Manganese and Total Dissolved Solids Special Study

Humboldt Creamery
WDR Order No. R1-2014-0026

Prepared for:

Foster Dairy Farms, Inc. dba Humboldt Creamery

SHN Consulting Engineers & Geologists, Inc.
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August 2014
011095.151

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Reference: 011095.151

August 21, 2014

Ms. Lisa Bernard
North Coast Regional Water Quality Control Board
5550 Skylane Blvd., Suite A
Santa Rosa, CA 95403

Subject: Manganese and Total Dissolved Solids Special Study; Order No. R1-2014-0026; NPDES Permit No. CA0005584; WDID No. 1B80185OHUM

Dear Ms. Bernard:

SHN Consulting Engineers & Geologists, Inc. is submitting this manganese and total dissolved solids (TDS) special study on behalf of Foster Dairy Farms, Inc. dba Humboldt Creamery in response to your draft National Pollutant Discharge Elimination System permit (Order R1-2014-0026). The report contained herein is a designated level study that develops alternative water quality objectives for manganese and TDS based on site-specific attenuation factors developed for the Humboldt Creamery facility.

If you have any questions, please call me or Nathan Sanger at 707-441-8855.

Sincerely,

SHN Consulting Engineers & Geologists, Inc.

Lisa Stromme, PE
Water Resources Engineer

LKS:lms

Enclosure: Manganese and Total Dissolved Solids Special Study
c. w/encl.: Mike Callihan, FDF/HC

Reference: 011095.151

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QA/QC: PNB

Table of Contents

Appendices

List of Illustrations

Figures **Follows Page**

Tables **Page**

Abbreviations and Acronyms

gpd	gallons per day	mg	milligram
kg/L	kilograms per liter	mg/acre	milligram per acre
L	liter	mg/kg	milligrams per kilogram
L/kg	liter per kilogram	mg/L	milligrams per liter
lb/ft^3	pounds per cubic foot		

A	discharge area
A*f*	attenuation factor
ASTM	American Society for Testing and Materials-International
BGS	below ground surface
B-MW-#	soil boring number
C	average annual discharge concentration
COW	condensate of whey
Cs	Concentration in soil
Cw	Concentration in water
C_{xxx}	adjusted annual discharge concentration
dba	doing business as
E	average annual evapotranspiration
EPA	U.S. Environmental Protection Agency
FDF/HC	Foster Dairy Farms, Inc. dba Humboldt Creamery
Kd	partition coefficient
LND-#	land-application monitoring point-number
M	average annual mass discharge/moisture content
Mn	manganese
MW-#	groundwater monitoring well point number
n	number of constituents considered
NPDES	National Pollutant Discharge Elimination System
NR	no reference
Pb	dry bulk density
PC	percent composition
R	average annual rainfall
R1	riser
RL	reporting limit
RR	mass removal rate from crops
RWQCB	North Coast Regional Water Quality Control Board
SHN	SHN Consulting Engineers & Geologists, Inc.
SM	standard method
TDS	total dissolved solids
USGS	United States Geological Survey
V	average annual discharge volume
WDR	Waste Discharge Requirements
WQOs	water quality objectives
WWTF	wastewater treatment facility

1.0 Introduction

Foster Dairy Farms, Inc. dba. Humboldt Creamery (FDF/HC) maintains and operates wastewater collection, treatment, and disposal facilities in Fernbridge, California (Figure 1). FDF/HC is currently discharging treated and untreated wastewater at their Fernbridge facility in accordance with National Pollutant Discharge Elimination System (NPDES) Permit No. CA0005584, Order No. R1-2008-0020. The order became effective on March 1, 2009, and expired on March 1, 2014.

SHN Consulting Engineers & Geologists, Inc. is submitting this manganese (Mn) and total dissolved solids (TDS) special study on behalf of FDF/HC in response to a draft NPDES permit (Order R1-2014-0026) issued by the North Coast Regional Water Quality Control Board (RWQCB). We believe the new order to be more conservative than is necessary to be protective of water quality. The report contained herein is a designated level study that develops alternative water quality objectives (WQOs) for Mn and TDS based on site-specific attenuation factors developed for the Humboldt Creamery facility.

The intent of this special study is to determine site-specific final effluent limitation levels for manganese and TDS at the Humboldt Creamery facility, which will also be protective of waters of the state. The following report presents a special study of manganese and TDS at the subject site. Specifically, the following designated level study addresses the suitability of the land applied wastewater based on a comparison of discharge application constituent levels to site-specific designated levels.

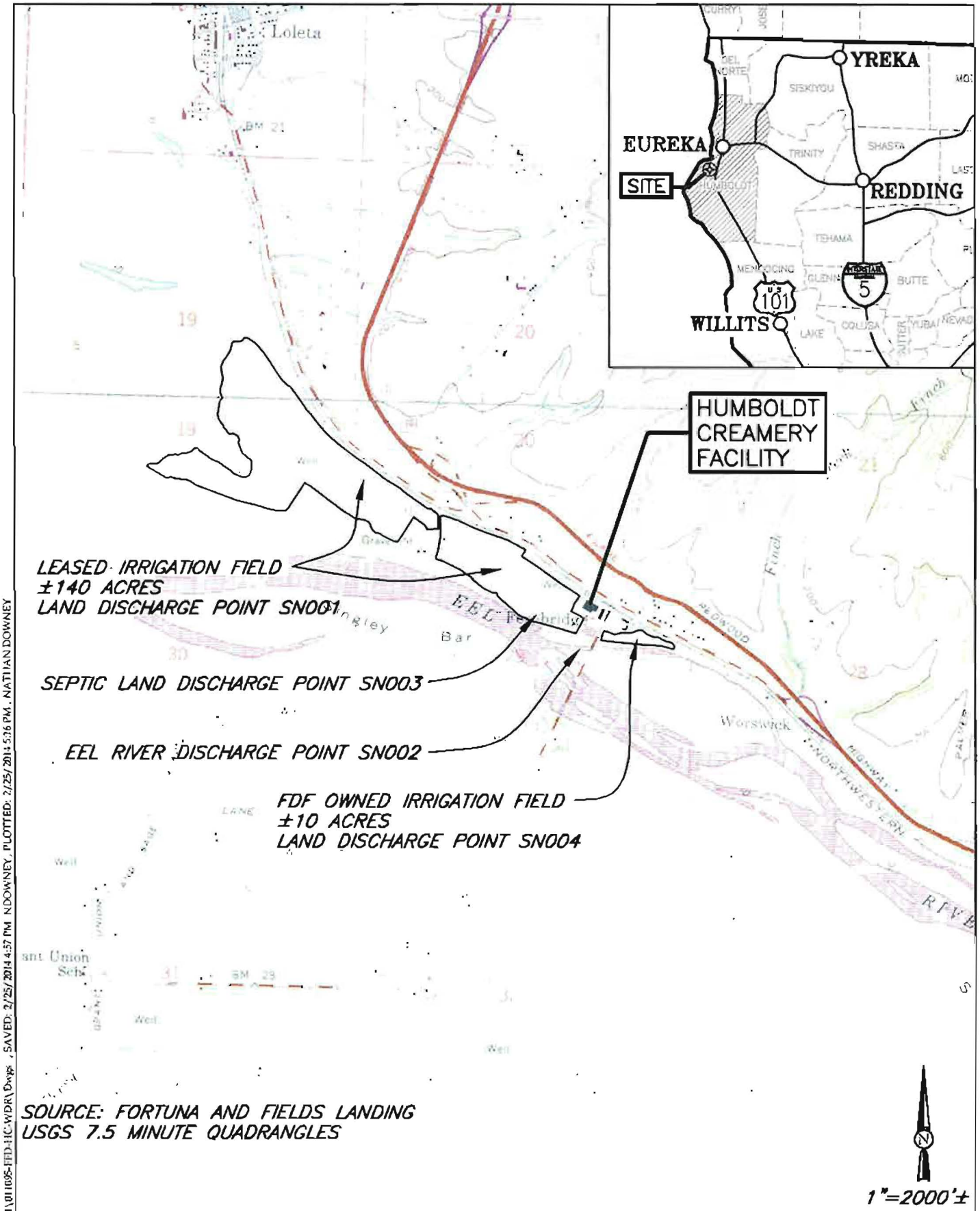
1.1 Site Background

Foster Dairy Farms, Inc. owns and operates Humboldt Creamery, a dairy products processing facility. Products produced at the Humboldt Creamery facility include dry condensed and evaporated products, ice cream and frozen desserts, and fluid milk. Process wastewater generated at the facility consists of milk tanker truck washout; acid and caustic rinse water; boiler blow down; and waste products from the wash down processes including, but not limited to, cleaning of dairy processing equipment. Process wastewater also includes dry condensed milk condensate and non-contact cooling water.

Humboldt Creamery's wastewater treatment facility (WWTF) was constructed in the early 1970s and consists of the treatment aeration pond; a settling basin; a permitted discharge to the Eel River for dry condensed milk condensate and non-contact cooling water (Condensate of Whey [COW] water); and approximately 150 acres of grazed pasture that is used for land discharge of combined industrial process wastewater, COW water, and domestic wastewater. The location of the Humboldt Creamery facility and the elements of the WWTF are shown in Figure 2.

1.2 Regulatory Context

The RWQCB regulates the discharge of effluent from Humboldt Creamery under NPDES Permit No. CA0005584 and Waste Discharge Requirements (WDR) Order No. R1-2008-0020 (Facility I.D. No. 1B80185OHUM). The order became effective on March 1, 2009, and is still being enforced until a new NPDES permit is finalized.



