Infrastructure Needs and Reuse on the Samoa Peninsula

Redwood Marine Terminal II

Prepared for:

County of Humboldt and
Humboldt Bay Harbor, Recreation and Conservation District

Project Funding Provided by:

The HUD Community Development Block Grant No. 14-CDBG-9890

Prepared by:

SHN Engineers & Geologists

ch2m

HEMPHILL water engineering

February 2016 015147

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Reference: 015147

February 25, 2016

Ms. Paula Mushrush
Humboldt County Community Development
520 E St.
Eureka, CA 95501

Subject: Infrastructure Needs and Reuse on the Samoa Peninsula, Redwood Marine Terminal II

Dear Ms. Mushrush:

Attached is the reuse evaluation of water and wastewater infrastructure at the Redwood Marine Terminal II, in Samoa, California. Water and wastewater infrastructure on the peninsula is a vital part of future improvements that will provide housing and economic growth to the nearby communities. This evaluation considered several onsite and offsite alternatives that could potentially be used with the existing infrastructure at RMT II. In addition, we evaluated improvements that may be required for the potential alternatives examined and associated planning-level costs associated with those improvements.

This document is intended to be used a guide for Humboldt County and the Humboldt Bay Harbor, Recreation and Conservation District on the potential future uses identified in this report.

Sincerely,

SHN Engineers & Geologists

Mike Foget, PE
Principal Engineer
707-441-8855

MKF/BGH:lms

Enclosures: Report

Reference: 015147

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QA/QC:MKF___

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Abbreviations and Acronyms

CY	cubic yards
ft	foot
gpd	gallons per day
gpm	gallons per minute
hp	horsepower
kg	kilogram
kva	kilovolt ampere
lbs/day	pounds per day
LF	linear feet
MG	million gallon
mg/L	milligrams per liter
MGD	million gallons per day
ml/L	milliliter per liter
NTU	nephelometric turbidity units
psu	practical salinity units
SF	square foot
SY	square yard
ug/L	microgram per liter

AAF	average annual flow
ACOE	U.S. Army Corps of Engineers
BMPs	best management practices
BOD	biochemical oxygen demand
BOD_5	five-day biochemical oxygen demand
CCC	California Coastal Commission
CDFW	California Department of Fish & Wildlife
CDP	coastal development permit
CDWR	California Department of Water Resources
CEQA	California Environmental Quality Act
City	City of Eureka
County	County of Humboldt
CSLC	California State Lands Commission
DW	dissolved waste
EA	each
EIR	environmental impact report
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
HBHRCD	Humboldt Bay Harbor, Recreation and Conservation District
HDD	horizontal directional drilling
HDPE	high density polyethylene
HWE	Hemphill Water Engineering
LS	lump sum
LSA	lake and streambed alteration
MH-#	manhole-number
$MMWWF_5$	maximum monthly average wet weather flow (with a 5-year recurrence level)
N	nitrogen
NA	not available
NAVD88	North American Vertical Datum, 1988
NH_4	ammonia
NMFS	National Marine Fisheries Service
NOAA	National Oceanic & Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NR	no reference
P	phosphorus
$PDAF_5$	peak daily average flow (for a 5-year, 24-hour storm)
PIF_5	peak instantaneous flow (attained during 5-year 24-hour storm)
RMT II	Redwood Marine Terminal II
RWQCB	North Coast Regional Water Quality Control Board
SHN	SHN Engineers & Geologists
SLR	sea level rise
SW	solid waste
SWRCB	State Water Resources Control Board
TSS	total suspended solids
TW	total waste
USFWS	United States Fish and Wildlife Service
WDR	Waste Discharge Requirement
WQS	water quality standard
WWTF	wastewater treatment facility

1.0 Introduction

This planning- and feasibility-level report analyzes potential reuse of existing water and wastewater infrastructure located at the Redwood Marine Terminal II (RMT II) site (Figure 1). Reuse of the existing infrastructure at RMT II can benefit communities on the Samoa Peninsula and Humboldt Bay through economic development (aquaculture and a cost-effective method for processing dredge spoils), and environmental health (disposal of treated effluent through the ocean outfall limits impacts to groundwater from existing on site disposal activities).

RMT II is the site of the Former Louisiana Pacific Pulp Mill located at 1 TCF Drive, Samoa, California. The site is a 72-acre parcel (Assessor's parcel number 401-112-021) acquired by the Humboldt Bay Harbor, Recreation and Conservation District (HBHRCD) in 2013. This report was prepared by SHN Engineers & Geologists for the HBHRCD and the County of Humboldt (County). Additional support was provided by CH2M and Hemphill Water Engineering (HWE) to conduct engineering analyses for proposed upgrades. Individual engineering reports are included as appendices.

This report evaluates several key assets at the RMT II site for reuse or repurposing:

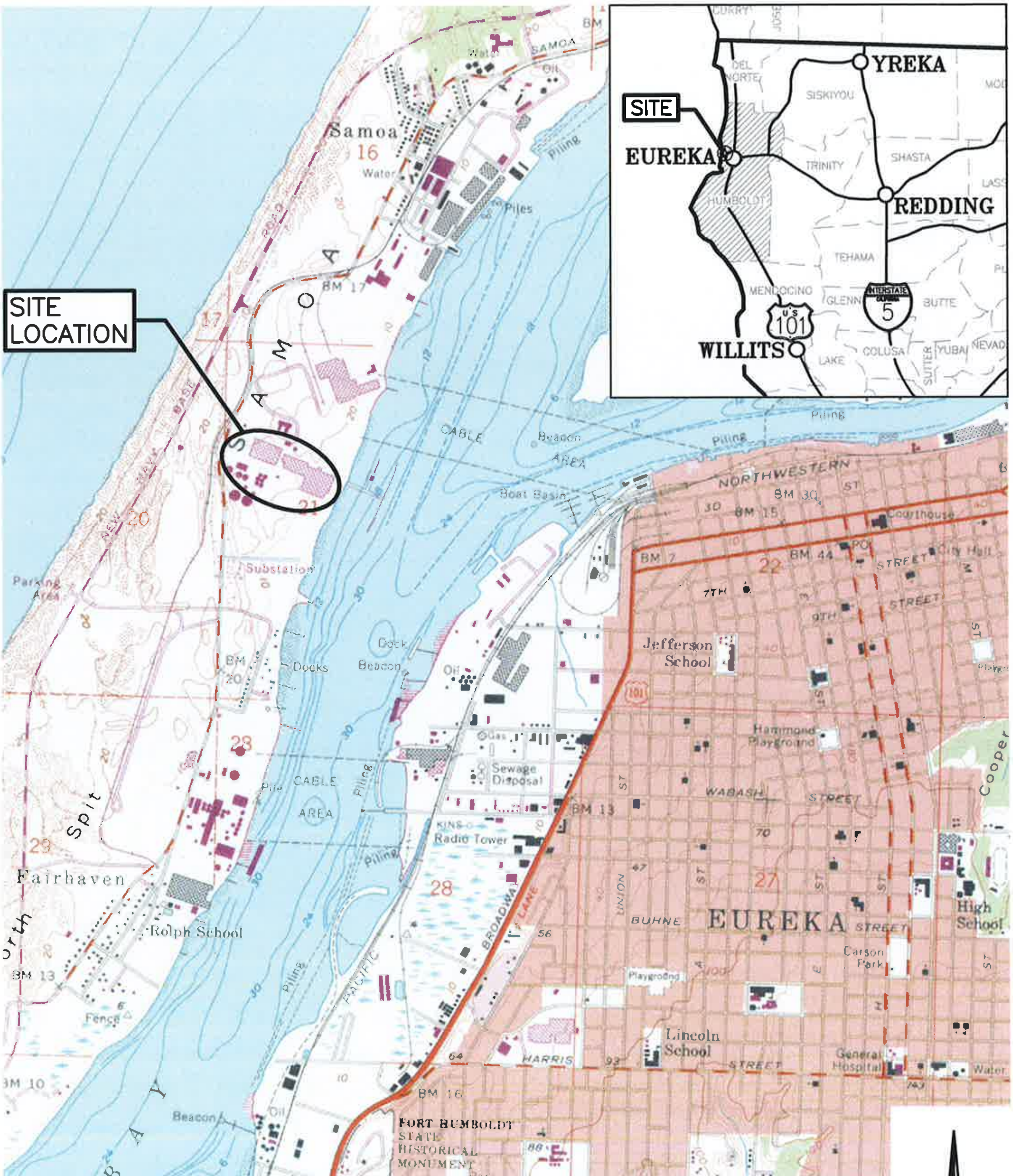
- An industrial water filtration system with a 30-million gallon per day (MGD) capacity, including two 1.5-million gallon (MG) clarifier ponds, fourteen 17,000-gallon water filters, four 150-horsepower (hp) pumps, a MicroFloc water filter system, and a 1,000-kilovolt amperes (kva) electrical substation
- An ocean outfall that is 1.5 miles in length, with a 48-inch diameter steel pipe and anchoring system with a 32-inch diameter high density polyethylene (HDPE) sleeve with an 800-foot long diffuser system at the ocean floor
- A large domestic wastewater treatment system that includes a collection system, septic tank, and leachfield

This study also evaluates several possible future uses and presents planning-level cost estimates for these reuse options:

- Use of the existing water treatment facility and ocean outfall pipe for treatment and discharge of water used for aquaculture operations
- Use of the existing ocean outfall pipe for discharge of wastewater collected from nearby areas, including the Samoa Peninsula and possibly the City of Eureka
- Use of the existing MicroFloc industrial water treatment facility for the dewatering and discharge of dredge slurry from a projected 30,000 to 50,000 cubic yards of dredge materials generated annually from HBHRCD dredging operations and piped to the site from the bay channel.

Challenges for reuse of the existing infrastructure include potential impacts from sea level rise.

Based on available models for the rate and magnitude of projected global sea level rise (SLR), and inundation models for the Samoa Peninsula, it appears that the former pulp mill site is not subject to impacts related to potential rise in sea level. This conclusion is based on review of the California Coastal Commission's sea level rise policy guidance manual and Humboldt Bay Sea Level Rise Adaptation Planning Project's final Humboldt Bay sea level rise modeling inundation mapping report. (Northern Hydrology, 2015). The Coastal Commission's guidance document includes a



SOURCE: EUREKA USGS 7.5 MINUTE QUADRANGLE

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1"=2000'±

SHN Consulting Engineers & Geologists, Inc.	The County of Humboldt Redwood Marine Terminal II Samoa, California		Site Location Map SHN 015147
	January 2016	015147-SITE-LCTN	Figure 1

\\Eureka\Projects\2015\015147-redwood-marine-terminal-II\Dwgs , SAVED: 1/8/2016 2:09 PM CNEWELL, PLOTTED: 1/8/2016 2:10 PM, CHRIS D. NEWELL table that outlines the projected magnitude of SLR for the region. For areas north of Cape Mendocino (including the subject site), the projected SLR ranges from 4 inches to as much as 56 inches. Because the site is at an elevation of between 23 and 25 feet, it would appear that even the largest projected amount of SLR along the north coast would not result in inundation at the former pulp mill, even under extreme situations (during a king tide coincident with a storm surge, for example). This interpretation is supported by mapping within the final Humboldt Bay sea level rise modeling inundation mapping report, which includes an image (Figure 6.4) that shows areas around Humboldt Bay vulnerable to inundation from a 2-meter SLR scenario (which is a greater rise in sea level than endorsed by the California Coastal Commission); the former pulp mill site is shown outside the areas vulnerable to SLR. Due to the extensive SLR modeling completed to date for Humboldt Bay, it does not appear that additional studies would be required to verify the absence of SLR-related impacts at the site.

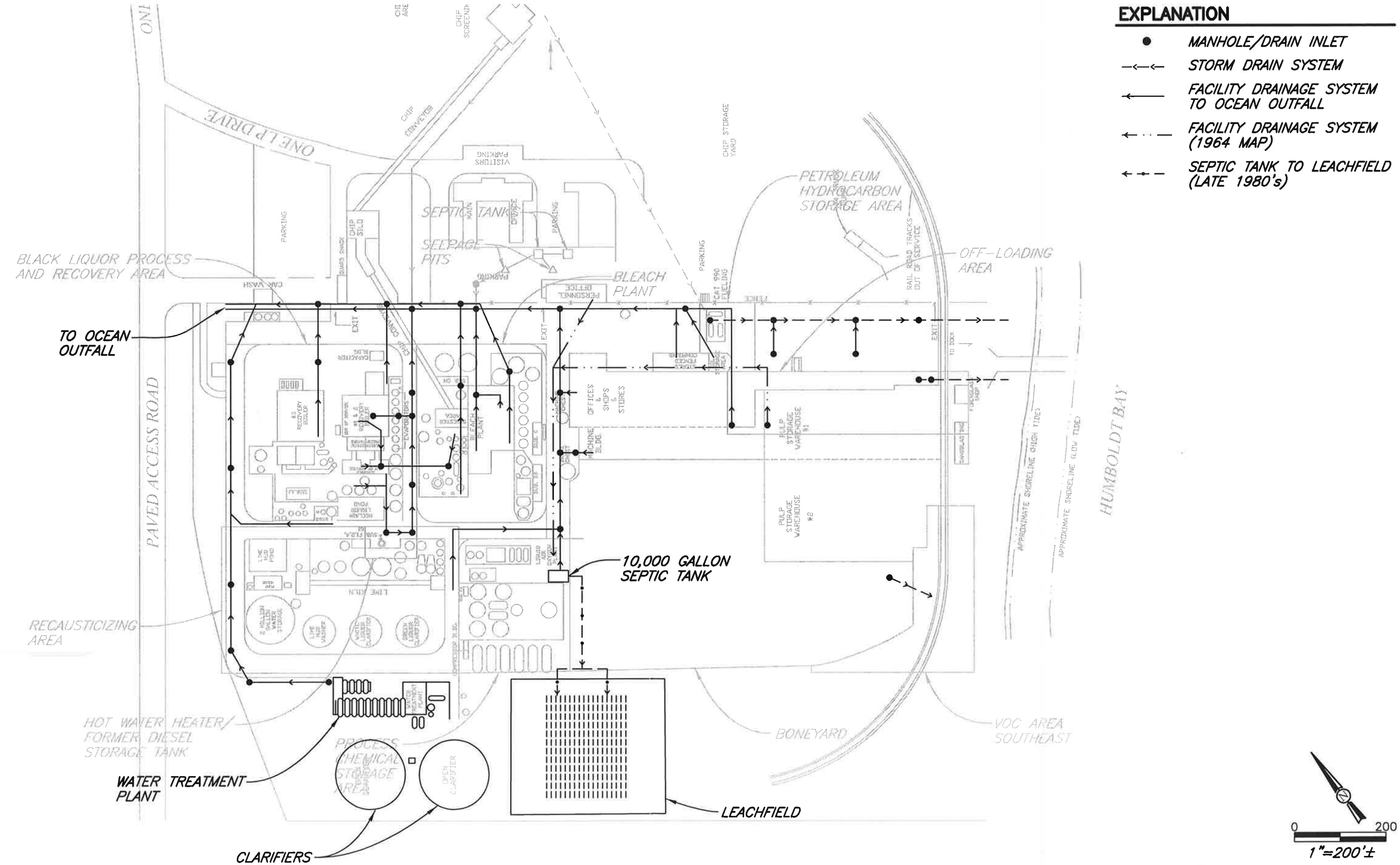
2.0 Existing Infrastructure

Existing infrastructure at the site includes a septic tank and leachfield designed to treat flows from the RMT II site's sanitary sewer system, a MicroFloc industrial water treatment system, and manhole-5 (MH-5) which discharges into the 1.5 mile long ocean outfall with diffuser system (Figure 2).

Currently, DG Fairhaven Power, located in Fairhaven, California, discharges approximately 170,000 gallons per day (gpd) of process water, following treatment, through the RMT II ocean outfall. Discharges from DG Fairhaven Power are regulated by a National Pollutant Discharge Elimination System (NPDES) permit under North Coast Regional Water Quality Control Board (RWQCB) Order No. R1-2012-0027.

2.1 Septic Tank and Leachfield

The sanitary sewer system collects wastewater from facility restrooms and sinks in 6- to 10-inch vitrified clay pipe, and conveys it to a 10,000-gallon septic tank. The septic tank size has been calculated as 16,000 gallons. The cause of the discrepancy is unknown. Prior to 1988, the wastewater from the septic tank was discharged through the site's ocean outfall. The design drawing for a proposed leachfield (dated April 1988) is included in Appendix A, and indicates a dual leachfield system wherein discharge from the septic tank would be split and then distributed to 34, 4-inch diameter, 90-foot long perforated leachlines. The leachlines would be spaced 10 feet apart by way of two separate distribution boxes. The footprint of the leachfield was to be approximately 170 by 180 feet. It is believed that the leachfield was constructed shortly after the date of the design drawings (Figure 2). Measured daily flow of wastewater to the septic tank was 14,700 gpd (Integral, 2014). The existing leachfield is designed to handle effluent flows up to 17,000 gpd. In 2014, the leachfield was split so that half of the leachfield takes mariculture waste (up to 8,500 gpd) and the remainder is dedicated to disposal of domestic waste. Existing aquaculture effluent flows are approximately 2,400 gpd.



NOTE: ALL LOCATIONS ARE APPROXIMATE

SHN Consulting Engineers & Geologists, Inc.	The County of Humboldt Redwood Marine Terminal II Samoa, California	Facility Drainage Schematic SHN 015147
	January 2016 / 015147-FCLTY-DRAIN	Figure 2

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2.2 MicroFloc Water Treatment System

A preliminary inspection of the MicroFloc industrial water treatment system was conducted at the RMT II site on September 28, 2015, as a part of the overall assessment of infrastructure at the site. No internal inspections of the filters were conducted at this time, but will be required if the filters are to be placed back in service. The full inspection report is included in Appendix B.

The system includes a chemical feed system, two 1.5 MG clarifiers, ten horizontal pressure filters, four softeners, and a seawater filter. The system was designed for a nominal capacity of 30 MGD (20,800 gallons per minute [gpm]) with a peak flow capacity of 25,000 gpm. The design documentation states that the design influent loading for the filters was 100 nephelometric turbidity units (NTU), which would typically correspond to approximately 100 milligrams per liter (mg/L) suspended solids.

The condition of various components was assessed by means of a walk through. Piping galleries, valves, and related equipment appear to be in reasonably good condition. The control system is as supplied in the 1960s, and the panels appear to be significantly corroded and are outdated. It should be assumed that replacement of controls and field instruments with modern digital devices would be required for any future uses. Although the internals of the pressure filters could not be inspected, it is reasonable to assume that they are in operable condition, based on reports that they were in normal service when the plant was shut down in 2008. This would need to be confirmed by conducting internal inspections of the tanks and filter media. It is also reasonable to assume that most valves would be operational following a minor rebuild. The condition of the softening system could not be assessed, and it should be assumed that the resin would need to be replaced prior to use.

2.3 Ocean Outfall and Diffuser System


Photo 1: MH-5 Ocean Outfall

The existing ocean outfall is an approximately 1.5 mile long, 48-inch diameter pipe with 144 diffuser ports.

The capacity of the outfall is defined by pipe diameter, number of available diffuser ports, and port diameter. Available dilution capacity is controlled by effluent flow rate and density. Detailed modeling was performed by CH2M to assess dilution performance based on varying effluent flow, salinity, and temperature. Key findings include:

- Hydraulic assessment indicates the outfall can discharge up to 40 MGD based on 144, 2.4-inch ports. However, effluent with higher salinity content would reduce dilution.
- Dilution decreases with increase in flow, but target dilution of greater than 100:1 was easily achieved for flows up to 40 MGD for all conditions evaluated with the exception of effluent salinity of 30 practical salinity units (psu).

- Dilution increases with increased effluent temperature. Effluent temperatures approximating receiving water temperatures provided significantly lower dilution than temperatures above that of the receiving water when salinities were greater than 10 psu.
- Dilution decreases with increased salinity. The target dilution of 100:1 may not be met when effluent salinity is greater than 30 psu.

The complete diffuser performance assessment report is included in Appendix C.

Historically, all onsite industrial process water discharges to MH-5, which discharges into the ocean outfall. The effluent pumps at MH-5 consist of two 350-hp sump pumps.


Photo 2: Effluent Pumps

3.0 Onsite Wastewater Sources

3.1 Aquaculture

Aquaculture has been identified as an industry with opportunities for growth in Humboldt County. The existing facilities at the RMT II could be reused to provide critical infrastructure for aquaculture operations. These facilities include access to both seawater and fresh water, marine dock access, an existing onsite water treatment/disposal facility, and a permitted ocean outfall for discharge of treated water.

Aquaculture operations currently exist at the RMT II facility with the operation of a small scale oyster hatchery. Waste flows from the current operation go to the existing leachfield.

Treatment of aquaculture wastes is a primary concern in planning for the reuse of RMT II infrastructure. A preliminary conceptual level estimation of waste loads was performed for use in planning and scaling of aquaculture facilities. The complete aquaculture waste load analysis is presented in Appendix D, and summarized below.

Waste loads and water requirements are species dependent, particularly when different taxa (such as, finfish and bivalves) are considered. A bivalve hatchery mariculture operation at RMT II would generate only a minimal amount of waste and would in all likelihood qualify for an exemption to NPDES permitting requirements under the Environmental Protection Agency's (EPA) regulation of the Clean Water Act. The EPA requires NPDES permitting only for cold-water operations that produce more than 20,000 pounds of organisms per year and use 5,000 pounds of feed per month. Because algae feed for oyster hatcheries is most often grown onsite by culturing algae cells already present in the source water, trace nutrients, and solar energy, hatcheries are normally exempt from these requirements. For example, the private oyster mariculture hatchery operation currently being developed in Humboldt Bay by Coast Seafood will be exempt from NPDES reporting requirements under this criterion.

On the other hand, finfish operations require daily feed to grow fish. The waste loads from a finfish operation would also be higher than bivalve mariculture. As a result, to develop a conservative estimate of aquaculture waste loads, steelhead (*Onchorhynchus mykiss*) was selected as the target species.

Steelhead are essentially anadromous rainbow trout that yield medium-to-high market value and would minimize the use of freshwater at the RMT II site, where previous studies have documented that available freshwater sources are prohibitively expensive for profitable aquaculture use. Steelhead fingerlings are readily available in the area, as are established purchasers for recreational use.

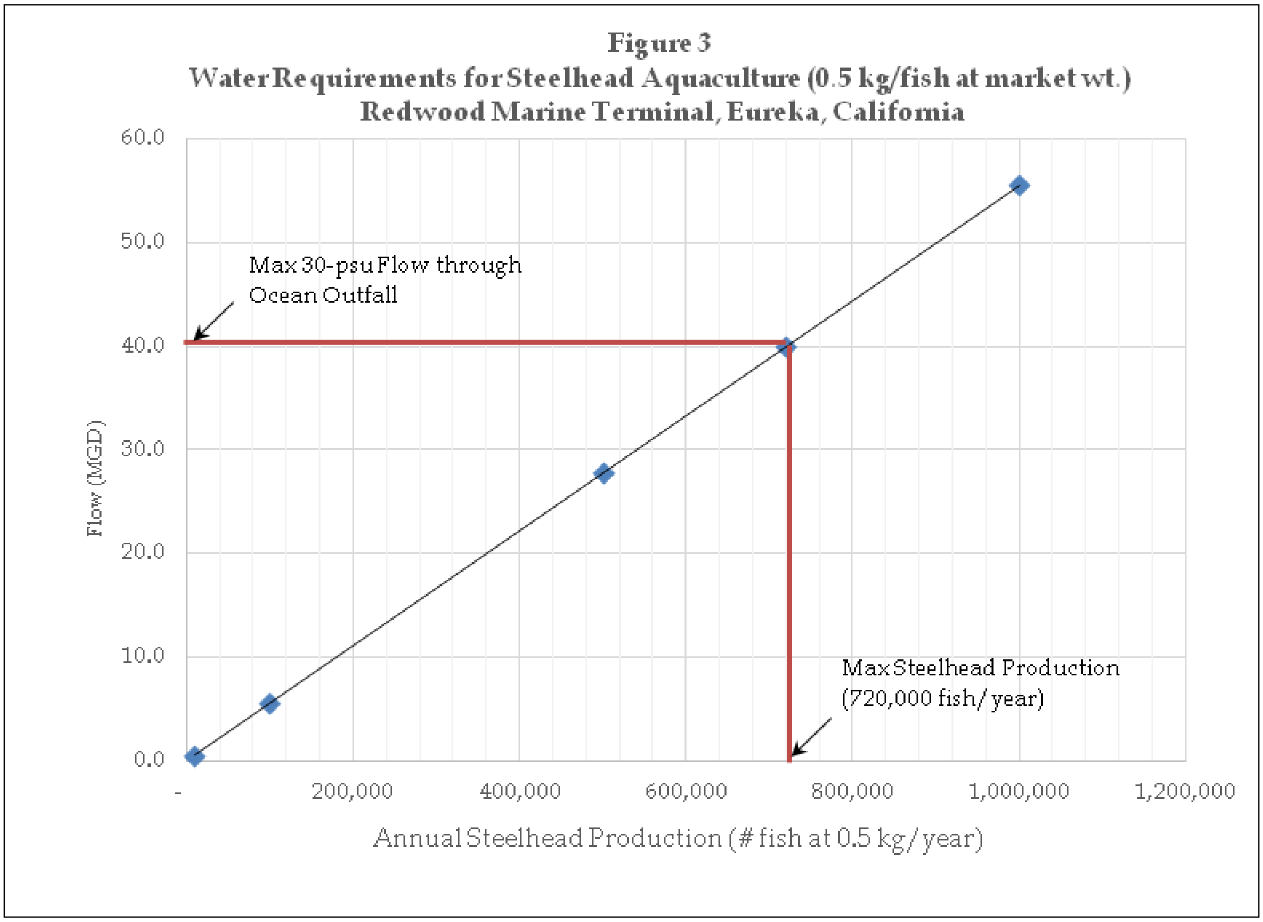
Estimated waste loads based on quantity of fish produced over a 30-week production period are summarized in Table 1.

Table 1
Estimated Waste Production for Steelhead
RMT II Infrastructure Reuse Evaluation, Eureka, California

	Total Fish Production							
	5,000		50,000		250,000		500,000	
Waste Load[1]	**kg**[2]	**lbs/day**[3]	**kg**	**lbs/day**	**kg**	**lbs/day**	**kg**	**lbs/day**
Total Solid Waste (SW)	1,532	16.08	15,324	161	76,622	804	153,244	1,609
Solid N Waste (SW_N)	68	0.71	679	7.13	3,396	35.7	6,792	71.3
Solid P Waste (SW_P)	28	0.29	280	2.94	1,399	14.7	2,799	29.4
Dissolved N Waste (DW_N)	211	2.22	2,108	22.1	10,542	111	21,084	221
NH_4-N Waste ($DW_{NH4\text{-}N}$)	169	1.77	1,687	17.7	8,433	88.5	16,867	177
Dissolved P Waste (DW_P)	17	0.18	167	1.75	833	8.74	1,666	17.5
Total N Waste (TW_N)	279	2.93	2788	29.3	13,938	146	27,876	293
Total P Waste (TW_P)	45	0.47	446	4.68	2,232	23.4	4,464	46.9

1. Waste loads estimated for a 30-week production period
2. kg: kilogram
3. lbs/day: pounds per day, estimate is an average for a 30-week production period.

Based on the results of the ocean outfall diffuser modeling summarized in Section 2.3 and presented in detail in Appendix C, the diffuser would have sufficient capacity to hydraulically discharge up to 40 MGD of 30 psu wastewater from a potential finfish aquaculture facility in the absence of any other contributors to the ocean outfall. The quantity of flow-through water available for use at the aquaculture facility would serve as an important constraint on the potential size of the production operation. For an un-aerated steelhead raceway, a conservative estimate of the required water flow rate is approximately one liter per minute per kilogram (kg) of fish. Because a maximum of 40 MGD is available, a total of 360,000 kg of fish could be supported per year. Assuming that the market weight of steelhead is 500 grams, there would be an annual production capacity of 720,000 steelhead per year. Figure 3 illustrates the relationship between water flow rate to the aquaculture facility and the annual production capacity for steelhead.



Using the mass loading rates developed in detail Appendix C and the flow and finfish production rates developed above, the concentrations of total solids, nitrogen, and phosphorus wastes of the aquaculture effluent can be estimated. Figure 4 summarizes the waste loading rates per kilogram of fish produced, and Table 2 presents the estimated concentrations of total solids, nitrogen, and phosphorus in the aquaculture effluent prior to discharge to the ocean outfall.

Figure 4
Annual Waste Loads
Redwood Marine Terminal, Eureka, California

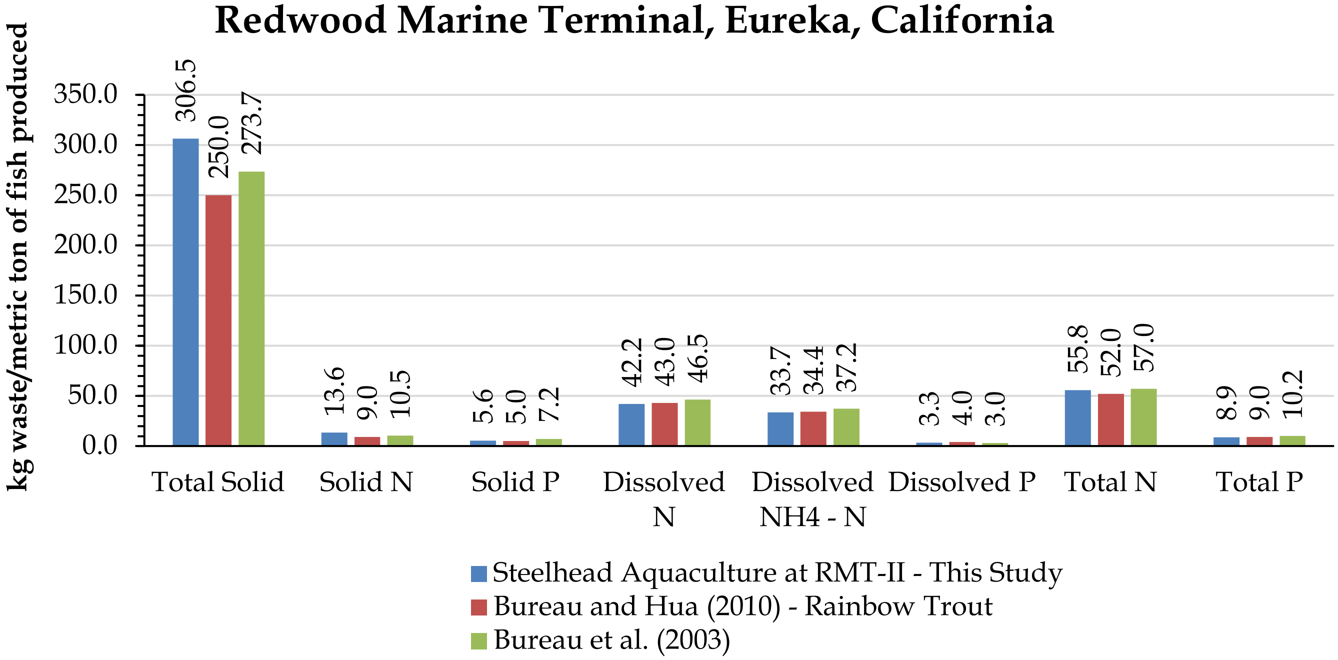


Table 2
Estimated Waste Concentration of Steelhead Effluent
RMT II Infrastructure Reuse Evaluation, Eureka, California
(in mg/L)[1]

Total Solids Concentration	Total N[2] Concentration	Total P[3] Concentration
1.99	0.36	0.06

1. mg/L: milligrams per liter
2. N: nitrogen
3. P: phosphorous

As described in detail in Appendix B, the minimum dilution factor applicable to the maximum flow and salinity, and the minimum water temperature was estimated to be at least 75. This would result in post-dilution concentrations of 26 micrograms per liter (ug/L) of total solids, 5 ug/L of total nitrogen, and less than 1 ug/L of total phosphorus in the receiving water, far below the maximum levels allowed in the Ocean Plan.

3.2 Dredge Slurry

Disposal of approximately 30,000 cubic yards of dredge solids is required as part of annual maintenance dredging operations in Humboldt Bay. Dredge spoils have a low solids content and require dewatering prior to final disposition. For potential discharge through the ocean outfall at RMT II, dredge slurry effluent turbidity must be reduced to less than 75 NTU (approximately 75 mg/L suspended solids) (SWRCB, 2012).

3.2.1 MicroFloc Water Treatment System


Photo 3: MicroFloc Filters

A preliminary analysis of dredge spoils processing using the existing MicroFloc system at the RMT II site has been developed by HWE. The full dredge spoils processing report is included in Appendix E.

Under this concept, the dredge slurry would pump directly to the existing water treatment system and be directed to one of the two clarifiers. The clarifier basins would be modified by removing the existing rake arms and installing a porous base/underdrain system covering the existing floor to prevent dredged solids from entering the hoppers in the floor, while allowing drainage of water. The drained water would be pumped away using the existing waste pumps, supplemented with new vertical can pumps installed near the center of each clarifier. Free water would also be allowed to overflow the clarifiers by means of existing weirs. The overflowed water would be combined with the pumped drain water in the clarifier effluent sump in the filter building.

Water quality standards for the outfall require turbidity to be below 75 NTU. It is unknown whether the discharge would meet this standard without filtering, and it should be assumed that three of the existing filters, possibly with coagulant, would be needed. If coagulant is required, an NPDES permit for the discharge may also be required.

Pumping would be alternated between the two clarifiers weekly. One clarifier would be receiving dredge slurry, while the other would be allowed to drain free water and excavate/remove solids using traditional mobile machinery.


Photo 4: Existing Clarifier

In addition to renovations to the clarifier, described above, and improvements needed to get the filters into operable condition, a new system to provide backwash water will be required. The existing filtration system requires at least four filters in operation to provide sufficient backwash water for a single filter. The backwash requirement for each filter is approximately 5,700 gpm and a total volume of approximately 56,000 gallons. It is proposed that the existing seawater filtration storage tank, with a capacity of 100,000 gallons, be used to store water for backwash. This will require additional infrastructure, including new 75-100 hp pumps, new piping and valves, and modifications to the piping manifold serving the filters. See Appendix E for a detailed description of recommended infrastructure additions.

3.2.2 Geotubes

Dewatering of dredge spoils using geotextile tubes, or geotubes, is proposed as an alternative to retrofitting and using the existing water treatment system. Dewatering using geotubes is accomplished by injecting a polymer into the dredge slurry and pumping it into the geotubes. Water filters through the wall of the tubes during multiple fill cycles. Tubes are then allowed to drain, and are cut open to remove solids.

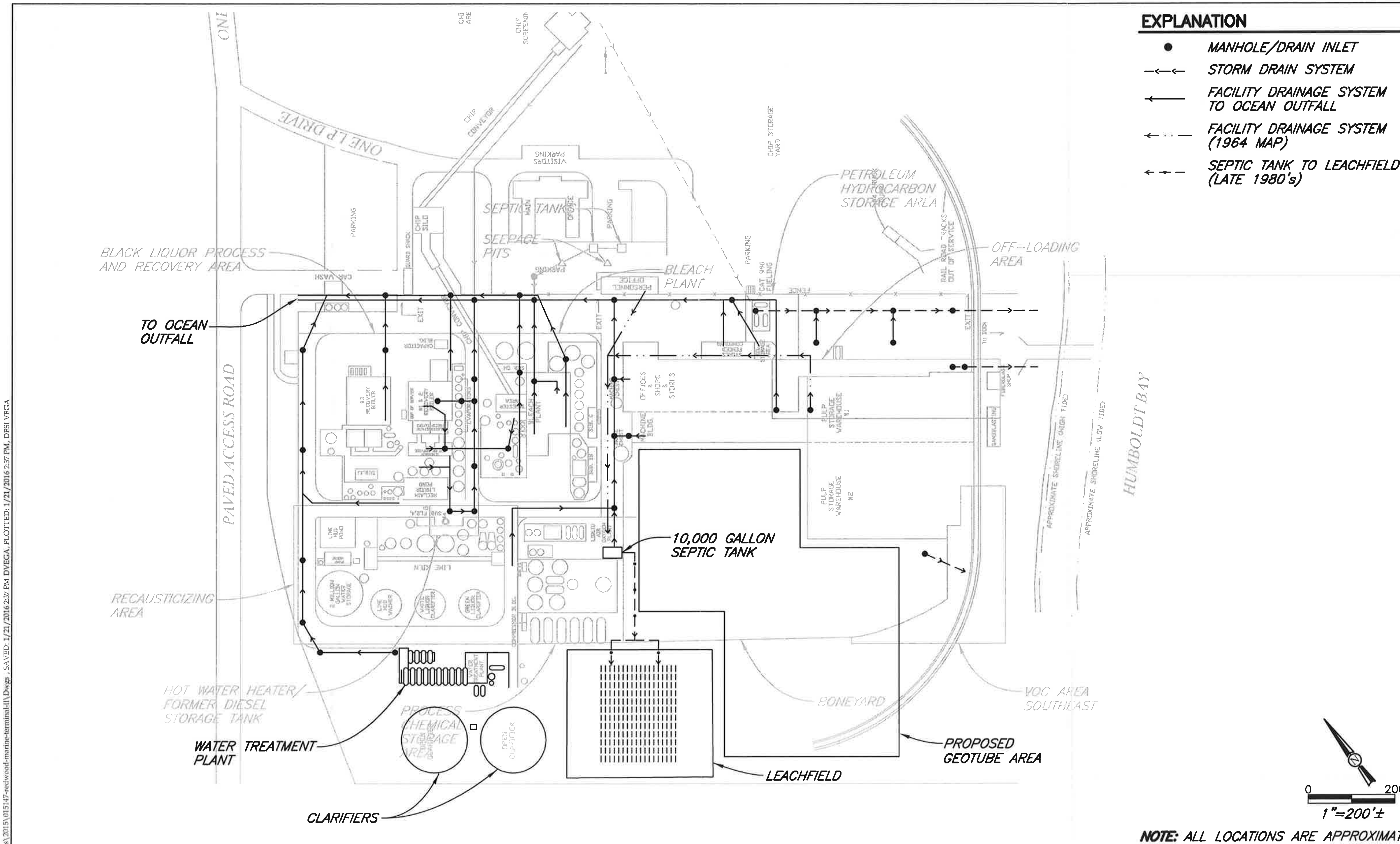
Assuming a total volume of 30,000 cubic yards of dredge solids and a geotube width of approximately 16 feet and a height of approximately 5 feet, approximately 4 acres will be required for geotubes and related drainage structures, and equipment access. The 4-acre field would be graded to drain to a single location and lined with an impervious material with a sand cover. Geotubes would be placed on top of the sand layer. The shape of the required area is flexible; geotubes can be ordered in varying lengths, and arranged as needed. A proposed geotube area is shown on Figure 5. A reduction in acreage may be achieved by stacking the geotubes. Water from the drainage structures will be piped to the ocean outfall by way of MH-5. It is assumed that geotube effluent will meet the California Ocean Plan turbidity limit of 75 NTU (SWRCB, 2012). Additional testing will be required to ensure that all permit limits are met. If turbidity does not meet the limit, standard stormwater best management practices (BMPs) or the existing clarifiers may be used for additional turbidity reduction.

