/13 were analyzed by the WCD for this summary. To date, data results do not indicate any impacts to the stream caused by the mining operations. It should be noted, quick unsustained spikes in turbidity have been recorded at both stream monitoring locations, independent of each other, previous to any mining activities occurring, and in the absence of recorded rainfall. Possible explanations for these anomalies include logger error, sediment adhering to the sensor, animal activity in the stream, or some other natural phenomenon. These data have been included in the final dataset to show that very short fluctuations in stream turbidity have been recorded previous to and outside of any mining activities. A reading of 1616 NTU (Nephelometric Turbidity Units) was recorded at Zavoral Creek on 11/17/13 at 8:00 pm (after site preparation but before any hauling activity began) and is not thought to be a result of any mining activities, mainly due to the time it occurred and the adjacent 15-minute periods recorded 0 NTU. This is an example of sediment possibly adhering to the sensor or some other cause of a quick anomaly in the data. Tables and hydrographs showing the data collected at Zavoral Creek and Crystal Springs in 2013 can be found at the end of this report.

Groundwater data collected by Leggette, Brashears, and Graham, Inc. was compared to the surface water data to determine if a correlation exists between the two datasets. The groundwater elevation data suggests that groundwater is potentially flowing in a southeast direction towards Middle Creek. Currently no monitoring activities are taking place on Middle Creek and in order to assess any groundwater impacts on the creek, it is recommended that a surface water monitoring station collecting the same continuous parameters

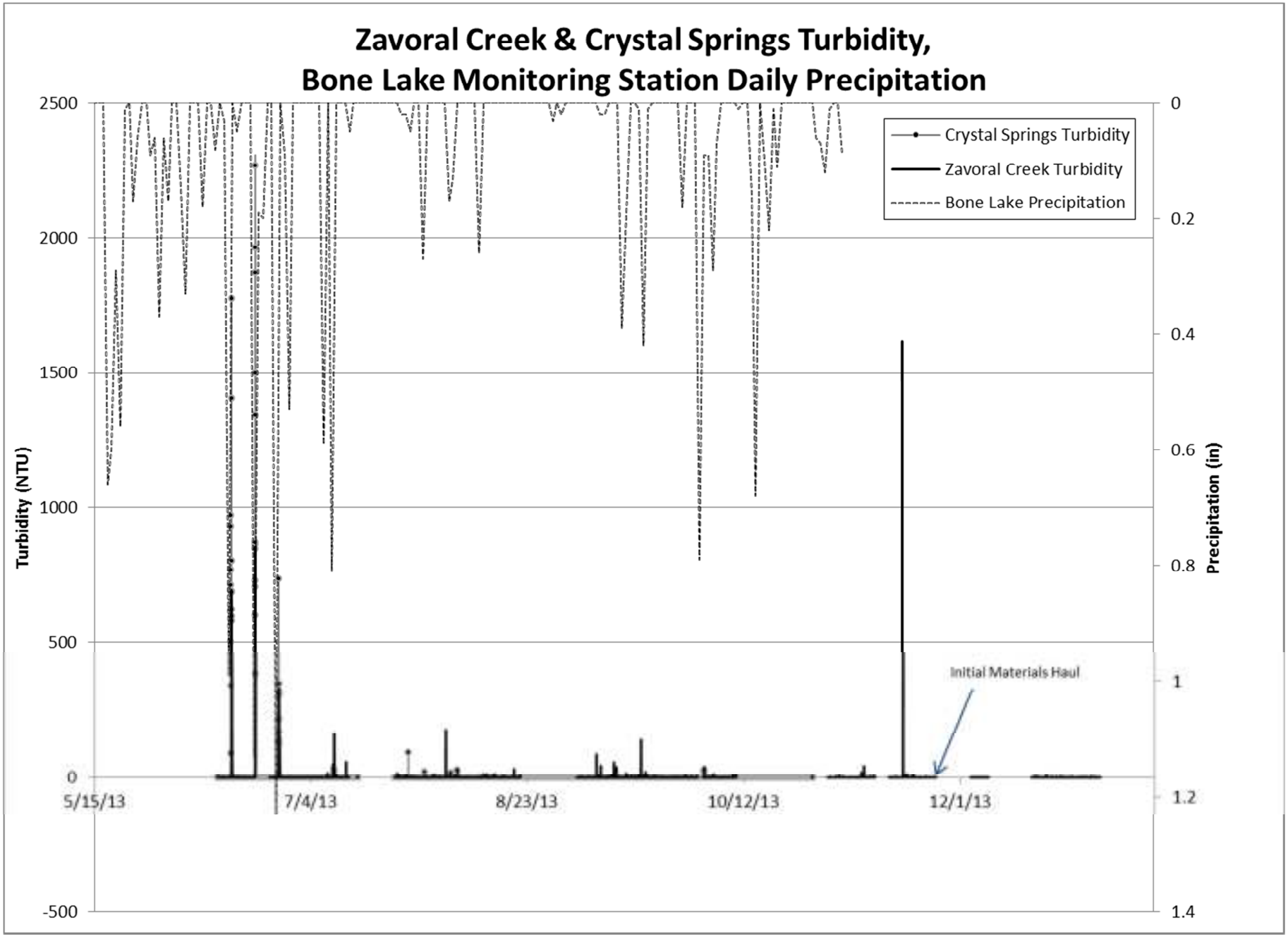
as the existing stations be installed. I recommend monitoring the same locations on Zavoral Creek and Crystal Springs in 2014, following the same procedures and methods as in 2013.