SHN Consulting Engineers & Geologists, Inc.	Foster Dairy Farms dba Humboldt Creamery Fernbridge, California	Site Location Map SHN 011095.100	
	February 2014	011095-100-ANNUAL-REPORT-LCTN	Figure 1

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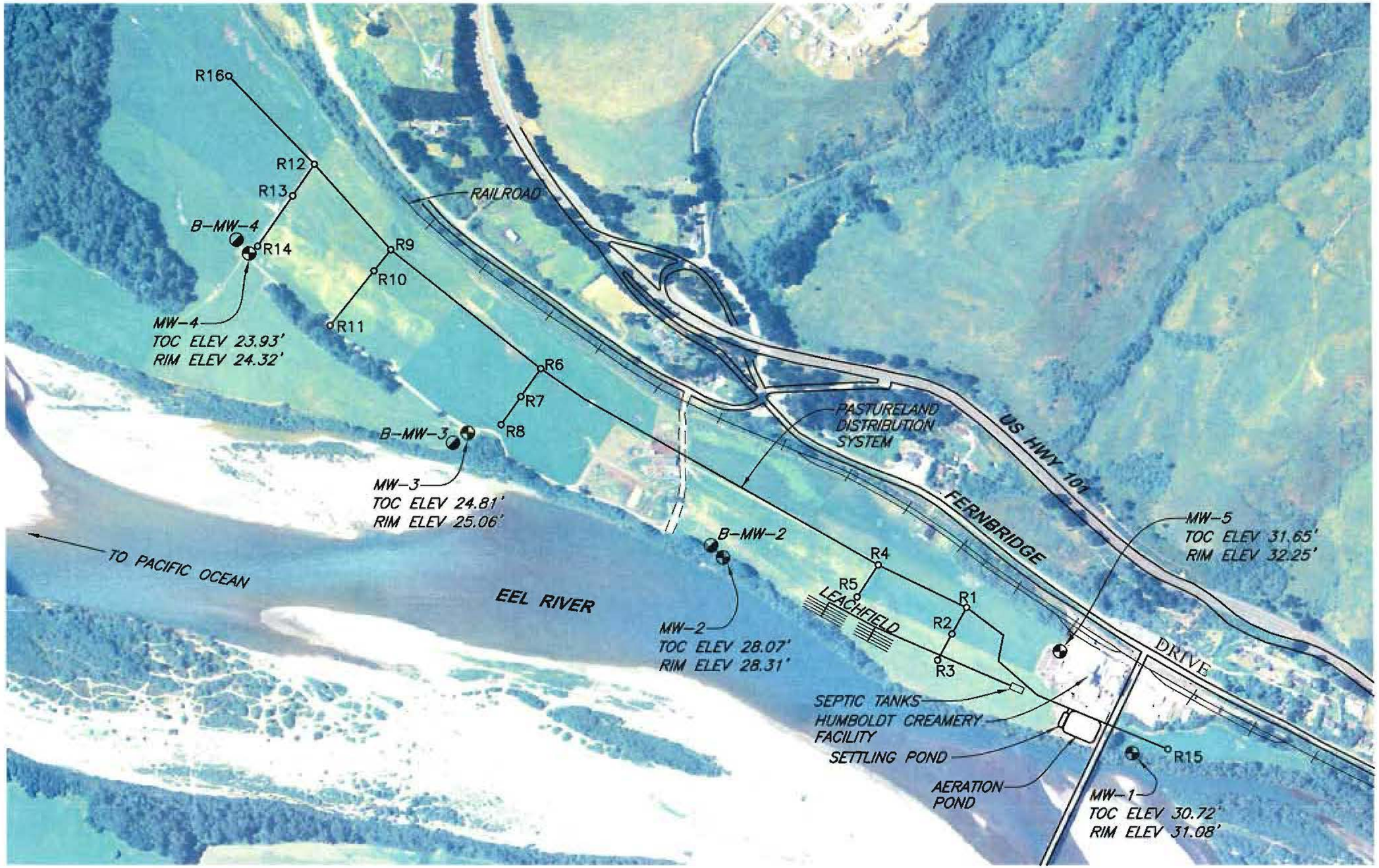

EXPLANATION

- R1 — RISER (APPROXIMATE LOCATION)
- MW-5 — EXISTING MONITORING WELL LOCATION AND DESIGNATION
- B-MW-3 — SOIL BORING LOCATION AND DESIGNATION

N

0 600

1"=600'±

NOTE: ALL LOCATIONS ARE APPROXIMATE

SHN Consulting Engineers & Geologists, Inc.	Foster Dairy Farms, Inc. Humboldt Creamery Fernbridge, California	Site Plan SHN 011095.151
	August 2014 | 011095-0151-SITE	Figure 2

On May 27, 2014, a draft NPDES permit (Order R1-2014-0026) was issued for the facility, which contains many of the same WQOs set forth in the original permit.

In written comments to the RWQCB, SHN requested increasing the final effluent limitation levels for manganese and TDS because the proposed WQOs set forth in the permit were more conservative than necessary to be protective of waters of the state (SHN, June 2014).

In response to the request to increase the final effluent limitations for manganese and TDS at the site, the RWQCB requested that a special study for these constituents be conducted. The special study would need to create a scientific basis for determining site-specific WQOs for the facility.

2.0 Designated Level Development

2.1 Designated Level Methodology

The designated level methodology is a technique that has been developed for determining site-specific WQOs for a given facility (CVRWQCB, 1986). Designated levels are measures of the minimum concentrations of waste constituents that, after accounting for environmental attenuation, have the potential to exceed WQOs. A designated levels study establishes site-specific limits for parameters of concern below which it is assumed that a given material would not have adverse impacts to waters of the state.

The key *process* to consider in assessing the degree to which waste constituent concentrations become attenuated as they migrate toward groundwater and surface waters are the following:

- Adsorption
- Ionic Bonding
- Filtration
- Chemical/Biochemical Degradation
- Volatilization
- Dispersion/Dilution

Some of the key *characteristics* that influence the environmental fate of waste constituents in *groundwater* include:

- Depth to water
- Net recharge
- Vadose zone characteristics (porosity, clay, organic content, pH, ion exchange capacity)
- Pollutant characteristics (polarity, ionic strength, volatility, viscosity, degradability)
- Topography
- Mass loading
- Volumetric groundwater flow rate
- Uncertainty or other factors

The total designated level for a constituent of a liquid waste is calculated by multiplying the water quality goal by the environmental attenuation factor that takes into account site-specific characteristics for the facility:

$$\text{Total Designated Level (mg/L)} = \text{Water Quality Goal (mg/L)} \times \text{Attenuation Factor}$$

Where, mg/L: milligrams per liter

2.2 Site Specific Attenuation Factors

The site-specific characteristics that were considered in developing attenuation factors for the Humboldt Creamery facility included vadose zone characteristics, dilution, and biological removal.

2.2.1 Vadose Zone Attenuation Factor

The vadose zone attenuation factor quantifies the tendency for a given constituent to adsorb to soil particles after it has been discharged to the land surface:

$$Af_{vadose} = \left(1 + \frac{Pb}{M} Kd\right)$$

Where:

Af = vadose zone attenuation factor
Pb = dry bulk density (kg/L)
M = volumetric moisture content (%)
Kd = partition coefficient (L/kg)

The partition coefficient is calculated by the following equation:

$$Kd = \frac{C_s}{C_w}$$

Where:

Cs = Concentration in soil (mg/kg)
Cw = Concentration in water (mg/L)

The vadose zone attenuation factor for TDS was calculated by adding up the attenuation factors for the constituents of TDS in the waste stream as follows:

$$Af_{vadose,TDS} = \sum (Af \times PC) - (n - 1)$$

Where:

Af = attenuation factor for each constituent
PC = percent composition of total TDS for each constituent
n = number of constituents considered

2.2.2 Dilution Attenuation Factor

The dilution attenuation factor quantifies the effect of diluting the discharge concentration with the net recharge from rainfall at the site:

$$Af_{dilution} = \frac{C}{C_{diluted}}$$

Where:

C = average annual discharge concentration (mg/L)
$C_{diluted}$ = adjusted annual discharge concentration (mg/L)

The adjusted dilution concentration is calculated by dividing the average annual mass discharge by the average annual discharge volume plus the net recharge volume from rainfall. Net recharge is equal to the average annual rainfall minus the average annual evapotranspiration applied across the discharge area:

$$C_{diluted} = \frac{M}{V + (R - E)\,x\,A}$$

Where

M = average annual mass discharge (mg)
V = average annual discharge volume (L)
R = average annual rainfall (inches)
E = average annual evapotranspiration (inches)
A = discharge area (acre)

2.2.3 Removal Attenuation Factor

The removal attenuation factor quantifies the effect of crop removal for each constituent at the site:

$$Af_{removed} = \frac{C}{C_{removed}}$$

Where:

C = average annual discharge concentration (mg/L)
$C_{removed}$ = adjusted annual discharge concentration (mg/L)

The adjusted annual discharge concentration is determined by the following equation:

$$C_{removed} = \frac{M - (RR\,x\,A)}{V}$$

Where

$C_{removed}$ = adjusted average annual discharge concentration (mg/L)
M = average annual mass discharge (mg)
RR = mass removal rate from crops (mg/acre)
A = discharge area (acre)
V = average annual discharge volume (L)

2.2.4 Total Attenuation Factor

The total attenuation factor for each constituent is the summation of each of the attenuation factors considered. Each attenuation factor has been developed to be a standalone factor (greater than one), so the total attenuation factor must also subtract the number of factors considered as follows:

$$Af_{total} = Af_{vadose} + Af_{dilution} + Af_{removal} - (n - 1)$$

Where

Af_{vadose} = attenuation factor from vadose zone interactions
$Af_{dilution}$ = attenuation factor from dilution
$Af_{removal}$ = attenuation factor from crop removal
n = number of attenuation factors considered

3.0 Field Activities

Field activities were designed and implemented to collect the data necessary to develop the vadose zone attenuation factors for the site. The field program consisted of collecting groundwater and soil samples directly adjacent to the monitoring wells under the influence of the land discharge irrigation system (MW-2, MW-3, and MW-4).