Using polymer to process dredge slurry would increase permitting requirements. Water decanted from dredging activities is eligible for discharge under Section 404 of the Clean Water Act and the discharger may apply for coverage under the United States Army Corps of Engineers (ACOE) Nationwide Permit No. 16. However, whether polymer is added to the dredged material or is processed for offsite use, the discharge would no longer qualify under Section 404, and would not be eligible for Nationwide Permit No. 16. Instead, it would need to be covered under an individual NPDES permit.

4.0 Offsite Wastewater Sources

Three potential offsite wastewater sources were evaluated for disposal at the existing Redwood Marine Terminal permitted ocean outfall. These include the City of Eureka (City), and the communities of Samoa and Fairhaven.

Future residential, commercial, or industrial development in the communities of Fairhaven and Samoa require improved wastewater treatment and disposal facilities. Both communities are listed as severely economically disadvantaged communities, which are communities having an annual median household income less than 60 percent of the statewide average (CDWR, 2016). Improved infrastructure will promote both affordable housing and job opportunities in these communities, and improve the environmental health of these communities.



SHN Consulting Engineers & Geologists, Inc.

The County of Humboldt
Redwood Marine Terminal II
Samoa, California

Proposed Geotube Area

SHN 015147

January 2016 | 015147-PROP-GEOTUBE-AREA | Figure 5

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4.1 City of Eureka

The City of Eureka currently disposes of treated wastewater from the Elk River wastewater treatment facility (WWTF) pursuant to RWQCB Order No. R1-2009-0033. The facility serves approximately 45,000 people from the city and unincorporated areas within the Humboldt Community Services District (RWQCB, 2009).

Currently, the Elk River WWTF discharges treated wastewater to Humboldt Bay through a 3,000-foot outfall line that terminates on the east side of the shipping channel at a depth of 30 feet (RWQCB, 2009) Discharge is only permitted on an ebb tide to ensure that effluent is conveyed to the Pacific Ocean. Treated wastewater is stored in an 8-MG equalization basin at Elk River WWTF, to be discharged during an ebb tide.

4.1.1 Wastewater Flows

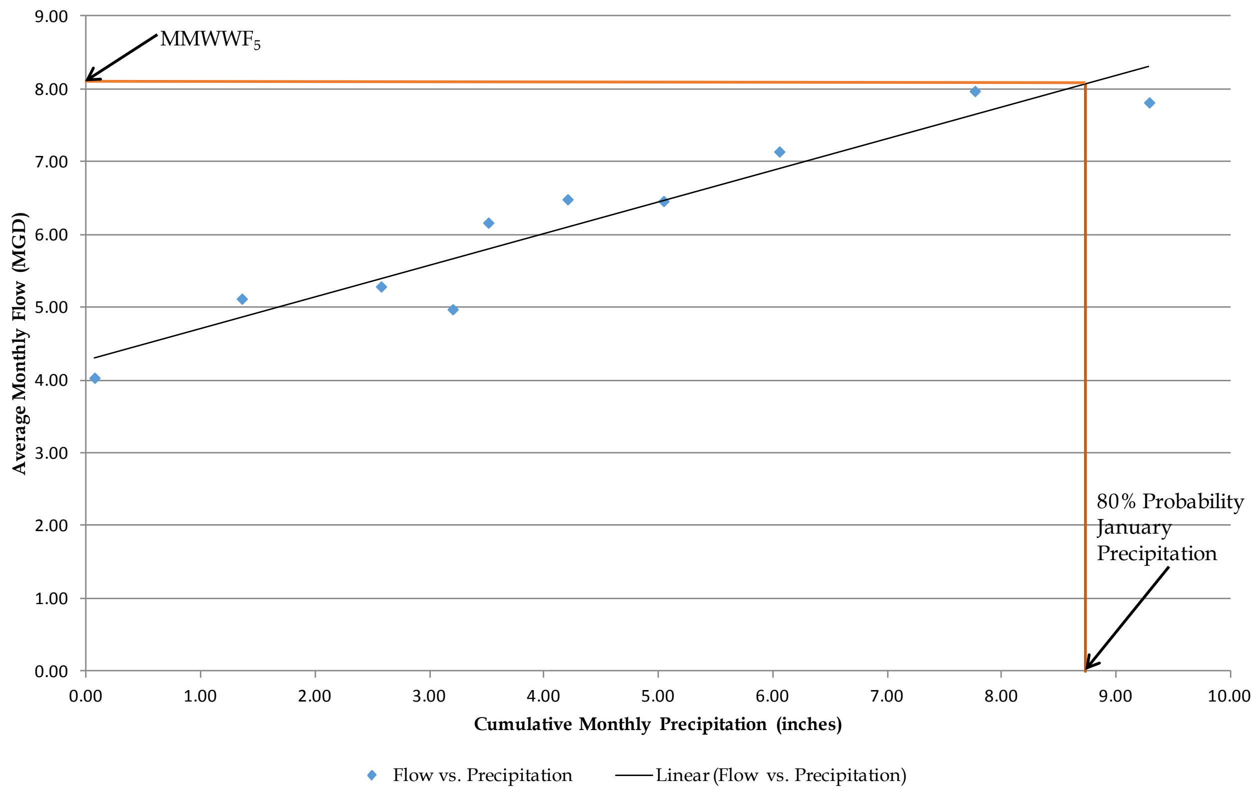
The average annual flow (AAF), the maximum monthly average wet weather flow with a 20% probability of occurrence ($MMWWF_5$), the peak daily average flow associated with a 5-year, 24-hour storm ($PDAF_5$), and peak instantaneous flow attained during a 5-year PDAF (PIF_5) were estimated using daily effluent data provided by the treatment plant for January 2010 through October 2015.

The AAF was estimated using data from the calendar year 2010. The years 2011 through 2015 were not used in this estimation, because of unusually dry conditions during that period. The AAF for the Elk River WWTF is 5.91 MGD.

The $MMWWF_5$ represents the wettest wet season monthly average flow that is anticipated to have a five-year recurrence interval.

Based on monthly total precipitation data from the Eureka Rainfall Station, the rainfall with a 1-in-5 year recurrence interval in January is 8.73 inches. On Figure 6, this corresponds to a $MMWWF_5$ of 8.07 MGD.

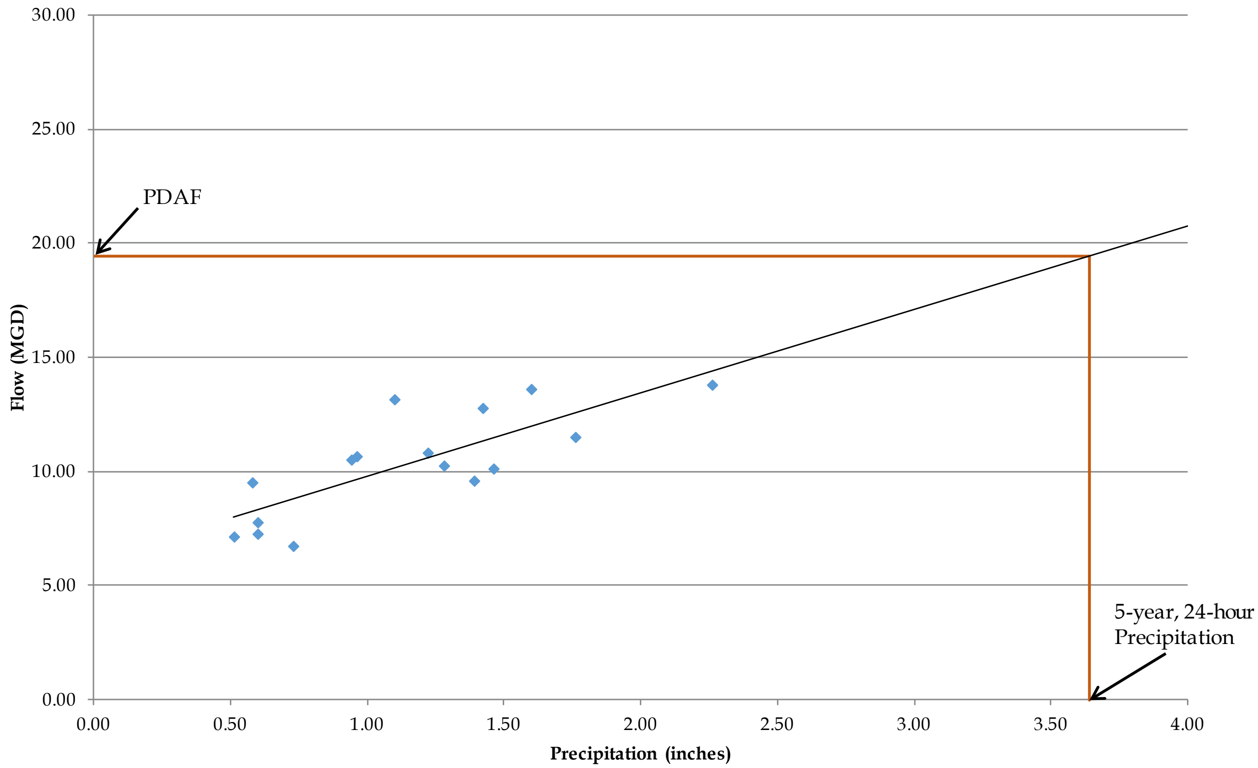
Figure 6
Elk River WWTF Flow vs. Precipitation
Redwood Marine Terminal, Eureka, California



The $PDAF_5$ is the largest daily flow associated with a 5-year, 24-hour precipitation event. The peak day average flow has a 0.27% probability of occurrence or 1 day in 365 days of any given year. Estimation of peak day flow is based on a regression analysis of daily plant flows during or immediately following wet season significant rainfall events. $PDAF_5$ is shown on Figure 7.

Because the increased influent flow to the WWTF during wet weather is highly correlated with rainfall, evaluation of this regression can be used to define peak day flow associated with a specific rainfall event. The $PDAF_5$ event is determined from a plot of the recorded daily flow that occurred during, or 24 hours after, a significant rainfall event (Figure 7).

Figure 7
Elk River WWTF $PDAF_5$
Redwood Marine Terminal, Eureka, California

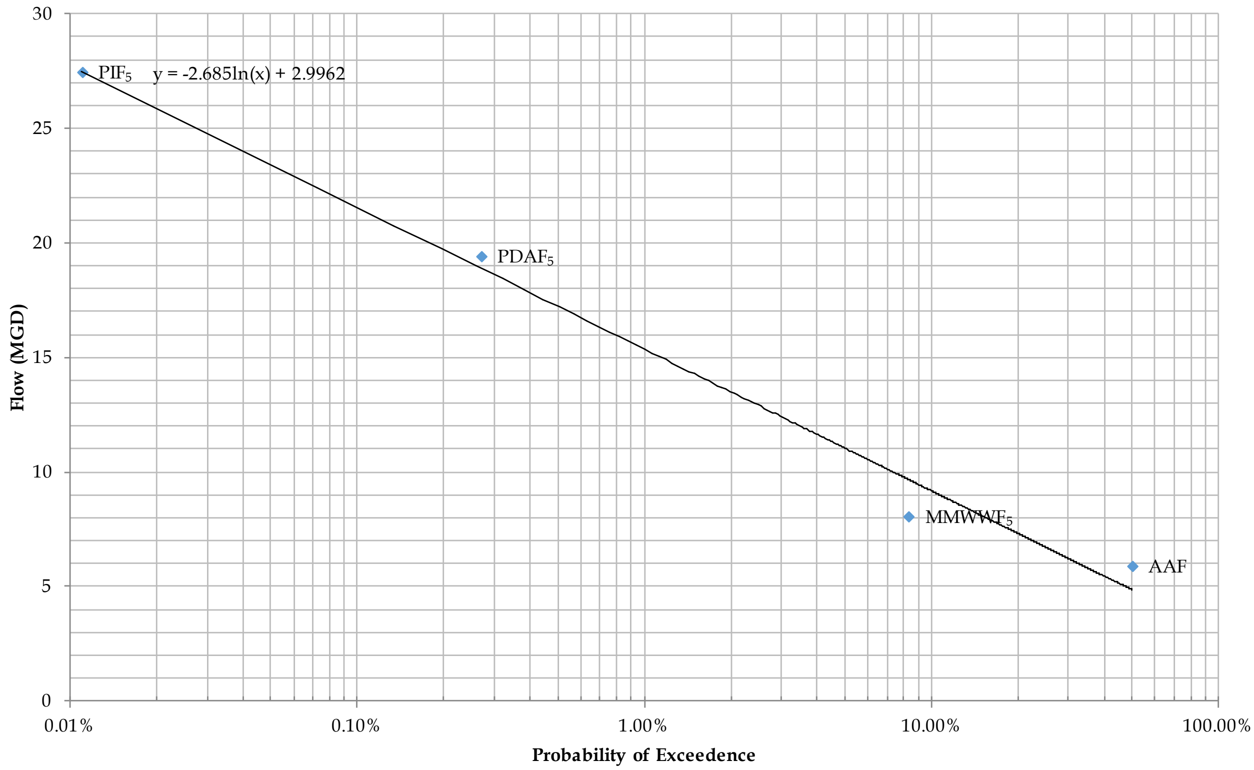


By performing a regression analysis of data, a linear relationship is established, as shown in Figure 7. The $PDAF_5$ is based on the intercept of this line with the 5-year, 24-hour precipitation event. To calculate the estimated $PDAF_5$, the 5-year, 24-hour precipitation event for the Eureka area was set equal to 3.64 inches (NOAA, 2015). Based on the regression analysis shown in Figure 7, the resulting $PDAF_5$ for a 3.64-inch event is equal to approximately 19.43 MGD.

The PIF_5 is the highest sustained hourly flow rate during wet weather. The PIF_5 has 0.011% probability of occurrence (1 hour in 8,760 hours of the year). Hydraulic design of channels and pumps at a treatment facility is usually based on this flow.

The PIF_5 attained during a 5-year, 24-hour storm event is determined from a probability projection of the AAF, $MMWWF_5$, and the $PDAF_5$ parameters. The projection plot shown in Figure 8 shows that the PIF_5 for the Elk River WWTF is estimated to be 27.47 MGD.

Figure 8
Elk River WWTF Peak Instantaneous Flow
Redwood Marine Terminal, Eureka, California



Although the PIF_5 is typically used to design channels and pumps, the $PDAF_5$ (19.43 MGD) was considered more appropriate for this project. Instantaneous and hourly peaks will be equalized using the existing 8-MG equalization basin.

4.1.2 Wastewater Characterization

Effluent biochemical oxygen demand (BOD) and total suspended solids (TSS) for the Elk River WWTF were obtained from the facilities 2013 Annual Report (City of Eureka, 2014). Maximum and average concentrations are summarized in Table 3.

Table 3
Flow and Loading Estimates
RMT II Infrastructure Reuse Evaluation, Eureka, California

Location	Flow Description	Flow (MGD)[1]	BOD_5[2] (mg/L)[3]	BOD_5 (lb/day)[4]	TSS[5] (mg/L)	TSS (lb/day)	Settleable Solids (ml/L)[6]
Fairhaven[7,8]	Avg.	0.027	30	6.8	30	6.8	NA[9]
Samoa	Avg. [10]	0.061	30[11]	7.6	30	30	0.1[11]
	Peak[10]	0.131	30[11]	22	30	30	0.2[11]
Eureka[12]	AAF[13]	5.91	11.7[14]	353[14]	11[14]	345[14]	NA
	$PDAF_5$[15]	19.43	24[16]	599[16]	28[16]	765[16]	NA

1. MGD: million gallons per day
2. BOD_5: five day biochemical oxygen demand as milligrams oxygen consumed per liter
3. mg/L: milligrams per liter
4. lb/day: pounds per day
5. TSS: total suspended solids
6. ml/L: milliliter per liter
7. The flow rate for Fairhaven was determined by adding estimated flows from businesses, residents, and apartments. Flow rates for businesses were determined on a per employee basis using typical commercial flow rates from Davis, M. L. (2011). Flow rates for residents were determined using an average domestic daily flow rate of 380 liters per day (Davis, M. L. 2011). The number of houses in Fairhaven was estimated using Google Earth, and a conservative value of 2.94 people/household from the US Census Bureau (2015) was used to determine the total number of residents.
8. BOD_5 and TSS based on typical regulatory limits
9. NA: not available
10. Full build out for proposed wastewater treatment facility that serves existing town and post development (SHN, 2015)
11. Discharge limitations for treated effluent from proposed Samoa WWTF, Order No. R1-2014-0031–would not need to meet if we met ocean outfall plan and secondary treat standards.
12. Effluent BOD_5 and TSS from City of Eureka 2013 Annual Report (City of Eureka, 2014)
13. AAF: average annual flow, based on plant flow data from 2010
14. Average effluent BOD and TSS for 2013 (City of Eureka, 2014)
15. $PDAF_5$: peak daily average flow attained during the 5-year, 24-hour storm; estimated using plant data from January 2010 to April 2015
16. Peak effluent BOD and TSS based on maximum daily values in 2013

4.2 Samoa

The Town of Samoa is located northeast of the RMT II on the Samoa peninsula (Figure 9). The population during the 2010 census was 258 people (U.S. Census Bureau, 2015). The town of Samoa is identified as a severely economically disadvantaged community, which is defined as having an annual median household income less than 60 percent of the statewide average (CDWR, 2016). The Town of Samoa has a master plan to subdivide and redevelop the town in two phases. Phase 1 will include rehabilitation of existing homes and an 80-unit affordable housing complex. Funding for the affordable housing project is contingent on construction beginning in 2016. Phase 2 will include construction of additional new homes, as well as new commercial and industrial business parks. Phase 1 will require the construction of a new WWTF to provide services for the new and existing homes and businesses.

4.2.1 Wastewater Flows

The Town of Samoa is served by two disposal systems. The eastern system serves approximately 75 homes, the downtown retail area, and the Samoa Cookhouse, and has an average dry weather flow of 17,000 gpd, and an average wet weather flow of 32,000 gpd. The western system serves approximately 25 homes and has an average flow of 7,500 gpd (RWQCB, 2014).

Following implementation of Phase 1 and Phase 2, development average influent flows are anticipated to be 61,000 gpd, with peak flows of approximately 131,000 gpd (SHN, 2015).

4.2.2 Wastewater Characterization

A WWTF is proposed to replace the eastern and western systems and treat the additional wastewater from Phase 1 and Phase 2 developments. The proposed Samoa WWTF is subject to permit requirements under Draft Waste Discharge Requirements (WDR) Order No. R1-2014-0031. Concentration limits[1] for BOD and settleable solids are included in the existing permit, and summarized in Table 3.

Wastewater discharged through the RMT II ocean outfall would be subject to the Ocean Plan, and would be required to meet EPA secondary effluent standards.

4.3 Fairhaven

Fairhaven is an unincorporated community located on Samoa Peninsula, southwest of the RMT II (see Figure 9). The community consists of approximately 83 single-family residences (Google Earth) and the Fairhaven Business Park. The community of Fairhaven is identified as a severely economically disadvantaged community, which is defined as having an annual median household income less than 60 percent of the statewide average (CDWR, 2016)

1. Discharge limitations for treated effluent from proposed Samoa WWTF, Order No. R1-2014-0031.

4.3.1 Wastewater Flows

Currently, no wastewater collection infrastructure exists within the community of Fairhaven. Individual properties maintain onsite septic tanks, leachfields, or other individual wastewater treatment and disposal systems. Costs for maintenance and repair of aging septic and leachfield systems are currently the responsibility of individual property owners within the community.

An approximate wastewater flow of 27,000 gpd was estimated using literature values for typical wastewater production from residential and commercial sources. Existing businesses include offices, a dive shop, a boat yard, and a water bottling facility. Residential population was estimated to be 244 people based on an estimated 83 houses and an estimated 2.94 persons per household (U.S. Census Bureau, 2015).

4.3.2 Wastewater Characterization

Wastewater effluent strength for the community of Fairhaven was estimated based on typical regulatory standards. It is assumed that wastewater effluent will be treated so that concentrations of BOD and TSS will be less than 30 mg/L. Estimated BOD and TSS values are included in Table 3.

4.4 Projected Growth

Humboldt County has a projected annual growth rate of 0.44%, based on the Department of Finance population database. The City of Eureka uses a 0.5% growth rate for planning purposes (City of Eureka, 2011). Using a 0.5% growth rate, the total population increase expected from the combined communities of Fairhaven, Samoa, and the City of Eureka is approximately 5,000 people by 2030. Using a standard literature value for domestic wastewater of 100 gallons per capita per day, this population equates to an increase in wastewater flows of approximately 0.5 MGD.

5.0 Conceptual Plan for Treatment of Onsite Industrial Wastewater

Photo 5: Clarifier

The existing leachfield has been modified for disposal of effluent flows from aquaculture. The maximum daily flow is 8,500 gpd. Any aquaculture flows in excess of 8,500 gpd would need to be routed to the ocean outfall.

Section 3.0 indicates that wastewater from onsite users could include aquaculture wastes and free water from dredge slurry decanted in the onsite clarifiers. Depending on the configuration of the onsite finfish aquaculture facility, the accumulation of solid wastes in the basins could be managed either by the removal of settled wastes directly from the aquaculture raceways or by settling in separate basins. Whichever method the aquaculture facility were to employ to collect settled solids, a post-equalization/settled solids storage tank could be provided by the HBHRCD to facilitate the continuous discharge of settled aquaculture waste to the ocean outfall, rather than the high-strength batch loading that would occur when the aquaculture facility would periodically harvest the solids. Such a solids storage system could be as simple as an HDPE tank and a small centrifugal pump.

The storage volume of the tank and the capacity of the pump would depend on the design of the aquaculture facility. However, the settling zone volume required to accommodate 660 pounds of daily total solid waste produced by steelhead at the facility's maximum annual production capacity was estimated to be 440 gallons, assuming that solids in the settling zones are 18 percent dry solids. If the facility were to discharge solids to the storage tank weekly, the required useable HDPE tank volume would be roughly 3,080 gallons and the pumping rate to discharge that volume over a continuous interval would be 18 gallons per hour. This system could, therefore, be comprised of a 4,000-gallon HDPE tank and a small positive displacement pump designed for high solids. At a conceptual-level, this equipment might be estimated to cost from $30,000 to $50,000 to purchase, install, and integrate.

Installation of a new drainage line from the proposed solids settling tank to the discharge line to the ocean outfall would be required. A proposed alignment for this line is shown on Figure 10.

6.0 Conceptual Plan for Disposal of Offsite Wastewater

The proposed infrastructure consists of approximately 18,000 linear feet of 30-inch diameter sewer line from the outfall of the existing equalization basin at the Elk River WWTF to MH-5 located at the RMT II (Figure 9). This line would transport treated wastewater from the Elk River WWTF and the community of Fairhaven to the RMT II for discharge at the RMT II permitted ocean outfall. Installation would be performed in three sections:

1. The City of Eureka line–from the Elk River WWTF equalization basin to the eastern shore of Humboldt Bay (Figure 11)
2. The horizontal directional drill (HDD) line–approximately 3,200 feet from the eastern shore of Humboldt Bay to the community of Fairhaven on the western side of Humboldt Bay (Figure 12)
3. The Fairhaven line–from the western shore of Humboldt Bay, through the community of Fairhaven, to MH-5 on the RMT II property (Figure 13)

An additional 4,000 linear feet of 4-inch diameter sewer line also would be installed from the future site of the Samoa WWTF to MH-5 (Figure 14).

The installation of pump stations would be required in all three communities.

6.1 City of Eureka Line

Effluent flows from the Elk River WWTF range from a minimum of 2.2 MGD to an estimated peak hour flow of 27.5 MGD, with an average of approximately 5.91 MGD. From January 2010 through October 2015, the maximum daily flow coinciding with a rainfall event was 18.77 MG, and flows exceeding 15 MGD typically occurred on two to three days per year. To achieve appropriate minimum and maximum pipe velocities, it is assumed that the existing 8-MG equalization basin would be used to regulate flows to between 5 and 19 MGD. A pump station with a minimum pumping capacity of 5,500 gpm will be required to ensure minimum velocities are great enough to prevent solids settling in the pipes.

The proposed alignment for the City of Eureka force main begins at the outfall of the existing 8 MG equalization basin and extends approximately 4,500 feet to the proposed location to the entry pit for the HDD line (Figure 11). A pump station would also be required with a capacity to pump 5 to 19 MGD.

6.2 Horizontal Directional Drill

The potential alignment for the HDD line is shown on Figure 12. Based on information obtained from the ACOE, the dredge depth in Humboldt Bay is approximately 48 feet below the mean lower low water elevation of 0 feet North American Vertical Datum, 1988 (NAVD88). The HDD line would be installed approximately 20 feet below the minimum dredge elevation. The estimated length of pipe required from the entry pit to the exit location reaching the required depth is approximately 3,200 feet.

6.3 Fairhaven Line

6.3.1 With City of Eureka

The Fairhaven line would convey flows from the HDD line approximately 10,000 feet to the connection point with the ocean outfall pipe on RMT II property. The 30-inch line would also collect flows from the community of Fairhaven.

A pump station to pump effluent from the community of Fairhaven into the 30-inch line from Eureka would be required. This would consist of a manhole/wet well with duplex pumps capable of pumping approximately 100 gpm.

6.3.2 Fairhaven Only Alternative

In the event that disposal is required for the community of Fairhaven, but no effluent from the City of Eureka will be routed to the RMT II, a 4-inch diameter line would be installed from an assumed small community wastewater treatment facility, located on the northern side of the community, to MH-5 (Figure 15). Treated effluent would be pumped approximately 1.25 miles from the WWTF to MH-5 for disposal. A pump station consisting of a manhole/wet well with duplex pumps capable of pumping approximately 100 gpm would be required.

6.4 Samoa Line

Effluent from the proposed Samoa WWTF would be routed to the connection point with the ocean outfall at RMT II by approximately 5,200 feet of 4-inch diameter line. A pump station consisting of a manhole/wet well with duplex pumps capable of pumping approximately 150 gpm would be required.

SHN Consulting Engineers & Geologists, Inc.

The County of Humboldt Redwood Marine Terminal II Samoa, California		Project Overview SHN 015147
January 2016	015147-OVERVIEW	Figure 9

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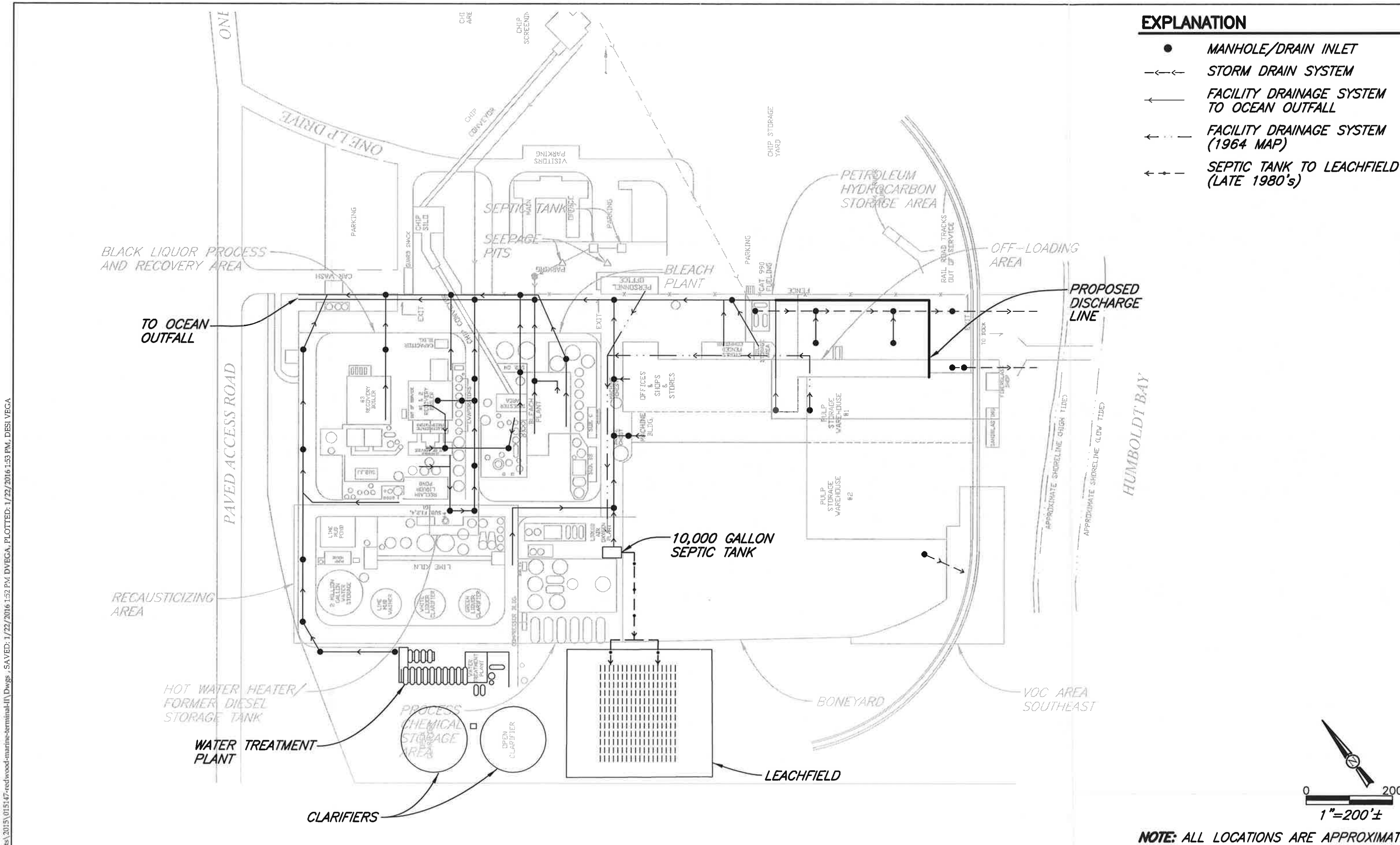

SHN
Consulting Engineers & Geologists, Inc.

The County of Humboldt
Redwood Marine Terminal II
Samoa, California

Aquaculture Discharge Line

SHN 015147

January 2016 | 015147-AQACLTR-DISCRG-LINE | Figure 10

SHN Consulting Engineers & Geologists, Inc.	The County of Humboldt Redwood Marine Terminal II Samoa, California	Eureka Alignment SHN 015147
	January 2016 / 015147-EKA-ALIGN	Figure 11

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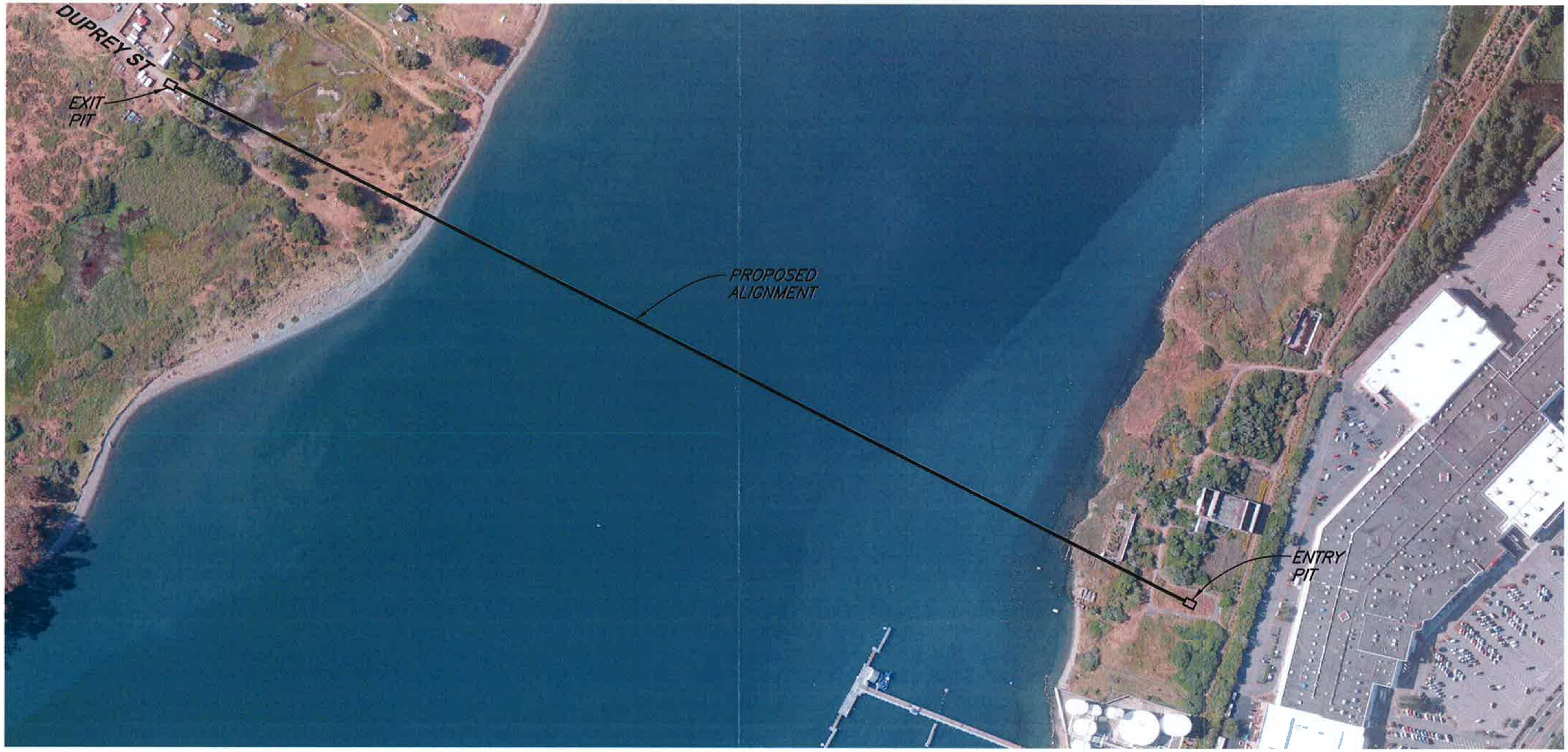

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SHN Consulting Engineers & Geologists, Inc.	The County of Humboldt Redwood Marine Terminal II Samoa, California		Horizontal Directional Drill SHN 015147
	January 2016	015147-HDD-ALIGN	Figure 12

SHN Consulting Engineers & Geologists, Inc.	The County of Humboldt Redwood Marine Terminal II Samoa, California	Fairhaven Alignment SHN 015147
	January 2016 — 015147-FRHVN-LONG-ALIGN	Figure 13

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SHN Consulting Engineers & Geologists, Inc.	The County of Humboldt Redwood Marine Terminal II Samoa, California	Samoa Alignment SHN 015147
	January 2016 / 015147-SAMOA-ALIGN	Figure 14

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SHN Consulting Engineers & Geologists, Inc.