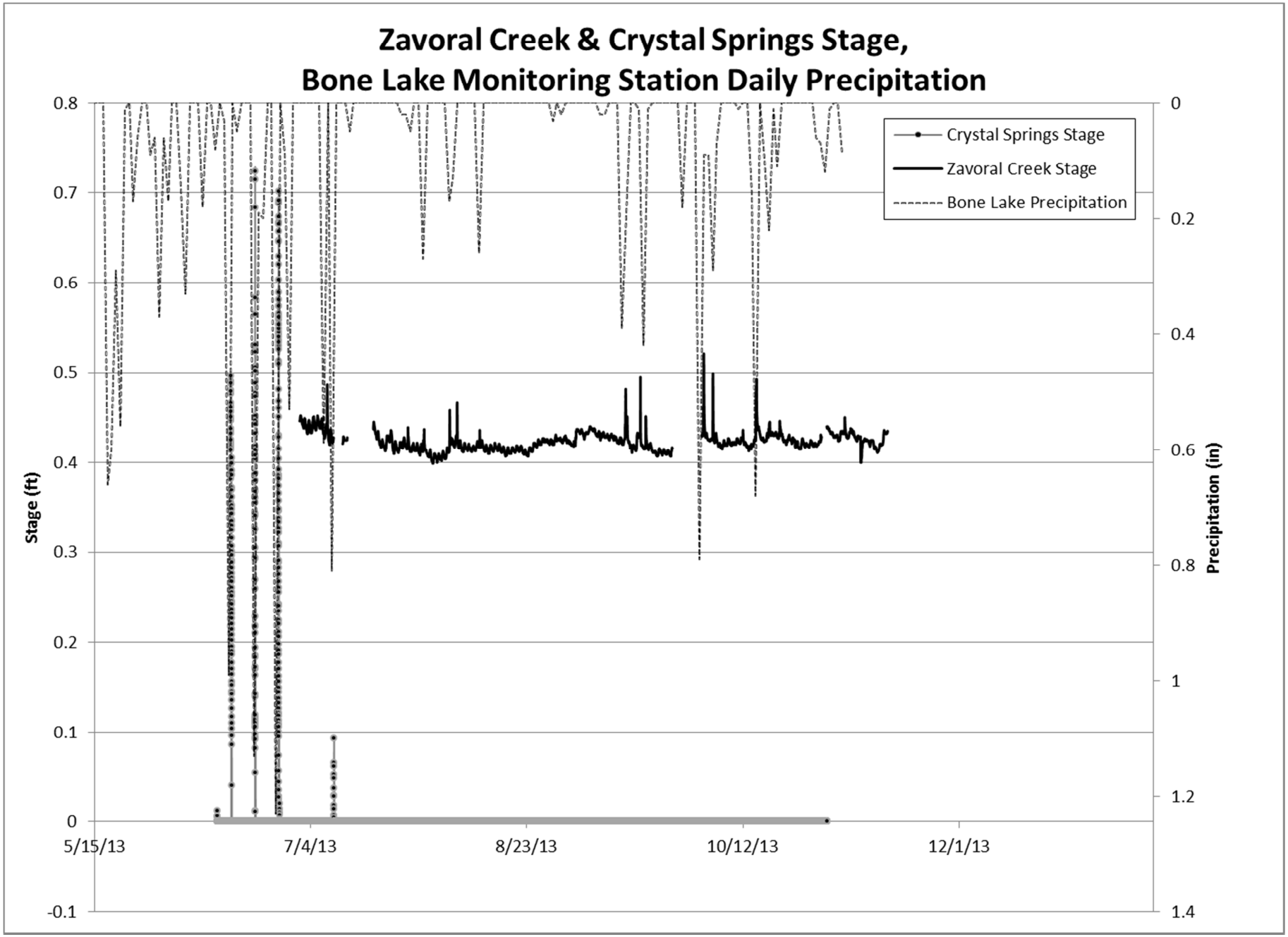
2013	Zavoral Creek	Crystal Springs
Average Baseflow Discharge (cfs)	0.27	No baseflow
Peak Discharge (cfs)*	0.69	1.66
Average Baseflow Turbidity (NTU)	0	No baseflow
Peak Turbidity (NTU)**	854	2268

