Final Technical Memorandum

DATE	February 22, 2021
TO	Andre Sonksen and Jacob Rollins
FROM	Thomas Arthur
CC	Kristina Hysler and Roshan Christoph
SUBJECT	**Conductivity and Salinity Analysis for Chollas Creek Bacteria TMDL Monitoring Locations and San Diego Bay Near the Mouth of Chollas Creek**

Background and Purpose

Annual compliance monitoring for the Chollas Creek Bacteria TMDL Compliance Monitoring Program began in 2013, to meet the requirements of the Bacteria TMDL as incorporated into Attachment E of MS4 Permit. Three compliance monitoring locations were selected to assess compliance with the Bacteria TMDL: two mass loading stations (MLSs) – SD8(1) (north Chollas Creek location) and Z Street[1] (south Chollas Creek location) to represent the two major forks of Chollas Creek, and a third location (CTL(1)) located below the confluence of the two forks of Chollas Creek.

The Bacteria TMDL as incorporated in MS4 Permit Attachment E categorizes listings as Pacific Ocean Shoreline, creek, or creek mouth: Chollas Creek is listed as a freshwater creek. Thus, results are compared with the freshwater creek TMDL numeric targets. However, dry weather water quality measurements collected at CTL(1) have an average salinity of 34.2 parts per thousand (ppt), indicating that water at this location is predominantly seawater, fed by tidal exchanges with San Diego Bay. Furthermore, the lack of dry weather flows observed at the north and south MLSs during routine, year-round dry weather sampling events suggest that CTL(1) is rarely connected to the upper watershed. Collectively, these data indicate that CTL(1) is not representative of dry weather watershed loading and is therefore not appropriate for dry weather compliance assessments with the Bacteria TMDL listing for Chollas Creek.

To further investigate the representativeness of CTL(1) as a compliance monitoring location for a freshwater creek listing, historical water quality data from San Diego Bay near the mouth of Chollas Creek were mined to compare ambient conditions at CTL(1) with those of San Diego Bay, and to assess whether ambient conditions at CTL(1) are significantly different from the north and south fork MLSs. Available dry weather conductivity and salinity water quality data were statistically compared to investigate whether significant differences were present between San Diego Bay, the Chollas Creek tidally influenced segment (CTL(1)), and the MLSs (SD8(1) and Z Street). This technical memorandum presents the results of that comparison.

Data Sources

Archived historical dry weather water quality results were referenced from various water quality studies[2] to generate a comparison between salinity conditions in San Diego Bay and the Chollas Creek compliance

[1] The south fork MLS of Chollas Creek was relocated to Z Street in 2014 because of scheduled channel restoration activities at the former location (DPR3). Because of their proximity, they are considered equally representative of the Chollas Creek south fork and are evaluated as a single MLS.

[2] 2013 *Regional Harbor Monitoring Program (RHMP), Final Core Monitoring Report*. January 2016.
2018 *Regional Harbor Monitoring Program (RHMP), Final Core Monitoring Report*. December 2020.
Chollas Creek Investigative Order – Phase 1 (CCIO). 2016.
Chollas Creek Bacteria Total Maximum Daily Load Compliance Monitoring Program. 2013–2020.

monitoring locations during dry weather conditions (2013-present). Programs/data sources, data types, dominant environmental conditions (freshwater or marine), total available sample count, and year(s) the data were collected were used in the analysis and are presented in Table 1.

Table 1: Summary of Historical Dry Season Water Quality Data Used for Chollas Creek and San Diego Bay Analysis

Program/ Data Source	Data Type	*n* Stations	Location	Environment	*n* Samples	Date Range
Chollas Creek Bacteria TMDL Monitoring Program	Sp. Conductivity[1]	2	Chollas MLSs	Freshwater	21 [2]	2013–2020
		1	Chollas Tidal Segment	Tidal	78 [2]	2018–2020
Regional Harbor Monitoring Program (RHMP)	Sp. Conductivity and Salinity	5	San Diego Bay	Marine	46 [3]	2013, 2018
Naval Base San Diego Ambient Water Sediment Monitoring	Sp. Conductivity and Salinity	6	San Diego Bay	Marine	6	2015
Chollas Creek Investigative Order (CCIO) - Phase 1	Sp. Conductivity and Salinity	11	San Diego Bay	Marine	11	2016