The County of Humboldt
Redwood Marine Terminal II
Samoa, California

Fairhaven Only Alignment

SHN 015147

January 2016 | 015147-FRHVN-ONLY-ALIGN | Figure 15

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7.0 Cost Analysis

Cost estimates presented in the following sections are for planning and feasibility assessment purposes only.

7.1 Permitting

This section addresses special studies, California Environmental Quality Act (CEQA) compliance, and permits anticipated to be needed for three potential project options: 1) the entire wastewater conveyance and ocean outfall disposal project discussed previously in this document 2) wastewater conveyance from Fairhaven and Samoa to RMT II including maintenance and repair of (and disposal through) the ocean outfall; and 3) maintenance and repair of the ocean outfall only.

7.1.1 Special Studies

A variety of special studies would be needed in support of the project engineering design, permit applications, and CEQA compliance. Necessary special studies would likely include many of the following, although the full range of required documentation would depend upon specific agency requirements following their review of detailed project applications. Not all of these studies may be required. Estimated cost ranges are very approximate given the current limitations on project definition and agency concerns. Estimated timeframes are provided per task; many timeframes would presumably overlap with the preparation of other special studies and the initiation of the permit processes. Table 4a presents anticipated special studies for the entire project. Table 4b presents anticipated special studies for wastewater conveyance from Fairhaven and Samoa to RMT II including maintenance and repair of (and disposal through) the ocean outfall. Table 4c presents anticipated special studies for maintenance and repair of the ocean outfall only.

Table 4a
Anticipated Special Studies, Entire Project
RMT II Infrastructure Reuse Evaluation, Eureka, California

Special Study	Estimated Cost Range	Estimated Timeframe
Natural resources assessment	\$6,000-\$12,000	3-6 months
Biological assessment(s)	\$6,000-\$15,000	3-6 months
Wetland/riparian/other waters delineation	\$6,000-\$15,000	3-6 months
Biological mitigation, monitoring, and reporting plan	\$5,000-\$10,000	2-4 months
Cultural resources study	\$6,000-\$12,000	2-4 months
Greenhouse gas emissions analysis	\$5,000-\$10,000	2-4 months
Geotechnical report with hydraulic fracture analysis (Eureka effluent line only)	\$40,000-\$50,000	2-4 months
TOTAL	**\$74,000-\$124,000**	**3-9 months**

Table 4b Anticipated Special Studies, Wastewater Conveyance and Disposal from Fairhaven and Samoa to RMT II RMT II Infrastructure Reuse Evaluation, Eureka, California		
Special Study	**Estimated Cost Range**	**Estimated Timeframe**
Natural resources assessment	$6,000-$12,000	3-6 months
Biological assessment(s)	$6,000-$12,000	3-6 months
Wetland/riparian/other waters delineation	$6,000-$15,000	3-6 months
Biological mitigation, monitoring, and reporting plan	$5,000-$10,000	2-4 months
Cultural resources study	$6,000-$12,000	2-4 months
Greenhouse gas emissions analysis	$5,000-$10,000	2-4 months
TOTAL	**$34,000-$71,000**	**3-9 months**

Table 4c Anticipated Special Studies, Ocean Outfall Maintenance/Repair Only RMT II Infrastructure Reuse Evaluation, Eureka, California		
Special Study	**Estimated Cost Range**	**Estimated Timeframe**
Biological assessment(s)	$5,000-$10,000	2-4 months
TOTAL	**$5,000-$10,000**	**2-4 months**

Natural Resources Assessment. The natural resources assessment would characterize the environmental setting and habitat at the site, query databases for special status species and habitats reported in the project vicinity, and assess the project's potential impacts to special status species and habitats. It would also include seasonally-appropriate floristic survey(s) if applicable, which need to occur during spring-summer, depending upon the species of concern. The 3- to 6-month timeframe assumes that the natural resources assessment fieldwork would be conducted during the appropriate time of year. The cost of the natural resources assessment would be higher the more variety of habitat types is involved and the larger the project footprint.

Biological Assessment(s). The U.S. Army Corps of Engineers (ACOE) typically consults with National Marine Fisheries Service (NMFS) and/or U.S. Fish & Wildlife Service (USFWS) regarding impacts to federally listed species and their habitats (such as, salmonids and certain whales). For actions that "may affect" federally listed species, these agencies require preparation of a biological assessment. Depending on which species are involved, biological assessments may need to be prepared for both NMFS and USFWS. Biological assessment(s) are anticipated to be needed regardless of which project element(s) go forward. The cost would be higher depending on how many federally listed species require Section 7 consultation and whether consultation with one or both the NMFS and USFWS are required.

Wetland/Riparian/Other Waters Delineation. A delineation of wetlands, riparian areas, and/or other jurisdictional waters will be needed if the project involves work in or near such features. The delineation would be used to quantify the project's impacts to jurisdictional waters pursuant to permitting and CEQA compliance. The cost would be higher with more potential wetlands/waters present.

Biological Mitigation, Monitoring, and Reporting Plan. Impacts to special status species, wetlands, and/or other jurisdictional waters may require mitigation to meet agency permit requirements. This may include revegetation efforts or other mitigation plantings, which would need to be monitored for a period of typically five years with annual reporting to the agencies. The biological mitigation, monitoring, and reporting plan would detail necessary mitigation efforts, and would be made a condition of approval of the various permits. A biological mitigation, monitoring, and reporting plan may be needed for any ground disturbing project element, depending on biological impacts. The cost would be higher with more biological impacts.

Cultural Resources Study. Agency requirements would likely include the preparation of a cultural resources study, which would investigate the project's potential to have an adverse effect on historical, archaeological, or paleontological resources. A cultural resources study would likely be required for any project involving ground disturbing activity, especially in previously undisturbed locations. The cost would be higher the more ground disturbance is included.

Greenhouse Gas Emissions Analysis. The CEQA lead agency may require an analysis of the project's contributions to greenhouse gas (GHG) emissions, pursuant to CEQA compliance. GHG emissions from both construction and operation would be considered. The cost of GHG analysis would be higher with inclusion of more project elements.

Geotechnical Report with Hydraulic Fracture Analysis. A geotechnical report with hydraulic fracture analysis would be needed for appropriate design of the HDD and identification of appropriate mitigation measures for potential hydraulic fracture. This study would only be needed for project elements involving HDD (at this time, limited to conveyance of Eureka's wastewater under Humboldt Bay).

7.1.2 California Environmental Quality Act

CEQA compliance would occur concurrently with the permit processes, but permitting agencies will need a completed CEQA document prior to issuing permit approvals. The most likely CEQA lead agency for the entire project would be the HBHRCD, a state funding agency, or the RWQCB. For the wastewater conveyances from Fairhaven and Samoa to RMT II only or ocean outfall repair/maintenance only, the most likely CEQA lead agency would be the HBHRCD.

The most likely CEQA documentation for the entire project or for the wastewater conveyances from Fairhaven and Samoa to RMT II only would be an initial study/mitigated negative declaration, which could cost $10,000-$20,000 plus necessary special studies (described above). If the lead agency determines that an environmental impact report (EIR) is required, the cost would be substantially higher. The most likely CEQA documentation for the ocean outfall repair/maintenance only would be a categorical exemption (class 1 existing facilities, Class 2 replacement or reconstruction, and/or Class 4 minor alterations to land) which could cost $1,000-$2,000 plus any necessary special study (described above).

The CEQA cost would be higher with the full project and lower with a reduced scope project. The CEQA cost is subject to numerous uncertainties at this stage given the current limitations on project definition, site-specific conditions, and agency concerns.

It is noted that the CEQA documentation and associated costs discussed here are understood to be for the wastewater conveyance and ocean outfall disposal project discussed previously in this document (the entire project or portions thereof). CEQA compliance for potential aquaculture project(s), dredging project(s), and/or other development project(s) would likely require additional or separate CEQA compliance.

7.1.3 Permitting

Permits or approvals required for the project are expected to include, but are not necessarily limited to, the following: Table 5a presents anticipated permits and authorizations for the entire project. Table 5b presents anticipated permits and authorizations for wastewater conveyance from Fairhaven and Samoa to RMT II including maintenance and repair of (and disposal through) the ocean outfall. Table 5c presents anticipated permits and authorizations for maintenance and repair of the ocean outfall only.

Table 5a
Anticipated Permits and Authorizations, Entire Project
RMT II Infrastructure Reuse Evaluation, Eureka, California

Agency	Permit/Authorization	Estimated Cost Range[1]	Estimated Timeframe[2]
US Army Corps of Engineers	Section 404/Section 10 Permit	$5,000-$10,000	6-12 months
USFWS[3]	Biological Opinion	$3,000-$9,000	3-9 months
NMFS[4]	Biological Opinion	$3,000-$9,000	3-9 months
RWQCB[5]	Section 401 Water Quality Certification	$8,000-$16,000	3-6 months
RWQCB	NPDES[6] Permit(s)	$30,000-$60,000	6-12 months
SWRCB[7]	Construction General Permit	$5,000-$8,000	1-2 months
CDFW[8]	Streambed Alteration Agreement	$6,000-$12,000	3-6 months
CA Coastal Commission	Coastal Development Permit (consolidated[9])	$15,000-$50,000	6-12 months
CA State Lands Commission	CSLC[10] Lease	$6,000-$9,000	3-6 months
HBHRCD[11]	Harbor District Development Permit	$3,000-$6,000	3-6 months
City of Eureka	Conditional Use Permit	$8,000-$13,000	3-6 months
County of Humboldt	Conditional Use Permit	$8,000-$13,000	3-6 months
	TOTAL	**$100,000-$215,000**	**9-18 months**

Table 5a Anticipated Permits and Authorizations, Entire Project RMT II Infrastructure Reuse Evaluation, Eureka, California			
Agency	**Permit/Authorization**	**Estimated Cost Range[1]**	**Estimated Timeframe[2]**

1. Estimated cost ranges include estimated agency permit fees (ACOE-$100 fee; RWQCB 401-$3,000 fee; RWQCB NPDES-$2,000 fee; SWRCB-$700 fee; CDFW-$1,500 fee; California Coastal Commission-$6,000 fee; CSLC-$3,000 fee; HBHRCD-$100 fee; City-$3,000 fee; County-$3,000 fee)
2. Timeframes provided are following submission of a complete permit application.
3. USFWS: United States Fish and Wildlife Service
4. NMFS: National Marine Fisheries Service
5. RWQCB: North Coast Regional Water Quality Control Board
6. NPDES: National Pollutant Discharge Elimination System
7. SWRCB: State Water Resources Control Board
8. CDFW: California Department of Fish & Wildlife
9. Coastal development permits from California Coastal Commission, City of Eureka, and/or County of Humboldt would be consolidated to the California Coastal Commission
10. CSLC: California State Lands Commission
11. HBHRCD: Humboldt Bay Harbor, Recreation and Conservation District

Table 5b
Anticipated Permits and Authorizations, Wastewater Conveyance and Disposal from Fairhaven and Samoa to RMT II
RMT II Infrastructure Reuse Evaluation, Eureka, California

Agency	Permit/Authorization	Estimated Cost Range[1]	Estimated Timeframe[2]
US Army Corps of Engineers	Section 404/Section 10 Permit	$4,000-$8,000	6-12 months
USFWS[3]	Biological Opinion	$3,000-$6,000	3-9 months
NMFS[4]	Biological Opinion	$3,000-$6,000	3-9 months
RWQCB[5]	Section 401 Water Quality Certification	$8,000-$14,000	3-6 months
RWQCB	NPDES[6] Permit(s)	$30,000-$60,000	6-12 months
SWRCB[7]	Construction General Permit	$5,000-$8,000	1-2 months
CDFW[8]	Streambed Alteration Agreement	$6,000-$12,000	3-6 months
CA Coastal Commission	Coastal Development Permit (consolidated[9])	$15,000-$40,000	6-12 months
CA State Lands Commission	CSLC[10] Lease	$6,000-$9,000	3-6 months
County of Humboldt	Conditional Use Permit	$8,000-$13,000	3-6 months
	TOTAL	**$88,000-$176,000**	**9-18 months**

Table 5b Anticipated Permits and Authorizations, Wastewater Conveyance and Disposal from Fairhaven and Samoa to RMT II RMT II Infrastructure Reuse Evaluation, Eureka, California			
Agency	**Permit/Authorization**	**Estimated Cost Range[1]**	**Estimated Timeframe[2]**

1. Estimated cost ranges include estimated agency permit fees (ACOE-$100 fee; RWQCB 401-$3,000 fee; RWQCB NPDES-$2,000 fee; SWRCB-$700 fee; CDFW-$1,500 fee; California Coastal Commission-$6,000 fee; County-$3,000 fee)
2. Timeframes provided are following submission of a complete permit application.
3. USFWS: United States Fish and Wildlife Service
4. NMFS: National Marine Fisheries Service
5. RWQCB: North Coast Regional Water Quality Control Board
6. NPDES: National Pollutant Discharge Elimination System
7. SWRCB: State Water Resources Control Board
8. CDFW: California Department of Fish & Wildlife
9. Coastal development permits from California Coastal Commission and County of Humboldt would be consolidated to the California Coastal Commission
10. CSLC: California State Lands Commission

Table 5c
Anticipated Permits and Authorizations, Ocean Outfall Maintenance/Repair Only
RMT II Infrastructure Reuse Evaluation, Eureka, California

Agency	Permit/Authorization	Estimated Cost Range[1]	Estimated Timeframe[2]
US Army Corps of Engineers	Section 404/Section 10 Permit	$4,000-$8,000	6-12 months
USFWS[3]	Biological Opinion	$3,000-$6,000	3-9 months
NMFS[4]	Biological Opinion	$3,000-$6,000	3-9 months
RWQCB[5]	Section 401 Water Quality Certification	$8,000-$12,000	3-6 months
RWQCB	NPDES[6] Permit(s)	$30,000-$60,000	6-12 months
CA Coastal Commission	Coastal Development Permit (or waiver)	$10,000-$35,000	4-12 months
CA State Lands Commission	CSLC[7] Lease	$6,000-$9,000	3-6 months
	TOTAL	**$64,000-$136,000**	**9-18 months**

1. Estimated cost ranges include estimated agency permit fees (ACOE-$100 fee; RWQCB 401-$3,000 fee; RWQCB NPDES-$2,000 fee; California Coastal Commission-$1,000-$6,000 fee)
2. Timeframes provided are following submission of a complete permit application.
3. USFWS: United States Fish and Wildlife Service
4. NMFS: National Marine Fisheries Service
5. RWQCB: North Coast Regional Water Quality Control Board
6. NPDES: National Pollutant Discharge Elimination System
7. CSLC: California State Lands Commission

Actual permitting requirements will depend upon detailed project information and additional coordination with the various agencies. Estimated cost ranges are very approximate given the current limitations on project definition and agency concerns. Estimated timeframes would presumably overlap during the permitting processes.

ACOE Section 404/Section 10 Permit. An ACOE Clean Water Act Section 404/Section 10 permit would be required if the project were to involve filling of or work in Waters of the U.S. As part of its permit process, the ACOE typically consults with NMFS and/or USFWS regarding impacts to federally listed species and their habitats (such as, salmonids and certain whales). For this project, an ACOE permit is anticipated to be needed regardless of which project element(s) go forward. Work at the ocean outfall, HDD under Humboldt Bay, and/or impacts to other jurisdictional surface waters or wetlands would all trigger the need for an ACOE permit. The cost would be affected by how many federally listed species require Section 7 consultation, whether one or both the NMFS and USFWS require consultations, and whether Section 7 consultation is informal or formal.

USFWS Biological Opinion. A biological opinion would be required from USFWS if the ACOE/ USFWS's Section 7 Endangered Species Act consultation proceeds to formal consultation. The cost would be affected by how many federally listed species require Section 7 consultation with USFWS.

NMFS Biological Opinion. A biological opinion would be required from NMFS if the ACOE/ NMFS's Section 7 Endangered Species Act consultation proceeds to formal consultation. The cost would be affected by how many federally listed species require Section 7 consultation with NMFS.

RWQCB Section 401 Water Quality Certification. An RWQCB Clean Water Act Section 401 water quality certification would be required if an ACOE permit were required or if the project were to involve filling of or work in Waters of the State. For this project, a water quality certification is anticipated to be needed regardless of which project element(s) go forward. The cost would be affected by the magnitude of the permit fee, which is impact-dependant.

RWQCB NPDES Permit(s). NPDES permits, also referred to as waste discharge requirements, are issued to regulate the discharge of municipal wastewater or industrial process, cleaning, or cooling, wastewaters; commercial wastewater; treated groundwater from cleanup projects; or other wastes to surface waters (in this case; the Pacific Ocean). It is anticipated that various potential users will provide appropriate treatment and discharge through the single (joint) ocean outfall owned and operated by HBHRCD.

There has been a variety of approaches by regulatory agencies to this type of situation. As is the case for this project, when one entity owns the outfall (and may discharge its own effluent), but the outfall is used for multiple discharges, each discharge would have a separate NPDES discharge permit. Each effluent would need to meet water quality standards (WQS) independently. In some cases, there may be a trade-off between discharges that allows one effluent to exceed WQS if the combined discharge meets WQS. However, because various discharges for this project are yet to be determined and may come online at different times, the actual permitting process is not clear. One approach would be to apply for permits for individual discharges as needed, and modifying existing permits as needed at the time the new discharger is permitted, with the objective being to synchronize the permit expiration dates. However, as each discharge is added, consultation with the RWQCB would be required to determine the process to be followed. For this project, NPDES permitting is anticipated to be needed regardless of which project element(s) go forward. The cost would be affected by the number of NPDES permits required and the extent of necessary effluent and receiving water characterization and specific calculations.

SWRCB Construction General Permit. The project will require coverage under the SWRCB construction general permit (including preparation of a stormwater pollution prevention plan) if it involves one acre or more of ground disturbance.

California Department of Fish & Wildlife (CDFW) Streambed Alteration Agreement. Fish and Game Code Section 1602 requires an entity to notify the CDFW prior to commencing any activity that may do one or more of the following:

- substantially divert or obstruct the natural flow of any river, stream, or lake;
- substantially change or use any material from the bed, channel, or bank of any river, stream, or lake; and/or
- deposit debris, waste, or other materials that could pass into any river, stream, or lake.

CDFW requires a Lake and Streambed Alteration (LSA) Agreement when it determines that the activity, as described in a complete LSA Notification, may substantially adversely affect existing fish or wildlife resources. LSA Notification is anticipated to be required if any project element involves work in a CDFW-jurisdictional watercourse or ditch (or its associated riparian vegetation). However, there is a low probability that this project would require an LSA and streambed alteration agreement. The cost would be affected by the magnitude of the permit fee, which is project-cost-dependant.

CA Coastal Commission Coastal Development Permit. The full project includes components located within the coastal development permit (CDP) jurisdiction of the Coastal Commission, County of Humboldt, and City of Eureka. Regardless of which project element(s) may go forward, the CDP process is expected to be consolidated to the Coastal Commission resulting in a single CDP. The permit fee and level of effort required to demonstrate project consistency with the California Coastal Act are difficult to predict, resulting in the wide cost range.

California State Lands Commission (CSLC) Lease. The CSLC's jurisdiction includes the beds of California's naturally navigable rivers, lakes, and streams, as well as the State's tide and submerged lands that extend from the shoreline out to three miles offshore. Therefore a CSLC lease is anticipated to be required for the HDD under Humboldt Bay and potentially for the use of the ocean outfall if a SLCS lease is not already in place for that. The $3,000 fee estimate is based on a public agency lease; however if CSLC determines the project is commercial or industrial, the fee could be $25,000.

HBHRCD Development Permit. A development permit from HBHRCD may be required depending on what entity is the project proponent and what project element(s) go forward. The cost also depends on what project element(s) go forward.

City of Eureka Conditional Use Permit. A conditional use permit from City of Eureka may be required for the pipeline section within the City limits. If the project did not include that element, this permit would be unnecessary.

County of Humboldt Conditional Use Permit. A County conditional use permit may be required for the pipeline sections within County jurisdiction. However, if the project is seen as exclusively a municipal/public project, this permit may not be required.

7.2 Offsite Wastewater Sources

Offsite wastewater sources originate from several communities on the Samoa peninsula, and the City of Eureka. The HBHRCD would not be responsible for paying for the improvements (effluent lines and effluent pump stations) and associated permitting listed in this section for the offsite wastewater sources. In addition, the HBHRCD would receive fees from these communities for the use of the outfall structure. The rate the HBHRCD would assess each community would be based on the each community's proportional share of the total volume discharged (averaged over a year) and the HBHRCD's operation and maintenance costs of the ocean outfall and MH-5 effluent pump station, and reserves necessary for eventual replacement of the outfall and effluent pumps.

Infrastructure costs to dispose of treated effluent from offsite wastewater sources are detailed in Table 6.

Table 6
Infrastructure Estimated Costs, Offsite Water Users
RMT II Infrastructure Reuse Evaluation, Eureka, California

Name	Description	Unit	Quantity	Unit Cost	Total Cost
Eureka Line	30-inch line	ft[1]	4,800	$ 500	$ 2,400,000
Samoa Line	4-inch line	ft	4,000	$ 90	$ 360,000
Fairhaven Line	30-inch line	ft	10,000	$ 500	$ 5,000,000
Horizontal Direction Drill	30-inch line	ft	3,200	$ 700	$ 2,240,000
Samoa Pump Station	Site Work	LS[2]	1	$ 10,000	$ 10,000
	Wet well	LS	1	$ 20,000	$ 20,000
	Mechanical	LS	1	$ 20,000	$ 20,000
	Electrical	LS	1	$ 5,000	$ 5,000
Fairhaven Pump Station	Site Work	LS[2]	1	$ 10,000	$ 10,000
	Wet well	LS	1	$ 15,000	$ 15,000
	Mechanical	LS	1	$ 20,000	$ 20,000
	Electrical	LS	1	$ 5,000	$ 5,000
Eureka Pump Station	Site Work	LS	1	$ 25,000	$ 25,000
	Wet well	LS	1	$ 100,000	$ 100,000
	Mechanical	LS	1	$ 350,000	$ 350,000
	Electrical	LS	1	$ 75,000	$ 75,000
				Subtotal	$ 10,655,000
				Mobilization (10%)	$ 1,065,000
				Contingency (20%)	$ 2,130,000
				Engineering (20%)	$ 2,130,000
				Total Cost	**$ 15,980,000**

1. ft. feet
2. LS: lump sum

Table 7 details costs to install infrastructure for the communities of Fairhaven and Samoa if the City of Eureka does not use the ocean outfall at RMT II.

Table 7 Infrastructure Costs, Fairhaven and Samoa RMT II Infrastructure Reuse Evaluation, Eureka, California					
Name	**Description**	**Unit**	**Quantity**	**Unit Cost**	**Total Cost**
Fairhaven Line	4-inch line	ft[1]	7,000	$ 90	$ 630,000
Fairhaven Pump Station	Site Work	LS[2]	1	$ 10,000	$ 10,000
	Wet well	LS	1	$ 15,000	$ 15,000
	Mechanical	LS	1	$ 20,000	$ 20,000
	Electrical	LS	1	$ 5,000	$ 5,000
Samoa Line	4-inch line	ft	4,000	$ 90	$ 360,000
Samoa Pump Station	Site Work	LS[2]	1	$ 10,000	$ 10,000
	Wet well	LS	1	$ 20,000	$ 20,000
	Mechanical	LS	1	$ 20,000	$ 20,000
	Electrical	LS	1	$ 5,000	$ 5,000
				Subtotal	**$ 1,095,000**
				Mobilization (10%)	$ 109,500
				Contingency (20%)	$ 219,000
				Engineering (20%)	$ 219,000
				Total Cost	**$ 1,642,500**

1. ft. feet 2. LS: lump sum

7.3 Onsite Wastewater Sources

Cost estimates for various onsite wastewater sources of the existing infrastructure are presented in the following sections. All costs are for planning and feasibility purposes only.

7.3.1 Dredge Spoils

7.3.1.1 MicroFloc Water Treatment System

Estimated costs to dewater dredge spoils using the onsite wastewater treatment system are summarized in Tables 8 and 9. Table 8 summarizes full costs to rehabilitate the MicroFloc system, including clarifiers and filters. Table 9 lists the cost of components to rehabilitate the clarifiers only. This cost assumes that the clarifier effluent meets regulatory requirements for turbidity without filtration. Costs do not include permitting costs for discharge of supernatant or disposal of solids following dewatering. It is assumed that repairs to filters will be minor and existing media is in usable condition.

Table 8a
Dredge Spoils Processing, MicroFloc Rehabilitation Costs–Clarifiers and Filters
RMT II Infrastructure Reuse Evaluation, Eureka, California

Description	Units	Quantity	Unit Cost	Cost
Empty & clean clarifier tanks	LS[1]	1	$ 10,000	$ 10,000
Remove & store two bridge/collector mechanisms	LS	1	$ 20,000	$ 20,000
Perforated plate covers over sludge hoppers	EA[2]	2	$ 1,500	$ 3,000
18" layer rock on clarifier floors	CY[3]	1,960	$ 40	$ 78,400
Perforated pipe laterals; 6″ diameter	LF[4]	720	$ 20	$ 14,400
Geotextile fabric, installed	SY[5]	4,100	$ 5.00	$ 20,500
Dredge discharge pipe connections	LS	1	$ 15,000	$ 15,000
Excavator access ramps	LS	1	$ 8,000	$ 8,000
Supernatant pump systems, piping	EA	2	$ 10,000	$ 20,000
Pipe from waste sump to clarifier effluent sump; 6"	LF	60	$ 55	$ 3,300
Backwash pumps	EA	2	$ 8,000	$ 16,000
Refurbish two filter feed pumps	LS	2	$ 4,000	$ 8,000
Backwash supply piping; 18"	LF	200	$ 170	$ 34,000
Backwash valves	EA	3	$ 5,000	$ 15,000
Backwash waste piping to flash mix basin; 18"	LF	20	$ 170	$ 3,400
Filter controls package	LS	1	$ 30,000	$ 30,000
Filter valve overhaul	LS	1	$ 10,000	$ 10,000
Miscellaneous improvements filter system	LS	1	$ 40,000	$ 40,000
			Subtotal	$349,000
			Mobilization (10%)	$ 34,900
			Contingency (20%)	$ 69,800
			Engineering (20%)	$ 69,800
			Total Cost	**$ 523,500**

1. LS: lump sum
2. EA: each
3. CY: cubic yard
4. LF: linear foot
5. SY: square yard

Table 8b Dredge Spoils Processing, MicroFloc Rehabilitation Costs–No Filtration Required RMT II Infrastructure Reuse Evaluation, Eureka, California				
Description	**Units**	**Quantity**	**Unit Cost**	**Cost**
Empty & clean clarifier tanks	LS[1]	1	$ 10,000	$ 10,000
Remove & store two bridge/collector mechanisms	LS	1	$ 20,000	$ 20,000
Perforated plate covers over sludge hoppers	EA[2]	2	$ 1,500	$ 3,000
18" layer rock on clarifier floors	CY[3]	1,960	$ 40	$ 78,400
Perforated pipe laterals; 6″ diameter	LF[4]	720	$ 20	$ 14,400
Geotextile fabric, installed	SY[5]	4,100	$ 5.00	$ 20,500
Dredge discharge pipe connections	LS	1	$ 15,000	$ 15,000
Excavator access ramps	LS	1	$ 8,000	$ 8,000
Supernatant pump systems, piping	EA	2	$ 10,000	$ 20,000
Pipe from waste sump to clarifier effluent sump; 6"	LF	60	$ 55	$ 3,300
			Subtotal	$192,600
			Mobilization (10%)	$ 19,260
			Contingency (20%)	$ 38,520
			Engineering (20%)	$ 38,520
			Total Cost	**$ 288,900**
1. LS: lump sum 2. EA: each 3. CY: cubic yard 4. LF: linear foot 5. SY: square yard				

7.3.1.2 Geotubes

Estimated costs to dewater dredge spoils using geotubes are provided in Table 9. Costs do not include additional infrastructure that may be required to meet discharge limitations for turbidity, disposal of sediment following dewatering, or potential permitting costs. Polymer requirements vary significantly depending on the chemical makeup and solids content of the slurry, and require a bench test of dredge spoils to for a final estimate.

An NPDES permit will be required for the discharge of water from dredge spoils if polymer is used, or the dredge spoils are processed in any way for offsite use.

Table 9 Dredge Spoils Processing, Geotube Costs RMT II Infrastructure Reuse Evaluation, Eureka, California				
Description	**Units**	**Quantity**	**Unit Cost**	**Cost**
Geotubes (950 CY[1] capacity)	EA[2]	32	$ 11,200	$ 358,400
Polymer	tote	10	$ 6,500	$ 65,000
Geotube supervisor	days	60	$ 2,800	$ 168,000
Polymer Skid	month	2	$ 29,200	$ 58,400
Geosynthetic Liner	SF[3]	175,000	$ 0.85	$ 148,750
Earthwork	LS[4]	1	$ 150,000	$ 150,000
		Subtotal		$ 948,550
		Mobilization (10%)		$ 94,850
		Contingency (20%)		$ 189,700
		Engineering (5%)		$ 47,450
		Total Cost		**$1,280,550**

1. CY: cubic yard
2. EA: each
3. SF: square feet
4. LS: lump sum

7.3.2 Aquaculture

The existing leachfield can accept up to 8,500 gpd of aquaculture flows. Any flow in excess of 8,500 gpd would need to be routed to the ocean outfall.

Estimated costs associated with wastewater disposal for increased aquaculture operations at RMT II are summarized in Table 10. Necessary infrastructure will include the settling tank discussed in Section 5.0, a discharge line, and manhole and pumps in MH-5. Costs for the rehabilitation of the ocean outfall are discussed in Section 7.4.

Table 10 Aquaculture Wastewater Disposal Infrastructure Costs RMT II Infrastructure Reuse Evaluation, Eureka, California				
Description	**Units**	**Quantity**	**Unit Cost**	**Cost**
Settling Tank	LS[1]	1	$ 50,000	$ 50,000
Proposed Drain Line	LF[2]	500	$ 150	$ 75,000
New Manhole	LS	1	$ 10,000	$ 10,000
		Subtotal		$ 135,000
		Mobilization (10%)		$ 13,500
		Contingency (20%)		$ 27,000
		Engineering (20%)		$ 27,000
		Total Cost		**$ 202,500**

1. LS: lump sum
2. LF: linear feet

7.4 Ocean Outfall

Table 11 presents the estimated costs for complete cleaning and rehabilitation of the ocean outfall. Costs are based on MMDiving's rate of $14,750 per 10-hour day, operating from the HBHRCD's Fire 1 vessel. This daily rate has been averaged to include the weekend rate, due to the uncertain nature of daily conditions. The estimate includes three days for exposing the diffuser section; ten days for clearing the diffuser internally; and five days to inspect, take a cathodic protection reading, and install anodes for cathodic protection. An additional 30-percent contingency for inclement weather delays has been applied in order to hedge against the frequent unstable operating weather.

Table 11
Ocean Outfall Rehabilitation Costs
RMT II Infrastructure Reuse Evaluation, Eureka, California

Description	Units	Quantity	Unit Cost	Cost
Expose Diffuser Section	Days(1)	3	$ 14,750	$ 44,250
Clear Diffuser Internally	Days	10	$ 14,750	$147,500
Inspect, Take CP Readings, Install Cathodic Protection	Days	5	$ 14,750	$ 73,750
Mobilization/Demobilization	LS(2)	1	$ 10,000	$ 10,000
Internal Jet Fabrication & Consumables	LS	1	$ 5,000	$ 5,000
Inclement Weather Contingency (30%)	LS	1	$ 84,000	$ 84,000
MH-5 Pumps[3]	LS	1	$ 220,000	$ 220,000
		Subtotal		$ 584,500
		Mobilization (10%)		$ 58,400
		Contingency (20%)		$ 116,800
		Engineering (20%)		$ 116,800
		Total Cost		$ 876,750

1. MM Diving Rate w/Harbor District's Fire 1 Vessel per 10 hr day
2. LS: lump sum
3. MH-5 pumps required only when flows to ocean outfall exceed 15 million gallons per day.

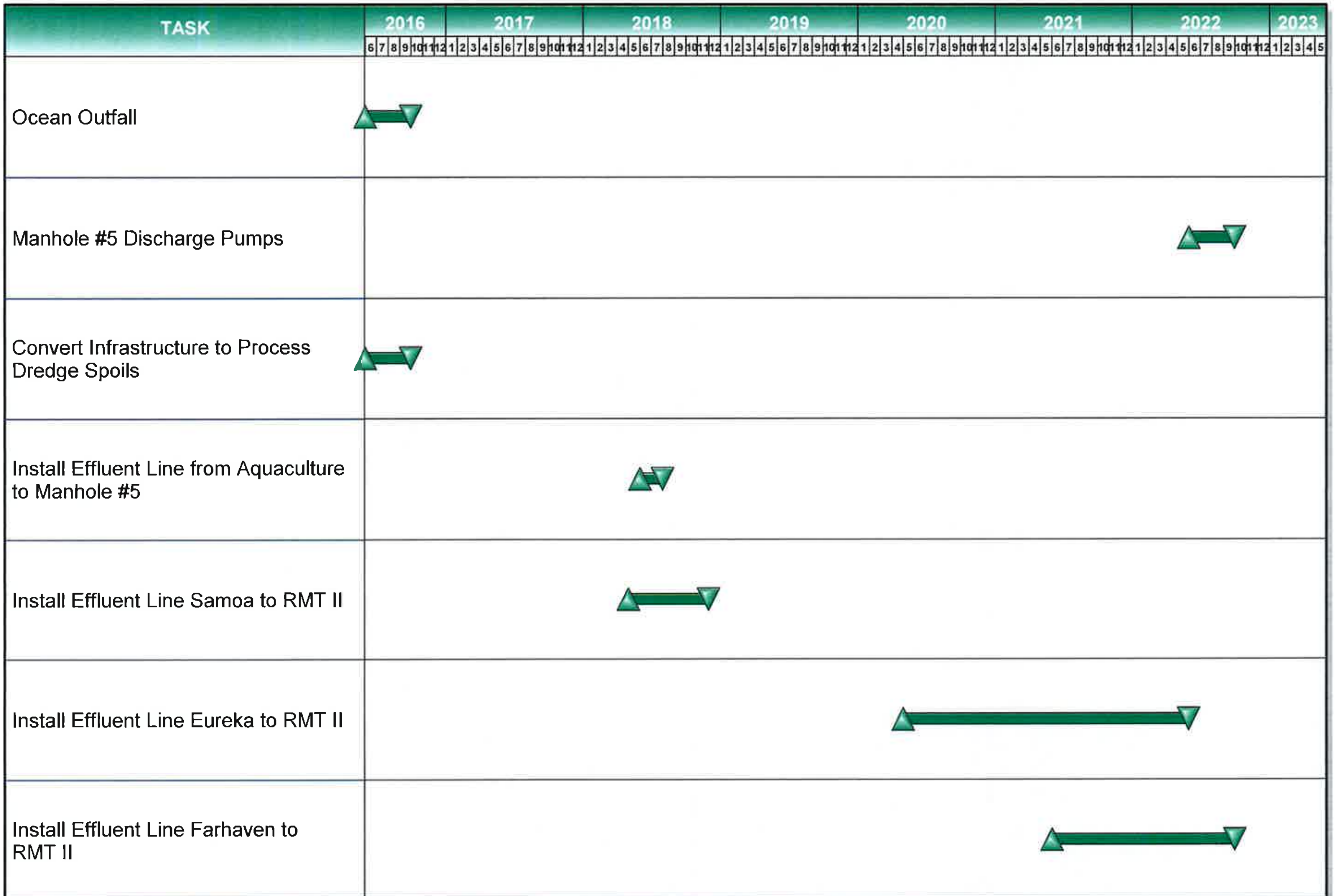
8.0 Proposed Schedule

Figure 16 presents a proposed schedule of when anticipated discharges would be added. Please note these are only anticipated time lines and many factors that are beyond the HBHRCD's control influence the proposed schedules.

8.1 Rehabilitation of Ocean Outfall and MH-5

Work on the ocean outfall is based upon when the expanded discharges will be added. If the outfall will be used to discharge treated water from dredging operations in Fall 2016, then the outfall rehabilitation should occur this summer. Otherwise, the HBHRCD should link the ocean outfall repair to the addition of the Samoa discharge or the expansion of aquaculture discharge when it exceeds the 8,500 gpd limit of the existing leachfield.

Figure 16
Proposed Schedule
Wastewater Infrastructure RMT II



The repair to the two 350-hp discharge pumps at MH-5 will only be necessary when the cumulative discharge in the outfall reaches 15 MGD. The only discharge options that would require rehabilitation of the outfall pumps are the City of Eureka discharging treated effluent to the ocean outfall or onsite aquaculture operations approaching 15 MGD. For the purposes of this study, we anticipate rehabilitation of the ocean outfall pumps in 2022.