3.1 Monitoring Well Sampling

SHN conducted groundwater monitoring on August 8, 2014. As part of the monitoring program, wells MW-2 through MW-4 were purged and sampled (Figure 2). Prior to purging, each well was measured for depth-to-groundwater to the nearest 0.01 foot using an electronic water level probe.

Electrical conductivity, pH, and temperature were monitored periodically during purging activities using portable instrumentation. All wells were also measured for dissolved oxygen.

A groundwater sample was then collected from each well using a disposable polyethylene bailer. Samples collected for analysis of dissolved metals were filtered in the field using new disposable 0.45-micron filters. The water samples were collected in laboratory-supplied containers, labeled, immediately placed in an ice-filled cooler, and submitted to the laboratory for analyses under appropriate chain-of-custody. Appendix A presents field notes and groundwater-monitoring data sheets. Copies of the laboratory analytical reports are included in Appendix B.

3.2 Soil Boring Sampling

On August 8, 2014, three soil borings (B-MW-2, B-MW-3, B-MW-4) were installed directly adjacent to monitoring wells MW-2 through MW-4 using a hand auger to a maximum depth of 12 feet below ground surface (BGS). Figure 2 shows the boring locations.

Each soil sample was labeled with location, depth, date and time of collection, analysis requested, and the sampler's initials. Soil samples were placed in an iced cooler and transported under chain-of-custody documentation to a State of California-certified analytical laboratory for chemical analysis.

After sample collection at 10 feet BGS, each open borehole was backfilled with dry bentonite chips to 1 foot BGS, followed by soil cuttings to match existing grade.

3.3 Laboratory Analyses

Groundwater and soil samples were analyzed for:

- TDS in general accordance with Standard Method (SM) 20th Edition 2540 C;
- chloride in general accordance with the U.S. Environmental Protection Agency (EPA) Method No. 300.0, Rev 2.1;
- dissolved calcium, magnesium, manganese, potassium, and sodium in general accordance with EPA Method No. 200.7 Rev 4.4.

Soil samples were additionally analyzed for moisture density in general accordance with American Society for Testing and Materials-International (ASTM) Method D2937.

SHN's state-certified soil testing laboratory in Eureka, California performed moisture density testing. North Coast Laboratories Ltd., a state-certified analytical laboratory located in Arcata, California, performed all sample analytical analyses. Copies of the laboratory analytical reports are included in Appendix B.

3.4 Equipment Decontamination Procedures

All monitoring and sampling equipment was cleaned prior to arriving onsite and between each well. All small equipment that required onsite cleaning was washed in a water solution containing Liquinox® cleaner, followed by two distilled-water rinses.

3.5 Investigation Derived Waste Management

All purge water and rinse water generated during site monitoring activities was disposed onsite. Soil cuttings were used as backfill for the upper portion of the boreholes, and also spread onsite at the ground surface to match existing grade.

4.0 Results

The following section summarizes the data collected during the field activities conducted at the Humboldt Creamery irrigation fields.

4.1 Groundwater Analytical Results

The laboratory analytical results for the groundwater samples collected during the August 8, 2014 monitoring event are summarized in Table 1.

Table 1
Groundwater Analytical Results, August 8, 2014
Foster Dairy Farms, Inc. dba Humboldt Creamery, Fernbridge, California
(in mg/L)[1]

Sample Location	Calcium[2]	Magnesium[2]	Manganese[2]	Potassium[2]	Sodium[2]	Chloride[3]	TDS[4]
MW-2	79	57	0.008	5.7	120	230	920
MW-3	110	42	0.020	8.0	110	800	1,100
MW-4	86	37	0.023	5.5	67	120	660
Average	**92**	**45**	**0.017**	**6.4**	**99**	**383**	**893**

1. mg/L: milligrams per liter
2. Dissolved calcium, magnesium, manganese, potassium, and sodium analyzed in general accordance with EPA Method No. 200.7 Rev. 4.4
3. Chloride analyzed in general accordance with EPA Method No. 300.0 Rev. 2.1
4. TDS: total dissolved solids analyzed in general accordance with Standard Method 20th Edition 2540 C

4.2 Soil Analytical Results

The laboratory analytical results for the soil samples collected during the August 8, 2014 monitoring event are summarized in Table 2.

Table 2 Soil Analytical Results, August 8, 2014 Foster Dairy Farms, Inc. dba Humboldt Creamery, Fernbridge, California (in mg/kg[1], unless noted otherwise)								
Sample Location	Calcium[2]	Magnesium[2]	Manganese[2]	Potassium[2]	Sodium[2]	Chloride[3]	Pb[4] (lb/ft^3)[5]	M[4] (%)
B-MW-2@10'	5,000	16,000	530	1,900	230	13	90.5	11.1
B-MW-3@10'	5,100	14,000	490	2,100	150	18	99.8	12.8
B-MW-4@10'	5,000	15,000	610	2,100	190	35	90.5	28.0
Average	**5,033**	**15,000**	**543**	**2,033**	**190**	**22**	**93.6**	**17.3**

1. mg/L: milligrams per liter
2. Dissolved calcium, magnesium, manganese, potassium, and sodium analyzed in general accordance with EPA Method No. 200.7 Rev. 4.4.
3. Chloride analyzed in general accordance with EPA Method No. 300.0 Rev. 2.1
4. Pb: bulk density, and M: moisture content analyzed in general accordance with ASTM D2937
5. lb/ft^3: pounds per cubic foot

5.0 Attenuation Factor Input Values

The following section lists the input values used to calculate the manganese and TDS site-specific attenuation factors for the Humboldt Creamery facility.

5.1 Vadose Zone Input Values

The arithmetic mean bulk density (Pb), and moisture content (M) values from B-MW-2 through B-MW-4 were used as vadose zone interaction input values. Partition coefficient (Kd) values were set equal to the average soil concentration from B-MW-2 through B-MW-4 divided by the average site investigation groundwater concentration from MW-2 through MW-4 for each constituent.

Additionally, to determine the vadose zone attenuation factor for TDS, the percent composition of the individual constituents found in the process water was necessary. The TDS composition of the process water was studied by SHN in the sodium and total dissolved solids special study (May 2013), and the results are listed in Table 3.

Table 3 Effluent Total Dissolved Solids Composition Analysis, January 9, 2013 Foster Dairy Farms, Inc. dba Humboldt Creamery, Fernbridge, California		
Analyte	Discharge Concentration at LND-001 (mg/L)[1]	Percent of Total Dissolved Solids Composition
Total Dissolved Solids	500	100%
Calcium	31	6.2%
Magnesium	22	4.4%
Potassium	200	40%
Chloride	100	20%
Sodium	73	14.6%
Total Cations and Anions	426	85.2%

1. mg/L: milligrams per liter

5.2 Dilution Input Values

Historical data was compiled from the annual reports for the Humboldt Creamery facility from 2012-2013, which were the only two complete years of data for the site during the previous NPDES permit cycle (SHN, March 2013; SHN, February 2014). Table 4 shows the historical data used for determining the average annual mass discharge for manganese and TDS at the facility.

Table 4
Historical Discharge Data and Annual Average Mass Estimates, 2012-2013
Foster Dairy Farms, Inc. dba Humboldt Creamery, Fernbridge, California

Date	Mn[1] (mg/L)[2]	TDS[3] (mg/L)	Average Daily Discharge (gpd)[4]	Monthly Discharge Volume (L)[5]	Mn (mg)[6]	TDS (mg)
Jan-12	1.1	940	268,759	31,534,792	34,688,271	29,642,704,334
Feb-12	0.9	650	296,265	31,398,201	28,258,381	20,408,830,809
Mar-12	1.5	830	315,408	37,008,348	55,512,523	30,716,929,234
Apr-12	1	620	310,419	35,248,130	35,248,130	21,853,840,873
May-12	1.1	800	305,500	35,845,808	39,430,389	28,676,646,748
Jun-12	1.3	1,100	166,291	18,882,354	24,547,061	20,770,589,846
Jul-12	1.4	1,100	295,570	34,680,755	48,553,057	38,148,830,671
Aug-12	1.5	720	277,788	32,594,285	48,891,428	23,467,885,387
Sep-12	1.4	640	232,437	26,393,236	36,950,531	16,891,671,354
Oct-12	1.5	800	238,531	27,988,084	41,982,126	22,390,467,272
Nov-12	1.1	670	231,108	26,242,347	28,866,582	17,582,372,802
Dec-12	1.6	620	288,326	33,830,750	54,129,200	20,975,065,084
Jan-13	1.4	680	302,791	35,527,937	49,739,111	24,158,996,864
Feb-13	1.1	920	287,525	30,471,911	33,519,102	28,034,157,987
Mar-13	1.5	860	315,590	37,029,741	55,544,612	31,845,577,514
Apr-13	1.1	990	311,648	35,387,638	38,926,402	35,033,761,590
May-13	1.1	1,000	344,593	40,432,793	44,476,072	40,432,793,160
Jun-13	1.3	860	299,302	33,985,723	44,181,440	29,227,721,931
Jul-13	1.1	950	288,892	33,897,120	37,286,832	32,202,264,105
Aug-13	1.1	1,100	293,492	34,436,914	37,880,606	37,880,605,510
Sep-13	1.2	1,200	251,871	28,599,963	34,319,956	34,319,956,086
Oct-13	1.2	580	144,122	16,910,574	20,292,689	9,808,132,801
Nov-13	1.4	950	128,088	14,544,381	20,362,133	13,817,161,993
Dec-13	1.6	950	212,993	24,991,519	40,736,175	23,741,942,589
Annual Average	**1.27**	**855**	**3,203,655**	**368,931,654**	**467,161,405**	**316,014,453,271**

1. Mn: dissolved manganese analyzed in general accordance with EPA Method No. 200.7 Rev. 4.4.
2. mg/L: milligrams per liter
3. TDS: total dissolved solids analyzed in general accordance with Standard Method 20th Edition 2540 C.
4. gpd: gallons per day
5. L: liters
6. mg: mg

Table 5 displays the average annual rainfall data used to determine the net recharge at the site, which was originally published as part of the land disposal evaluation (SHN, 2011) for the facility.