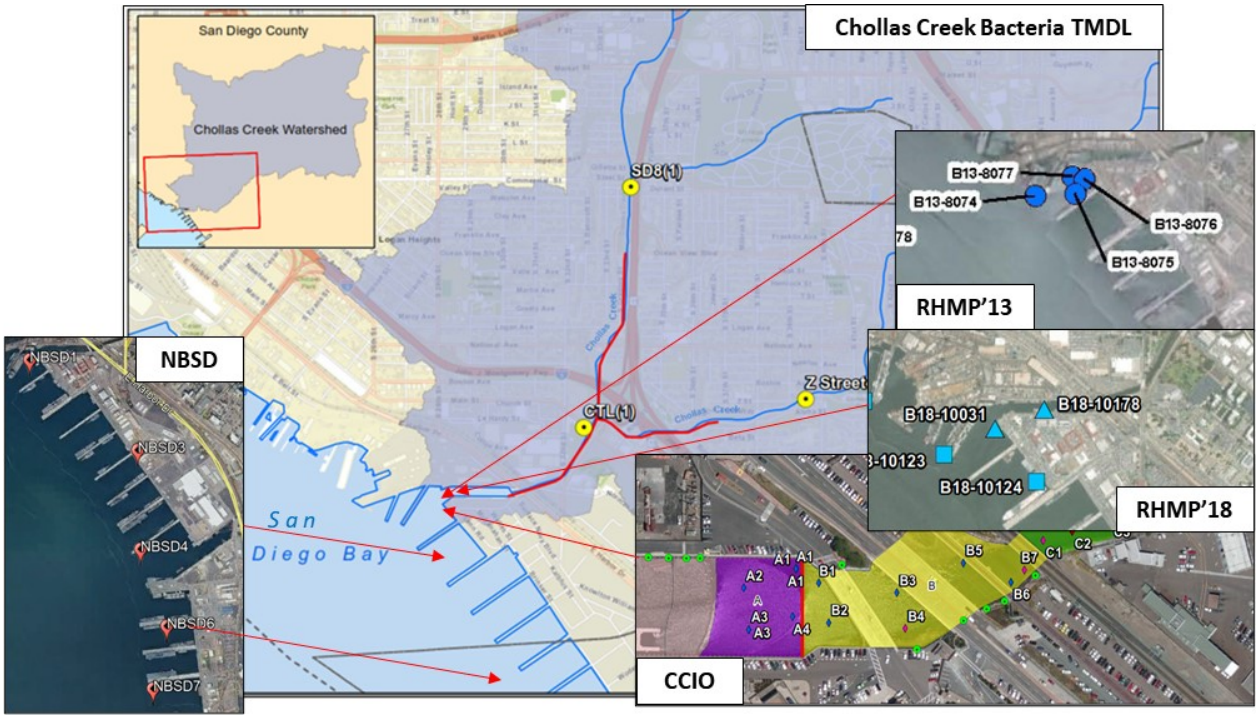
Notes:
1. Salinity data not recorded for this program. Conversion formulas were used in the analysis to generate representative salinity results[3].
2. Samples collected under dry weather conditions. Discrepancies in the number of samples between both MLS sites and the Tidal Segment are due to the frequent lack of dry weather flow at both MLS sites during dry weather conditions.
3. Samples were collected at different depths for each site.

n = sample size; MLS = mass loading station; TMDL = total maximum daily load.

Figure 1 presents a map of Chollas Creek near where the mouth discharges to San Diego Bay. The map illustrates the approximate location of each project in relation to the mouth of Chollas Creek and includes the stations where water quality data were leveraged to conduct the analysis.

Naval Base San Diego Receiving Water and Sediment Monitoring Final Report. 2019.

[3] https://www.hamzasreef.com/Contents/Calculators/SalinityConversion.php



Notes:
Chollas Creek Bacteria TMDL = Chollas Creek Bacteria TMDL Compliance Monitoring Program
RHMP'13 = 2013 Regional Harbor Monitoring Program
RHMP'18 = 2018 Regional Harbor Monitoring Program
CCIO = Chollas Creek Investigative Order – Phase 1
NBSD = Naval Base San Diego Receiving Water and Sediment Monitoring Program.

Figure 1. San Diego Bay and Chollas Creek Project Locations

Water bodies can be classified into different categories depending on their salt content. While quantitative definitions of these terms vary, it is generally understood that seawater has a salinity concentration of approximately 35 parts per thousand (ppt). Table 2 presents the classification of water bodies by salinity utilized by the United States Geological Survey (USGS)[4].