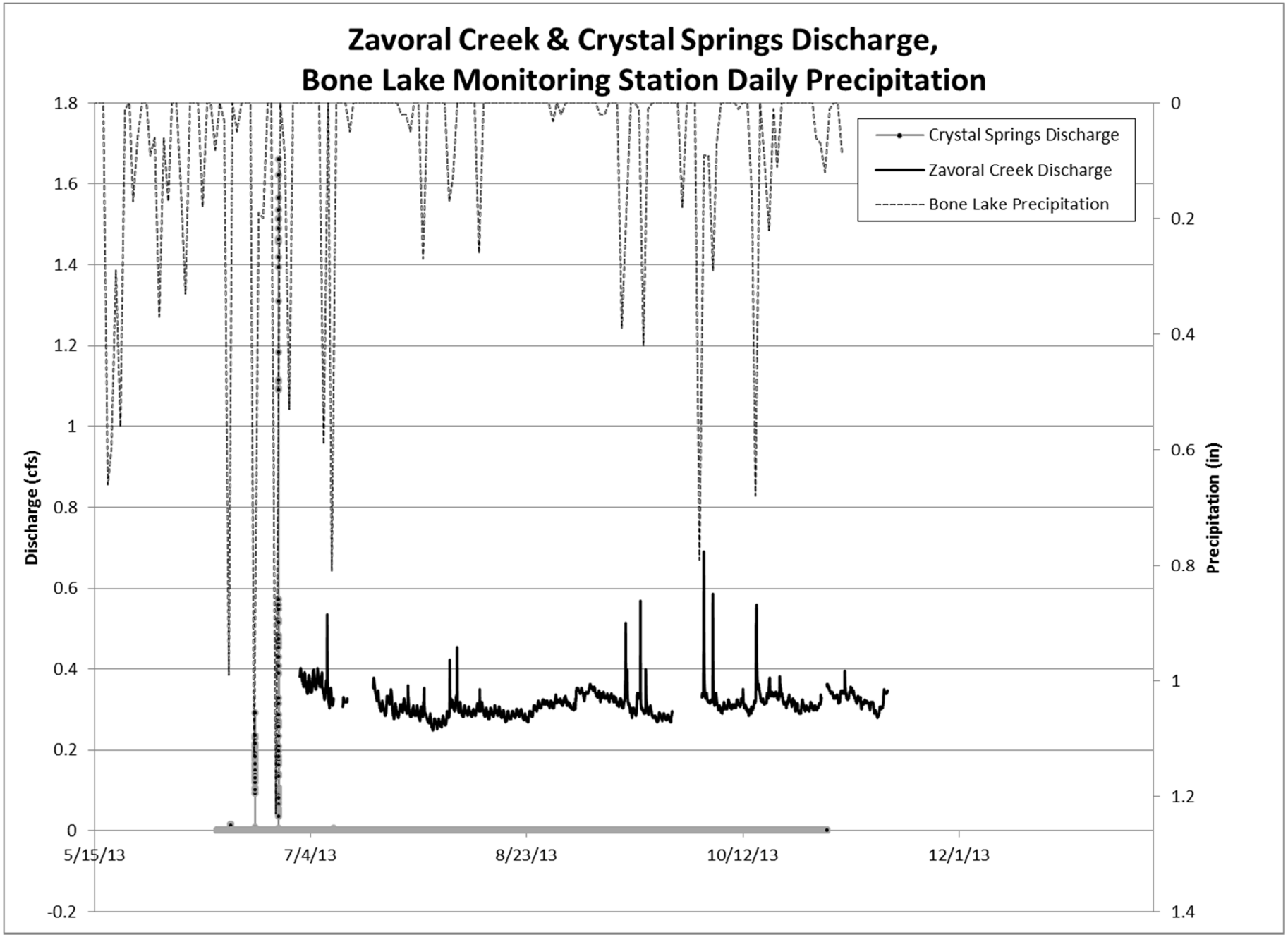
* Discharge was not collected at Zavoral Creek during the Crystal Springs peak discharge event
**Excludes anomaly data