Table 5
Average Annual Climate Data for Fernbridge, California
Foster Dairy Farms, Inc. dba Humboldt Creamery, Fernbridge, California

Parameter	Wet Season				Dry Season					Wet Season			
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (inches)[1]	6.78	5.38	5.24	3.05	1.69	0.65	0.14	0.33	0.75	2.65	5.63	7.11	**39.4**
ET_0 (inches)[2]	0.56	0.84	1.81	3.01	3.83	4.28	4.05	3.22	2.64	1.81	0.78	0.37	**27.2**

1. Eureka at Woodley Island for period of record 1948-2009 (WRCC, 2010)
2. ET_0: Reference evapotranspiration (CIMIS, 1999)

5.3 Crop Removal Input Values

Crop removal rate inputs for manganese and TDS were obtained from published literature values. The irrigation fields at the Humboldt Creamery facility typically grow perennial grasses, clover, and buttercup (SHN, 2011). A manganese removal rate of 0.44 lbs/acre-year was assumed, which is equal to the removal rate for clover published by the Alabama Cooperative Extension Program (ACEP, 2014). A TDS removal rate of 2,083 lbs/acre-year was assumed, which is equal to the removal rate for tall fescue published in the Manual of Good Practice for Land Application of Food Processing/Rinse Water (Brown and Caldwell, 2007).

6.0 Site-Specific Designated Levels

Table 6 shows the site-specific attenuation factors, and subsequent designated levels developed for manganese and TDS. Attenuation factor calculation details for each constituent are included in Appendix C.

Table 6
Site-Specific Attenuation Factors, Manganese and TDS[1]
Foster Dairy Farms, Inc. dba Humboldt Creamery, Fernbridge, California

	Manganese	TDS
Af_{vadose}	2,798	13.6
$Af_{dilution}$	1.48	1.48
$Af_{removal}$	1.06	1.72
Af_{total}	**2,799**	**14.8**
WQO[2] (mg/L)[3]	1.20	450
Designated Level (mg/L)	**3,359**	**6,660**

1. TDS: total dissolved solids
2. WQO: water quality objective from the draft NPDES permit for the site (WDR Order No. R1-2014-0026)
3. mg/L: milligrams per liter

7.0 Discussion and Conclusion

The designated level study of manganese and TDS establishes site-specific WQOs for the Humboldt Creamery facility that are approximately 2,800 and 15 times greater, respectively, than the proposed WQOs found in the draft NPDES permit for the site. The elevated designated levels are largely due to vadose zone interaction attenuation factors for each constituent, which shows a large salt adsorbtion capacity within the irrigation area.

We request that the WQOs for manganese and TDS be increased to reflect the site-specific capacity of the Humboldt Creamery irrigation fields to attenuate these constituents prior to the attenuated process water reaching groundwater. We propose increasing the WQOs of manganese and TDS to 3,000 mg/L and 6,500 mg/L, respectively.

8.0 References Cited

Alabama Cooperative Extension Program. (Accessed August 12, 2014). "Nutrient Removal by Alabama Crops." Accessed at: http://www.aces.edu/pubs/docs/A/ANR-0449/

Brown and Caldwell. (March 14, 2007). *Manual of Good Practice for Land Application of Food Processing/Rinse Water*. Davis, CA:Brown and Caldwell.

Central Valley Regional Water Quality Control Board. (October 1986, updated June 1989). *The Designated Level Methodology for Waste Classification and Cleanup Level Determination.* Sacramento, CA:CVRWQCB.

California Irrigation Management Information System. (1999). "Reference Evapotranspiration Zones." Sacramento, CA:CDWR.

North Coast Regional Water Quality Control Board. (March 1, 2009). "National Pollutant Discharge Elimination System Permit No. CA0005584, Order No. R1-2008-0020." Santa Rosa, CA:RWQCB.

---. (2014). "Draft National Pollutant Discharge Elimination System Permit (Order R1-2014-0026)." Santa Rosa, CA:RWQCB.

SHN Consulting Engineers & Geologists, Inc. (September 29, 2011). *Land Disposal Evaluation, Humboldt Creamery, WDR Order No. R1-2008-0020.* Eureka, CA:SHN.

---. (March 1, 2013). *2012 Annual Discharge Report, Humboldt Creamery, NPDES Permit No. CA0005584, WDR Order No. R1-2008-0020, Facility ID. No. 1B80185OHUM.* Eureka, CA:SHN.

---. (May 13, 2013). *Compliance with Sodium and Total Dissolved Solids Final Effluent Limitations at LND-001, WDR Order No. R1-2008-0020.* Eureka, CA:SHN.

---. (February 28, 2014). *2013 Annual Discharge Report, Humboldt Creamery, NPDES Permit No. CA0005584, WDR Order No. R1-2008-0020, Facility ID. No. 1B80185OHUM.* Eureka, CA:SHN.

---. (June 27, 2014). "Comments on Draft NPDES Permit, Foster Dairy Farms, Inc. dba Humboldt Creamery, Fernbridge Facility; Order No. R1-2014-0026; NPDES Permit No. CA0005584; EPA I.D. No. 1B80185OHUM." Eureka, CA:SHN.

United States Geological Survey. (NR). Fortuna and Fields Landing 7.5-Minute Quadrangles. NR:USGS.

Western Regional Climate Center. (2010). "Eureka WSO City, California–Climate Summary." Accessed at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca2910

Appendix A

Field Notes

SHN CONSULTING ENGINEERS & GEOLOGISTS, INC.
812 W. Wabash • Eureka, CA 95501-2138 • 707/441-8855 • FAX: 707/441-8877 • shninfo@shn-engr.com

Daily Field Report

Job No. 005228.140
Page 1 of 1

Project Name	Client/Owner	Weather
Humboldt Creamery	Foster Farms Dairy dba Humboldt Creamery	sunny
General Location of Work	**Project Manager**	**Date / Day of Week**
Fernbridge, CA	Pat Barsanti	8/8/14 / friday
Type of Work		**Technician**
Ground Water Sampling & soil sampling		N. Sanger

6:00	Onsite.
6:02	open MW-5.
6:05	measure depth to water in MW-5.
6:10	calibrate DO & pH meters.
6:25	Begin purging MW-5 with its own, new, clean bailer.
6:38	MW-5 purged dry at 10.5 gallons, move on to next well.
7:10	Begin purging MW-1 with its own, new, clean bailer.
7:40	sample MW-1. close & lock well. MW-1
8:05	Sample MW-5 close & lock well. MW-5
8:35	Begin purging MW-3 with its own, new, clean bailer.
9:00	Sample MW-3, close & lock well. MW-3
9:30	Begin hand augering of B-MW-3. Advance to 12 ft BGS before refusal from cobbles.
10:20	Sample B-MW-3@10' B-MW-3@10'
10:30	Backfill borehole with bentonite & soil cuttings.
10:45	Begin purging MW-4 with its own, new, clean bailer.
11:05	Advance hand auger of B-MW-4. Advance to 10 ft BGS
11:40	Sample B-MW-4@10' B-MW-4@10'
11:50	Backfill borehole with bentonite & soil cuttings to grade.
12:00	Sample MW-4. close & lock well. MW-4
12:10	Advance hand auger of B-MW-2. Advance to 10 ft BGS.
12:30	Sample B-MW-2@10' B-MW-2@10'
12:50	Backfill Borehole with bentonite & soil cuttings to grade.
13:10	Begin purging MW-2 with its own, new, clean bailer.
13:40	Sample MW-2. MW-2
13:50	Clean up. close all gates & wells.
14:00	Off site, deliver samples directly to lab for rush turn around.
***	note: all purge water discharged to ground surface.