8.2 Onsite Wastewater Sources

8.2.1 Aquaculture

Currently, all waste discharges from onsite aquaculture operations discharge to the existing leachfield are estimated to be 2,400 gpd. If the HBHRCD elects to expand aquaculture operations beyond the capacity of the existing leachfield (approximately 8,500 gpd) the HBHRCD would need to discharge aquaculture effluent to the ocean outfall. It is anticipated the HBHRCD would start using the ocean outfall for aquaculture waste in 2018.

8.2.2 Dewatering Dredge Spoils

The HBHRCD recently purchased a cutterhead suction dredge and is in the process of permitting a pilot scale dredging and dewatering operation. If permitting for maintenance dredging of Humboldt Bay is in place, the HBHRCD anticipates using the RMT II facility to dewater dredge material as soon as Fall 2016.

8.3 Offsite Wastewater Sources

8.3.1 Samoa

The community of Samoa is very interested in discharging its treated effluent to the ocean outfall. Preliminary discussions with the HBHRCD have already occurred. Assuming the town of Samoa decides to pursue the ocean outfall alternative by this spring and begin permitting and design, Samoa could begin construction in Spring 2018 and be online by Fall 2018.

8.3.2 Fairhaven

Currently, there is no requirement for the community of Fairhaven to upgrade its method of wastewater disposal (on site). It is assumed for this study, that Fairhaven would participate with the City of Eureka if Eureka were to install an effluent line to the ocean outfall. For this study, we have assumed this would occur in 2022.

8.3.3 Eureka

Currently, the City of Eureka discharges to Humboldt Bay during an outgoing (ebb) tide. At this time, the City is not interested in extending a wastewater effluent line to the ocean outfall. However, the RWQCB has expressed interest in the City pursuing use of the ocean outfall option. If the City were to pursue this alternative, it would take several years to permit, design, and install the effluent line from Eureka to Samoa. For this study, we have assumed a period of 5 years for that process. Assuming the City initiates this alternative in 2017, the estimated timeline for the City to discharge into the ocean outfall would be in 2022.

9.0 Summary

Several potential onsite and offsite uses were evaluated for use of existing infrastructure at RMT II. In addition, we evaluated what improvements would be required for the potential uses; associated planning level costs were presented in Section 7.0.

9.1 Existing Infrastructure

Existing infrastructure at RMT II has reuse potential for discharge of treated wastewater effluent, processing of dredge spoils, and aquaculture activities. All potential uses require investment in infrastructure and coordination with various regulatory agencies to acquire necessary permits.

9.2 Aquaculture

Aquaculture facilities are currently operating at the site. Wastewater from these operations is discharged to the existing septic tank and leachfield system. The existing leachfield capacity is approximately 8,500 gpd. Expanded aquaculture operations producing more than 8,500 gpd would require infrastructure improvements, including rehabilitation of the existing ocean outfall; the addition of a solids settling tank; a discharge line; and, for flows exceeding 15 MGD, pumps for MH-5.

Based on the estimated flow required per kilogram of fish and the waste loadings produced by finfish operations, solids, total nitrogen, and total phosphorous concentrations in the discharge would be well below limits set by the Ocean Plan. Therefore, nutrient treatment would not be required for finfish operations, and bivalve production may be exempt from NPDES permitting requirements.

9.3 Dredge Spoils Processing

Disposal of approximately 30,000 cubic yards of solids is required as part of annual dredging operations in Humboldt Bay. Two options for dredge spoils processing were examined in this report. The first option would use the existing onsite MicroFloc water treatment system. This option would alternate pumping of dredge slurry between the two existing clarifiers, then filtering the supernatant using three of the existing filters. The supernatant would be discharged through the ocean outfall, and the solids would be excavated from the clarifiers and either stored elsewhere onsite, or sent off site for disposal. The second option would use geotubes to dewater dredge spoils, and either pump supernatant to the ocean outfall or return it to the bay through standard stormwater BMPs. Planning level cost estimates are presented in Section 7.0.

Both options for dredge spoils processing may require the use of a coagulant to reduce effluent turbidity below relevant limits. The ocean plan requires discharge turbidity to be below 75 NTUs, which corresponds to approximately 75 mg/L TSS. The use of a coagulant may require the discharge to be regulated by an NPDES permit. Please note that construction of a temporary storage site for dredge material dewatering was not evaluated.

9.4 Offsite Water Sources

The ocean outfall at RMT II can be used as a disposal point for treated wastewater effluent from surrounding communities. Expected quantities and characteristics of treated effluent were estimated for the City of Eureka, and the communities of Samoa and Fairhaven (Section 4.0). Required infrastructure for each line is discussed in detail in Section 6.0, but generally includes pipelines from each community to MH-5 at the RMT II, and pumping facilities commensurate with expected flows from each community. Installation of a pipeline from the City of Eureka would include installation of a pipeline below Humboldt Bay using HDD.

Permitting the installation of pipelines is fairly complex, and requires permits from numerous agencies. Most permits take anywhere from 1 to 12 months, but it is assumed that the application process for most permits would occur concurrently. Most permits are required regardless of which portions of the project are implemented, although costs are reduced if the project scope is reduced.

Each individual community would be responsible for costs associated with installation of pipelines from their community. Individual communities also would be responsible for maintaining individual NPDES permits and meeting required effluent standards.

9.5 Outfall

The existing ocean outfall is an approximately 1.5-mile long, 48-inch diameter pipe with 144 diffuser ports. It is currently used to discharge approximately 170,000 gpd of process water from DG Fairhaven Power. The total hydraulic capacity of the outfall is estimated at 40 MGD, for discharges with a salinity less than 30 psu. Expanded use of the outfall will require cleaning and rehabilitation of the existing diffuser ports. Estimated costs for the rehabilitation are presented in Section 7.4.

10.0 References

California Coastal Commission. (August 12, 2015). *Sea Level Rise Policy Guideline: Interpretive Guidelines for Addressing Sea Level Rise in Local Coastal Programs and Coastal Development Permits*. NR:CCC.

California Department of Water Resources. (NR). Integrated Regional Water Management Resources Disadvantaged Communities (DAC) Mapping Tool. Accessed at: http://www.water.ca.gov/irwm/grants/resources_dac.cfm

City of Eureka. (June 2011). *City of Eureka Urban Water Management Plan, 2010 Update.* Eureka, CA:City of Eureka.

---. (2014). *2013 Annual Report.* Eureka, CA:City of Eureka.

Davis, Mackenzie L (2011). *Water and Wastewater Engineering, Design Principles and Practice.* USA:McGraw-Hill.

Google Earth (1990). Samoa, California. Lat: 40.804128° and Long: -124.191471°. Accessed January 2016. NR:Google Earth.

Northern Hydrology & Engineering. (April 2015). *Humboldt Bay: Sea Level Rise, Hydrodynamic Modeling, and Inundation Vulnerability Mapping.* McKinleyville, CA: Northern Hydrology & Engineering.

Integral Consulting Inc. (January 30, 2014). "Potential Reuse of Leachfield." Oakland, CA:Integral.

National Oceanic & Atmospheric Administration. (2015). "NOAA Atlas 14 Point Precipitation Frequency Estimates: CA." Accessed at: http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ca

North Coast Regional Water Quality Control Board. (2009). Order No. R1-2009-0033. Santa Rosa, CA:RWQCB.

---. (2014). Order No. R1-2014-0031. Santa Rosa, CA:RWQCB.

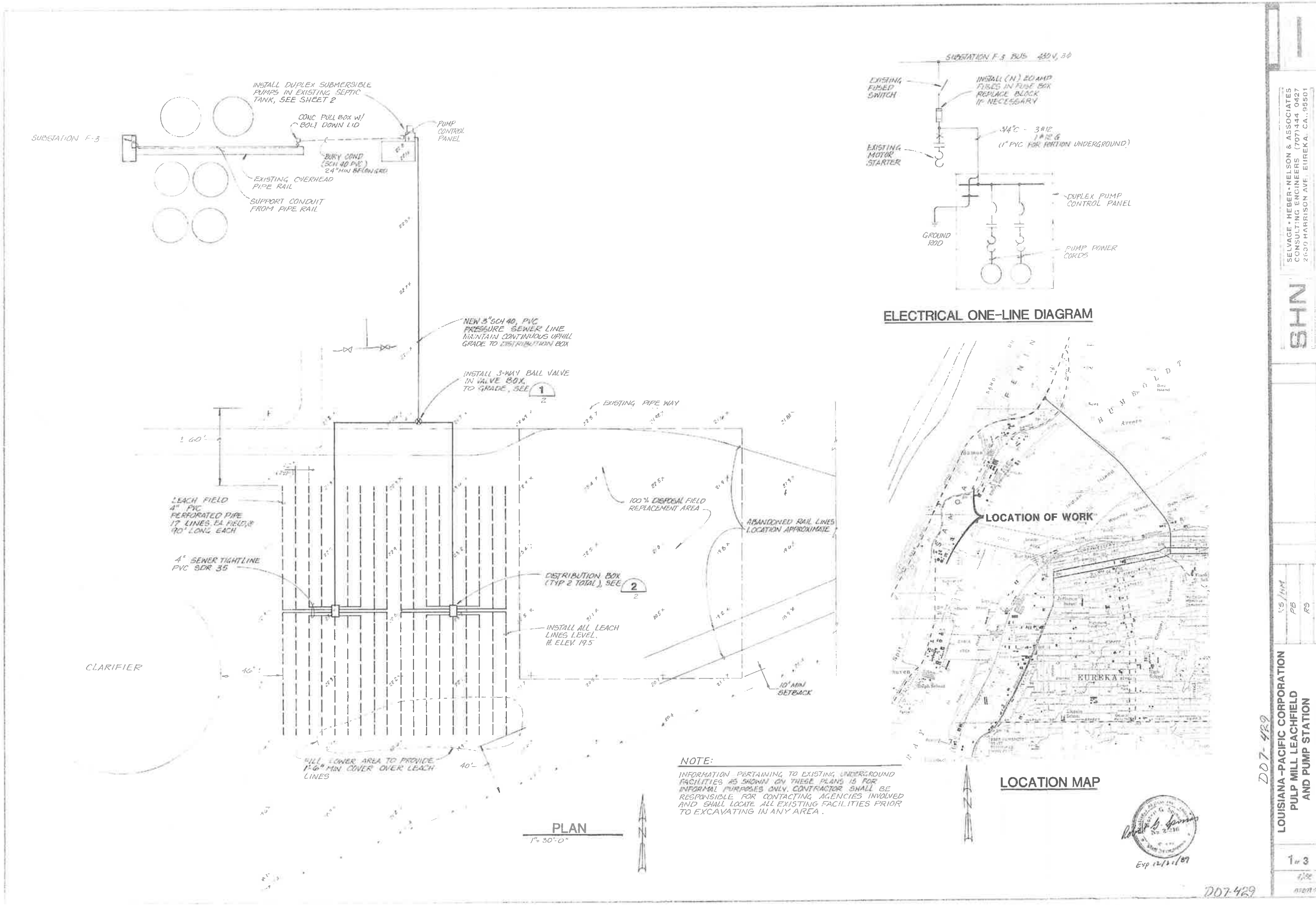
SHN Engineers & Geologists. (March 10, 2015). *Groundwater Modeling Report, Proposed Wastewater Treatment Facility, Samoa, California* Eureka, CA:SHN.

State Water Resources Control Board. (2012). California Ocean Plan 2012. Sacramento, CA:SWRCB. Accessed at: http://www.swrcb.ca.gov/water_issues/programs/ocean/

U.S. Census Bureau. (2015). "State & County QuickFacts," Accessed at: http://quickfacts.census.gov/qfd/states/06/06023.html

A

1988, LP Pulp Mill Plan and Location Drawing


SUBSTATION F-3
INSTALL DUPLEX SUBMERSIBLE PUMPS IN EXISTING SEPTIC TANK, SEE SHEET 2
CONC PULL BOX W/ BOLT DOWN LID
PUMP CONTROL PANEL
BURY COND (SCH 40 PVC) 24" MIN BELOW GRD
EXISTING OVERHEAD PIPE RAIL
SUPPORT CONDUIT FROM PIPE RAIL
NEW 3" SCH 40 PVC PRESSURE SEWER LINE MAINTAIN CONTINUOUS UPHILL GRADE TO DISTRIBUTION BOX
INSTALL 3-WAY BALL VALVE IN VALVE BOX, TO GRADE, SEE 1/2
EXISTING PIPE WAY
LEACH FIELD 4" PVC PERFORATED PIPE 17 LINES EA FIELD, @ 90' LONG EACH
100% DISPOSAL FIELD REPLACEMENT AREA
ABANDONED RAIL LINES LOCATION APPROXIMATE
4" SEWER TIGHTLINE PVC SDR 35
DISTRIBUTION BOX (TYP 2 TOTAL), SEE 2/2
INSTALL ALL LEACH LINES LEVEL. ℄ ELEV. 19.5
CLARIFIER
10' MIN SETBACK
FILL LOWER AREA TO PROVIDE 1'-6" MIN COVER OVER LEACH LINES
NOTE:
INFORMATION PERTAINING TO EXISTING UNDERGROUND FACILITIES AS SHOWN ON THESE PLANS IS FOR INFORMAL PURPOSES ONLY. CONTRACTOR SHALL BE RESPONSIBLE FOR CONTACTING AGENCIES INVOLVED AND SHALL LOCATE ALL EXISTING FACILITIES PRIOR TO EXCAVATING IN ANY AREA.
PLAN
1" = 30'-0"
N
SUBSTATION F-3 BUS 480V, 3Φ
EXISTING FUSED SWITCH
INSTALL (N) 20 AMP FUSES IN FUSE BOX REPLACE BLOCK IF NECESSARY
3/4"C - 3#12 1#12 G (1" PVC FOR PORTION UNDERGROUND)
EXISTING MOTOR STARTER
DUPLEX PUMP CONTROL PANEL
GROUND ROD
PUMP POWER CORDS
ELECTRICAL ONE-LINE DIAGRAM
LOCATION OF WORK
EUREKA
HUMBOLDT
LOCATION MAP
N
SHN
SELVAGE • HEBER • NELSON & ASSOCIATES
CONSULTING ENGINEERS (707) 444 0427
2600 HARRISON AVE. EUREKA, CA. 95501
LOUISIANA-PACIFIC CORPORATION
PULP MILL LEACHFIELD
AND PUMP STATION
PLAN & LOCATION
1 of 3
Exp 12/31/89
D07-429
D07-429

B

HWE Preliminary Review of Existing MicroFloc Treatment System

HEMPHILL water engineering

Memorandum

To:	Mike Foget, PE/SHN Consulting Engineers and Geologists, Inc.		
From:	Brian Hemphill	Project:	Redwood Marine Terminal II
CC:			
Date:	January 15, 2016	Job No:	
Re:	Preliminary Review of Existing Microfloc Treatment System		

INTRODUCTION

This memorandum presents the results of the preliminary inspection of the existing Microfloc industrial wastewater treatment system at the Samoa facility. This is a part of the overall assessment of infrastructure at the site, and development of potential future uses.

A site visit was conducted on September 28, 2015. It consisted of a walk-through of the site and treatment facilities. No internal inspections were completed; these are deferred to a later point at which specific potential uses have been identified and a detailed condition assessment will be required.

SYSTEM DESIGN BASIS

Some of the original design documents were found at the site. These reveal that the system was originally designed in 1966 for the Georgia-Pacific paper mill. A simplified flow schematic of the system is provided in Figure 1 on the following page.

The system includes a chemical feed system; two large clarifiers to settle solids; ten horizontal pressure filters to further remove fine solids; four softeners that remove dissolved solids from filtered water; and a sea water filter intended to produce water to regenerate the softeners. The softening system is designed to treat a portion of the filtered water. The fully softened product is blended with filter effluent, which results in a partially softened water that is suitable for general process requirements.

The system was designed for a nominal capacity of 30 million gallons per day (mgd), which is equivalent to 20,800 gallons per minute (gpm). Peak flow capacity is 25,000 gpm.

Other pertinent design parameters taken from design documentation are provided in Table 1.

FIGURE 1. MICROFLOC TREATMENT SYSTEM SCHMATIC

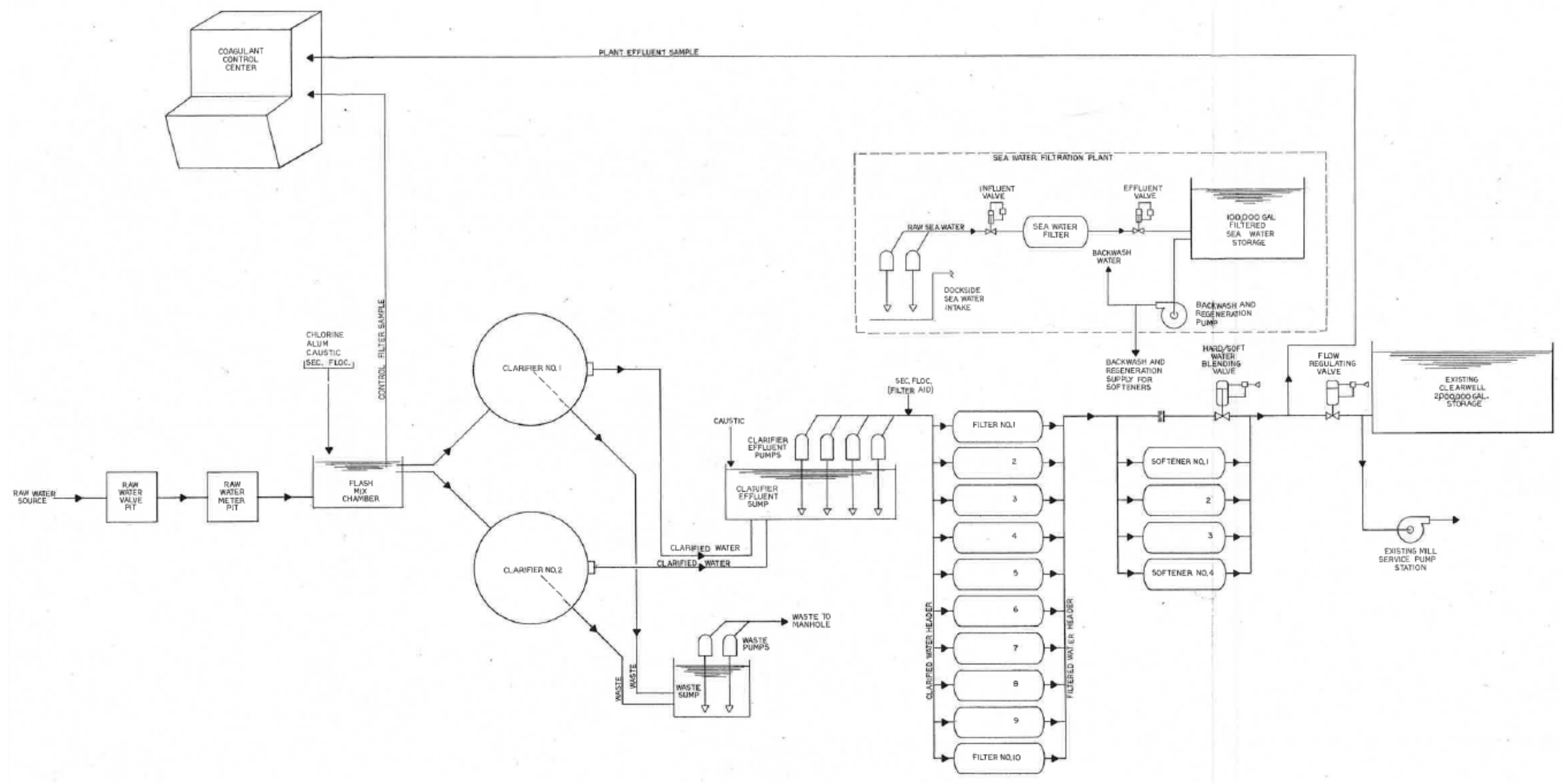


TABLE 1. WATER TREATMENT SYSTEM DESIGN SUMMARY	
PROCESS EQUIPMENT	
Number of Clarifiers	2
Diameter	150 ft.
Sidewater Depth	8.0 ft.
Total Clarifier Surface Area	35,343 sq. ft.
Clarifier Volume, Each	1,470,000 gallons
Number of Filters	10
Filter Dimensions	10' diameter x 37' long
Total Filter Surface Area	3,700 sq. ft.
Design Capacity, Nominal @ Load Rate	20,800 gpm @ 5.6 gpm/ sq. ft.
Design Capacity, Maximum	25,000 gpm @ 6.7 gpm/ sq. ft.

The design documentation states that the design influent loading for the filters was 100 NTU (nephelometric turbidity units), which would typically correspond to about 100 mg/l of suspended solids.

The system employs the method of using filter effluent as the source of backwash water. This avoids the need for a storage tank for filtered water and separate backwash supply pumps, and is common in installations with multiple independent filters. However, this method requires that at least four other filters are operating while another is in backwash, since the required backwash water flow rate is typically 3-5 times the filter effluent flow.

ASSESSMENT OF SYSTEM CONDITION

The system was assessed by means of a walk-through. It is reported to not having been operational since 2008. It was not possible to operate any of the machinery.

The system is equipped throughout with pneumatically-actuated butterfly valves, which is typical for this type of system. It appears that many of the valves are original, and some have been replaced. The piping galleries, valves, and related equipment appear to be in reasonably good condition.

The control system is as supplied in the 1960s, based on electromechanical control devices and pneumatically powered instruments and actuators. The panels appear to be significantly corroded, and it should be assumed that the control devices themselves are no longer serviceable. Even if they were, they are obsolete. Any future operation should assume replacement of the controls and field instruments (such as level and pressure sensors) with modern digital devices.

It was not feasible to inspect the internals of the pressure filters because of difficult access conditions and the requirement to observe confined space entry procedures. It was reported that the filters were in normal service when the plant was shut down in 2008, with the expectation that they would be restarted. It turned out that they were not restarted. It is reasonable to assume that the filter media and underdrain system in the filters are still in operable condition. This would need to be confirmed based on an internal inspection of the tanks and the filter media. It is probably reasonable to assume that most of the valves would be operable following a minor rebuild.

The condition of the softening system is more difficult to assess. The longevity of the resin in the filters is unknown. To be safe, it should be assumed that the resin would be replaced if it is to be used again for softening.

SYSTEM CAPABILITIES

The combination of clarifiers and pressure filters provides a robust treatment system that could produce high quality water from a wide range of contaminated feed streams. This system is designed to remove suspended particles, including very small particles and certain dissolved organic and inorganic substances (such as natural color and dissolved iron and manganese) that can be coagulated or precipitated using chemical treatment such as alum or ferric chloride.

The design surface loading rate of 5.6 gpm/sq. ft. (nominal) is conservative by modern design standards, so the rated capacity of 30 mgd would be valid for most applications.

Specific applications need to be carefully reviewed.

C

CH2M Diffuser Performance Assessment

Final

Diffuser Performance Assessment Report for the Redwood Marine Terminal II Ocean Outfall

Prepared for:

County of Humboldt and
Humboldt Bay Harbor, Recreation and Conservation District

Project Funding Provided by:

HUD Community Development Block Grant 14-CDBG-9890

February 2016

ch2m

2525 Airpark Drive
Redding, CA 96001

Contents

Acronyms and Abbreviations

°C	degrees Celsius
cfs	cubic feet per second
DGPS	differential global positioning system
EPA	U.S. Environmental Protection Agency
ft	feet
fpsec	feet per second
in	inches
m	meters
m/s	meters per second
MGD	million gallons per day
NPDES	National Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
Psi	Pounds per square inch
psu	practical salinity units
TM	technical memorandum

SECTION 1.0

Introduction

CH2M has conducted a planning-level feasibility analysis of the use of the Redwood Marine Terminal II (RMT II) ocean outfall/diffuser system to dispose of process wastewater under varying effluent flow, salinity, and temperature ranges. The Humboldt Bay Harbor, Recreation and Conservation District (HBHRCD) is interested in utilizing the ocean outfall/diffuser system for the purposes of discharging effluent from a variety of possible municipal, commercial, and/or industrial clients. The exact makeup of the future clientele and of the effluent flow and characteristics is not yet fully known.

1.1 Purpose

This Technical Memorandum (TM) provides a planning level feasibility analysis of potential ocean outfall/diffuser performance (port velocities, head loss, and initial dilution) under a range of effluent conditions and diffuser configurations. This information will be used to assess potential future National Pollutant Discharge Elimination System (NPDES) permitting and mixing zone needs. It is anticipated that the range of effluent flows, effluent densities, and diffuser configurations (number of open ports) selected as model inputs will provide a sufficient range of effluent discharge conditions to demonstrate outfall suitability for the majority of potential outfall users.

Ambient receiving water conditions were based on existing receiving water hydrographic profiles collected around the outfall for a previous mixing zone assessment study. The report also documents the input variable selection of the hydraulic and dilution models used in the assessment and the corresponding results demonstrating diffuser performance.

1.2 Background

The headworks of the ocean outfall are located on the Samoa Peninsula between Humboldt Bay and the Pacific Ocean near Eureka in Humboldt County, California (Figure 1). The outfall was formerly used to discharge approximately 15 million gallons per day (MGD) of treated industrial wastewater from the Evergreen Pulp Mill into the Pacific Ocean (Figure 2). A detailed description of the outfall and diffuser and provided in Section 2.1. At the time this TM was produced, the pulp mill facility was no longer in operation and the outfall was being used to dispose of less than 200,000 gallons per day of industrial process water from the DG Fairhaven Power Plant.

The HBHRCD is the current owner of the outfall, headworks, former Evergreen facility, and associated property. The HBHRCD has received HUD Community Development Block Grant funding to investigate potential future uses of the land, facilities, and outfall system. Possible uses include aquaculture/mariculture, consolidation of regional wastewater treatment plant effluent for disposal, temporary decanting and drying of dredge spoils, and industrial clients. This TM examines the performance of the ocean outfall's diffuser under the range of effluent flows and densities that could be anticipated with these potential discharges.

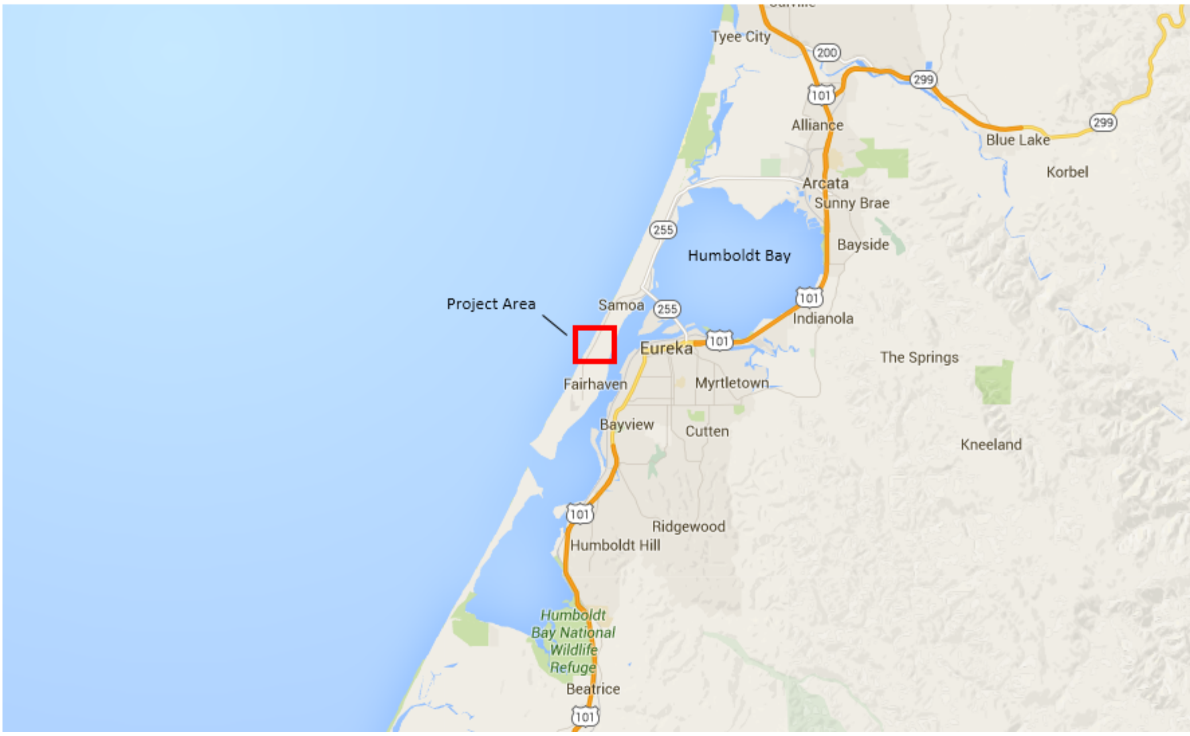


Figure 1. A map of the general area near Eureka, California, where the ocean outfall, outlined in red, is located.

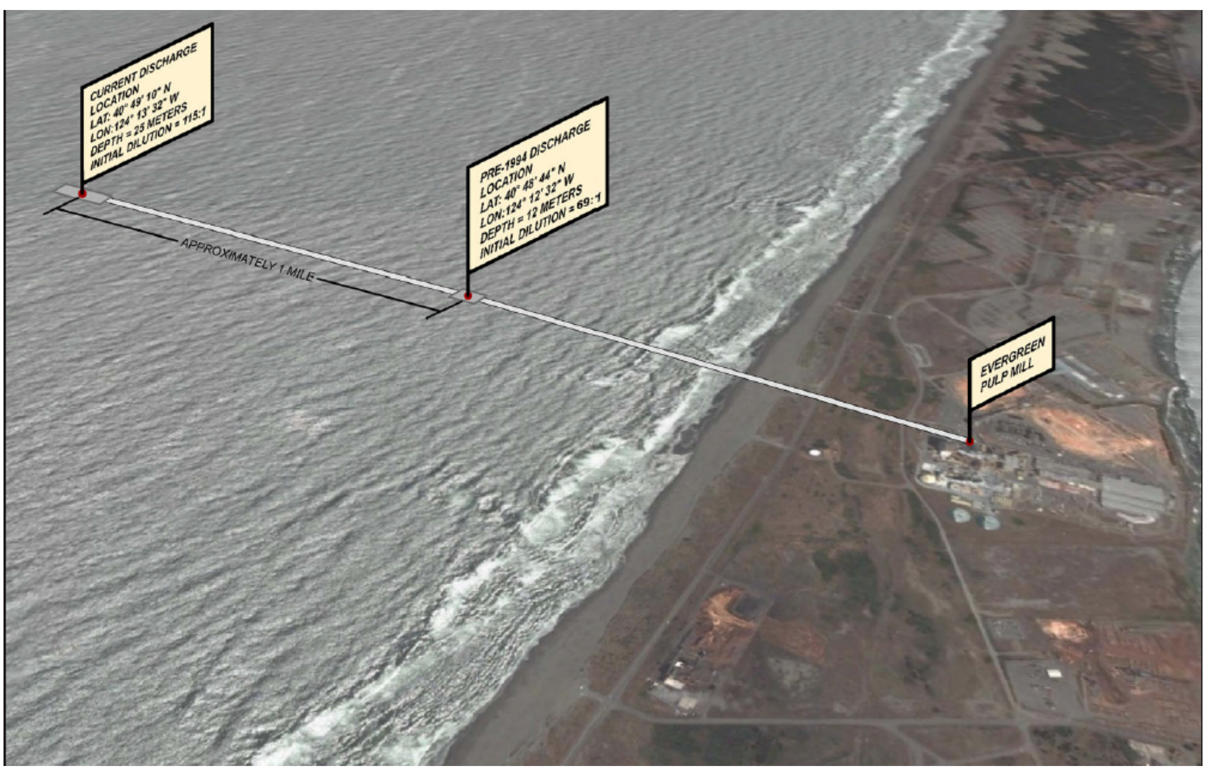


Figure 2. A picture of the location of the RMT II ocean outfall and diffuser.

1.3 Approach

The approach to evaluating the effectiveness and performance of an outfall/diffuser system used in this TM involves the following:

- Define the physical attributes of the existing outfall and diffuser system.
- Characterize the receiving water physical properties needed to evaluate diffuser performance.
- Characterize the effluent flow and properties of the potential discharge.
- Evaluate expected port velocities required to conform to the regulatory requirements of a high rate diffuser and the corresponding head required for the flow ranges considered. The model selected for use is CH2M's HYDRO model.
- Evaluate the expected dilution performance that such an outfall/diffuser system would provide using an initial dilution model. The model selected for use is the U.S. Environmental Protection Agency's UDKHDEN model.

1.4 Scope and Limitations

This TM is a planning-level feasibility evaluation. At the time of this analysis, the expected daily flow rate is unknown and will be dependent on the combined volume of future clients. In addition, the effluent density will be dependent on waste flows potentially from both freshwater and seawater effluent streams. As a result, a range of various effluent flows and salinities was modeled to allow greater flexibility in the utility of modeled results. Receiving water data needed for the model input came from existing data sets and no new field measurements were collected.

This document provides the rational for model input variable selection, model inputs used, and corresponding dilution and mixing zone dimensions. Calculation of parameter specific dilution is not addressed here and is dependent on effluent and receiving water concentrations of the specific parameter of interest. However, based on known effluent flow rate and density, the modeled dilution closest to the conditions of interest can be used to calculate final dilution or compare dilution required to predicted available dilution.

SECTION 2.0

Model Selection and Input Requirements

The hydraulics of the existing diffuser were modeled using CH2M's HYDRO model for multiport diffusers. The results of this model provide the flow distributions through the ports and the head loss through the diffuser under varying effluent flows and numbers of open ports. The EPA's initial dilution model UDKHDEN was used to predict diffuser dilution performance. The model predicts the initial dilution and plume trapping level (depth below the surface) for each flow and port configuration considered. The dilution model also provides the Froude number (Frρ) for use in assessing seawater intrusion (back flooding and clearing requirements) and potential port wear. The remainder of this section addressed the model input data requirements for the models and values selected.

2.1 Outfall and Diffuser Description

The on-shore end of the outfall is located on the narrow North Spit of the Samoa Peninsula between the coast of the Pacific Ocean and the north arm of Humboldt Bay (Figure 1). Effluent would be discharged through an existing submerged outfall that is approximately 8,200 feet (2,497 m) long and terminates in an 852-foot (258-meter) multiport diffuser aligned perpendicular to the shoreline. The diffuser contains a total of 144 ports, each with a diameter of 2.4 inches Ports are paired, so that there are 72 ports on each side of the barrel (pipe) with a spacing of 12 feet (3.66 m) on center between ports (Figure 3). The diffuser has a 36-inch (0.91-m) internal diameter, and its ports discharge at a 45-degree vertical orientation, as shown on Figure 4. The diffuser is approximately 82 feet (25 meters maximum depth) below the surface.

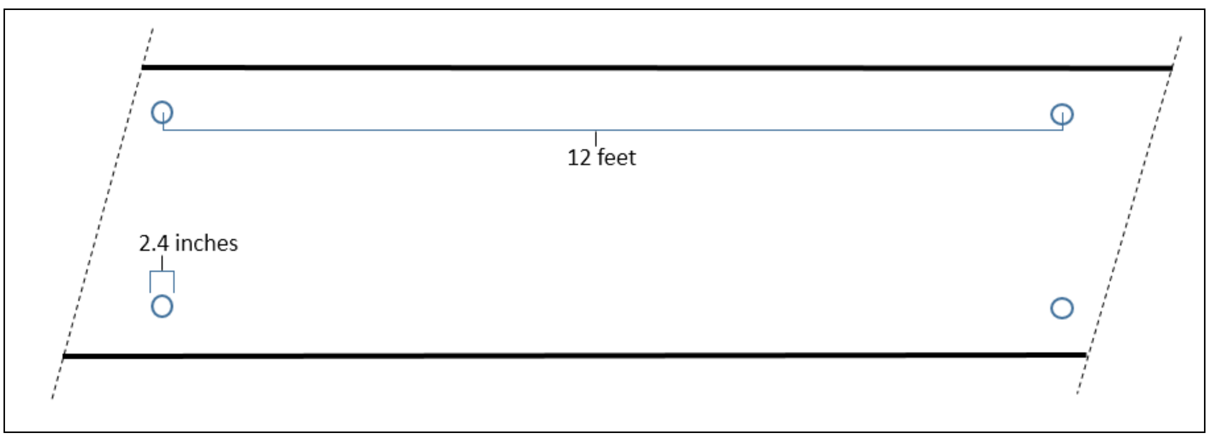


Figure 3. A plan view diagrams of a section of the diffuser showing port pairing, diameter, and spacing.