Table 2: USGS Waterbody Classification Based on Salinity

Classification	Salinity (ppt)
Fresh water	<1
Slightly saline water	1 – 3
Moderately saline water	3 – 10
Highly saline water	10 – 35
Ocean water	~35

Notes:
ppt = parts per thousand; USGS = United States Geological Survey.

[4] https://www.usgs.gov/special-topic/water-science-school/science/saline-water-and-salinity?qt-science_center_objects=0#qt-science_center_objects

Analysis and Findings

Conductivity and salinity data were averaged for each project station. Mean concentrations of specific conductivity and salinity and waterbody classifications, per USGS guidance, are presented for the Chollas Creek MLSs, the Chollas Creek tidal location (CTL(1)), and the San Diego Bay locations in Table 3. Note that for some locations, salinity data were not recorded; therefore, salinity results were estimated using specific conductivity and a conversion calculator[5].

Table 3: Water Body Classification Based on Salinity

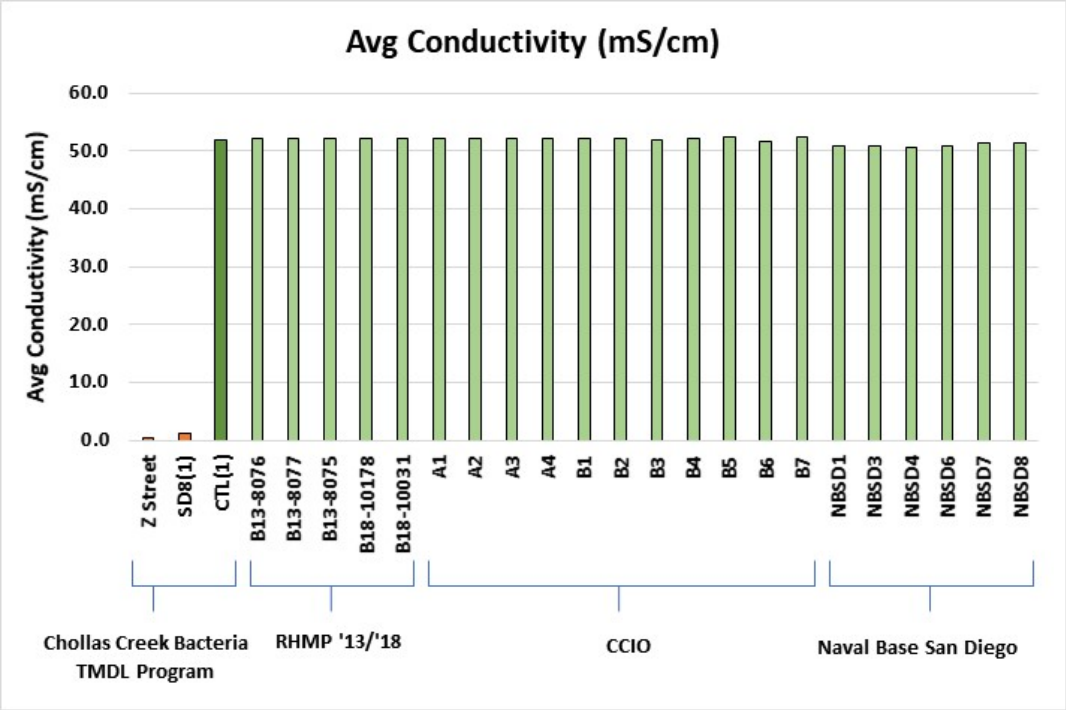
Location Type	Mean Specific Conductivity (mS/cm)	Mean Salinity (ppt)	USGS Classification
Chollas Creek MLS	0.94	0.47[1]	Freshwater
Chollas Creek Tidal Location	51.91	34.18[1]	Highly Saline
San Diego Bay	51.99	34.20[2]	Highly Saline

Notes:
1. Salinity values calculated using specific conductivity.
2. Salinity values calculated using specific conductivity for sites in the NBSD Receiving Water and Sediment Monitoring Program.

mS/cm = milliSiemens per centimeter; ppt = parts per thousand; USGS = United States Geological Survey.