Well	Purged	Sampled
MW-1	✓	✓
MW-2	✓	✓
MW-3	✓	✓
MW-4	✓	✓
MW-5	✓	✓

Copy given to:

Reported By:

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Project Name:	Humboldt Creamery	Date/Time:	8/8/14
Project No.:	005228.140	Sampler Name:	N. Singer
Location:	Fernbridge	Sample Type:	Ground Water
Well #:	MW-2	Weather	Sunny
Hydrocarbon Thickness/Depth (feet):	—	Key Needed:	None

Total Well Depth (feet)	-	Initial Depth to Water (feet)	=	Height of Water Column (feet)	x	0.163 gal/ft (2-inch well) / 0.653 gal/ft (4-inch well)	=	1 Casing Volume (gal)
29.60	-	23.10	=	6.50	x	.163	=	~1.25

Time	DO (mg/L)	EC (uS/cm)	Temp (°C)	pH	Turbidity (NTU)	Water Removed (gal)	Comments
13:10	1.44	-	-	-	-	0 gal.	
13:16	-	1549	15.6	7.29	-	1.25	
13:20	-	1539	14.9	6.86	-	2.5	
13:26	-	518	14.3	6.79	-	3.75	

Purge Method: _____ Total Volume Removed: 3.75 (gal)

Laboratory Information				
Sample ID	# & Type of Containers	Preservative / Type	Laboratory	Analyses
MW-2	250 ml plastic	H2SO4	NCL	Ammonia
MW-2	500 ml plastic	–	NCL	Nitrate/Nitrite/TDS
MW-2	250 ml plastic	--	NCL	Total Na, Al, Mn, Fe

Well Condition: _____

Remarks: Recharged 23.82 at sample time 13:40

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Project Name:	Humboldt Creamery	Date/Time:	8/8/2014
Project No.:	005228.140	Sampler Name:	N. Sanger
Location:	Fernbridge	Sample Type:	Ground Water
Well #:	MW-3	Weather	Foggy
Hydrocarbon Thickness/Depth (feet):	---	Key Needed:	None

Total Well Depth (feet)	-	Initial Depth to Water (feet)	=	Height of Water Column (feet)	x	0.163 gal/ft (2-inch well) / 0.653 gal/ft (4-inch well)	=	1 Casing Volume (gal)
29.45	-	20.25	=	9.20	x	.163	=	1.50

Time	DO (mg/L)	EC (uS/cm)	Temp (°C)	pH	Turbidity (NTU)	Water Removed (gal)	Comments
8:35	0.54	--	--	--	--	0 gal.	
8:40	--	1645	13.7	7.00	--	1.5	
8:45	--	1695	13.6	6.85	--	3.0	
8:52	--	1703	13.5	6.82	--	4.5	

Purge Method: _____ Total Volume Removed: 4.5 (gal)

Laboratory Information				
Sample ID	# & Type of Containers	Preservative / Type	Laboratory	Analyses
MW-3	250 ml plastic	H2SO4	NCL	Ammonia
MW-3	500 ml plastic	--	NCL	Nitrate/Nitrite/TDS
MW-3	250 ml plastic	--	NCL	Total Na, Al, Mn, Fe

Well Condition: _____

Remarks: Recharged 20.32 at sample time 9:00

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Project Name:	Humboldt Creamery	Date/Time:	8/8/2014
Project No.:	005228.140	Sampler Name:	N. Sanger
Location:	Fernbridge	Sample Type:	Ground Water
Well #:	MW-4	Weather	sunny
Hydrocarbon Thickness/Depth	—	Key Needed:	None

Total Well Depth (feet)	-	Initial Depth to Water (feet)	=	Height of Water Column (feet)	x	0.163 gal/ft (2-inch well) / 0.653 gal/ft (4-inch well)	=	1 Casing Volume (gal)
29.45	-	19.26	=	10.19	x	.163	=	~1.75

Time	DO (mg/L)	EC (uS/cm)	Temp (°C)	pH	Turbidity (NTU)	Water Removed (gal)	Comments
10:45	0.71	—	—	—	—	0 gal.	
10:50		1094	17.2	7.02	—	1.75	
10:54		1068	15.8	7.18	—	3.5	
10:57		1065	15.0	7.85	—	5.25	
11:00		1064	15.2	7.98	—	7.0	

Purge Method: _____ Total Volume Removed: 7.0 (gal)

Laboratory Information

Sample ID	# & Type of Containers	Preservative / Type	Laboratory	Analyses
MW-4	250 ml plastic	H2SO4	NCL	Ammonia
MW-4	500 ml plastic	--	NCL	Nitrate/Nitrite/TDS
MW-4	250 ml plastic	--	NCL	Total Na, Al, Mn, Fe

Well Condition: _____

Remarks: Recharged 19.31 at sample time 12:00

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5680 West End Road · Arcata · CA 95521-9202
707-822-4649 Fax 707-822-6831

Chain of Custody

LABORATORY NUMBER:

Attention: Diana Ward
Results & Invoice to: SHN
Address: 812 W. Wabash Ave
Eureka CA 95501
Phone: (707) 441-8855
Copies of Report to: nsanger@shn-eng.com
Sampler (Sign & Print): Nathan Sanger

TAT: ☐ STD (2-3 Wk) ☒ Other: RUSH
PRIOR AUTHORIZATION IS REQUIRED FOR RUSH SAMPLES. 8/12/14

REPORTING REQUIREMENTS:
☐ State Forms
☒ Geotracker ☐ SWAMP ☐ Other EDD:
☒ Final Report PDF ☐ FAX By:

PROJECT INFORMATION
Project Number: 011095.151
Project Name: Humboldt Creamery
Purchase Order Number:

CONTAINER CODES: 1—½ gal. pl; 2—250 ml pl; 3—500 ml pl; 4—1 L Nalgene; 5—250 ml BG; 6—500 ml BG; 7—1 L BG; 8—40 ml VOA; 9—60 ml VOA; 10—125 ml VOA; 11—4 oz glass jar; 12—8 oz glass jar; 13—brass tube; 14—other
PRESERVATIVE CODES: a—HNO_3; b—HCl; c—H_2SO_4; d—$Na_2S_2O_3$; e—NaOH; f—$C_2H_3O_2Cl$; g—other

LAB ID	SAMPLE ID	DATE	TIME	MATRIX*	PRESERVATIVE	CONTAINER	ANALYSIS
	MW-2	8/8/14	13:40	GW	a	2	Calcium, Magnesium
	MW-3	↓	9:00	↓			Potassium, Sodium, Chloride, TDS
	MW-4	↓	12:00	↓		2	Calcium, Magnesium, Potassium, Sodium, Chloride, Manganese
	B- MW-2 @10'	8/8/14	12:30	S			
	B- MW-3 @10'		10:20				
	B- MW-4 @20'	↓	11:40	↓			

SPECIAL INSTRUCTIONS	SAMPLE CONDITION
Field filtered metals	Temperature 3.7 °C
	Received On Ice? Y / N
	Samples Intact? Y / N
	Preserved? Y / N
	Preserved @ NCL? Y / N / NA

RELINQUISHED BY (Sign & Print)	DATE/TIME	RECEIVED BY (Sign)	DATE/TIME
Nathan Sanger	8/8/14		8/8/14 1545

SAMPLE DISPOSAL
☒ NCL Disposal of Non-Contaminated
☐ Return ☐ Pickup

CHAIN OF CUSTODY SEALS Y/N/NA
SHIPPED VIA: UPS Fed-Ex Hand

***MATRIX:** DW=Drinking Water; Eff=Effluent; Inf=Influent; SW=Surface Water; GW=Ground Water; WW=Waste Water; S=Soil; O=Other.

ALL CONTAMINATED NON-AQUEOUS SAMPLES WILL BE RETURNED TO CLIENT

Appendix B

Laboratory Analytical Data

CONSULTING ENGINEERS & GEOLOGISTS, INC.
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DENSITY BY DRIVE- CYLINDER METHOD (ASTM D2937)

Project Name:	Humboldt Creamery	Project Number:	011095.151
Performed By:	011095.151	Date:	8/14/14
Checked By:		Date:	8/14/14
Project Manager:	PB		

Lab Sample Number	14-659	14-660	14-661		
Boring Label	B-MW-2	B-MW-3	B-MW-4		
Sample Depth (ft)	10	10	10		
Diameter of Cylinder, in	2.38	2.38	2.38		
Total Length of Cylinder, in.	8.00	7.46	7.90		
Length of Empty Cylinder A, in.	2.75	2.34	2.40		
Length of Empty Cylinder B, in.	0.00	0.00	0.00		
Length of Cylinder Filled, in	5.25	5.12	5.50		
Volume of Sample, in^3	23.36	22.78	24.47		
Volume of Sample, cc.	382.74	373.26	400.96		

Pan #	S30	S31	S32		
Weight of Wet Soil and Pan	696.5	750.0	824.6		
Weight of Dry Soil and Pan	634.7	673.5	661.6		
Weight of Water	61.8	76.5	163.0		
Weight of Pan	79.9	76.8	80.2		
Weight of Dry Soil	554.8	596.7	581.4		
Percent Moisture	11.1	12.8	28.0		
Dry Density, g/cc	1.45	1.60	1.45		
Dry Density, lb/ft^3	90.5	99.8	90.5		

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MATERIALS TESTING LABORATORY RECEIVING AND SCHEDULING OF TESTS

PROJECT NAME Humboldt Gateway | Date Sampled 8/8/14 | Sampled by U. Singer
JOB NUMBER 0R095.151 | Date Delivered 8/8/14 | Results to U. Singer
PROJECT MNGR Pat Barsanti | Date Recorded 8/13/14

TOTAL NUMBER OF SAMPLES | BAGS ____ | BUCKETS ____ | SHELBY TUBES 3 | BRASS LINERS ____

SAMPLE CONDITION: INTACT ☐ DAMAGED ☐ | COMPOSITE ☐ UNDISTURBED ☐

SAMPLE NO. & DEPTH	MOISTURE DENSITY	UNCONFINED COMPRESSION	USDA TEXTURAL ANALYSIS	COARSE SIEVE ANALYSIS 3" to No.4	FINE SIEVE ANALYSIS No.4 to No. 200	% PASSING 200	SAND EQUIVALENT	SPECIFIC GRAVITY	PLASTICITY INDEX	COMPACTION CURVE (ASTM-1557)	CAL TRANS CURVE (CT-216)	COMPACTION CHECK POINT	% ORGANICS	LA RATTLER	DURABILITY	SULFATE SOUNDNESS	RICE SPECIFIC GRAVITY	R VALUE	CONSOLIDATION *		DIRECT SHEAR **		LAB SAMP. #
B-MW-2 @10'	X																						14-659
B-MW-3 @10'	X																						14-660
B-MW-4 @10'	X																						14-661
TOTAL	3																						

COMMENTS:

8/14/14

* Indicate The Following: Consolidation Loads: _____ Note all points to be saturated

** Indicate The Following: Confining loads: _____ Consolidated Drained: ☐ Consolidated Undrained: ☐ Unconsolidated Undrained: ☐ Residual Cycles _____

NORTH COAST LABORATORIES LTD.