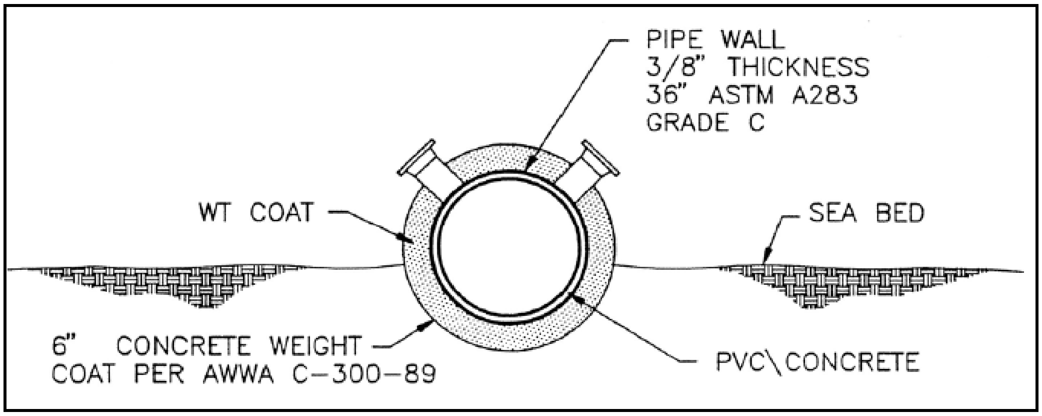


Figure 4. A diagram of the pipeline and diffuser cross-section showing pipe diameter and port orientation.

Model input variables use to characterize the diffuser include the following:

- Pipe diameter= 36-inch (0.91 m)
- Port diameter= 2.4-inch (0.06 m)
- Port elevation= 3.9 inches (0.01 m)
- Vertical Angle= 0
- Horizontal angle= 45 degrees (also exits at 135 degrees)
- Number of ports= 144 (72 on left side of pipe and 72 on right side in parallel)
- Port Spacing= 12 ft (3.66 m)
- Ave. port depth= 79 ft (24 m; range 22.9 to 25.0 m)

2.2 Receiving Water Hydrographic Data

In 2007, CH2M performed a study of the dissolved oxygen (DO) and sediment effects of the outfall discharge when the outfall was used by Evergreen Pulp, Inc[1]. As part of that study, CH2M reviewed existing data records of hydrographic data collected in the vicinity of the outfall. Because that data had only limited utility for model application, CH2M also performed two field sampling surveys to collected higher quality, site-specific hydrographic data. A series of profiles and current measurements were collected in June and October 2007. No additional hydrographic profile or current data from the outfall is known to have been collected since this study. The data collected in 2007, representing two seasons and providing profile data from the depth of the diffuser to the surface, is considered the best available data and was therefore selected to be representative of ambient conditions for the purposes of model input data.

The profiles screened for use in the dilution model to represent ambient receiving water (seawater) conditions are provided in Attachment 1 and include density profiles, temperature profiles, and salinity profiles. The temperature and salinity data of Cast 1 from June 2007 were used for dilution modeling. This is the same profile used for dilution modeling in the 2007 Dissolved Oxygen study footnoted above. Salinity and temperature values used in the model are provided in Table 1.

[1]CH2M. *2007 Receiving Water Monitoring Report – Evaluation of Dissolved Oxygen and Sediment Effects*. Prepared for Evergreen Pulp, Inc. Prepared by CH2M. December 2007.

Table 1. Salinity and Temperature Data Selected for the Dilution Model.

Depth* m	Salinity psu	Temperature °C	Depth* m	Salinity psu	Temperature °C
0	33.85	10.95	13	34.02	9.99
2	33.85	10.95	14	34.03	9.96
3	33.91	10.66	15	34.03	9.95
4	33.97	10.43	16	34.04	9.94
5	33.98	10.27	17	34.04	9.94
6	34.00	10.18	18	34.03	9.94
7	34.01	10.12	19	34.03	9.93
8	34.02	10.07	20	34.04	9.89
9	34.02	10.04	20	34.04	9.89
10	34.03	10.01	21	34.05	9.80
11	34.03	10.02	22	34.08	9.64
12	34.03	10.01	24	34.08	9.64

* Depth below the surface.

2.2.1 Current Speed and Direction

During the 2007 dissolved oxygen study hydrographic profiling field event, current speed was estimated using speed and direction data recorded from drogue tracking. The depth averaged current speed was reported as 0.072 m/s. Drogue tracking data from the 2007 study are provided in Attachment 2. Coastal currents along the northern Californian coast generally trend southward and are dominated by the California Current (Figure 5). Although there can be near-shore counter-currents, the general current trend along the North Spit of the Samoa Peninsula would be expected to be parallel to the coastline which runs roughly north-south. The diffuser extends into the ocean perpendicular to the coastline which would result in currents running perpendicular to the diffuser (an angle of 90 degrees to the diffuser barrel).

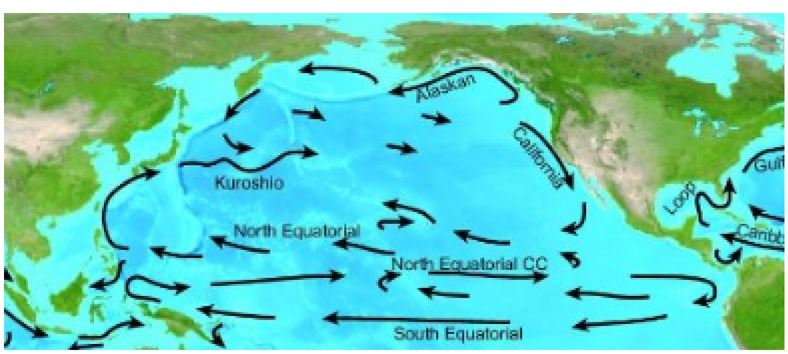


Figure 5. A map of ocean current directions (NOAA).

Model input variables use to characterize the ambient currents include the following:

• Current speed	0.072 m/s
• Current direction	90 degrees (to diffuser)

2.3 Effluent Characteristics

Effluent flow, salinity, and temperature are required by the initial dilution model. Effluent volume (flow) and density (salinity and temperature) will depend on the wastewater contributors with which the HBHRCD partners to use the outfall.

Discharge through the diffuser is controlled by pipe diameter, port size, port discharge rate (port velocity), and the number of available ports. The maximum port diameter and number of ports are fixed at 2.4 inches and 144 ports, respectively. A minimum port velocity of 10 fps is generally required by the permitting agencies to meet the definition of a high rate diffuser. Port velocity can be calculated as follows:

Port velocity (per port) = flow (cfs) / total port area (in sq ft).

For example, using the existing port diameter with all ports open would yeild:

At 25 MGD (38.6817 cfs), 2.4 inch ports (0.2 ft), and 144 open ports would yield

Port velocity = 38.6817 cfs/(PI x (0.2 ft/2)^2) x 144) = 8.55 fps

At 30 MGD (46.4181 cfs), 2.4 inch ports (0.2 ft), and 144 open ports would yield

Port velocity = 46.4181 cfs/(PI x (0.2 ft/2)^2) x 144) = 10.26 fps

A table of port velocity vs. flow and number of ports is provided in Attachment 3. A summary of required number of open ports to achieve target port velocities at selected flow increments are provided in Section 3. Flow was modeled incrementally at 1, 5, 10, 15, 20, 25, 30, 35, and 40 MGD.

Dilution occurs as the effluent plume disperses after exiting the diffuser. Dilution is increased as the plume rises through the water column. Plume properties that increase plume rise, such as lower salinity and increased temperature compared to the receiving water, increase dilution. Conversely, effluent salinity and temperature that are similar to the receiving water salinity and temperature would reduce dilution. Effluent with a density greater than the receiving water could significantly reduce dilution and result in the plume contacting the seabed which can increase the complexity of NPDES permitting.

A series of effluent temperatures was selected ranging from 10°C (ambient seawater) to 25°C (potential industrial wastewater). Salinity input data ranged from 0.1 psu (predominantly freshwater) to 30 psu (predominantly seawater).

Model input variables use to characterize the effluent include the following:

• Flow	1, 5, 10, 15, 20, 25, 30, 35 and 40 MGD
• Temperature	10, 15, 20, 25, and 30 °C
• Salinity	0.1, 1, 10, 20, and 25 psu

SECTION 3.0

Model Results

3.1 Port Velocity

The number of open ports on the diffuser controls the velocity of flow through each port. A high-rate diffuser is commonly defined by regulatory agencies as a diffuser with port velocities of ten feet per second or greater. However, port velocities in excess of roughly fifteen feet per second (fps) or greater can result in damage to the diffuser pipe and ports. As a result, the range of port velocities targeted in this study were between ten and fifteen feet per second.

Port velocities and the range of open ports ranging from numbers 1 to 144 (1 to 72 ports showing each port and 74 to 144 at paired port intervals) are provided for the selected flows (1, 5, 10, 15, 20, 25, 30, 35, and 40 MGD) in Attachment 3. Figure 6 provides a plot of port velocity (in MGD) vs. number of open ports for each flow increment. Boundaries for 10 and 15 fps are indicated. A summary of the range of open ports for each flow increment is provided in Table 2. It is noted that when the flow rate is held constant, port velocity decreases as additional ports are opened. This range of ports is then used to model head loss, Froude number, and dilution.

Table 2. Ranges of Port Velocities and Open Ports for Select Flows.

Flow Rate	Calculated Port Velocity Range	Range of Open Ports
MGD	fps	count
1	9.85 to 16.42	5 to 3
5	10.26 to 15.39	24 to 16
10	10.05 to 14.92	49 to 33
15	9.98 to 15.08	74 to 49
20	10.05 to 14.92	98 to 66
25	10.09 to 15.02	122 to 82
30	10.26 to 15.08	144 to 98
35	11.97 to 15.12	144 to 114
40	13.68 to 14.92	144 to 132
45	>15.39	144

Table 2 provides averaged port velocities. Minor variation in individual ports is expected and the variation increases with the number of open ports. In addition, differences in density (that is temperature and salinity) can also generate minor differences in port velocity. The model HYDRO was used to evaluate individual port velocities and assess variation attributed to temperature and salinity for the ranges considered in this TM. Attachment 4 provides the summary of minimum, maximum, and average port velocities for 0.1 psu and 30 psu and 10°C and 25°C cases for each flow rate. At the maximum flow rate (40 MGD) and greatest temperature and salinity, the variation in port velocity was less than 6 percent of the average port velocity.

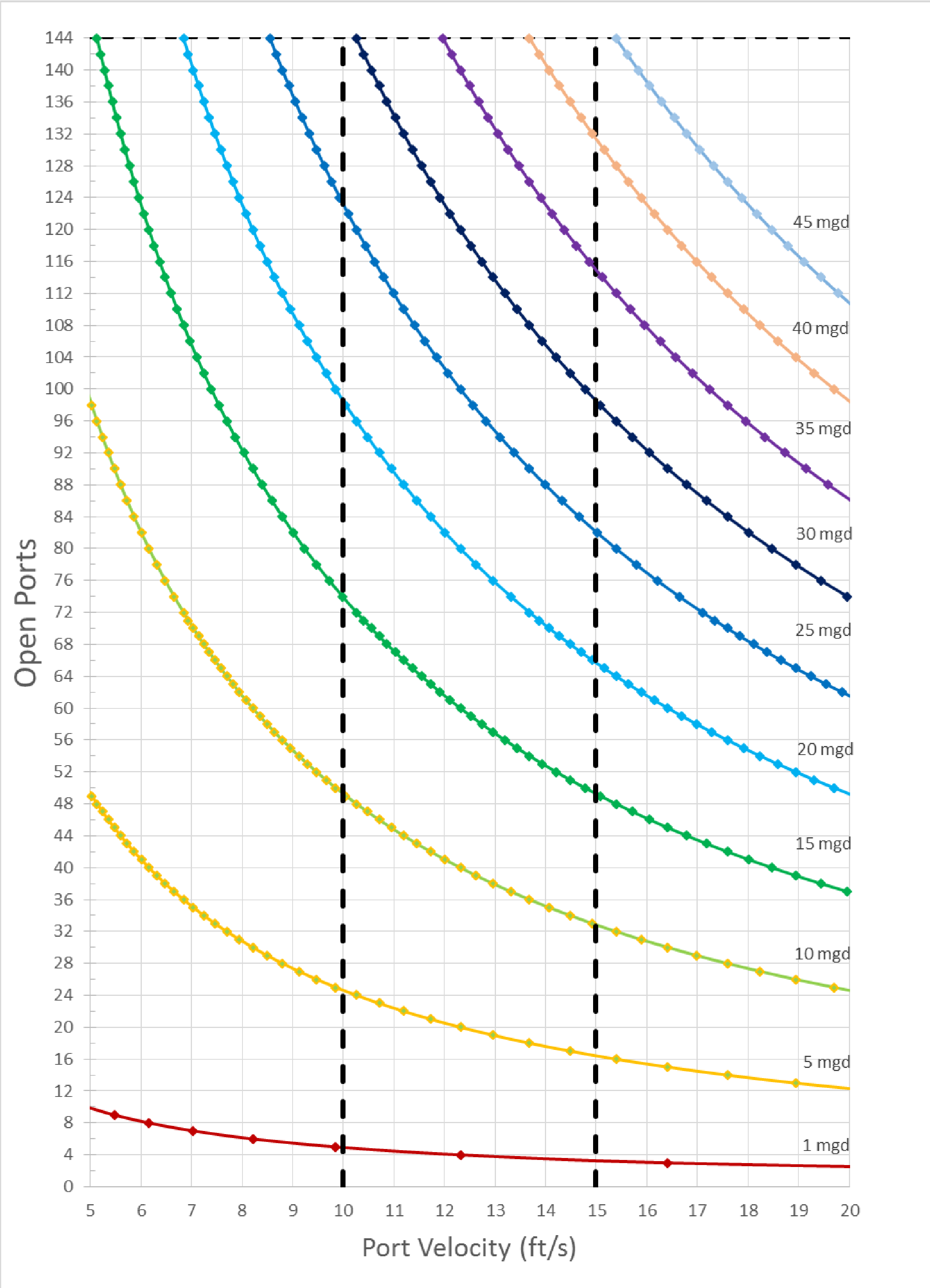
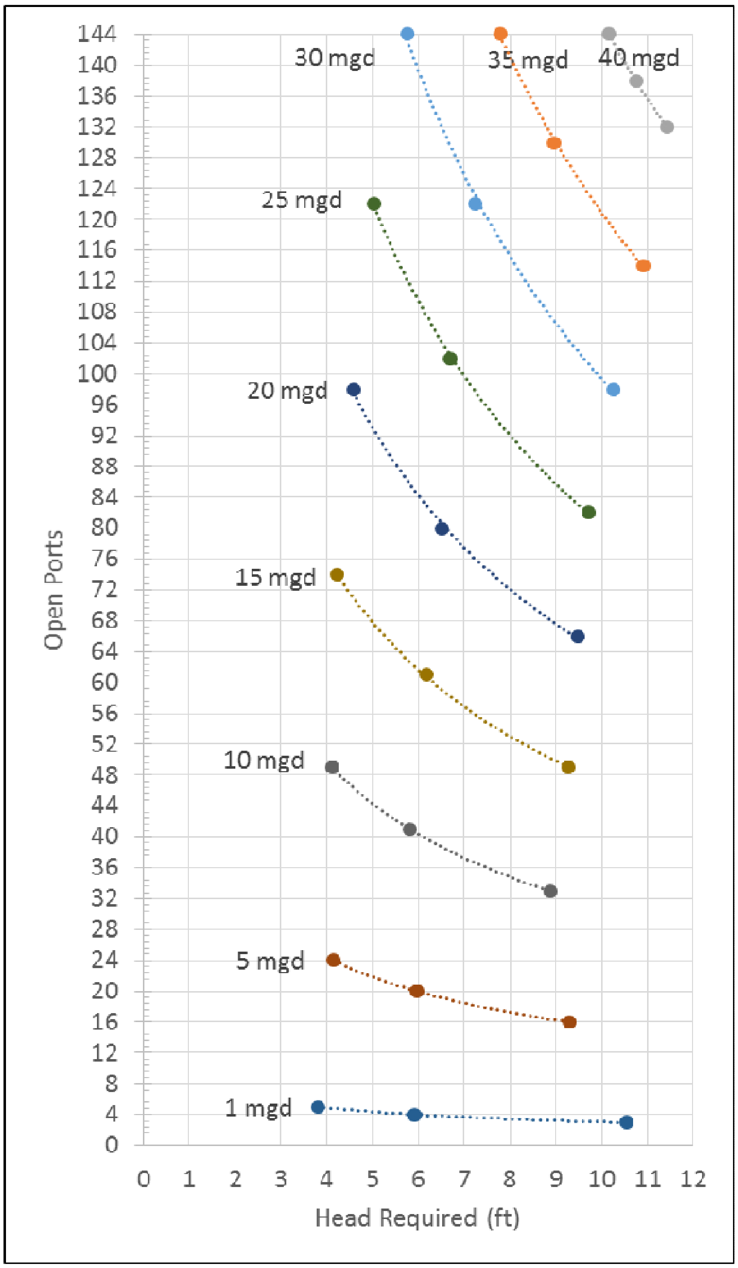


Figure 6. Port Velocities vs. Open Ports for Modeled Flow Increments.

3.2 Head Loss

The model HYDRO was used to calculate head loss (required head) for the flow, salinity, and temperature cases assessed. Variation in head loss attributed to temperature and salinity for a given discharge rate where insignificant at less than 0.02 feet (see Attachment 4 for individual values). Figure 7 provides the required head and pressure based on flow increments modeled.



Flow (MGD)	Open Ports	Head (feet)	Pressure (psi)
1	3	10.55	4.57
	4	5.93	2.57
	5	3.80	1.65
5	16	9.30	4.03
	20	5.97	2.58
	24	4.15	1.80
10	33	8.87	3.84
	41	5.81	2.52
	49	4.12	1.78
15	49	9.27	4.01
	61	6.17	2.67
	74	4.22	1.83
20	66	9.47	4.10
	80	6.51	2.82
	98	4.58	1.98
25	82	9.72	4.21
	102	6.69	2.90
	122	5.04	2.18
30	98	10.26	4.44
	122	7.25	3.14
	144	5.75	2.49
35	114	10.90	4.72
	130	8.97	3.88
	144	7.78	3.37
40	132	11.42	4.94
	138	10.74	4.65
	144	10.15	4.39

Figure 7. Required Head and Pressure for Model Flow Rates

3.3 UDKHDEN Model Results

Dilution modeling was performed for a range of flows up to 40 MGD starting at 1 MGD and increasing at 5 MGD increments from 5 to 40 MGD. The maximum flow of 40 MGD was selected based both on port velocity assessment and the hydraulic limitation of the diffuser with all ports open. For each flow increment, three diffuser configurations (number of open ports) were selected to bracket target port velocities. The number of open ports that yielded port velocities closest to 10 fps and 15 fps, respectively (refer to Table 2), and a port configuration of approximately midway between the two selected. For each flow increment and port configuration, salinity and temperature were varied to provide a representative range of effluent densities. As described above, salinity increments consisted of 0.1, 1, 10, 20, and 30 psu and temperature ranges consisted of 10, 15, 20, and 25ºC.

A total of 520 model runs were performed. Individual model run outputs are provided on CD. Model run name, flow, number of ports, salinity, temperature, port spacing, and resulting Froude number, trapping level, and dilution are listed in Attachment 5. Mixing zone size associated with a given model run are included in the model output files but were not summarized for this planning level study.

Effluent salinity has a more significant effect on dilution than does temperature at the ranges selected. Therefore data assessment and data presentation are in terms of dilution vs salinity. A summary of the range of open ports, trapping levels, and dilution that could be expected for a given flow under modeled salinity ranges are provided in Table 3. Graphical representation of the modeled dilution for each salinity and temperature range are provided in Figures 8 through 16.

High-rate diffusers are generally designed to provide at least a 100:1 dilution. As shown in Table 3, dilution decrease as effluent flow increases. At the coldest temperature (10°C) and highest salinity (30 psu), dilution falls below 100:1 and becomes dependent on the number of open ports.

Table 3. Modeled Dilution

Flow MGD	Range of Open Ports	Salinity (psu)	Trapping Level Below the Surface (m)			Plume Dilution		
1	3 to 5	0.1	7.27	to	9.21	589.71	to	856.94
		1.0	7.36	to	9.28	588.40	to	846.95
		10.0	8.39	to	13.36	529.80	to	673.25
		20.0	13.22	to	19.09	245.68	to	497.23
		30.0	20.05	to	21.26	88.63	to	150.01
5	16 to 24	0.1	7.46	to	9.12	618.76	to	828.38
		1.0	7.53	to	9.23	615.31	to	821.22
		10.0	8.59	to	13.29	556.56	to	773.21
		20.0	13.37	to	18.77	256.65	to	509.42

Table 3. Modeled Dilution

Flow MGD	Range of Open Ports	Salinity (psu)	Trapping Level Below the Surface (m)			Plume Dilution		
		30.0	20.15	to	21.23	91.85	to	147.09
10	33 to 49	0.1	7.50	to	9.20	635.25	to	837.35
		1.0	7.57	to	9.29	630.05	to	833.68
		10.0	8.83	to	13.32	569.13	to	787.04
		20.0	13.43	to	19.01	246.46	to	498.27
		30.0	20.17	to	21.24	92.79	to	150.88
15	49 to 74	0.1	6.93	to	8.53	507.07	to	755.90
		1.0	6.95	to	8.67	503.93	to	745.80
		10.0	7.80	to	9.64	468.50	to	681.17
		20.0	12.99	to	15.15	309.60	to	465.92
		30.0	20.12	to	21.16	86.65	to	143.14
20	66 to 98	0.1	6.36	to	7.69	434.10	to	644.17
		1.0	6.41	to	7.81	432.76	to	641.09
		10.0	7.37	to	9.29	405.10	to	587.73
		20.0	9.28	to	13.92	271.59	to	423.55
		30.0	19.70	to	21.08	77.77	to	134.27
25	82 to 122	0.1	5.82	to	7.16	375.82	to	512.68
		1.0	5.85	to	7.22	374.65	to	509.58
		10.0	6.82	to	8.53	349.13	to	481.57
		20.0	8.70	to	13.60	273.81	to	421.40
		30.0	19.20	to	21.08	73.65	to	115.66
30	98 to 144	0.1	5.80	to	7.11	375.71	to	505.22
		1.0	5.85	to	7.22	373.77	to	503.33
		10.0	6.78	to	8.36	349.05	to	474.43
		20.0	8.54	to	13.57	273.38	to	368.46
		30.0	19.20	to	21.09	73.51	to	115.80
35	114 to 144	0.1	6.07	to	6.70	411.10	to	450.67
		1.0	6.20	to	6.77	408.98	to	448.27
		10.0	7.15	to	7.75	382.83	to	421.74
		20.0	9.12	to	13.21	276.26	to	371.38
		30.0	19.45	to	21.01	75.51	to	113.41
40	132 to	0.1	5.79	to	6.29	377.53	to	410.62

Table 3. Modeled Dilution

Flow MGD	Range of Open Ports	Salinity (psu)	Trapping Level Below the Surface (m)			Plume Dilution		
	144	1.0	5.90	to	6.39	374.83	to	407.20
		10.0	6.81	to	7.48	350.25	to	385.10
		20.0	8.54	to	9.67	305.93	to	341.44
		30.0	19.21	to	20.86	73.86	to	108.14

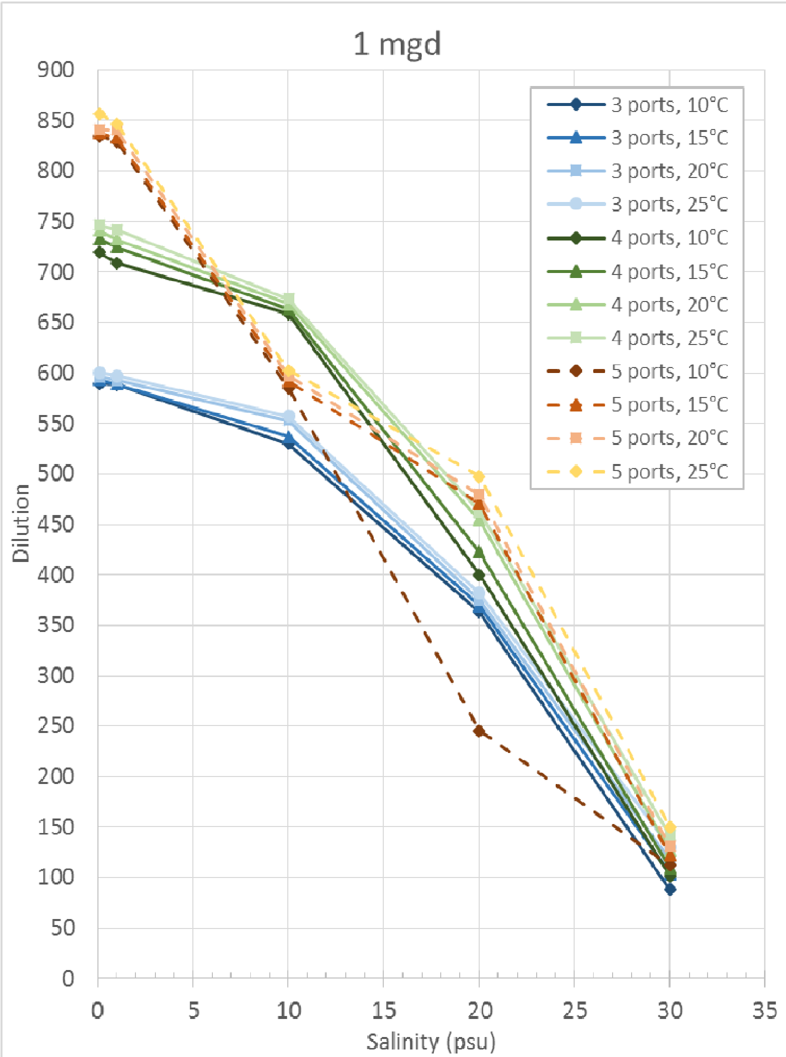


Figure 8. Dilution vs. Salinity for Selected Open Ports at 1 MGD.

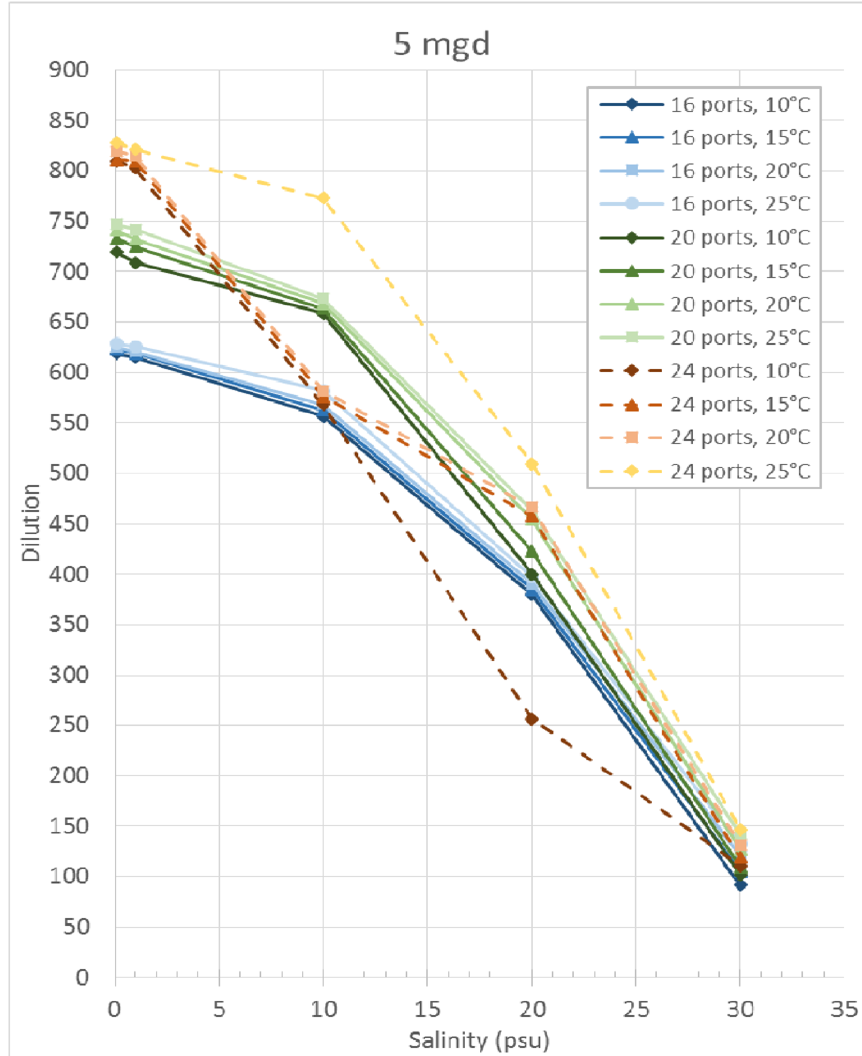


Figure 9. Dilution vs. Salinity for Selected Open Ports at 5 MGD.

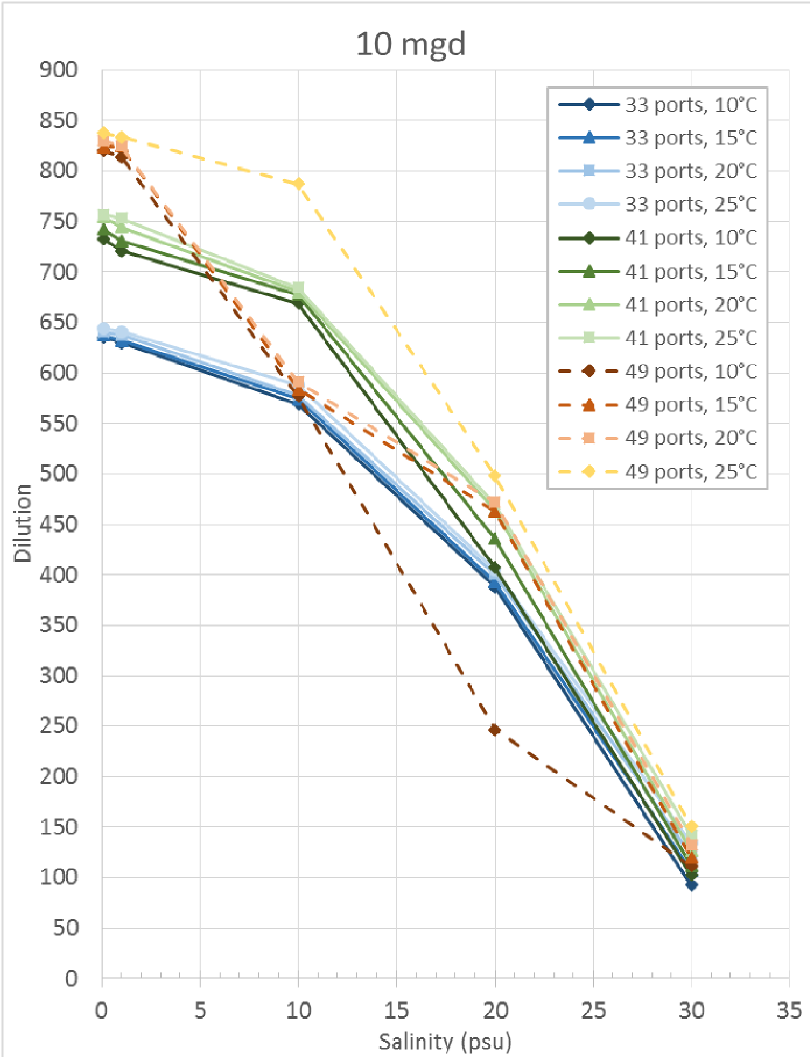


Figure 10. Dilution vs. Salinity for Selected Open Ports at 10 MGD.

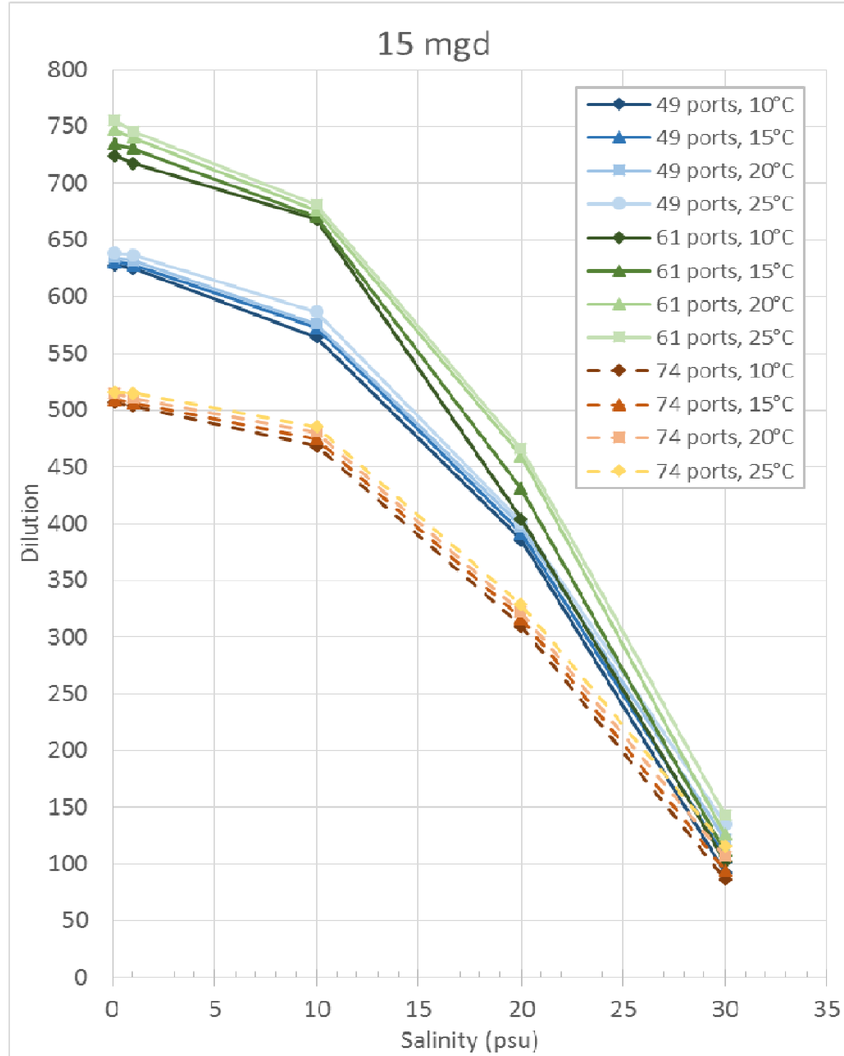


Figure 11. Dilution vs. Salinity for Selected Open Ports at 15 MGD.

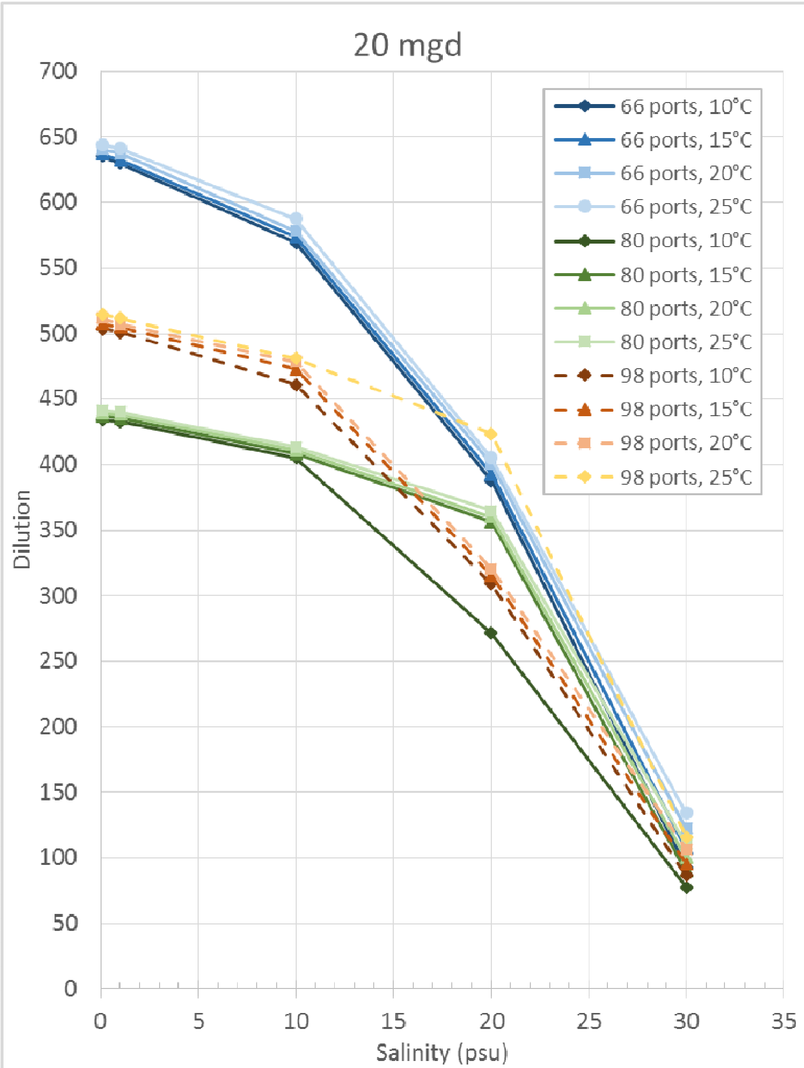


Figure 12. Dilution vs. Salinity for Selected Open Ports at 20 MGD.