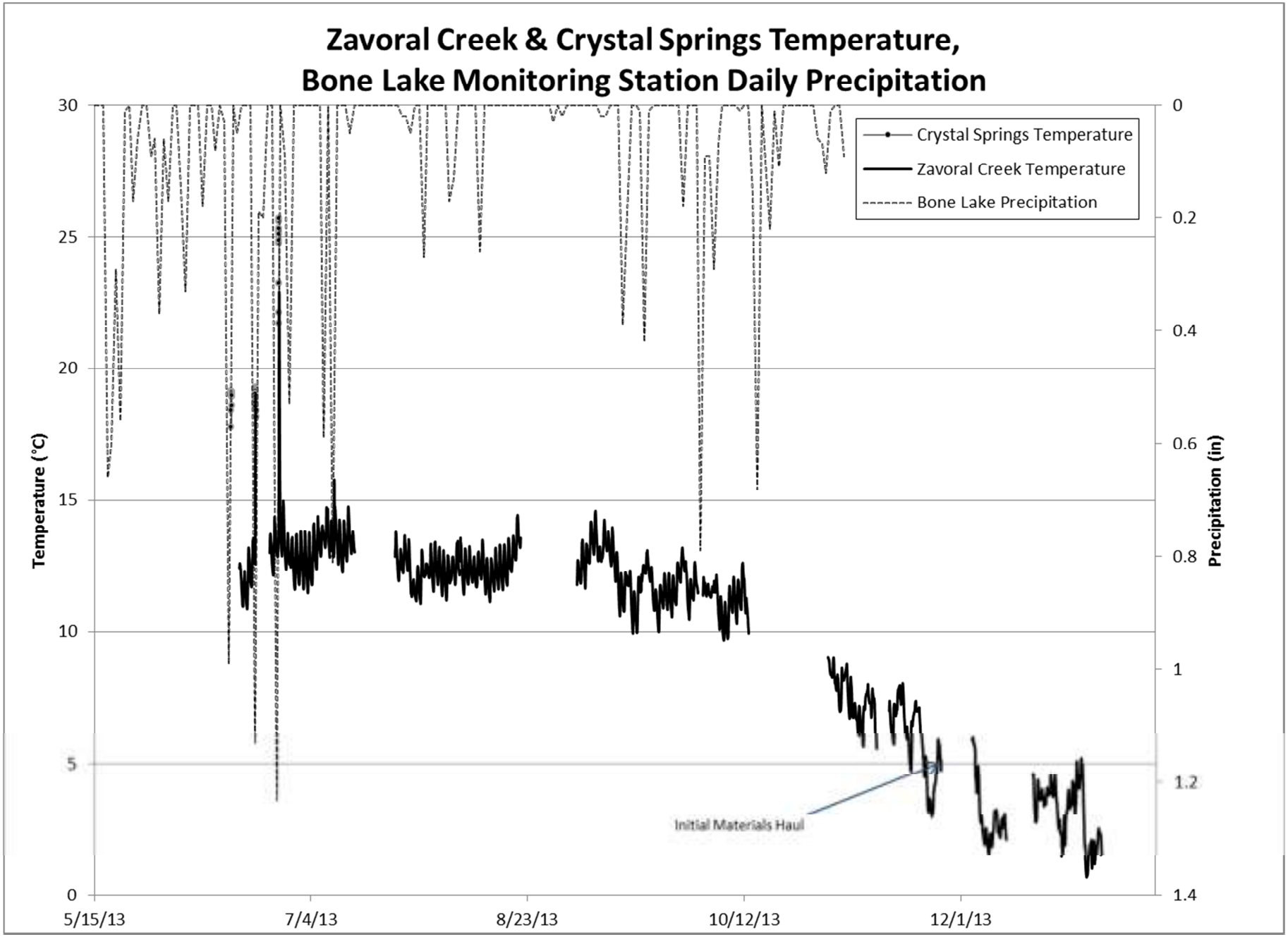
cfs: cubic feet per second

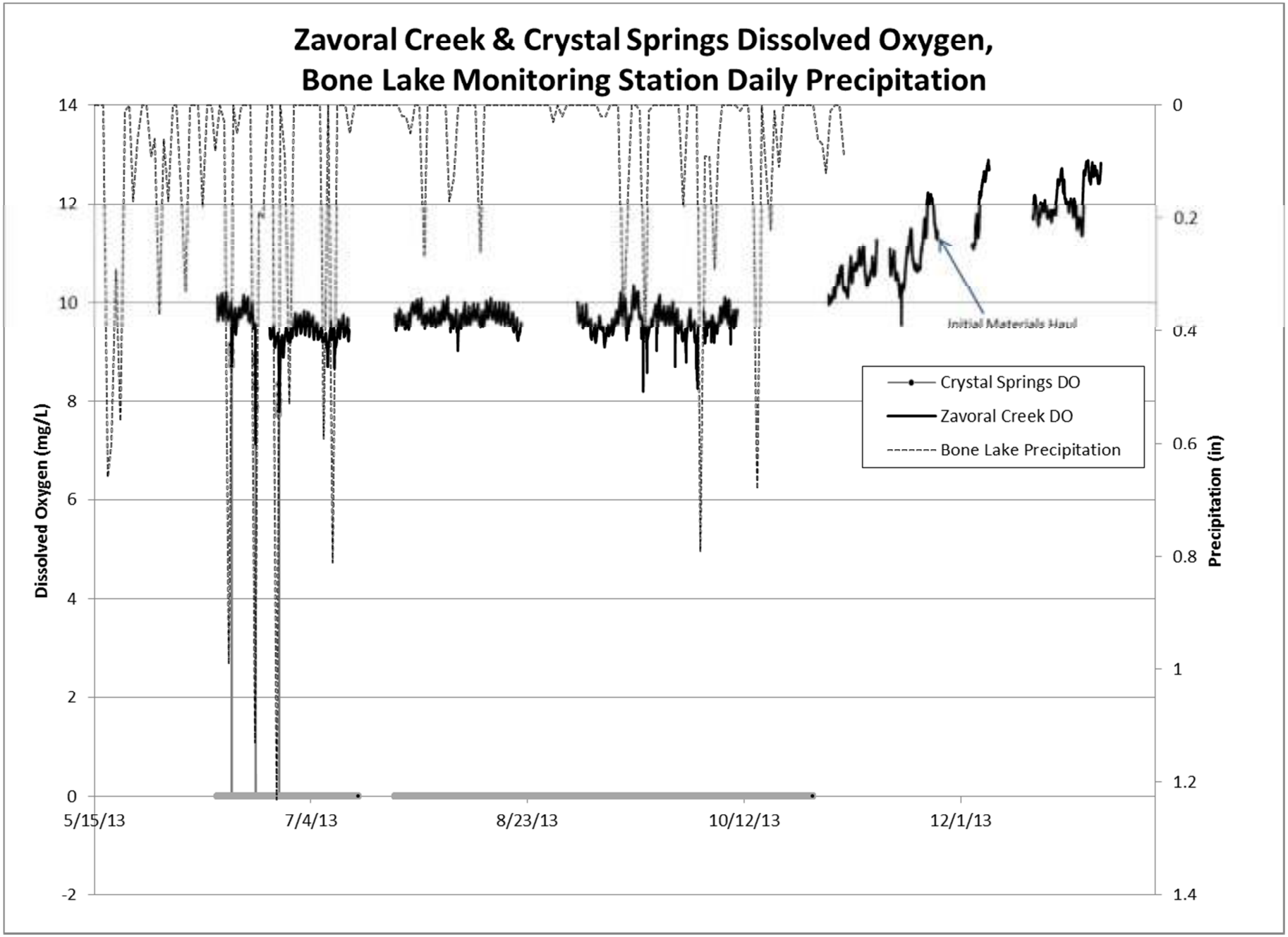
NTU: Nephelometric Turbidity Units

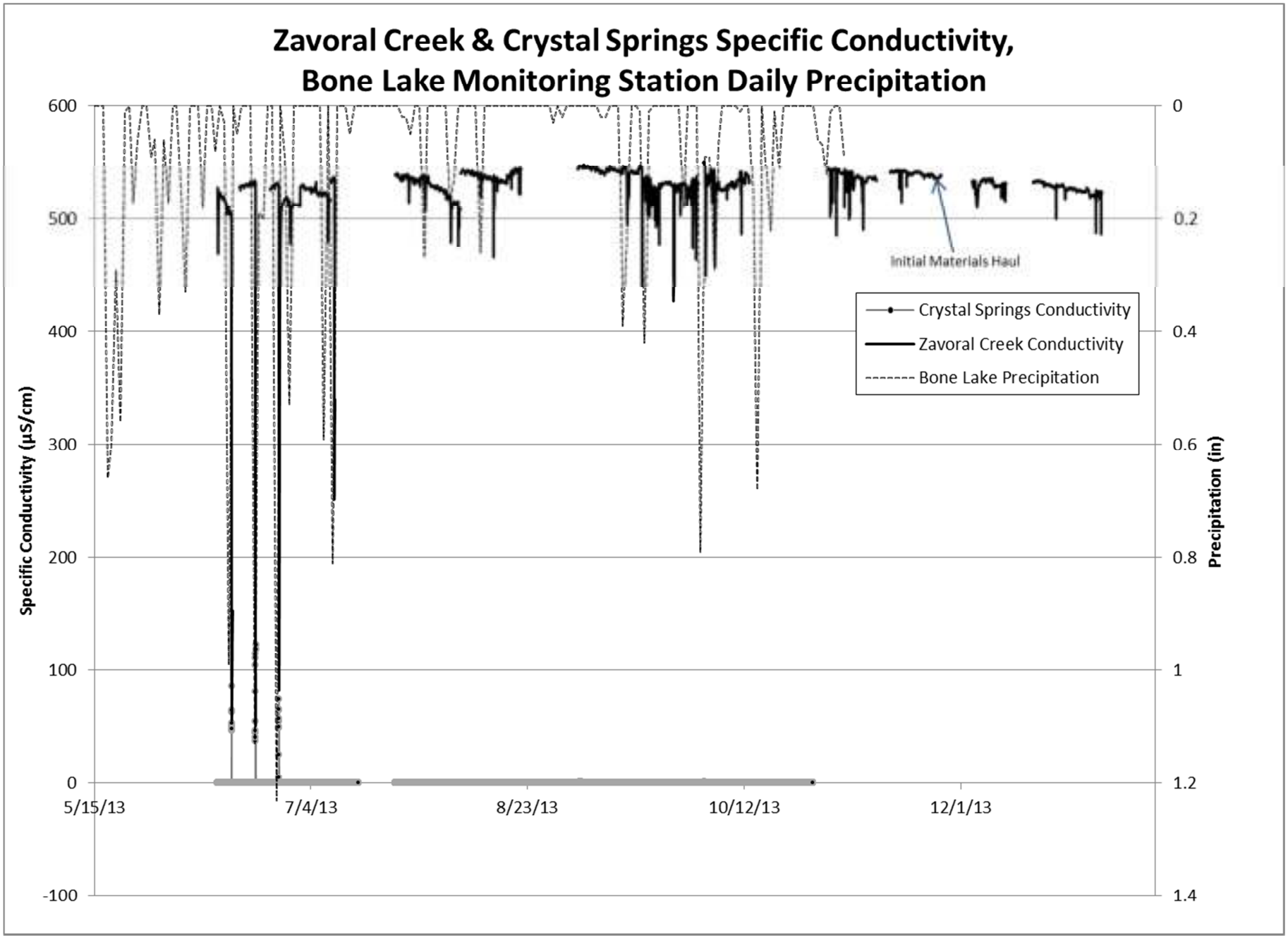

Zavoral Creek & Crystal Springs Turbidity,
Bone Lake Monitoring Station Daily Precipitation
Crystal Springs Turbidity
Zavoral Creek Turbidity
Bone Lake Precipitation
Turbidity (NTU)
Precipitation (in)
2500
2000
1500
1000
500
0
-500
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Initial Materials Haul
5/15/13
7/4/13
8/23/13
10/12/13