August 14, 2014

SHN Consulting Engineers and Geologists
812 West Wabash Avenue
Eureka, CA 95501

Attn: Diana Ward

RE: 011095.151 Humboldt Creamery

Order No.: 1408163
Invoice No.: 116873
PO No.:
ELAP No.1247-Expires July 2014

SAMPLE IDENTIFICATION

Fraction	Client Sample Description
01A	MW-2(DISSOLVED)
01B	MW-2
02A	MW-3(DISSOLVED)
02B	MW-3
03A	MW-4(DISSOLVED)
03B	MW-4
04A	B-MW-2 @ 10'
05A	B-MW-3 @ 10'
06A	B-MW-4 @ 10'

ND = Not Detected at the Reporting Limit
Limit = Reporting Limit
Flag = Explanation in Case Narrative
All solid results are expressed on a wet-weight basis unless otherwise noted.

REPORT CERTIFIED BY

Laboratory Supervisor(s)
FOR ROBERT STUART

QA Unit

Jesse G. Chaney, Jr.
Laboratory Director

North Coast Laboratories, Ltd. Date: 14-Aug-2014

CLIENT:	SHN Consulting Engineers and Geologists
Project:	011095.151 Humboldt Creamery
Lab Order:	1408163

CASE NARRATIVE

Calcium/Magnesium/Potassium/Sodium:
The matrix spike recoveries for Sample MW-4(DISSOLVED) were not evaluated due to the large amount of analyte in the sample.

Date: 14-Aug-2014
WorkOrder: 1408163

ANALYTICAL REPORT

Client Sample ID: MW-2(DISSOLVED)
Lab ID: 1408163-01A
Received: 8/8/2014
Collected: 8/8/2014 13:40

Test Name: ICAP Metals
Reference: EPA 200.7 Rev 4.4 (1994)

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Calcium	79,000		20	µg/L	1.0	8/11/2014	8/11/2014
Magnesium	67,000		20	µg/L	1.0	8/11/2014	8/11/2014
Manganese	7.5		1.0	µg/L	1.0	8/11/2014	8/11/2014
Potassium	5,700		10	µg/L	1.0	8/11/2014	8/11/2014
Sodium	120,000		40	µg/L	2.0	8/11/2014	8/11/2014

Client Sample ID: MW-2
Lab ID: 1408163-01B
Received: 8/8/2014
Collected: 8/8/2014 13:40

Test Name: Anions by Ion Chromatography
Reference: EPA 300.0 Rev 2.1 (1993)

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Chloride	230		4.0	mg/L	40		8/12/2014

Test Name: Total Dissolved Solids
Reference: Std. Meth. 20th Ed. 2540 C

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Total Dissolved Solids	920		10	mg/L	1.0		8/12/2014

Client Sample ID: MW-3(DISSOLVED)
Lab ID: 1408163-02A
Received: 8/8/2014
Collected: 8/8/2014 9:00

Test Name: ICAP Metals
Reference: EPA 200.7 Rev 4.4 (1994)

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Calcium	110,000		20	µg/L	1.0	8/11/2014	8/11/2014
Magnesium	42,000		20	µg/L	1.0	8/11/2014	8/11/2014
Manganese	20		1.0	µg/L	1.0	8/11/2014	8/11/2014
Potassium	8,000		10	µg/L	1.0	8/11/2014	8/11/2014
Sodium	110,000		40	µg/L	2.0	8/11/2014	8/11/2014

Client Sample ID: MW-3
Lab ID: 1408163-02B
Received: 8/8/2014
Collected: 8/8/2014 9:00

Test Name: Anions by Ion Chromatography
Reference: EPA 300.0 Rev 2.1 (1993)

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Chloride	800		10	mg/L	100		8/12/2014

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Date: 14-Aug-2014
WorkOrder: 1408163

ANALYTICAL REPORT

Client Sample ID: MW-3
Lab ID: 1408163-02B
Received: 8/8/2014
Collected: 8/8/2014 9:00

Test Name: Total Dissolved Solids
Reference: Std. Meth. 20th Ed. 2540 C

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Total Dissolved Solids	1,100		10	mg/L	1.0		8/12/2014

Client Sample ID: MW-4(DISSOLVED)
Lab ID: 1408163-03A
Received: 8/8/2014
Collected: 8/8/2014 12:00

Test Name: ICAP Metals
Reference: EPA 200.7 Rev 4.4 (1994)

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Calcium	88,000		20	µg/L	1.0	8/11/2014	8/11/2014
Magnesium	37,000		20	µg/L	1.0	8/11/2014	8/11/2014
Manganese	23		1.0	µg/L	1.0	8/11/2014	8/11/2014
Potassium	5,500		10	µg/L	1.0	8/11/2014	8/11/2014
Sodium	67,000		20	µg/L	1.0	8/11/2014	8/11/2014

Client Sample ID: MW-4
Lab ID: 1408163-03B
Received: 8/8/2014
Collected: 8/8/2014 12:00

Test Name: Anions by Ion Chromatography
Reference: EPA 300.0 Rev 2.1 (1993)

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Chloride	120		2.0	mg/L	20		8/12/2014

Test Name: Total Dissolved Solids
Reference: Std. Meth. 20th Ed. 2540 C

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Total Dissolved Solids	660		10	mg/L	1.0		8/12/2014

Client Sample ID: B-MW-2 @.10'
Lab ID: 1408163-04A
Received: 8/8/2014
Collected: 8/8/2014 12:30

Test Name: EPA 6010B
Reference: EPA 6010B

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Calcium	6,000		5.0	mg/kg	1.0	8/11/2014	8/12/2014
Magnesium	16,000		2.0	mg/kg	1.0	8/11/2014	8/12/2014
Manganese	530		1.0	mg/kg	1.0	8/11/2014	8/12/2014
Potassium	1,900		5.0	mg/kg	1.0	8/11/2014	8/12/2014
Sodium	230		5.0	mg/kg	1.0	8/11/2014	8/12/2014

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Date: 14-Aug-2014
WorkOrder: 1408163

ANALYTICAL REPORT

Client Sample ID: B-MW-2 @ 10'
Lab ID: 1408163-04A

Received: 8/8/2014
Collected: 8/8/2014 12:30

Test Name: F, SO4, Cl, NO3, NO2

Reference: EPA 300.0 Rev 2.1 (1993) Modified

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Chloride	13		10	mg/kg	1.0		8/12/2014

Client Sample ID: B-MW-3 @ 10'
Lab ID: 1408163-05A

Received: 8/8/2014
Collected: 8/8/2014 10:20

Test Name: EPA 6010B

Reference: EPA 6010B

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Calcium	5,100		5.0	mg/kg	1.0	8/11/2014	8/12/2014
Magnesium	14,000		2.0	mg/kg	1.0	8/11/2014	8/12/2014
Manganese	490		1.0	mg/kg	1.0	8/11/2014	8/12/2014
Potassium	2,100		5.0	mg/kg	1.0	8/11/2014	8/12/2014
Sodium	150		5.0	mg/kg	1.0	8/11/2014	8/12/2014

Test Name: F, SO4, Cl, NO3, NO2

Reference: EPA 300.0 Rev 2.1 (1993) Modified

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Chloride	18		10	mg/kg	1.0		8/12/2014

Client Sample ID: B-MW-4 @ 10'
Lab ID: 1408163-06A

Received: 8/8/2014
Collected: 8/8/2014 11:40

Test Name: EPA 6010B

Reference: EPA 6010B

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Calcium	5,000		5.0	mg/kg	1.0	8/11/2014	8/12/2014
Magnesium	15,000		2.0	mg/kg	1.0	8/11/2014	8/12/2014
Manganese	610		1.0	mg/kg	1.0	8/11/2014	8/12/2014
Potassium	2,100		5.0	mg/kg	1.0	8/11/2014	8/12/2014
Sodium	190		5.0	mg/kg	1.0	8/11/2014	8/12/2014

Test Name: F, SO4, Cl, NO3, NO2

Reference: EPA 300.0 Rev 2.1 (1993) Modified

Parameter	Result	Flag	Limit	Units	DF	Extracted	Analyzed
Chloride	35		10	mg/kg	1.0		8/12/2014

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CLIENT: SHN Consulting Engineers and Geologists
Work Order: 1408163
Project: 011095.151 Humboldt Creamery

QC SUMMARY REPORT
Method Blank

Sample ID MB-30904 Batch ID: 30904 Test Code: 6ICPS Units: mg/kg Analysis Date 8/12/2014 11:57:58 AM Prep Date 8/11/2014
Client ID: Run ID: INICP2_140812A SeqNo: 1147443

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	5.0									
Magnesium	ND	2.0									
Manganese	ND	1.0									
Potassium	ND	5.0									
Sodium	ND	5.0									

Sample ID MBLK 081114 Batch ID: R79240 Test Code: ICIONW Units: mg/L Analysis Date 8/11/2014 4:35:02 PM Prep Date
Client ID: Run ID: INIC2_140811A SeqNo: 1147508

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	0.10									

Sample ID MB-30906 Batch ID: 30906 Test Code: ICPX Units: µg/L Analysis Date 8/11/2014 1:04:29 PM Prep Date 8/11/2014
Client ID: Run ID: INICP2_140811C SeqNo: 1147278