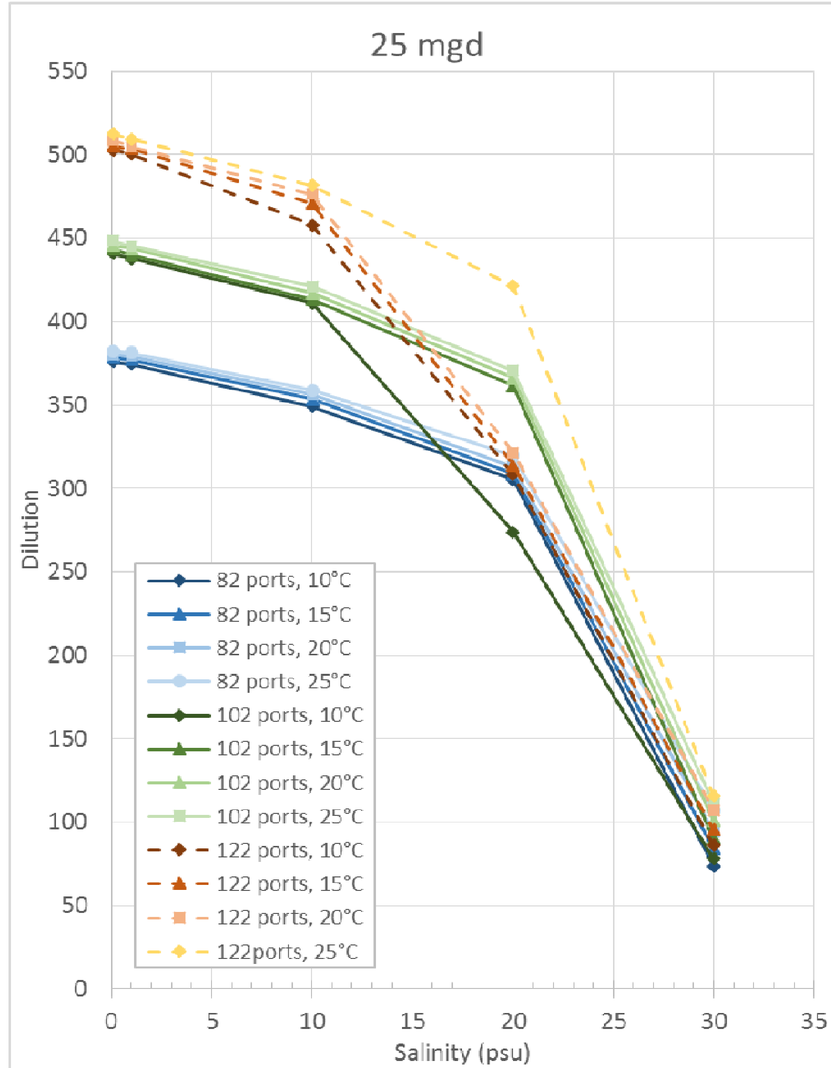


Figure 13. Dilution vs. Salinity for Selected Open Ports at 25 MGD.

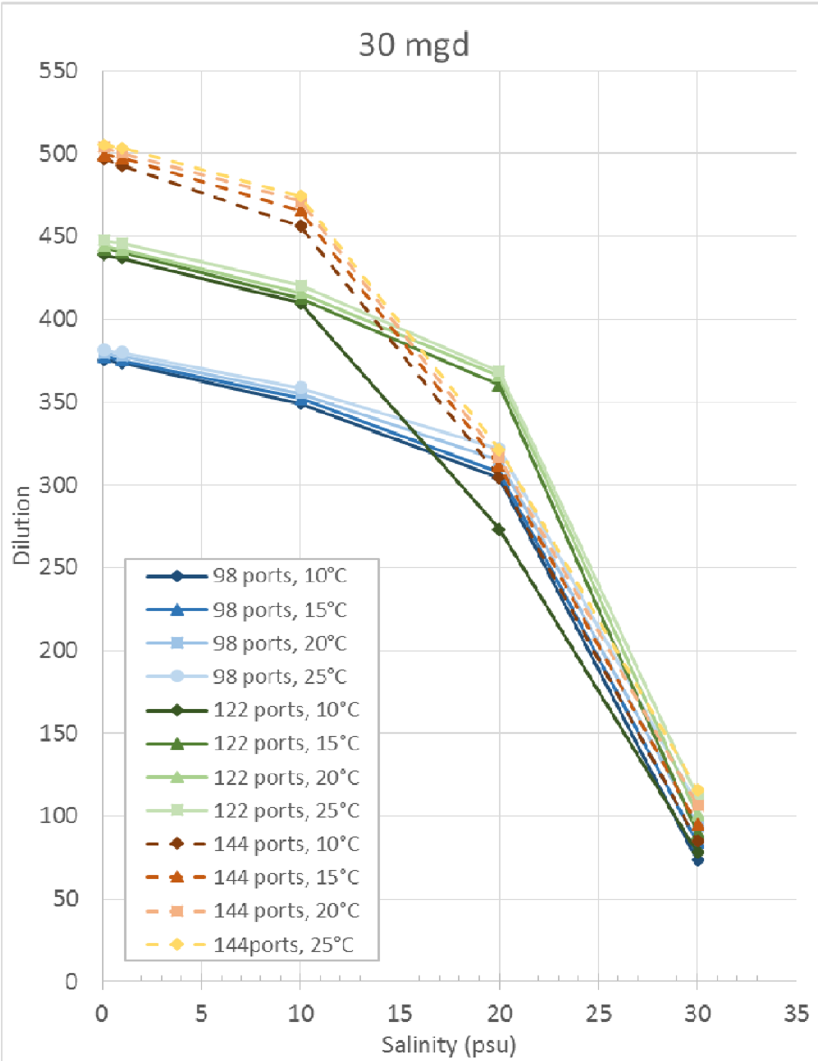


Figure 14. Dilution vs. Salinity for Selected Open Ports at 30 MGD.

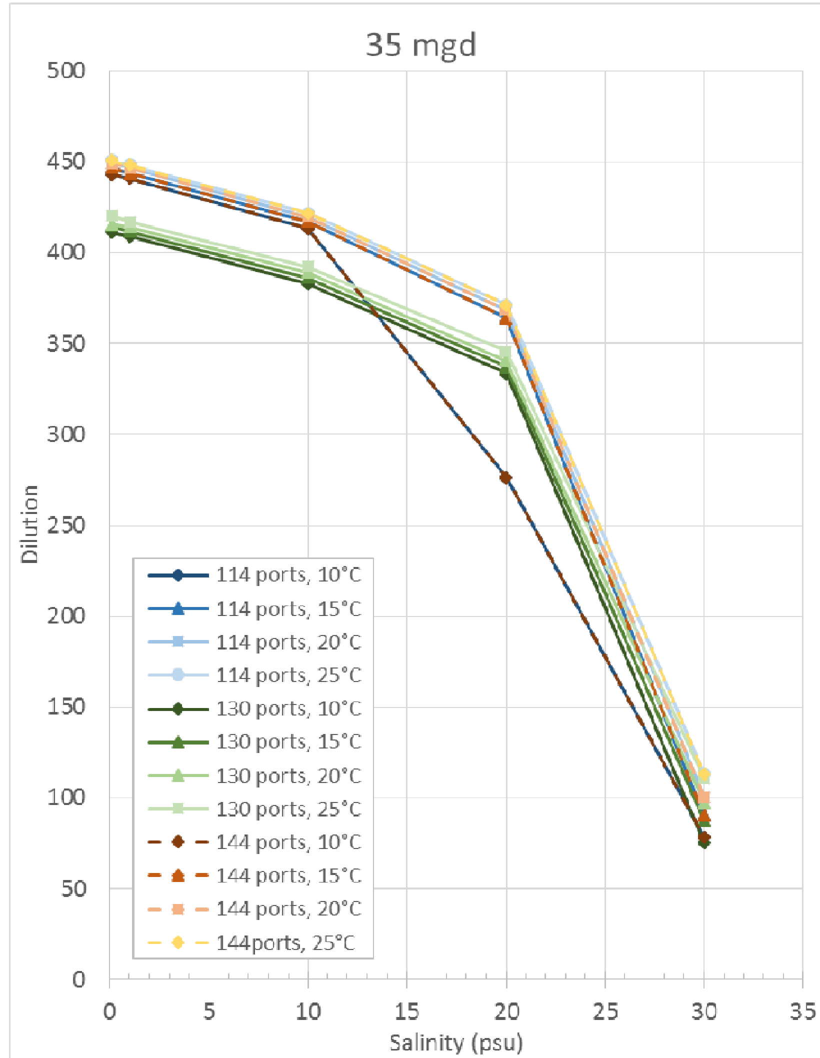


Figure 15. Dilution vs. Salinity for Selected Open Ports at 35 MGD.

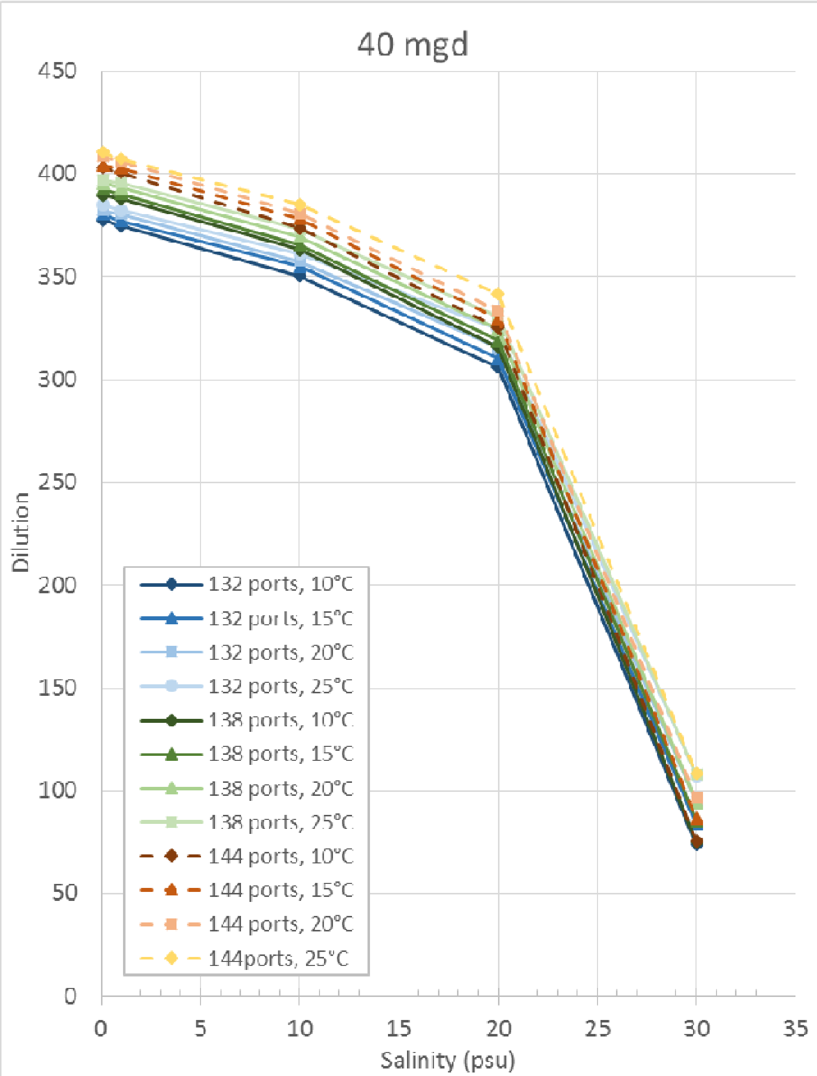


Figure 16. Dilution vs. Salinity for Selected Open Ports at 40 MGD.

SECTION 4.0

Discussion and Recommendations

The capacity of the Samoa Peninsula outfall is defined by pipe diameter, number of available diffuser ports, and port diameter. Available dilution capacity is controlled by effluent flow rate and density. Detailed modeling was performed to assess dilution performance based on varying effluent flow, salinity, and temperature. Key findings include:

- Hydraulic assessment indicates the outfall can discharge up to 40 MGD based on 144 2.4-inch ports, however effluent with a higher salinity content will reduce dilution.
- Targeted diffuser port velocities (10-15 fps) are achievable for flows between 1 and 40 MGD under existing diffuser design by establishing a port opening schedule.
- Required head for the target port velocities evaluated ranged from 3.8 to 11. 4 feet (1.65 to 4.94 psi).
- Dilution decreases with increased flow, but target dilution of greater than 100:1 was easily achieved for flows up to 40 MGD for all conditions evaluated with the exception of effluent salinity of 30 psu. At this salinity, lower dilution must be accepted at some conditions.
- Dilution increases with increased effluent temperature. Effluent temperatures approximating receiving water temperatures provided significantly lower dilution than temperatures above that of the receiving water when salinities were greater than 10 psu.
- Dilution decreases with increased effluent salinity. A target dilution of greater than 100:1 is easily achieved for the range of flows evaluated with salinities up to 20 psu. Salinities between 20 and 25 psu, while not specifically modeled, appear to maintain dilution greater than 100:1 under flow and temperature regimes tested based on trend line analysis. Salinities of 30 psu start to fall below the target dilution of 100:1 as effluent temperature decreases.
- Salinities between 30 and 35 psu (full strength seawater) can be discharged from the outfall, but dilution would be lower than that expected for the regulatory definition of a high rate diffuser. For example, effluent at 5 MGD at 32 psu at 15°C would yield a dilution of 84:1. If all effluent parameters met end of pipe water quality standards, that is, did not require a mixing zone, straight seawater could be discharged for purely disposal purposes.

Modeling was performed based on existing hydrographic profile data and current speed data collected in the vicinity of the outfall. Prior to applying for an NPDES permit for the outfall, it is recommended that additional hydrographic profiles and higher quality current data be collected. The hydrographic profile used in this study was representative of ambient conditions, but may not represent the critical conditions that would yield the lowest dilution for regulatory purposes. It is recommended that additional hydrographic profiles (conductivity, temperature, and pressure to calculate density, salinity, and depth) be collected over a time frame encompassing seasonal variation to establish a critical density profile. Further, it is recommended that an acoustic Doppler current profiler (ADCP) be placed in the vicinity of the outfall to collect current speed and direction data at various seasonal increments recording data for a minimum of 24 hours during each deployment to capture the full range of tidal variation. Dilution modeling should be performed again once better resolution of the nature of the effluent and the receiving water is available.

Attachment 1
Hydrographic Profiles from June and October 2007

Figure 1. Hydrographic Profile Measurement Locations from June 6, 2007.

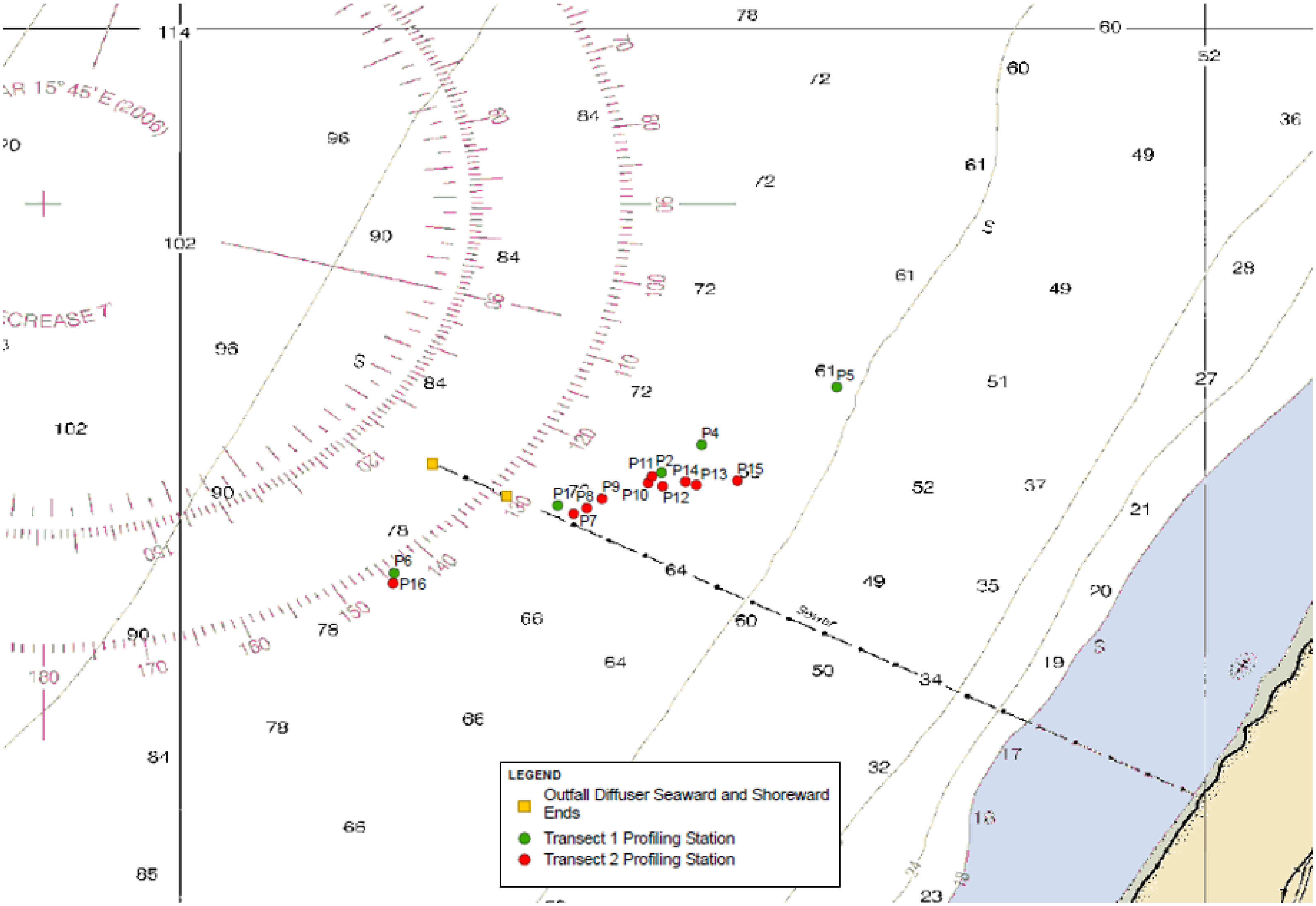


Figure 2. Hydrographic Profile measurement Locations from October 8, 2007.

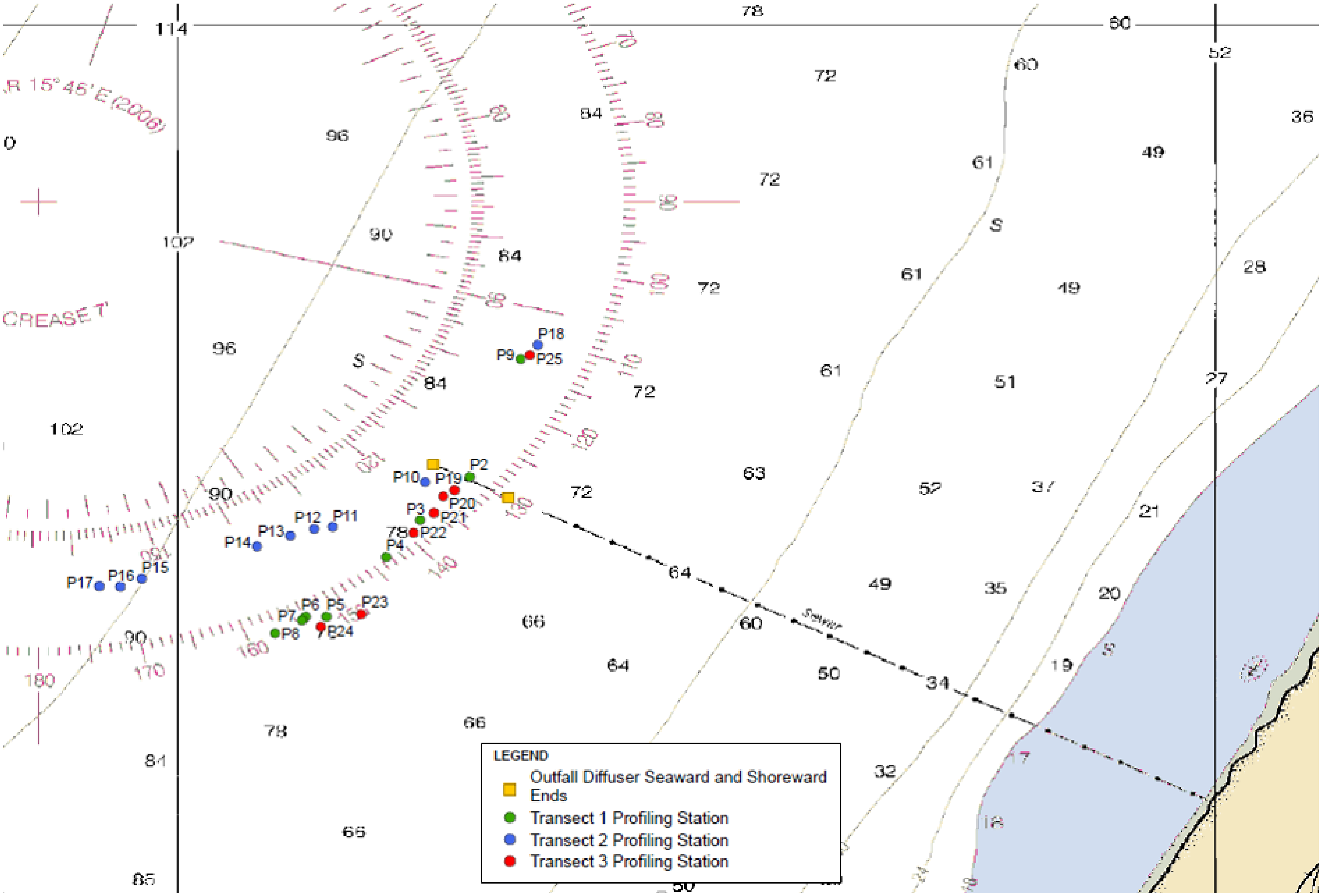


Figure 1. Plots of Density Profiles Based on Temperature and Salinity Data Collected on June 6, 2007 from Around the Samoa Peninsula Outfall.

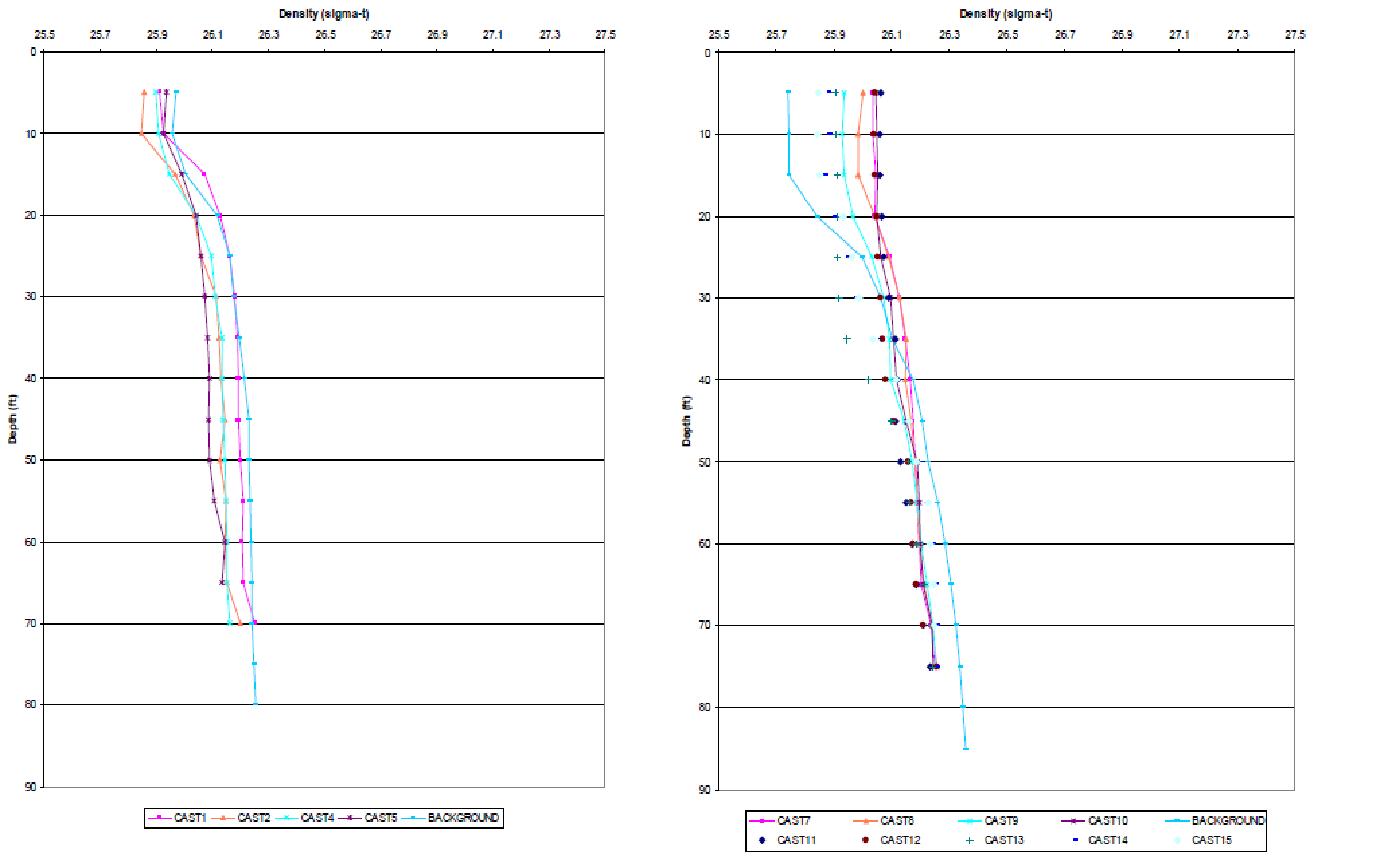


Figure 2. Plots of Density Profiles Based on Temperature and Salinity Data Collected on October 8, 2007 from Around the Samoa Peninsula Outfall.

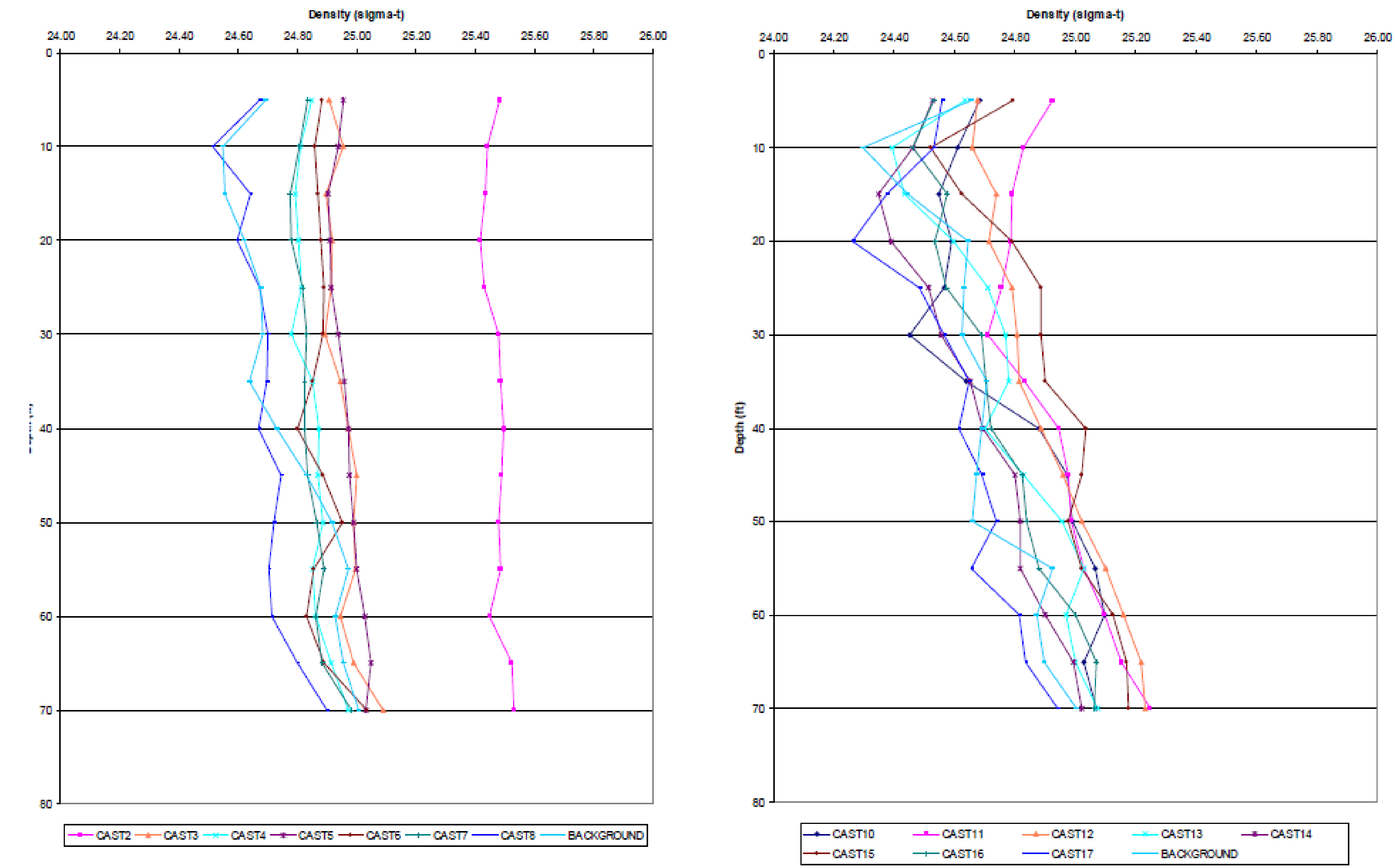


Figure 2 continued. . Plots of Density Profiles Based on Temperature and Salinity Data Collected on October 8, 2007 from Around the Samoa Peninsula Outfall.

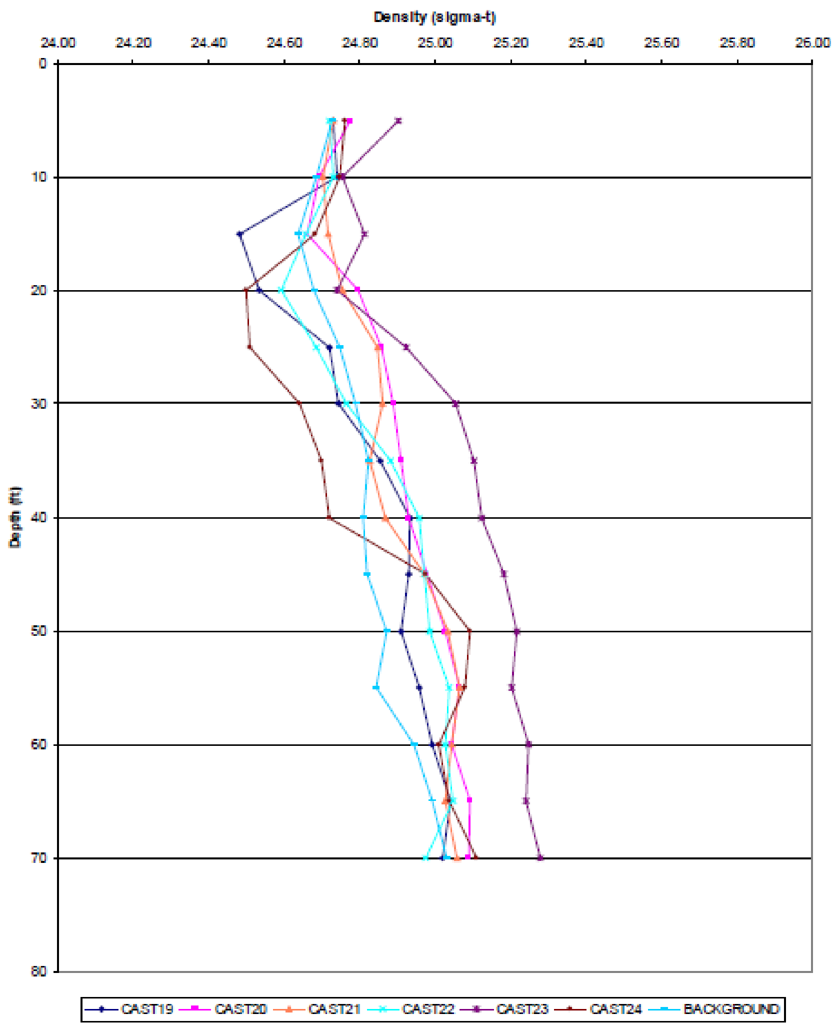
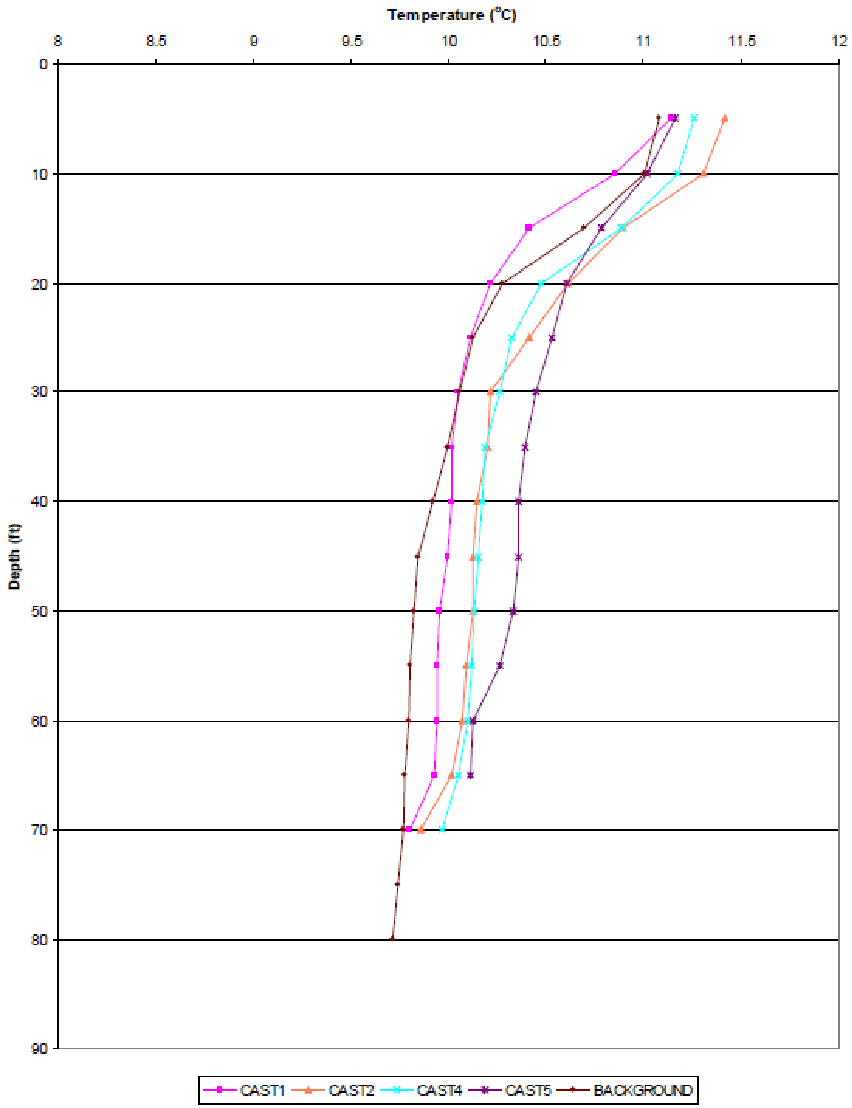


Figure 3. Plots of Temperature Profile Data Collected June 6, 2007 from Around the Samoa Peninsula Outfall.