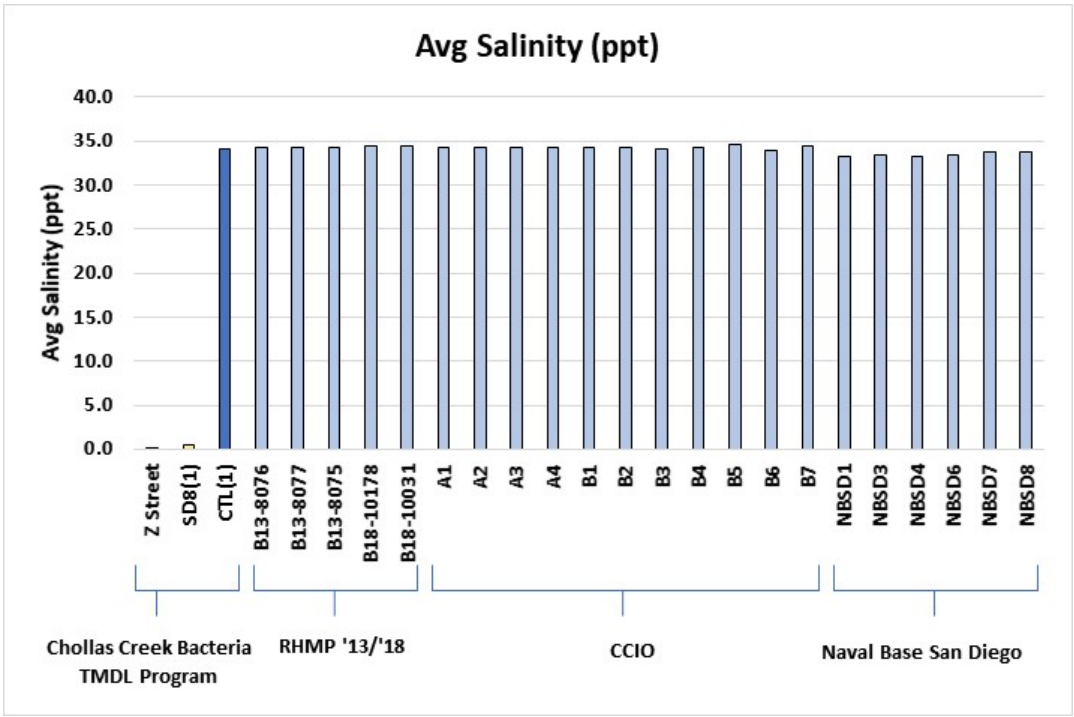
Mean concentration data were plotted for specific conductivity and salinity (Figures 2 and 3, respectively) and illustrate how the Chollas Creek freshwater MLSs differs significantly from the Chollas Creek tidal segment and San Diego Bay.

[5] https://www.hamzasreef.com/Contents/Calculators/SalinityConversion.php



Notes:
mS/cm = milliSiemens per centimeter.

Figure 2. Mean Specific Conductivity Concentrations for Chollas Creek and San Diego Bay Projects



Notes:
ppt = parts per thousand.

Figure 3. Mean Salinity Concentrations for Chollas Creek and San Diego Bay Projects

In addition to the mean plotted data, differences between sampling locations from the various studies were compared using a one-way analysis of variance (ANOVA) and Tukey's post-hoc analysis to determine which group's characteristics most closely resembled those of CTL(1). This was conducted for both salinity and conductivity measurements.

The one-way ANOVA test was performed using GraphPad Prism 8.4.2 (San Diego, CA). The results of the ANOVA and Tukey's tests are presented in Table 4. Results identified significant differences in both salinity ($F(2,159) = 1296$, $p<0.0001$) and conductivity ($F(2,159) = 1608$, $p<0.0001$) between the MLSs, SD Bay Sites, and CTL(1) locations. There were no significant differences for either salinity ($p=0.9983$) or conductivity ($p=0.9919$) between CTL(1) and the SD Bay Sites. Therefore, it appears that when evaluating both salinity and conductivity, CTL(1) exhibits properties that are more closely related to marine/salt-water environments than freshwater ones.

Table 4: ANOVA Test Results

Characteristic	One-way ANOVA		Post-hoc Tukey's Significance (P-Value)		
	F-statistic	P-value	CTL(1) vs SD Bay	CTL(1) vs MLSs	SD Bay vs MLSs
Specific Conductivity	1608	<0.0001	Not significant (0.9919)	Significant (P<0.0001)	Significant (P<0.0001)
Salinity	1296	<0.0001	Not significant (0.9983)	Significant (P<0.0001)	Significant (P<0.0001)