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	ND	20	0	0	0%	0	0	0			
Magnesium	ND	20	0	0	0%	0	0	0			
Manganese	ND	1.0	0	0	0%	0	0	0			
Potassium	ND	10	0	0	0%	0	0	0			
Sodium	ND	20	0	0	0%	0	0	0			

Sample ID MBLK 081114 Batch ID: R79241 Test Code: IONICS Units: mg/kg Analysis Date 8/11/2014 4:35:02 PM Prep Date
Client ID: Run ID: INIC2_140811B SeqNo: 1147539

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	10									

Qualifiers: ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

CLIENT: SHN Consulting Engineers and Geologists
Work Order: 1408163
Project: 011095.151 Humboldt Creamery

QC SUMMARY REPORT
Method Blank

Sample ID **MBLK** Batch ID: **R79276** Test Code: **TDS** Units: **mg/L** Analysis Date **8/12/2014** Prep Date
Client ID: Run ID: **WC_140812D** SeqNo: **1148006**

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Total Dissolved Solids	ND	10									

Qualifiers:
ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

CLIENT: SHN Consulting Engineers and Geologists
Work Order: 1408163
Project: 011095.151 Humboldt Creamery

QC SUMMARY REPORT

Sample Matrix Spike

Sample ID	1408163-03AMS	Batch ID: 30906	Test Code: ICPX	Units: µg/L	Analysis Date 8/11/2014 1:21:01 PM	Prep Date 8/11/2014
Client ID:	MW-4(DISSOLVED)		Run ID: INICP2_140811C		SeqNo: 1147284	

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Manganese	452.7	1.0	500	22.7	86.0%	70	130	0			

Sample ID	1408163-03AMSD	Batch ID: 30906	Test Code: ICPX	Units: µg/L	Analysis Date 8/11/2014 1:24:40 PM	Prep Date 8/11/2014
Client ID:	MW-4(DISSOLVED)		Run ID: INICP2_140811C		SeqNo: 1147285	

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Manganese	455.2	1.0	500	22.7	86.5%	70	130	453	0.567%	20	

Sample ID	1408163-04AMS	Batch ID: R79241	Test Code: IONICS	Units: mg/kg	Analysis Date 8/12/2014 11:29:35 AM	Prep Date
Client ID:	B-MW-2 @ 10'		Run ID: INIC2_140811B		SeqNo: 1147545	

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	31.89	10	20.0	13.1	93.8%	80	120	0			

Qualifiers:

ND - Not Detected at the Reporting Limit

J - Analyte detected below quantitation limits

S - Spike Recovery outside accepted recovery limits

R - RPD outside accepted recovery limits

B - Analyte detected in the associated Method Blank

CLIENT: SHN Consulting Engineers and Geologists
Work Order: 1408163
Project: 011095.151 Humboldt Creamery

QC SUMMARY REPORT
Laboratory Control Spike

Sample ID LCS-30904 Batch ID: 30904 Test Code: 6ICPS Units: mg/kg Analysis Date 8/12/2014 12:00:03 PM Prep Date 8/11/2014
Client ID: Run ID: INICP2_140812A SeqNo: 1147444

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	99.37	5.0	100	2.32	97.1%	80	120	0			
Magnesium	100.5	2.0	100	0	101%	80	120	0			
Manganese	104.2	1.0	100	0.0244	104%	80	120	0			
Potassium	444.2	5.0	500	0	88.8%	80	120	0			
Sodium	97.85	5.0	100	3.88	94.0%	80	120	0			

Sample ID LCS WL-081114-0 Batch ID: R79240 Test Code: ICIONW Units: mg/L Analysis Date 8/11/2014 4:52:40 PM Prep Date
Client ID: Run ID: INIC2_140811A SeqNo: 1147509

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.9887	0.10	1.00	0	98.9%	90	110	0			

Sample ID LCSD WL-081114- Batch ID: R79240 Test Code: ICIONW Units: mg/L Analysis Date 8/11/2014 5:10:18 PM Prep Date
Client ID: Run ID: INIC2_140811A SeqNo: 1147510

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	0.9938	0.10	1.00	0	99.4%	90	110	0.989	0.515%	10	

Sample ID LCS-30906 Batch ID: 30906 Test Code: ICPX Units: µg/L Analysis Date 8/11/2014 1:06:09 PM Prep Date 8/11/2014
Client ID: Run ID: INICP2_140811C SeqNo: 1147279

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	487.8	20	500	0	97.6%	85	115	0			
Magnesium	498.1	20	500	0	99.6%	85	115	0			
Manganese	495.2	1.0	500	0.198	99.0%	85	115	0			
Potassium	2,328	10	2,500	0	93.1%	85	115	0			
Sodium	476.4	20	500	0	95.3%	85	115	0			

Qualifiers: ND - Not Detected at the Reporting Limit; S - Spike Recovery outside accepted recovery limits; B - Analyte detected in the associated Method Blank
J - Analyte detected below quantitation limits; R - RPD outside accepted recovery limits

CLIENT: SHN Consulting Engineers and Geologists
Work Order: 1408163
Project: 011095.151 Humboldt Creamery

QC SUMMARY REPORT
Laboratory Control Spike Duplicate

Sample ID LCSD-30906 Batch ID: 30906 Test Code: ICPX Units: µg/L Analysis Date 8/11/2014 1:09:09 PM Prep Date 8/11/2014
Client ID: Run ID: INICP2_140811C SeqNo: 1147280

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Calcium	484.1	20	500	0	96.8%	85	115	488	0.750%	20	
Magnesium	497.1	20	500	0	99.4%	85	115	498	0.185%	20	
Manganese	491.7	1.0	500	0.198	98.3%	85	115	495	0.720%	20	
Potassium	2,322	10	2,500	0	92.9%	85	115	2,330	0.296%	20	
Sodium	475.9	20	500	0	95.2%	85	115	476	0.105%	20	

Sample ID LCS WL-081114-0 Batch ID: R79241 Test Code: IONICS Units: mg/kg Analysis Date 8/11/2014 4:52:40 PM Prep Date
Client ID: Run ID: INIC2_140811B SeqNo: 1147540

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	10	10.0	0	98.9%	90	110	0			

Sample ID LCSD WL-081114- Batch ID: R79241 Test Code: IONICS Units: mg/kg Analysis Date 8/11/2014 5:10:18 PM Prep Date
Client ID: Run ID: INIC2_140811B SeqNo: 1147541

Analyte	Result	Limit	SPK value	SPK Ref Val	% Rec	LowLimit	HighLimit	RPD Ref Val	%RPD	RPDLimit	Qual
Chloride	ND	10	10.0	0	99.4%	90	110	9.89	0.515%	10	

Qualifiers: ND - Not Detected at the Reporting Limit
J - Analyte detected below quantitation limits
S - Spike Recovery outside accepted recovery limits
R - RPD outside accepted recovery limits
B - Analyte detected in the associated Method Blank

NORTH COAST LABORATORIES LTD.
5680 West End Road • Arcata • CA 95521-9202
707-822-4649 Fax 707-822-6831

Chain of Custody

LABORATORY NUMBER: 1408163

Attention: Dana Ward
Results & Invoice to: SHN
Address: 812 W Wabash Ave, Eureka CA 95501
Phone: (707) 441-8855
Copies of Report to: nsanger@shn-engr.com
Sampler (Sign & Print): Nathan Sanger

TAT: ☐ STD (2-3 Wk) ☒ Other: RUSH
PRIOR AUTHORIZATION IS REQUIRED FOR RUSH SAMPLES. 8/12/14

REPORTING REQUIREMENTS:
☐ State Forms
☒ Geotracker ☐ SWAMP ☐ Other EDD:
☒ Final Report PDF ☐ FAX By:

CONTAINER CODES: 1—½ gal. pl; 2—250 ml pl; 3—500 ml pl; 4—1 L Nalgene; 5—250 ml BG; 6—500 ml BG; 7—1 L BG; 8—40 ml VOA; 9—60 ml VOA; 10—125 ml VOA; 11—4 oz glass jar; 12—8 oz glass jar; 13—brass tube; 14—other
PRESERVATIVE CODES: a—HNO_3; b—HCl; c—H_2SO_4; d—$Na_2S_2O_3$; e—NaOH; f—$C_2H_3O_2Cl$; g—other

PROJECT INFORMATION

Project Number: 011095.151
Project Name: Humboldt Creamery
Purchase Order Number:

LAB ID	SAMPLE ID	DATE	TIME	MATRIX*	PRESERVATIVE	CONTAINER	ANALYSIS
	MW-2	8/8/14	13:40	GW	a	2	X Calcium, magnesium, potassium, sodium, chloride, TDS
	MW-3		9:00				X
	MW-4		12:00				X
	B-MW-2@10'	8/8/14	12:30	S	-	2	Calcium, magnesium, potassium, sodium, chloride, manganese
	B-MW-3@10'		10:20				
	B-MW-4@10'		11:40				

SPECIAL INSTRUCTIONS	SAMPLE CONDITION
Field filtered metals	Temperature 3.2 °C
	Received On Ice? Y / N
	Samples Intact? Y / N
	Preserved? Y / N
	Preserved @ NCL? Y / N / NA

RELINQUISHED BY (Sign & Print)	DATE/TIME	RECEIVED BY: (Sign)	DATE/TIME
Nathan Sanger	8/8/14 15:05		8/8/14 1505

SAMPLE DISPOSAL
☒ NCL Disposal of Non-Contaminated
☐ Return ☐ Pickup

CHAIN OF CUSTODY SEALS Y/N/NA
SHIPPED VIA: UPS Fed-Ex Hand

*MATRIX: DW=Drinking Water; Eff=Effluent; Inf=Influent; SW=Surface Water; GW=Ground Water; WW=Waste Water; S=Soil; O=Other.