12/1/13


Zavoral Creek & Crystal Springs Stage,
Bone Lake Monitoring Station Daily Precipitation
Crystal Springs Stage
Zavoral Creek Stage
Bone Lake Precipitation
Stage (ft)
Precipitation (in)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
5/15/13
7/4/13
8/23/13
10/12/13
12/1/13


Zavoral Creek & Crystal Springs Discharge,
Bone Lake Monitoring Station Daily Precipitation
Crystal Springs Discharge
Zavoral Creek Discharge
Bone Lake Precipitation
Discharge (cfs)
Precipitation (in)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
5/15/13
7/4/13
8/23/13
10/12/13
12/1/13


Zavoral Creek & Crystal Springs Temperature,
Bone Lake Monitoring Station Daily Precipitation
Crystal Springs Temperature
Zavoral Creek Temperature
Bone Lake Precipitation
Temperature (°C)
Precipitation (in)
30
25
20
15
10
5
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
5/15/13
7/4/13
8/23/13
10/12/13
12/1/13
Initial Materials Haul


Zavoral Creek & Crystal Springs Dissolved Oxygen,
Bone Lake Monitoring Station Daily Precipitation
Dissolved Oxygen (mg/L)
Precipitation (in)
14
12
10
8
6
4
2
0
-2
0
0.2
0.4
0.6
0.8
1
1.2
1.4
5/15/13
7/4/13
8/23/13
10/12/13
12/1/13
Initial Materials Haul
Crystal Springs DO
Zavoral Creek DO
Bone Lake Precipitation


Zavoral Creek & Crystal Springs Specific Conductivity,
Bone Lake Monitoring Station Daily Precipitation
Specific Conductivity (µS/cm)
Precipitation (in)
600
500
400
300
200
100
0
-100
0
0.2
0.4
0.6
0.8
1
1.2
1.4
5/15/13
7/4/13
8/23/13
10/12/13
12/1/13
Initial Materials Haul
Crystal Springs Conductivity
Zavoral Creek Conductivity
Bone Lake Precipitation