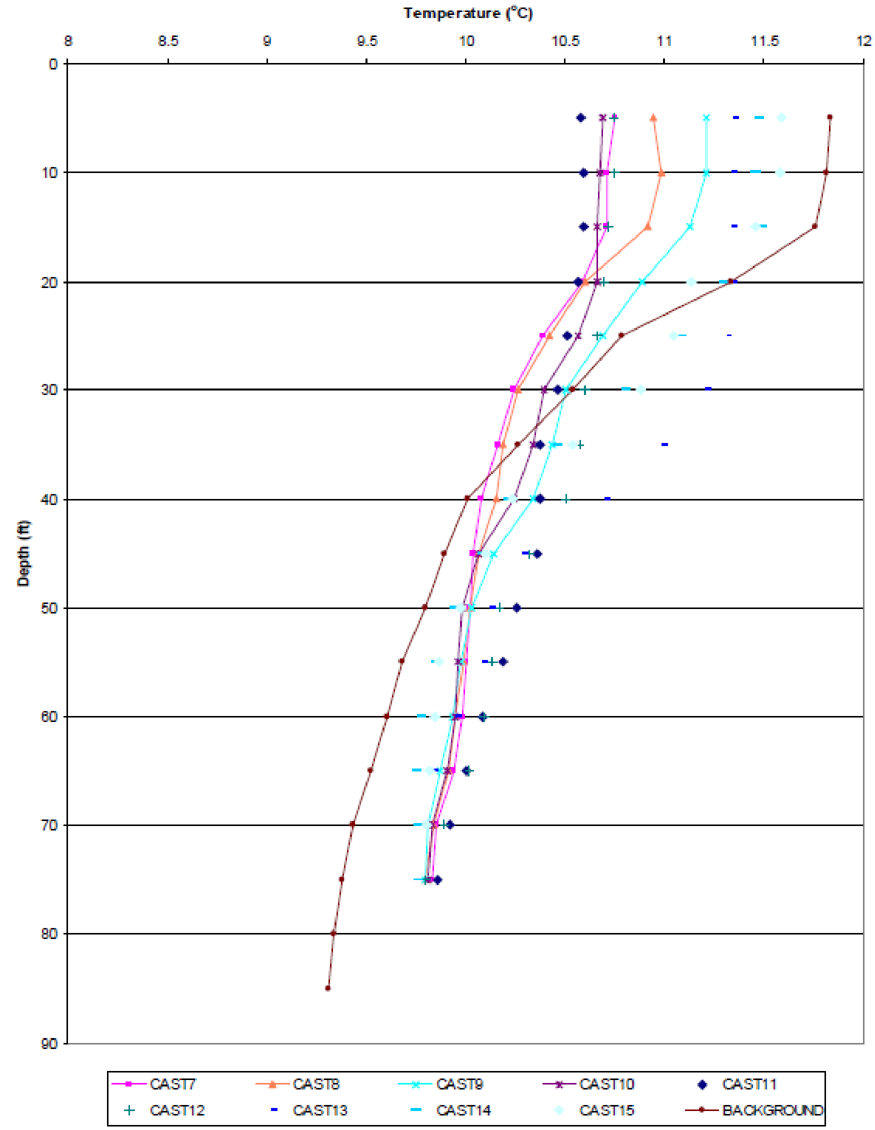


Figure 4. Plots of Temperature Profile Data Collected October 8, 2007 from Around the Samoa Peninsula Outfall.

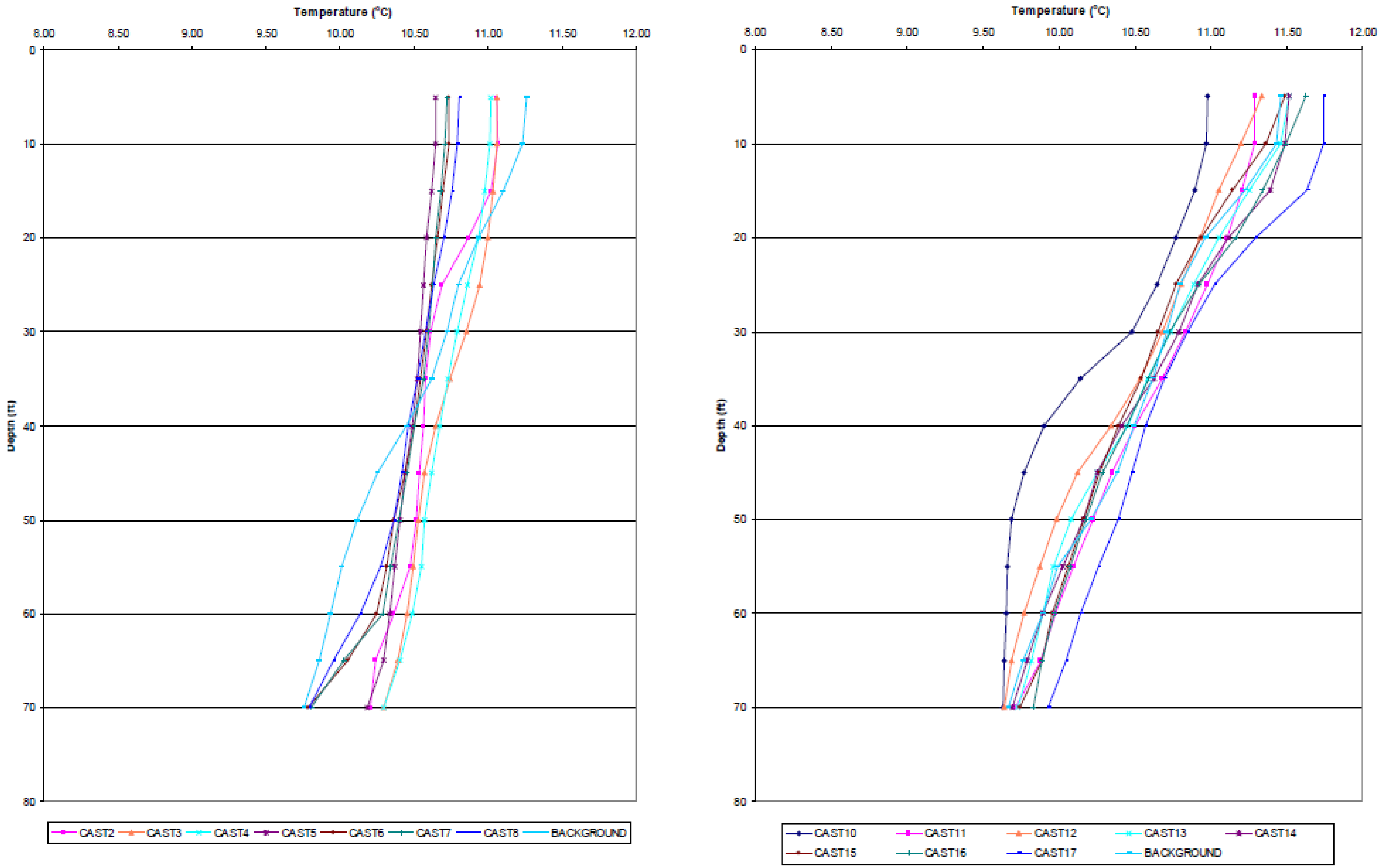


Figure 4 continued. Plots of Temperature Profile Data Collected October 8, 2007 from Around the Samoa Peninsula Outfall

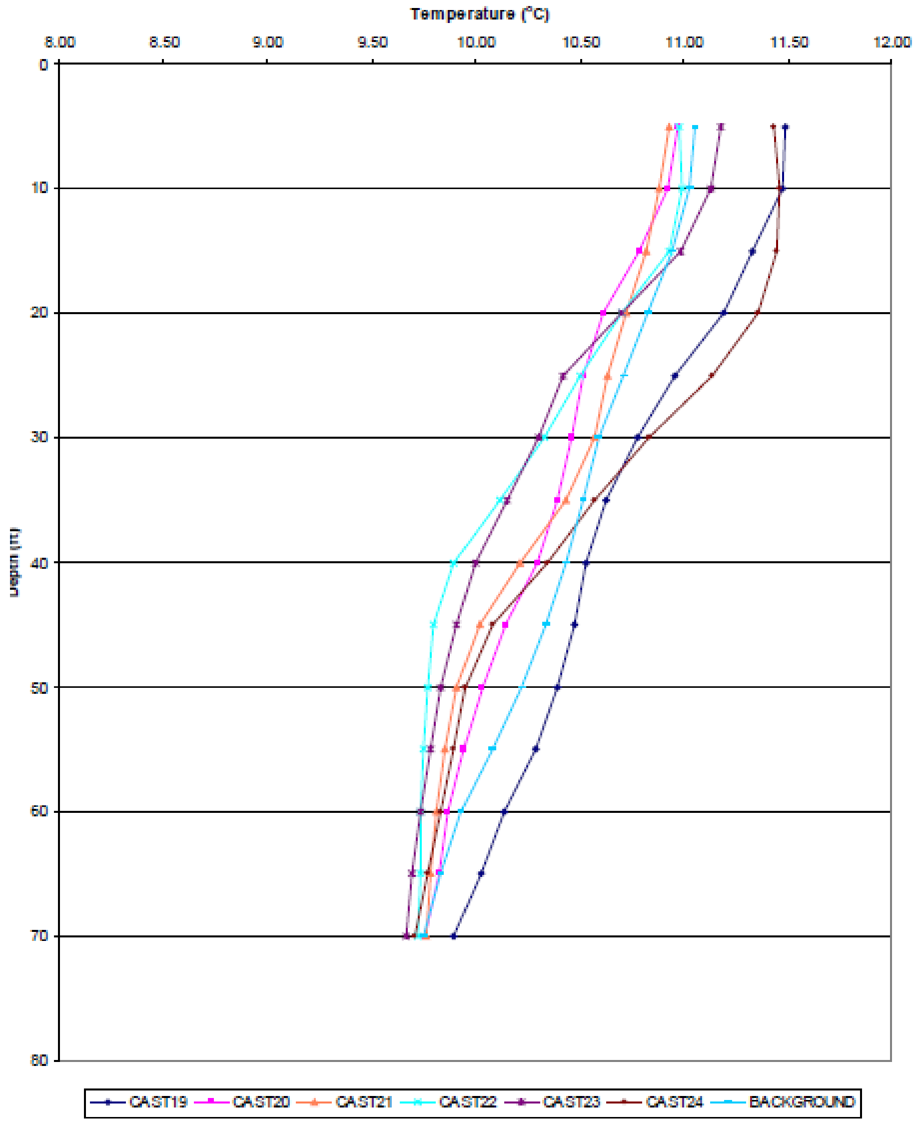
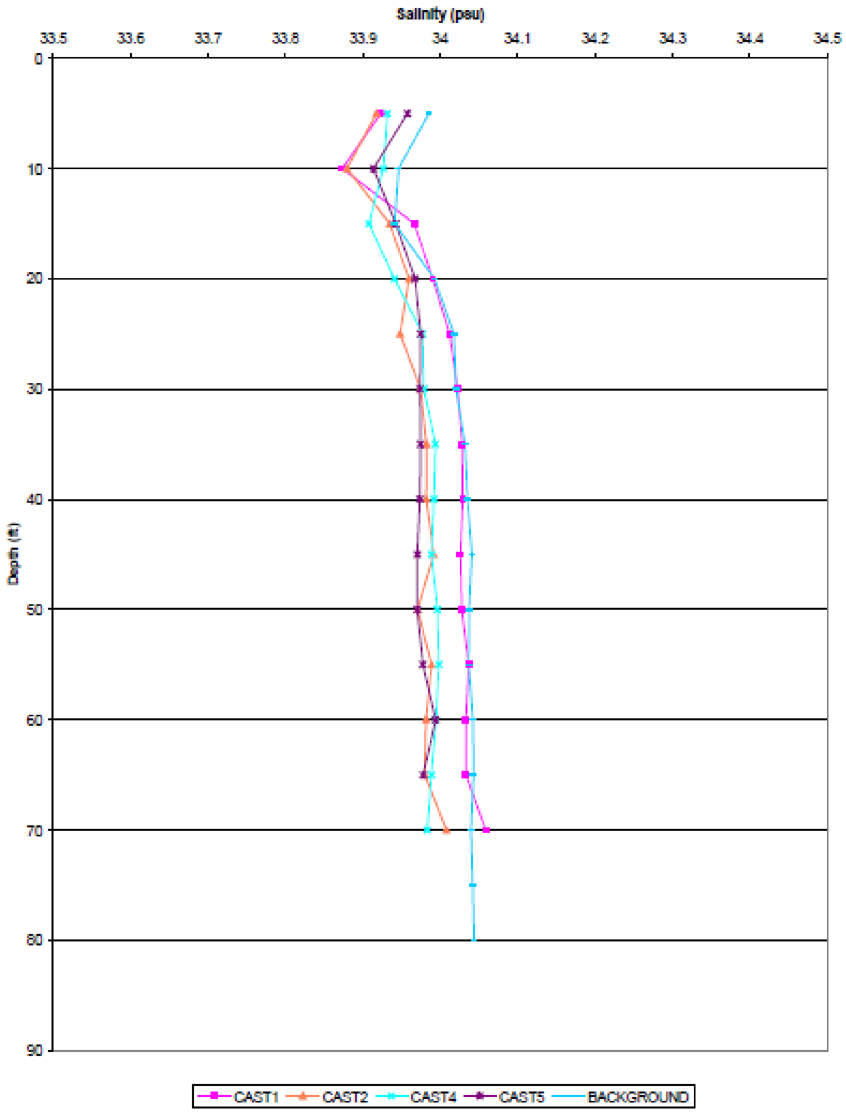


Figure 5. Plots of Salinity Profile Data Collected June 6, 2007 from Around the Samoa Peninsula Outfall



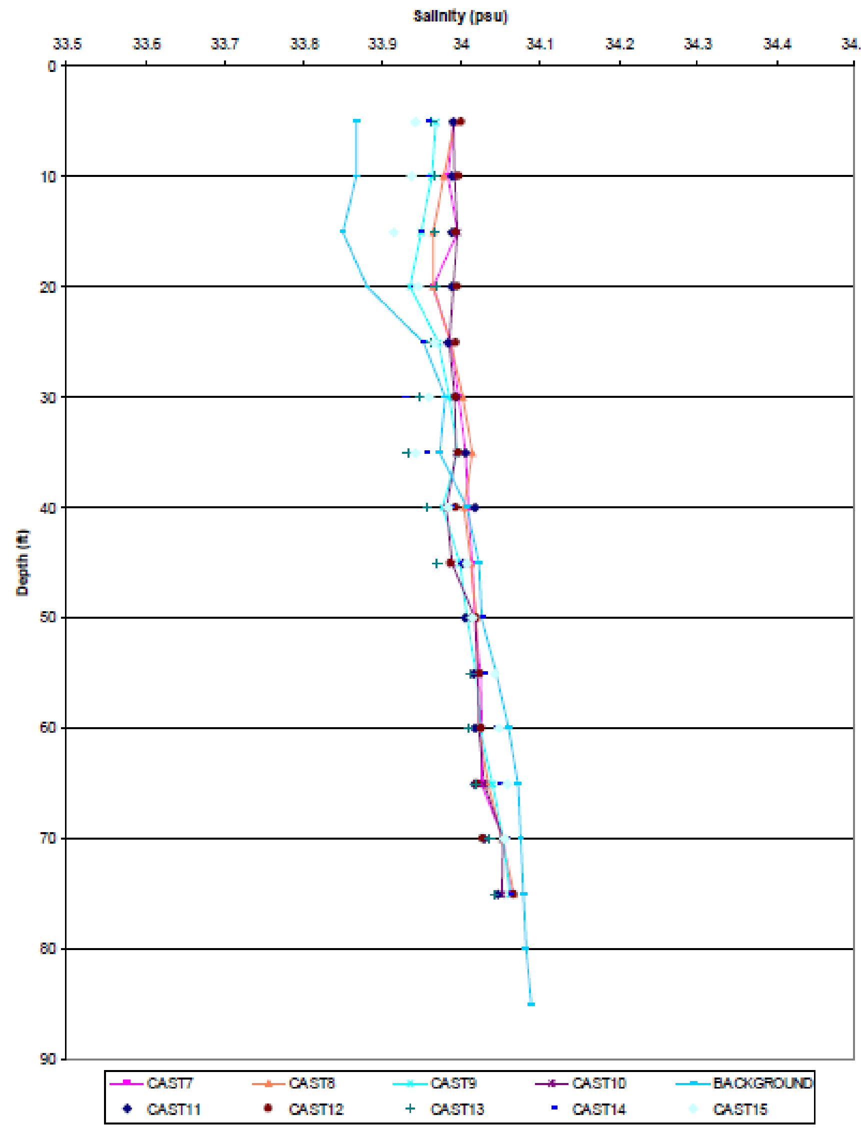


Figure 6. Plots of Salinity Profile Data Collected October 8, 2007 from Around the Samoa Peninsula Outfall.

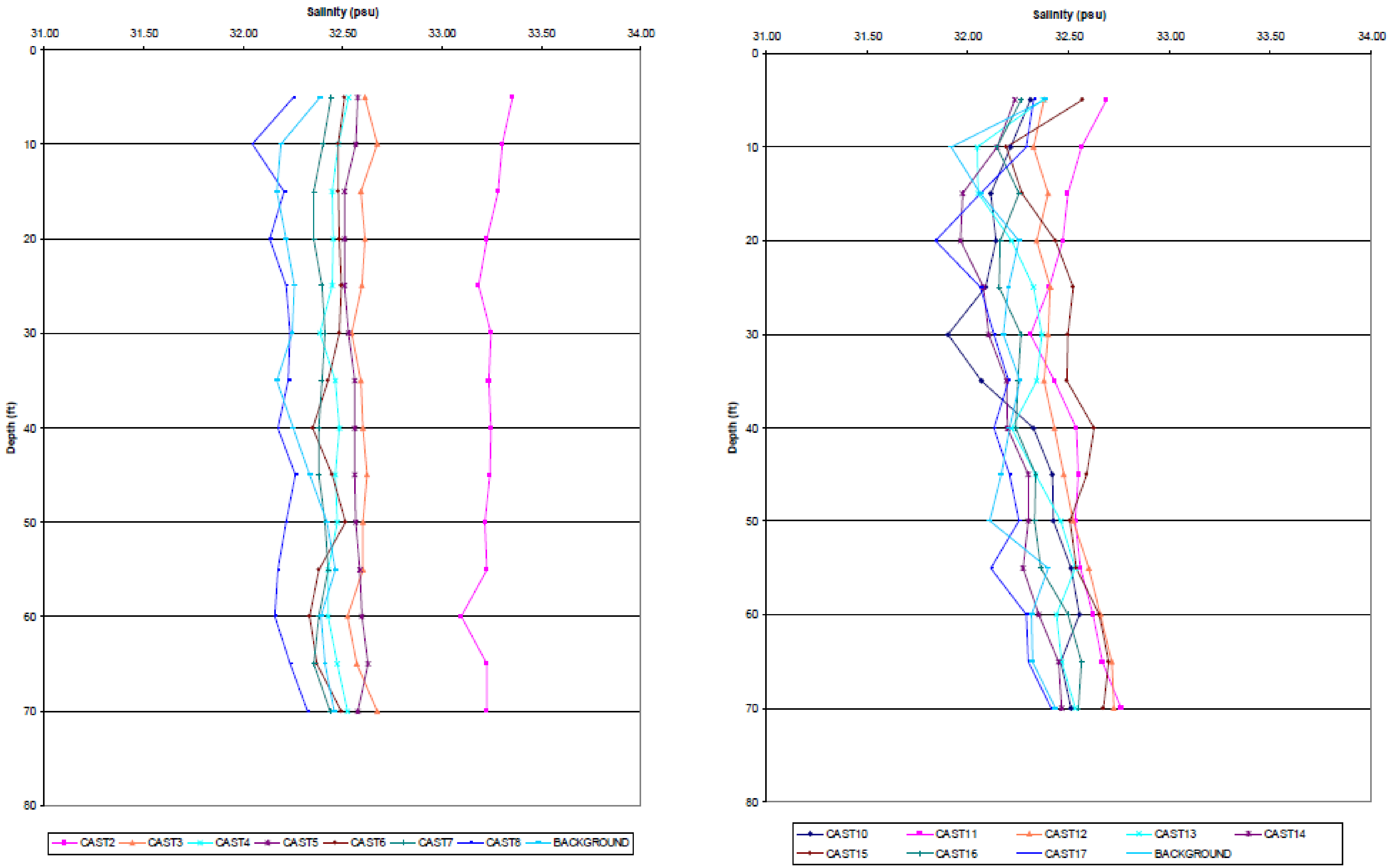
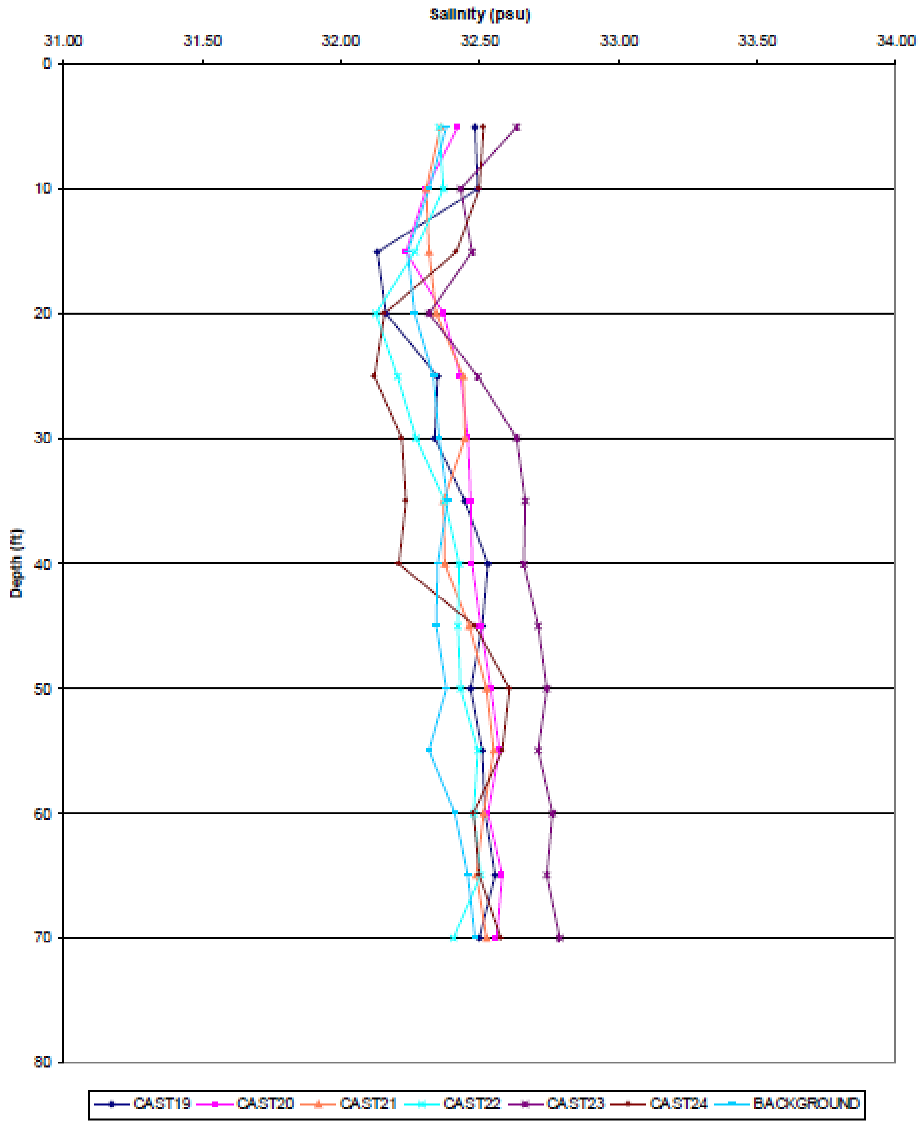


Figure 6 continued. Plots of Salinity Profile Data Collected October 8, 2007 from Around the Samoa Peninsula Outfall.



Attachment 2
Current Speed and Direction Data

Table 1. Current Speeds collect near the Evergreen Ocean Outfall 6 June 2007

Path (Cast No. to Cast No.)	Start	End	Duration	Duration (min)	Distance (ft)	Speed (ft/min)	Speed (m/s)
7 to 8	14:05	14:19	0:14	14	136	9.7	0.049
8 to 9	14:19	14:32	0:13	13	175	13.5	0.068
9 to 10	14:32	15:00	0:28	28	454	16.2	0.082
10 to 11	15:00	15:14	0:14	14	87	6.2	0.032
11 to 12	15:14	15:19	0:05	5	152	30.4	0.154
12 to 13	15:19	15:43	0:24	24	304	12.7	0.064
13 to 14	15:43	15:55	0:12	12	103	8.6	0.044
14 to 15	15:55	16:11	0:16	16	466	29.1	0.148
15 to Recovery	16:11	16:23	0:12	12	158	13.2	0.067
Average						15.5	
Total Path	14:05	16:23	2:18	138	2035	14.7	0.075
7 to recovery (direct)	14:05	16:23	2:18	138	1720	12.5	0.063
Average (15.5, 14.7, 12.5)						**14.2**	**0.072**

Attachment 3
Port Velocities Calculated for the Samoa Peninsula Outfall

Port Velocity vs. Flow and Number of Ports in Ft/Sec
for the RMT II Ocean Outfall

Number of Ports	Total Port Area (sq.ft)	Flow (mgd)									
		1	5	10	15	20	25	30	35	40	45
		Flow (cfs)									
		1.5473	7.7363	15.4727	23.2090	30.9454	38.6817	46.4181	54.1544	61.8908	69.6271
		Port Velocity (ft/sec)									
1	0.031	49.3	246.3	492.5	738.8	985.0	1231.3	1477.5	1723.8	1970.0	2216.3
2	0.063	24.6	123.1	246.3	369.4	492.5	615.6	738.8	861.9	985.0	1108.1
3	0.094	16.4	82.1	164.2	246.3	328.3	410.4	492.5	574.6	656.7	738.8
4	0.126	**12.3**	61.6	123.1	184.7	246.3	307.8	369.4	430.9	492.5	554.1
5	0.157	**9.9**	49.3	98.5	147.8	197.0	246.3	295.5	344.8	394.0	443.3
6	0.188	8.2	41.0	82.1	123.1	164.2	205.2	246.3	287.3	328.3	369.4
7	0.220	7.0	35.2	70.4	105.5	140.7	175.9	211.1	246.3	281.4	316.6
8	0.251	6.2	30.8	61.6	92.3	123.1	153.9	184.7	215.5	246.3	277.0
9	0.283	5.5	27.4	54.7	82.1	109.4	136.8	164.2	191.5	218.9	246.3
10	0.314	4.9	24.6	49.3	73.9	98.5	123.1	147.8	172.4	197.0	221.6
11	0.346	4.5	22.4	44.8	67.2	89.5	111.9	134.3	156.7	179.1	201.5
12	0.377	4.1	20.5	41.0	61.6	82.1	102.6	123.1	143.6	164.2	184.7
13	0.408	3.8	18.9	37.9	56.8	75.8	94.7	113.7	132.6	151.5	170.5
14	0.440	3.5	17.6	35.2	52.8	70.4	87.9	105.5	123.1	140.7	158.3
15	0.471	3.3	16.4	32.8	49.3	65.7	82.1	98.5	114.9	131.3	147.8
16	0.503	3.1	**15.4**	30.8	46.2	61.6	77.0	92.3	107.7	123.1	138.5
17	0.534	2.9	**14.5**	29.0	43.5	57.9	72.4	86.9	101.4	115.9	130.4
18	0.565	2.7	**13.7**	27.4	41.0	54.7	68.4	82.1	95.8	109.4	123.1
19	0.597	2.6	**13.0**	25.9	38.9	51.8	64.8	77.8	90.7	103.7	116.6
20	0.628	2.5	**12.3**	24.6	36.9	49.3	61.6	73.9	86.2	98.5	110.8
21	0.660	2.3	**11.7**	23.5	35.2	46.9	58.6	70.4	82.1	93.8	105.5
22	0.691	2.2	**11.2**	22.4	33.6	44.8	56.0	67.2	78.4	89.5	100.7
23	0.723	2.1	**10.7**	21.4	32.1	42.8	53.5	64.2	74.9	85.7	96.4
24	0.754	2.1	**10.3**	20.5	30.8	41.0	51.3	61.6	71.8	82.1	92.3
25	0.785	2.0	9.9	19.7	29.6	39.4	49.3	59.1	69.0	78.8	88.7
26	0.817	1.9	9.5	18.9	28.4	37.9	47.4	56.8	66.3	75.8	85.2
27	0.848	1.8	9.1	18.2	27.4	36.5	45.6	54.7	63.8	73.0	82.1
28	0.880	1.8	8.8	17.6	26.4	35.2	44.0	52.8	61.6	70.4	79.2
29	0.911	1.7	8.5	17.0	25.5	34.0	42.5	50.9	59.4	67.9	76.4
30	0.942	1.6	8.2	16.4	24.6	32.8	41.0	49.3	57.5	65.7	73.9
31	0.974	1.6	7.9	15.9	23.8	31.8	39.7	47.7	55.6	63.5	71.5
32	1.005	1.5	7.7	15.4	23.1	30.8	38.5	46.2	53.9	61.6	69.3
33	1.037	1.5	7.5	**14.9**	22.4	29.8	37.3	44.8	52.2	59.7	67.2
34	1.068	1.4	7.2	**14.5**	21.7	29.0	36.2	43.5	50.7	57.9	65.2
35	1.100	1.4	7.0	**14.1**	21.1	28.1	35.2	42.2	49.3	56.3	63.3
36	1.131	1.4	6.8	**13.7**	20.5	27.4	34.2	41.0	47.9	54.7	61.6
37	1.162	1.3	6.7	**13.3**	20.0	26.6	33.3	39.9	46.6	53.2	59.9
38	1.194	1.3	6.5	**13.0**	19.4	25.9	32.4	38.9	45.4	51.8	58.3
39	1.225	1.3	6.3	**12.6**	18.9	25.3	31.6	37.9	44.2	50.5	56.8
40	1.257	1.2	6.2	**12.3**	18.5	24.6	30.8	36.9	43.1	49.3	55.4
41	1.288	1.2	6.0	**12.0**	18.0	24.0	30.0	36.0	42.0	48.0	54.1
42	1.319	1.2	5.9	**11.7**	17.6	23.5	29.3	35.2	41.0	46.9	52.8
43	1.351	1.1	5.7	**11.5**	17.2	22.9	28.6	34.4	40.1	45.8	51.5
44	1.382	1.1	5.6	**11.2**	16.8	22.4	28.0	33.6	39.2	44.8	50.4
45	1.414	1.1	5.5	**10.9**	16.4	21.9	27.4	32.8	38.3	43.8	49.3
46	1.445	1.1	5.4	**10.7**	16.1	21.4	26.8	32.1	37.5	42.8	48.2
47	1.477	1.0	5.2	**10.5**	15.7	21.0	26.2	31.4	36.7	41.9	47.2
48	1.508	1.0	5.1	**10.3**	15.4	20.5	25.7	30.8	35.9	41.0	46.2
49	1.539	1.0	5.0	**10.1**	**15.1**	20.1	25.1	30.2	35.2	40.2	45.2
50	1.571	1.0	4.9	9.9	**14.8**	19.7	24.6	29.6	34.5	39.4	44.3
51	1.602	1.0	4.8	9.7	**14.5**	19.3	24.1	29.0	33.8	38.6	43.5
52	1.634	0.9	4.7	9.5	**14.2**	18.9	23.7	28.4	33.1	37.9	42.6
53	1.665	0.9	4.6	9.3	**13.9**	18.6	23.2	27.9	32.5	37.2	41.8
54	1.696	0.9	4.6	9.1	**13.7**	18.2	22.8	27.4	31.9	36.5	41.0
55	1.728	0.9	4.5	9.0	**13.4**	17.9	22.4	26.9	31.3	35.8	40.3
56	1.759	0.9	4.4	8.8	**13.2**	17.6	22.0	26.4	30.8	35.2	39.6
57	1.791	0.9	4.3	8.6	**13.0**	17.3	21.6	25.9	30.2	34.6	38.9
58	1.822	0.8	4.2	8.5	**12.7**	17.0	21.2	25.5	29.7	34.0	38.2
59	1.854	0.8	4.2	8.3	**12.5**	16.7	20.9	25.0	29.2	33.4	37.6

60	1.885	0.8	4.1	8.2	**12.3**	16.4	20.5	24.6	28.7	32.8	36.9
61	1.916	0.8	4.0	8.1	**12.1**	16.1	20.2	24.2	28.3	32.3	36.3
62	1.948	0.8	4.0	7.9	**11.9**	15.9	19.9	23.8	27.8	31.8	35.7
63	1.979	0.8	3.9	7.8	**11.7**	15.6	19.5	23.5	27.4	31.3	35.2
64	2.011	0.8	3.8	7.7	**11.5**	15.4	19.2	23.1	26.9	30.8	34.6
65	2.042	0.8	3.8	7.6	**11.4**	15.2	18.9	22.7	26.5	30.3	34.1
66	2.073	0.7	3.7	7.5	**11.2**	**14.9**	18.7	22.4	26.1	29.8	33.6
67	2.105	0.7	3.7	7.4	**11.0**	**14.7**	18.4	22.1	25.7	29.4	33.1
68	2.136	0.7	3.6	7.2	**10.9**	**14.5**	18.1	21.7	25.3	29.0	32.6
69	2.168	0.7	3.6	7.1	**10.7**	**14.3**	17.8	21.4	25.0	28.6	32.1
70	2.199	0.7	3.5	7.0	**10.6**	**14.1**	17.6	21.1	24.6	28.1	31.7
71	2.231	0.7	3.5	6.9	**10.4**	**13.9**	17.3	20.8	24.3	27.7	31.2
72	2.262	0.7	3.4	6.8	**10.3**	**13.7**	17.1	20.5	23.9	27.4	30.8
74	2.325	0.7	3.3	6.7	**10.0**	**13.3**	16.6	20.0	23.3	26.6	29.9
76	2.388	0.6	3.2	6.5	9.7	**13.0**	16.2	19.4	22.7	25.9	29.2
78	2.450	0.6	3.2	6.3	9.5	**12.6**	15.8	18.9	22.1	25.3	28.4
80	2.513	0.6	3.1	6.2	9.2	**12.3**	15.4	18.5	21.5	24.6	27.7
82	2.576	0.6	3.0	6.0	9.0	**12.0**	**15.0**	18.0	21.0	24.0	27.0
84	2.639	0.6	2.9	5.9	8.8	**11.7**	**14.7**	17.6	20.5	23.5	26.4
86	2.702	0.6	2.9	5.7	8.6	**11.5**	**14.3**	17.2	20.0	22.9	25.8
88	2.765	0.6	2.8	5.6	8.4	**11.2**	**14.0**	16.8	19.6	22.4	25.2
90	2.827	0.5	2.7	5.5	8.2	**10.9**	**13.7**	16.4	19.2	21.9	24.6
92	2.890	0.5	2.7	5.4	8.0	**10.7**	**13.4**	16.1	18.7	21.4	24.1
94	2.953	0.5	2.6	5.2	7.9	**10.5**	**13.1**	15.7	18.3	21.0	23.6
96	3.016	0.5	2.6	5.1	7.7	**10.3**	**12.8**	15.4	18.0	20.5	23.1
98	3.079	0.5	2.5	5.0	7.5	**10.1**	**12.6**	**15.1**	17.6	20.1	22.6
100	3.142	0.5	2.5	4.9	7.4	9.9	**12.3**	**14.8**	17.2	19.7	22.2
102	3.204	0.5	2.4	4.8	7.2	9.7	**12.1**	**14.5**	16.9	19.3	21.7
104	3.267	0.5	2.4	4.7	7.1	9.5	**11.8**	**14.2**	16.6	18.9	21.3
106	3.330	0.5	2.3	4.6	7.0	9.3	**11.6**	**13.9**	16.3	18.6	20.9
108	3.393	0.5	2.3	4.6	6.8	9.1	**11.4**	**13.7**	16.0	18.2	20.5
110	3.456	0.4	2.2	4.5	6.7	9.0	**11.2**	**13.4**	15.7	17.9	20.1
112	3.519	0.4	2.2	4.4	6.6	8.8	**11.0**	**13.2**	15.4	17.6	19.8
114	3.581	0.4	2.2	4.3	6.5	8.6	**10.8**	**13.0**	**15.1**	17.3	19.4
116	3.644	0.4	2.1	4.2	6.4	8.5	**10.6**	**12.7**	**14.9**	17.0	19.1
118	3.707	0.4	2.1	4.2	6.3	8.3	**10.4**	**12.5**	**14.6**	16.7	18.8
120	3.770	0.4	2.1	4.1	6.2	8.2	**10.3**	**12.3**	**14.4**	16.4	18.5
122	3.833	0.4	2.0	4.0	6.1	8.1	**10.1**	**12.1**	**14.1**	16.1	18.2
124	3.896	0.4	2.0	4.0	6.0	7.9	9.9	**11.9**	**13.9**	15.9	17.9
126	3.958	0.4	2.0	3.9	5.9	7.8	9.8	**11.7**	**13.7**	15.6	17.6
128	4.021	0.4	1.9	3.8	5.8	7.7	9.6	**11.5**	**13.5**	15.4	17.3
130	4.084	0.4	1.9	3.8	5.7	7.6	9.5	**11.4**	**13.3**	**15.2**	17.0
132	4.147	0.4	1.9	3.7	5.6	7.5	9.3	**11.2**	**13.1**	**14.9**	16.8
134	4.210	0.4	1.8	3.7	5.5	7.4	9.2	**11.0**	**12.9**	**14.7**	16.5
136	4.273	0.4	1.8	3.6	5.4	7.2	9.1	**10.9**	**12.7**	**14.5**	16.3
138	4.335	0.4	1.8	3.6	5.4	7.1	8.9	**10.7**	**12.5**	**14.3**	16.1
140	4.398	0.4	1.8	3.5	5.3	7.0	8.8	**10.6**	**12.3**	**14.1**	15.8
142	4.461	0.3	1.7	3.5	5.2	6.9	8.7	**10.4**	**12.1**	**13.9**	15.6
144	4.524	0.3	1.7	3.4	5.1	6.8	8.6	**10.3**	**12.0**	**13.7**	15.4