ALL CONTAMINATED NON-AQUEOUS SAMPLES WILL BE RETURNED TO CLIENT

Appendix C

Attenuation Calculations

Vadose Zone Attenuation Factor Calculation, Manganese

$$Af_{vadose} = \left(1 + \frac{Pb}{M} Kd\right)$$

Where
Pb = dry bulk density (kg/L)
M = volumetric moisture content (%)
Kd = partition coefficient (L/kg)

$$Kd = \frac{C_s}{C_w}$$

Where:
Cs = Concentration in soil (mg/kg)
Cw = Concentration in water (mg/L)

Input Parameters

			Source
Pb (bulk density)	93.6	lbs/ft^3	Average from three sample locations, collected 8/8/2014, see laboratory analytical report for details.
Pb (bulk density)	1.50	kg/L	
M (vol. moist. cont.)	17.3	%	
Cs (cont. conc. soil)	543	mg/kg	
Cw (cont. conc. h20)	0.017	mg/L	
Kd (part. coeff.)	32,277	L/kg	Calculation, based on laboratory results
Af_{vadose}	**2,798**		

conversion factors

lbs/ft^3	0.0160184	kg/L

Vadose Zone Attenuation Factor Calculation, TDS

$$Af_{vadose} = \left(1 + \frac{Pb}{M} Kd\right)$$

Where
Pb = dry bulk density (kg/L)
M = volumetric moisture content (%)
Kd = partition coefficient (L/kg)

$$Kd = \frac{C_s}{C_w}$$

Where:
Cs = Concentration in soil (mg/kg)
Cw = Concentration in water (mg/L)

$$Af_{vadose,TDS} = \sum(Af \times PC) - (n-1)$$

Where
Af = attenuation factor for each constituent
PC = percent composition of total TDS for each constituent
n = number of constituents considered

Input Parameters			Source
Pb (bulk density)	94	lbs/ft^3	Average from three sample locations, collected 8/8/2014, see laboratory analytical report for details.
Pb (bulk density)	1.50	kg/L	
M (vol. moist. cont.)	17	%	
Calcium			
Cs (cont. conc. soil)	5,033	mg/kg	Average from three sample locations, collected 8/8/2014, see laboratory analytical report for details.
Cw (cont. conc. h20)	92	mg/L	
Kd (part. coeff.)	55	L/kg	Calculation, based on laboratory results
PC (percent comp.)	6.2	%	Based on Sodium and TDS Study (SHN, 2013)
$Af_{vadose, Ca}$	1.30		
Magnesium			
Cs (cont. conc. soil)	15,000	mg/kg	Average from three sample locations, collected 8/8/2014, see laboratory analytical report for details.
Cw (cont. conc. h20)	45	mg/L	
Kd (part. coeff.)	331	L/kg	Calculation, based on laboratory results
PC (percent comp.)	4.4	%	Based on Sodium and TDS Study (SHN, 2013)
$Af_{vadose, Mg}$	2.26		
Potassium			
Cs (cont. conc. soil)	2,033	mg/kg	Average from three sample locations, collected 8/8/2014, see laboratory analytical report for details.
Cw (cont. conc. h20)	6.4	mg/L	
Kd (part. coeff.)	318	L/kg	Calculation, based on laboratory results
PC (percent comp.)	40	%	Based on Sodium and TDS Study (SHN, 2013)
$Af_{vadose, K}$	12.01		
Sodium			
Cs (cont. conc. soil)	190	mg/kg	Average from three sample locations, collected 8/8/2014, see laboratory analytical report for details.
Cw (cont. conc. h20)	99	mg/L	
Kd (part. coeff.)	2	L/kg	Calculation, based on laboratory results
PC (percent comp.)	14.6	%	Based on Sodium and TDS Study (SHN, 2013)
$Af_{vadose, Na}$	1.02		
Chloride			
Cs (cont. conc. soil)	22	mg/kg	Average from three sample locations, collected 8/8/2014, see laboratory analytical report for details.
Cw (cont. conc. h20)	383	mg/L	
Kd (part. coeff.)	0.06	L/kg	Calculation, based on laboratory results
PC (percent comp.)	20.0	%	Based on Sodium and TDS Study (SHN, 2013)
$Af_{vadose, Cl}$	1.00		Calculation, based on laboratory results
$Af_{vadose, TDS}$	13.6		

conversion factor

lbs/ft^3	0.0160184	kg/L

Dilution Attenuation Factor Calculation, Manganese

$$C_{diluted} = \frac{M}{V + (R - E) \times A}$$

Where
M = average annual mass discharge (mg)
V = average annual discharge volume (L)
R = average annual rainfall (in)
E = average annual evapotranspiration (in)
A = discharge area (acre)

$$Af_{dilution} = \frac{C}{C_{diluted}}$$

Where:
C = average annual discharge concentration (mg/L)
$C_{diluted}$ = ajusted annual discharge concentration (mg/L)

Input Parameters			Source
R (ave. annual rainfall)	39	inches/yr	Land Disposal Evaluation (SHN, 2013)
E (evapotranspiration)	27	inches/yr	
A (discharge area)	140	acres	
M (ave. annual disch. mass)	467,161,405	mg	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
V (ave. annual disch. volume)	368,931,654	L	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
V+(R-E)xA (adjusted ave. annual disch. volume)	544,497,303	L	Calculation, sum of average annual volume and net recharge
C (ave. annual disch. conc.)	1.27	mg/L	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
$C_{diluted}$ (diluted ave. annual disch. conc.)	0.86	mg/L	Calculation, average mass divided by adjusted volume
$Af_{dilution}$	1.48		

conversion factor

inch-acre	102,790	Liters

Dilution Attenuation Factor Calculation, TDS

$$C_{diluted} = \frac{M}{V + (R - E) \times A}$$

Where
M = average annual mass discharge (mg)
V = average annual discharge volume (L)
R = average annual rainfall (in)
E = average annual evapotranspiration (in)
A = discharge area (acre)

$$Af_{dilution} = \frac{C}{C_{diluted}}$$

Where:
C = average annual discharge concentration (mg/L)
$C_{diluted}$ = ajusted annual discharge concentration (mg/L)

Input Parameters			Source
R (ave. annual rainfall)	39	inches/yr	Land Disposal Evaluation (SHN, 2013)
E (evapotranspiration)	27	inches/yr	
A (discharge area)	140	acres	
M (ave. annual disch. mass)	316,014,453,271	mg	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
V (ave. annual disch. volume)	368,931,654	L	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
V+(R-E)xA (adjusted ave. annual disch. volume)	544,497,303	L	Calculation, sum of average annual volume and net recharge
C (ave. annual disch. conc.)	856.57	mg/L	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
$C_{diluted}$ (diluted ave. annual disch. conc.)	580	mg/L	Calculation, average mass divided by adjusted volume
$Af_{dilution}$	1.48		

conversion factor

inch-acre	102,790	Liters

Removal Attenuation Factor Calculation, Manganese

$$C_{removed} = \frac{M - RR\ x\ (yr)\ x\ A}{V}$$

Where
$C_{removed}$ = ajusted average annual discharge concentration (mg/L)
M = average annual mass discharge (mg)
R R = mass removal rate from crops (mg/acre-yr)
A = discharge area (acre)

$$Af_{removed} = \frac{C}{C_{removed}}$$

Where:
C = average annual discharge concentration (mg/L)
$C_{removed}$ = ajusted annual discharge concentration (mg/L)

Input Parameters

			Source
M (ave. annual disch. mass)	467,161,405	mg	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
RR (removal rate)	0.44	lbs/acre-yr	Clover removal rate from the Alabama Cooperative Extension Program, http://www.aces.edu/pubs/docs/A/ANR-0449/
A (discharge area)	140	acres	Land Disposal Evaluation (SHN, 2013)
V (ave. annual disch. volume)	368,931,654	L	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
C (ave. annual disch. conc.)	1.27	mg/L	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
$C_{removed}$ (adjusted ave. annual disch. conc.)	1.19	mg/L	Calculation, adjusted mass divided by discharge volume
$Af_{removed}$	1.06		

conversion factor

lb	453,592	mg

Removal Attenuation Factor Calculation, TDS

$$C_{removed} = \frac{M - RR\ x\ (yr)\ x\ A}{V}$$

Where
$C_{removed}$ = ajusted average annual discharge concentration (mg/L)
M = average annual mass discharge (mg)
R R = mass removal rate from crops (mg/acre-yr)

$$Af_{removed} = \frac{C}{C_{removed}}$$

Where:
C = average annual discharge concentration (mg/L)
$C_{removed}$ = ajusted annual discharge concentration (mg/L)

Input Parameters

			Source
M (ave. annual disch. mass)	316,014,453,271	mg	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
RR (removal rate)	2,083	lbs/acre-yr	Clover removal rate from the Alabama Cooperative Extension Program, http://www.aces.edu/pubs/docs/A/ANR-0449/
A (discharge area)	140	acres	Land Disposal Evaluation (SHN, 2013)
V (ave. annual disch. volume)	368,931,654	L	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
C (ave. annual disch. conc.)	857	mg/L	2012 and 2013 Annual Reports (SHN, 2012; SHN, 2013)
$C_{removed}$ (adjusted ave. annual disch. conc.)	498	mg/L	Calculation, adjusted mass divided by discharge volume
$Af_{removed}$	1.72		

conversion factor

lb	453,592	mg