Attachment 4
HYDRO Model Results for Head Loss and Port Velocity

	1 mgd											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	3	3	3	3	4	4	4	4	5	5	5	5
Port Spacing (ft)	12	12	12	12	12	12	12	12	12	12	12	12
Avg Port Vel (ft/sec)	16.42	16.42	16.42	16.42	12.31	12.31	12.31	12.31	9.85	9.85	9.85	9.85
Min Port Vel (ft/sec)	16.42	16.42	16.42	16.41	12.31	12.31	12.31	12.31	9.85	9.85	9.85	9.85
Max Port Vel (ft/sec)	16.42	16.42	16.42	16.42	12.31	12.31	12.31	12.31	9.85	9.85	9.85	9.85
Head loss	10.55	10.55	10.54	10.54	5.93	5.93	5.93	5.93	3.80	3.80	3.80	3.80
	5 mgd											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	16	16	16	16	20	20	20	20	24	24	24	24
Port Spacing (ft)	12	12	12	12	12	12	12	12	12	12	12	12
Avg Port Vel (ft/sec)	15.39	15.39	15.39	15.39	12.31	12.31	12.31	12.31	10.26	10.26	10.26	10.26
Min Port Vel (ft/sec)	15.39	15.39	15.39	15.38	12.31	12.31	12.3	12.3	10.26	10.25	10.25	10.25
Max Port Vel (ft/sec)	15.39	15.39	15.4	15.4	12.31	12.31	12.32	12.32	10.27	10.27	10.27	10.26
Head loss	9.30	9.30	9.30	9.30	5.97	5.97	5.97	5.96	4.16	4.16	4.15	4.15
	10											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	33	33	33	33	41	41	41	41	49	49	49	49
Port Spacing (ft)	12	12	12	12	12	12	12	12	12	12	12	12
Avg Port Vel (ft/sec)	14.92	14.92	14.92	14.93	12.01	12.01	12.01	12.01	10.05	10.05	10.05	10.05
Min Port Vel (ft/sec)	14.91	14.91	14.9	14.9	12.01	12.01	12	12	10.04	10.04	10.04	10.04
Max Port Vel (ft/sec)	14.93	14.94	14.94	14.93	12.05	12.05	12.03	12.03	10.11	10.12	10.09	10.1
Head loss	8.87	8.87	8.85	8.86	5.81	5.82	5.80	5.80	4.14	4.14	4.12	4.13
	15 mgd											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	49	49	49	49	61	61	61	61	74	74	74	74
Port Spacing (ft)	12	12	12	12	12	12	12	12	6	6	6	6
Avg Port Vel (ft/sec)	15.08	15.08	15.08	15.08	12.11	12.11	12.11	12.11	9.98	9.98	9.98	9.98
Min Port Vel (ft/sec)	15.06	15.06	15.05	15.05	12.1	12.1	12.09	12.09	9.92	9.92	9.9	9.91
Max Port Vel (ft/sec)	15.14	15.14	15.12	15.13	12.24	12.24	12.22	12.22	10.03	10.03	10.05	10.04
Head loss	9.27	9.27	9.26	9.26	6.17	6.17	6.15	6.15	4.23	4.23	4.22	4.22
	20 mgd											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	66	66	66	66	80	80	80	80	98	98	98	98
Port Spacing (ft)	12	12	12	12	6	6	6	6	6	6	6	6
Avg Port Vel (ft/sec)	14.92	14.92	14.92	14.92	12.31	12.31	12.31	12.31	10.05	10.05	10.05	10.05
Min Port Vel (ft/sec)	14.9	14.9	14.9	14.9	12.21	12.23	12.2	12.2	10	10	9.98	9.98
Max Port Vel (ft/sec)	15.1	15.1	15.08	15.08	12.39	12.39	12.35	12.35	10.11	10.19	10.17	10.17
Head loss	9.47	9.47	9.44	9.45	6.51	6.52	6.50	6.50	4.59	4.60	4.58	4.58
	25 mgd											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	82	82	82	82	102	102	102	102	122	122	122	122
Port Spacing (ft)	6	6	6	6	6	6	6	6	6	6	6	6
Avg Port Vel (ft/sec)	15.02	15.02	15.02	15.02	12.07	12.07	12.07	12.07	10.09	10.09	10.09	10.09
Min Port Vel (ft/sec)	14.9	4.88	14.86	14.87	11.99	11.99	11.98	11.98	10.04	10.04	10.03	10.03
Max Port Vel (ft/sec)	15.12	15.07	15.13	15.07	12.24	12.24	12.22	12.22	10.41	10.41	10.39	10.39
Head loss	9.72	9.72	9.70	9.70	6.69	6.69	6.67	6.67	5.07	5.07	5.04	5.05
	30 mgd											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	98	98	98	98	122	122	122	122	144	144	144	144
Port Spacing (ft)	6	6	6	6	6	6	6	6	6	6	6	6
Avg Port Vel (ft/sec)	15.08	15.08	15.08	15.08	12.11	12.11	12.11	12.11	10.26	10.26	10.26	10.26
Min Port Vel (ft/sec)	14.94	14.94	14.93	14.93	12.03	12.03	12.02	12.02	10.19	10.19	10.18	10.18
Max Port Vel (ft/sec)	15.22	15.22	15.22	15.22	12.21	12.46	12.44	12.44	10.84	10.84	10.81	10.81
Head loss	10.26	10.26	10.24	10.24	7.25	7.26	7.23	7.24	5.77	5.77	5.75	5.75

	35 mgd											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	114	114	114	114	130	130	130	130	144	144	144	144
Port Spacing (ft)	6	6	6	6	6	6	6	6	6	6	6	6
Avg Port Vel (ft/sec)	15.12	15.12	15.12	15.12	13.26	13.26	13.26	13.26	11.97	11.97	11.97	11.97
Min Port Vel (ft/sec)	15	15	14.99	14.99	13.17	13.17	13.16	13.16	11.88	11.88	11.87	11.87
Max Port Vel (ft/sec)	15.41	15.41	15.39	15.39	13.72	13.72	13.7	13.7	12.6	12.6	12.57	12.58
Head loss	10.90	10.91	10.88	10.89	8.97	8.97	8.95	8.95	7.81	7.81	7.78	7.79
	40 mgd											
Effluent Sal. (psu)	0.1	0.1	30	30	0.1	0.1	30	30	0.1	0.1	30	30
Effluent Temp. (°C)	10	25	10	25	10	25	10	25	10	25	10	25
Open Ports	132	132	132	132	138	138	138	138	144	144	144	144
Port Spacing (ft)	6	6	6	6	6	6	6	6	6	6	6	6
Avg Port Vel (ft/sec)	14.92	14.92	14.92	14.92	14.28	14.28	14.28	14.28	13.68	13.68	13.68	13.68
Min Port Vel (ft/sec)	14.81	14.81	14.8	14.8	14.17	14.17	14.16	14.16	13.57	13.57	13.57	13.57
Max Port Vel (ft/sec)	15.44	15.44	15.42	15.42	14.87	14.87	14.85	14.85	14.36	14.36	14.34	14.34
Head loss	11.42	11.42	11.40	11.40	10.74	10.74	10.72	10.72	10.15	10.15	10.15	10.13

Attachment 5
UDKHDEN Model Results Summary

Model Run	Flow mgd	Open Ports	Sal. psu	Temp. °C	Spacing m	Froude No.	Trapping Level	Dilution
1	1	3	0.1	10	3.66	41.38	7.54	589.71
2	1	3	1	10	3.66	41.96	7.57	588.40
3	1	3	10	10	3.66	49.36	9.13	529.80
4	1	3	20	10	3.66	64.71	13.79	363.02
5	1	3	30	10	3.66	119.74	21.04	88.63
6	1	3	0.1	15	3.66	40.91	7.46	593.18
7	1	3	1	15	3.66	41.46	7.56	589.08
8	1	3	10	15	3.66	48.43	8.93	537.17
9	1	3	20	15	3.66	62.39	13.60	369.36
10	1	3	30	15	3.66	105.49	20.69	104.09
11	1	3	0.1	20	3.66	40.23	7.39	596.07
12	1	3	1	20	3.66	40.74	7.47	592.70
13	1	3	10	20	3.66	47.22	8.49	553.02
14	1	3	20	20	3.66	59.69	13.43	374.72
15	1	3	30	20	3.66	93.18	20.37	117.27
16	1	3	0.1	25	3.66	39.40	7.27	600.54
17	1	3	1	25	3.66	39.88	7.36	597.14
18	1	3	10	25	3.66	45.82	8.39	556.99
19	1	3	20	25	3.66	56.82	13.22	382.03
20	1	3	30	25	3.66	82.96	20.05	130.35
21	1	4	0.1	10	3.66	31.04	8.43	719.04
22	1	4	1	10	3.66	31.47	8.64	708.66
23	1	4	10	10	3.66	37.02	9.63	658.53
24	1	4	20	10	3.66	48.53	15.11	399.90
25	1	4	30	10	3.66	89.81	21.15	101.80
26	1	4	0.1	15	3.66	30.68	8.15	732.98
27	1	4	1	15	3.66	31.09	8.31	724.94
28	1	4	10	15	3.66	36.32	9.54	663.18
29	1	4	20	15	3.66	46.79	14.62	422.47
30	1	4	30	15	3.66	79.12	21.00	109.56
31	1	4	0.1	20	3.66	30.17	7.99	741.36
32	1	4	1	20	3.66	30.56	8.17	732.35
33	1	4	10	20	3.66	35.41	9.43	668.44
34	1	4	20	20	3.66	44.76	13.94	454.32
35	1	4	30	20	3.66	69.88	20.68	127.21
36	1	4	0.1	25	3.66	29.55	7.89	746.56
37	1	4	1	25	3.66	29.91	7.99	741.52
38	1	4	10	25	3.66	34.36	9.34	673.25
39	1	4	20	25	3.66	42.62	13.76	462.22
40	1	4	30	25	3.66	62.22	20.39	142.16
41	1	5	0.1	10	3.66	24.83	9.21	834.61
42	1	5	1	10	3.66	25.18	9.28	829.61
43	1	5	10	10	3.66	29.61	13.36	585.20

44	1	5	20	10	3.66	38.83	19.09	245.68
45	1	5	30	10	3.66	71.84	21.26	112.23
46	1	5	0.1	15	3.66	24.54	9.17	837.36
47	1	5	1	15	3.66	24.87	9.24	833.20
48	1	5	10	15	3.66	29.06	13.24	592.12
49	1	5	20	15	3.66	37.43	15.36	470.50
50	1	5	30	15	3.66	63.29	21.10	122.34
51	1	5	0.1	20	3.66	24.14	9.12	840.83
52	1	5	1	20	3.66	24.45	9.11	840.85
53	1	5	10	20	3.66	28.33	13.16	597.20
54	1	5	20	20	3.66	35.81	15.18	479.40
55	1	5	30	20	3.66	55.91	20.96	130.99
56	1	5	0.1	25	3.66	23.64	8.86	856.94
57	1	5	1	25	3.66	23.93	9.02	846.95
58	1	5	10	25	3.66	27.49	13.07	602.65
59	1	5	20	25	3.66	34.09	14.86	497.23
60	1	5	30	25	3.66	49.78	20.67	150.01

D

CH2M Aquaculture Waste Load Estimation

TECHNICAL MEMORANDUM

Aquaculture Waste Load Estimation Redwood Marine Terminal II

PREPARED FOR:	County of Humboldt and Humboldt Bay Harbor, Recreation and Conservation District
PREPARED BY:	CH2M
DATE:	February 2016

1.0 Introduction

Aquaculture has been identified as a key industry with opportunities for growth in Humboldt County, and is one of several proposed uses of the Redwood Marine Terminal II (RMT II) site. The existing infrastructure and facilities at the RMT II site offer opportunities to develop, expand and diversify aquaculture in the region. Among these opportunities are the availability and access to both seawater and freshwater for aquaculture operations, marine dock access, a wastewater treatment facility that could potentially receive and treat waste from aquaculture operations, and an ocean outfall for discharge of the treated waste from aquaculture facilities.

Management of the wastewater generated by proposed aquaculture facilities is a key issue to consider early in the planning process for reuse of the RMT II site. Aquaculture wastewater is typically high in nutrients and turbidity from particulate and dissolved waste matter, and could potentially carry pathogens such as enteric bacteria and other disease causing agents. This wastewater may need treatment before discharge into Humboldt Bay to comply with permit requirements. The production capacity (kilograms of fish produced per year) of the aquaculture facility will also need to be scaled to that of the wastewater treatment facility and the ocean outfall so as not to overwhelm the wastewater treatment and disposal capacity of these systems. It is therefore necessary to understand the aquaculture waste loads that would be generated by this proposed reuse of the RMT II site.

This technical memorandum (TM) focuses on a preliminary conceptual level estimation of potential waste loads that an aquaculture facility could generate at the RMT II site.

2.0 Methods

2.1 Selection of Aquaculture Species and Operation

For an understanding of waste loads from an aquaculture facility, it is first necessary to select a target species. Waste loads are species dependent, particularly when different taxa such as finfish and bivalves are considered. Previous studies also indicate that the use of freshwater will be prohibitively expensive at the RMT II site (Vinci 2013). Selection of a species that could be cultured predominantly in saltwater would thus be advantageous.

Based on additional information received from discussions with Randy Lovell (California Department of Fish & Wildlife), Greg Dale (Coast Seafoods), and John Finger (Hog Island Oyster Company), steelhead (*Onchorhynchus mykiss*) culture with once-through seawater was selected as the target species and mode of operation, respectively, for the purpose of this analysis. Steelhead are essentially anadromous rainbow trout that yield medium-to-high market value and would minimize the use of freshwater at the RMT II site.

Discussions with the oyster producers also confirmed that oyster operations would not involve significant waste loads, relative to those generated from finfish operations. A bivalve hatchery mariculture operation at RMT II would generate only a minimal amount of waste and would in all likelihood qualify for an exemption to NPDES permitting requirements under the Environmental Protection Agency's (EPA) regulation of the Clean Water Act. The EPA requires NPDES permitting only for cold-water operations that produce more than 20,000 pounds of organisms per year and use 5,000 pounds of feed per month. Because algae feed for oyster hatcheries are most often grown onsite by culturing algae cells already present in the sourcewater, trace nutrients, and solar energy, hatcheries are normally exempt from these requirements. For example, the private oyster mariculture hatchery operation currently being developed in Humboldt Bay by Coast Seafood will be exempt from NPDES reporting requirements under this criteria. Therefore, selection of a finfish such as steelhead would allow estimation of maximum waste loads in order to appropriately size future potential waste treatment and discharge facilities at the RMT II site.

2.2 Nutritional Approach for Estimating Waste Loads from Steelhead Aquaculture

A nutritional approach is used to estimate waste loads from steelhead aquaculture operations (Bureau and Hua 2010). The key processes involved in waste generation are outlined in Figure 1. In this nutritional approach, feed is distributed to fish on a daily basis. The amount of feed distributed is dependent on the average size of the fish and water temperature at that time. Most of this feed is consumed by the fish, while some of it is wasted. This uneaten feed becomes a component of the total solid wastes. Most of the consumed feed is assimilated (digested) by the fish, while the undigested feed is eliminated as fecal waste. This fecal waste also contributes to the total solid wastes.

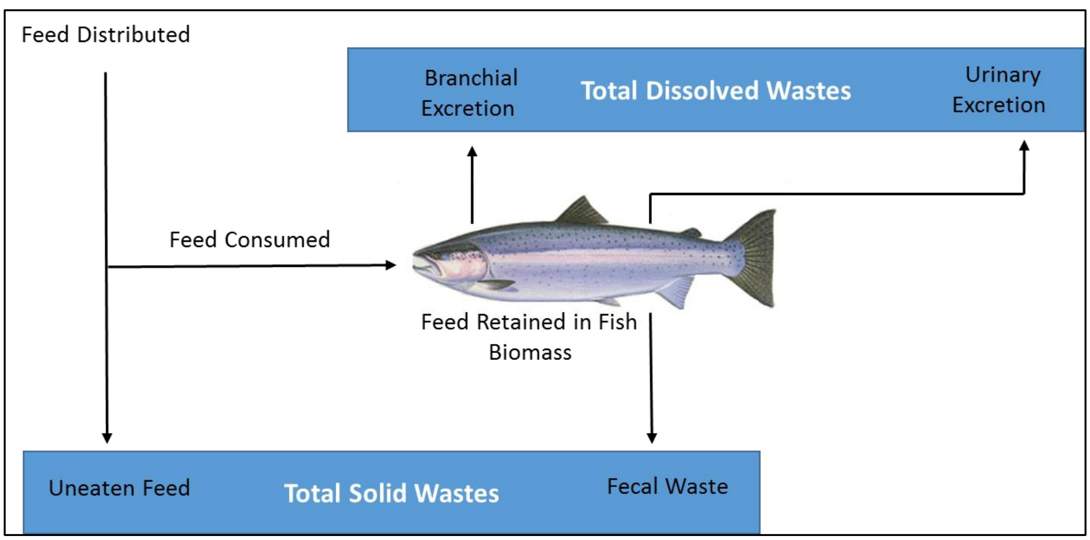


Figure 1. Schematic depicting the nutritional approach for estimating waste loads from finfish aquaculture

Total dissolved wastes are a direct function of the consumption, metabolism and retention of nutrients by the fish (Bureau and Hua, 2010). Nutrients assimilated from the consumed feed are absorbed and can potentially be metabolized by the fish to support various life processes and functions. A significant proportion of the assimilated nutrients is retained in fish biomass. The absorbed nutrients that are not retained are metabolized, and end-products of nutrient breakdown (catabolism) are eliminated by the fish through branchial or urinary excretion (Figure 1). For example, in saltwater fish, amino acid catabolism results in the production of NH_3-N/NH_4-N (henceforth called NH_4-N), which is excreted through the gills (branchial excretion), and accounts for 80-90% of nitrogenous metabolic wastes. The breakdown of nucleic acids present in the feed results in the production of urea, which is mainly excreted in the urine. Urea generally only represents about 10% of the dissolved nitrogenous waste. In addition, orthophosphates are the major form of dissolved P waste excreted by the fish.

2.3 Methods for Estimation of Waste Load Components

Wastes loads are estimated using the nutritional approach (Figure 1) that compartmentalizes the total wastes into solid and dissolved wastes. The solid and dissolved wastes components are further divided into nitrogenous and phosphorus wastes according to methods described by Bureau et al. (2003), Papatryphon et al. (2005), Roque d'Orbcastel et al. (2008), and Bureau and Hua (2010). The following sub-sections on solid waste and dissolved waste estimation describe the methods used in this analysis.

2.3.1 Solid Waste Estimation

Total Solid Wastes

The following equation describes the total solid wastes (SW) generated by fish.

$$SW = FE_w + UE_F$$

FE_W = Fecal Wastes = $F_C * (1 - ADC_{DM})$

UE_F = Uneaten Feed = $(F_D * F_W)$

Where;

ADC_{DM} = Apparent Digestibility Coefficient of Feed Dry Matter

F_W = Percent of Feed Wasted

F_C = Feed Consumed = $(F_D – UE_F)$

F_D = Feed Distributed = $(FBM * F_R)$

Where;

FBM = Fish Body Mass

F_R = Feeding Rate (as % of fish body mass per day)

Solid Nitrogenous (N) Wastes

The following equation describes the solid N waste (SW_N) generated by fish, which is a part of the total solid waste.

$$SW_N = FE_N + UE_N$$

FE_N = Fecal N Waste = $F_C * F_N * (1 – ADC_{Pr})$

UE_N = N in Uneaten Feed = $(UE_F * F_N)$

Where;

ADC_{Pr} = Apparent Digestibility Coefficient of Crude Protein in Feed

F_N = Percent N Content of Feed

F_C = Feed Consumed

UE_F = Uneaten Feed

Solid Phosphorus (P) Wastes

The following equation describes the solid P waste (SW_P) generated by fish, which is a part of the total solid waste.

$$SW_P = FE_P + UE_P$$

FE_P = Fecal P Waste = $F_C * F_P * (1 – ADC_P)$

UE_P = P in Uneaten Feed = (UE_F * F_P)

Where;

ADC_P = Apparent Digestibility Coefficient of P in Feed

F_P = Percent P Content of Feed

F_C = Feed Consumed

UE_F = Uneaten Feed

2.3.2 Dissolved Waste Estimation

Dissolved N Waste

The following equation describes the dissolved N waste (DW_N) generated by fish.

$$DW_N = C_N - FE_N - R_N$$

Where,

C_N = Consumed N = F_C * F_N

F_C = Feed Consumed

F_N = Percent N Content of Feed

FE_N = Fecal N Waste

R_N = N Retained by Fish = (F_C * B_N)/FCR

B_N = N Content of Whole Fish Body (as % of fish body mass)

FCR = Feed Conversion Ratio

Ammonia-N Waste

Ammonia-N waste is assumed to be 80% of DW_N (Papatryphon et al. 2005).

Dissolved P Waste

The following equation describes the dissolved P waste (DW_P) generated by fish.

$$DW_P = C_P - FE_P - R_P$$

Where,

C_P = Consumed P = F_C * F_P

F_C = Feed Consumed

F_P = Percent P Content of Feed

FE_P = Fecal P Waste

R_P = P Retained by Fish = (F_C * B_P)/FCR

B_P = P Content of Whole Fish Body (as % of fish body mass)

FCR = Feed Conversion Ratio

2.3.3 Total Waste Estimation

Total waste components for the purpose of this analysis include total solid waste, total N waste, and total P waste. Total solid waste is estimated as described in section 2.3.1. This section describes estimation methods for total N waste and total P waste.

Total N Waste

Total N waste (TW_N) is estimated with the equation,

$$TW_N = SW_N + DW_N$$

Where,

SW_N = Solid N Waste

DW_N = Dissolved N Waste

Total P Waste

Total P waste (TW_P) is estimated with the equation,

$$TW_P = SW_P + DW_P$$

Where,

SW_P = Solid P Waste

DW_P = Dissolved P Waste

2.4 Assumptions for Analysis of Waste Loads from Steelhead Aquaculture

The amount of waste loads generated from finfish aquaculture operations will depend on general factors such as water temperatures and fish growth (sizes achieved) during the production cycle, and the total annual production capacity. Specific feed-related factors are also important such as feed rations distributed, feed wastage (uneaten feed), feed composition, feed digestibility and feed conversion ratios, among other factors. Waste load estimation for steelhead aquaculture operations in this analysis uses the following assumptions and coefficients based on a literature review of these various factors (Tables 1, 2 and 3).

Table 1. General Factors Considered for Estimating Waste Loads From Steelhead Aquaculture Operations

General Factors	Assumptions and Rationale	Reference
Water Temperature	Assumption: Estimate waste loads for three water temperature scenarios: 10 ^{0}C, 15 ^{0}C, and 20 ^{0}C. Rationale: Steelhead can withstand a vast range of temperatures but spawning and growth occurs in a narrower range (9 ^{0}C - 14 ^{0}C) and the optimum temperature for culture is below 21 ^{0}C.	*FAO. Online article*
Fish Growth and Fish Sizes	Assumption: Estimate waste loads for four sizes of fish during this growth period, 5 g, 50 g, 250 g, and 500 g. Rationale: During the annual production cycle, steelhead grow from a startup size of 5 g fish to a 500 g (1.1 lb) fish at harvest (market size).	*1) FAO.* *2) Klontz (1991)*
Total Annual Fish Production Capacity	Assumption: Estimate waste loads for four fish production capacity scenarios, 5,000 kg; 50,000 kg; 250,000 kg; and 500,000 kg. Rationale: The RMT II site can be configured to house fish production systems that might produce as much as 500,000 kg of fish per year.	*Vinci (2013)*

Table 2. Aquaculture Feed and Fish Body Composition Factors Considered for Estimating Waste Loads From Steelhead Aquaculture Operations

Parameters	Symbol	Value	Reference
Feed Composition (%)			
Nitrogen	F_N	7.0	*Bureau and Hua (2010)*
Phosphorus	F_P	1.1	*Bureau and Hua (2010)*
Feed Wasted (%)			
Feed Wasted	F_W	5.0	*Bureau et al. (2003)*
Apparent Digestibility Coefficient (%)			
Feed Dry Matter	ADC_{DM}	78.0	*Bureau and Hua (2010)*
Crude Protein in Feed	ADC_{Pr}	88.0	*Bureau and Hua (2010)*
Phosphorus in Feed	ADC_P	60.0	*Bureau and Hua (2010)*
Feed Conversion Ratio (feed:gain)	FCR	1.1	*Bureau and Hua (2010)*
Whole Fish Body Composition (% of body weight)			
N Content of Whole Fish Body	B_N	2.65	*Roque d'Orbcastel et al. (2008)*
P Content of Whole Fish Body	B_P	0.4	*Papatryphon et al. (2005)*

In aquaculture operations, feed is distributed to steelhead on a daily basis to achieve growth of the fish to market size over a specific period of time. Daily feeding rates (daily rations) will depend on fish size and water temperatures on any particular day, which in turn will affect the amount of waste loads produced. Feeding rates are estimated as a percentage of fish body weight (% body mass/d) and are shown for the three water temperature and fish body size scenarios used to estimate waste loads (Table 3).

Table 3. Feeding Rates (Food Rations) Distributed to Steelhead as a Function of Fish Body Mass and Water Temperature.
Source for Feeding Rates: Hinshaw (1999

Individual Fish Mass (g)	**Feeding Rates (F_R) (% of body weight)**		
	10 ^{0}C	**15 ^{0}C**	**20 ^{0}C**
5.0	4.15	4.9	5.3
50.0	1.8	2.3	2.4
250.0	1.1	1.55	1.55
500.0	0.9	1.2	1.25

Notes: *Hinshaw (1999) provides fish size- and water temperature-specific feeding rates for rainbow trout where fish size is expressed as numbers of fish per pound. The number of fish/pound data in Hinshaw (1999) is converted to grams/individual fish (individual fish mass) based on 1 pound = 453.6 grams. For example, 100 fish/pound will have individual fish weighing 4.536 g each.*

2.5 Estimation of Aquaculture Waste Production

All solid and dissolved wastes are first estimated on a g/fish/d basis for fish of four different sizes under three different water temperature scenarios (Table 1). System-wide daily waste loads are estimated using individual fish waste production rates and scaling up to four aquaculture production capacity scenarios of 5,000, 50,000, 250,000 and 500,000 kg of fish (Table 1). At a market weight of 500 g (0.5 kg) per fish, these translate to fish production numbers of 10,000, 100,000, 500,000, and 1,000,0000 steelhead. Finally, annual waste loads generated by steelhead aquaculture are estimated and presented on a kilogram per metric ton of fish produced, and kilogram per annum basis.

3.0 Results and Discussion

This section describes the waste loads estimated for a steelhead aquaculture facility at the RMT II site. Waste load estimates presented in this section are based on feeding rates that are dependent on four sizes of steelhead that reflect various stages of growth, and at three water temperatures. The resulting amounts of feed distributed, feed consumed by the fish and feed left uneaten are presented in the Appendix (Table A-1).

Results of the solid and dissolved wastes loads are first described on an individual fish basis in sections 3.1-3.2. These individual fish waste load estimates are then projected to estimate system-wide daily waste loads based on total steelhead production capacity and described in section 3.3. Finally, annual waste loads expected from the steelhead aquaculture facility are presented in section 3.4.

3.1 Solid Wastes Generated by Individual Fish

Solid wastes include total solid wastes and its components, solid N wastes and solid P wastes, all of which increased by one to two orders of magnitude with increases in fish body mass and water temperatures (Appendix, Table A-2, Figures 2 and 3). At startup of system operations for example, a fish of 5 g at 10 ^{0}C produces 0.0537 g/d of solid waste, of which 0.0024 g is N waste and 0.001 g is P waste. At the end of one growth cycle of annual operations, a harvestable fish of 500 g (market size) at 20 ^{0}C produces approximately 1.6188 g/d of solid waste, of which 0.0718 g is N waste and 0.0296 g is P waste (Appendix Table A-2, Figures 2 and 3).

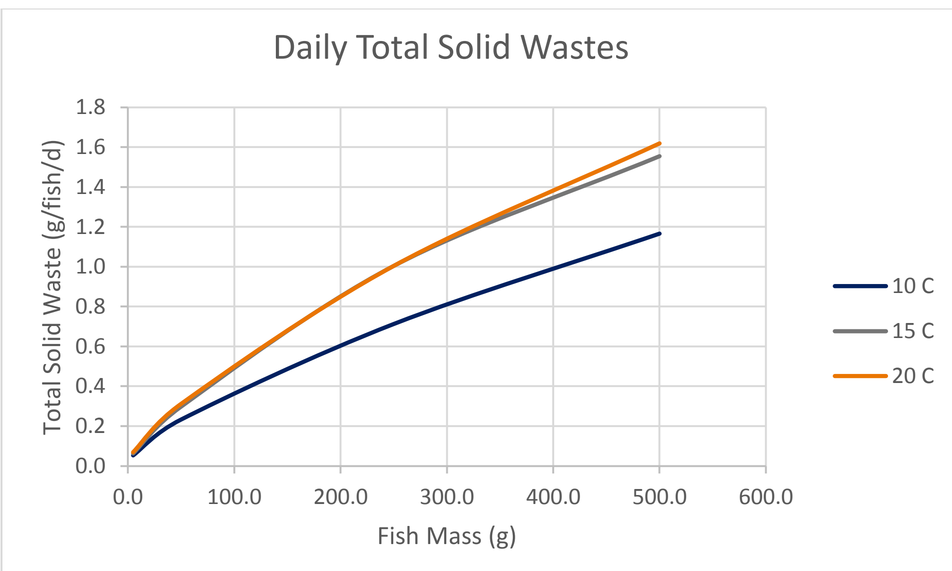


Figure 2. Estimated daily production of total solid wastes by individual steelhead trout

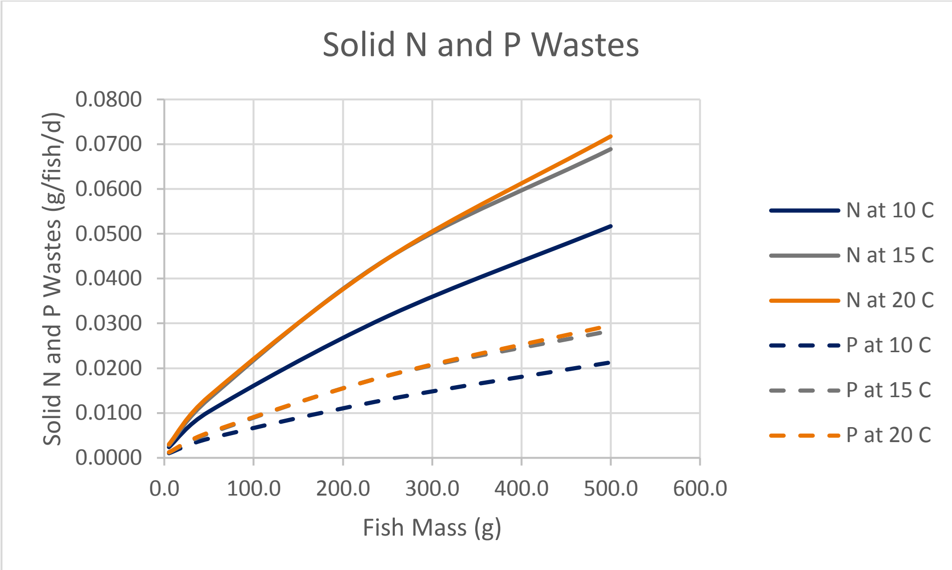


Figure 3. Estimated daily production of solid N and P wastes by individual steelhead trout

3.2 Dissolved Wastes Generated by Individual Fish

Dissolved wastes include dissolved N, of which 80% is NH_4-N waste, and dissolved P wastes. Fish body mass and water temperatures strongly affect production of each of these dissolved waste components (Appendix, Table A-3, Figures 4 and 5). At startup of system operations for example, a fish of 5 g at 10 ^{0}C produces 0.0074 g/d of dissolved N waste, of which 0.0059 g is as NH_4-N, and 0.0006 g is P waste. At the end of one growth cycle of annual operations, a harvestable fish of 500 g (market size) at 20 ^{0}C produces approximately 0.2227 g/d of dissolved N waste, of which 0.1782 g is as NH_4-N, and 0.0176 g of P waste (Appendix, Table A-3, Figures 4 and 5).

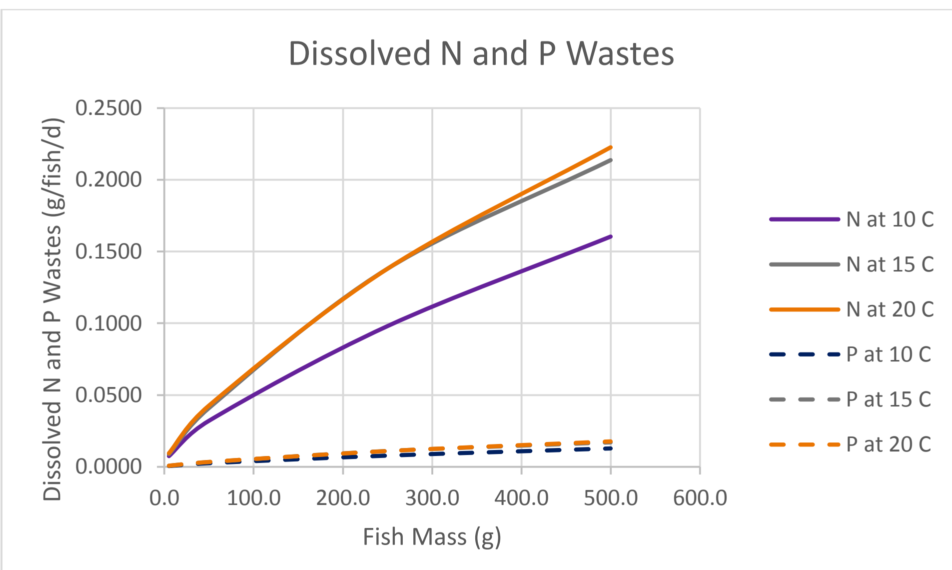


Figure 4. Estimated daily production of dissolved N and P wastes by individual steelhead trout

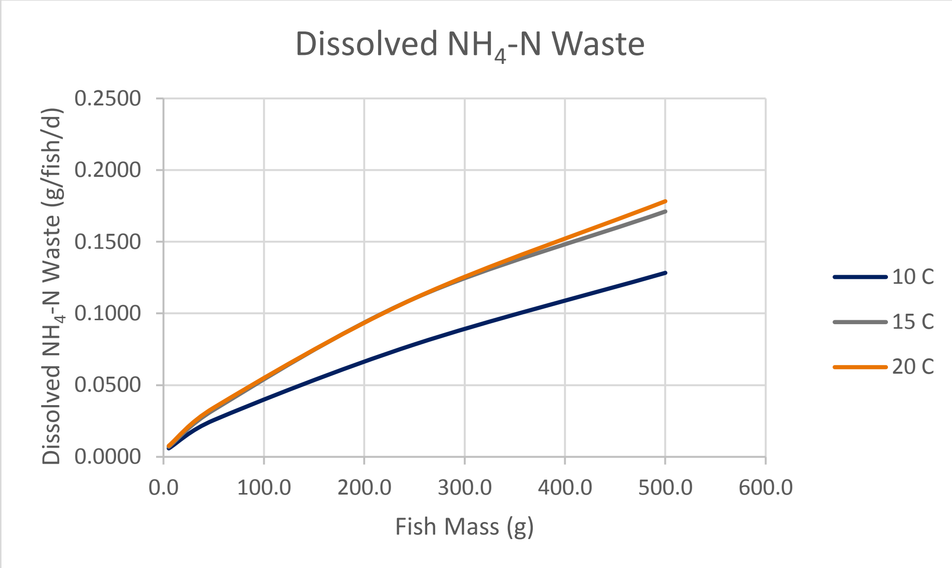


Figure 5. Estimated daily production of solid N and P wastes by individual steelhead trout

3.3 System-wide Daily Waste Loads Related to Total Steelhead Production Capacity

Daily wastes generated by steelhead aquaculture operating at various annual production capacities are evaluated at startup and harvest under three different water temperature regimes. Waste loads scaled to fish production capacities include total solid waste, total N and P waste (solid + dissolved N and P), NH_4-N waste, and dissolved P waste.

The ranges of daily total solid wastes, NH_4-N production, dissolved P waste production, and daily total N and P waste production all increase significantly with increasing fish production capacity (Appendix, Tables A-4 to A-8, Figures 6 to 10).

3.3.1 Daily Total Solid Wastes and Fish Production Capacity

The relationship between production of total solid wastes and fish production capacity is shown in Figure 6. For example, at a production capacity of 5,000 kg of steelhead (10,000 fish), total solid waste production is 0.5 kg/d at 10 ^{0}C at startup and increases to 16.2 kg/d at 20 ^{0}C at harvest, as fish grow through the production cycle. At 500,000 kg of steelhead produced (1,000,000 fish), total solid waste production ranges from 53.7 kg/d at 10 ^{0}C at startup, to 1,618.8 kg/d at 20 ^{0}C at harvest size, which is also the maximum daily load under the scenarios examined (Appendix, Table A-4, Figure 6).

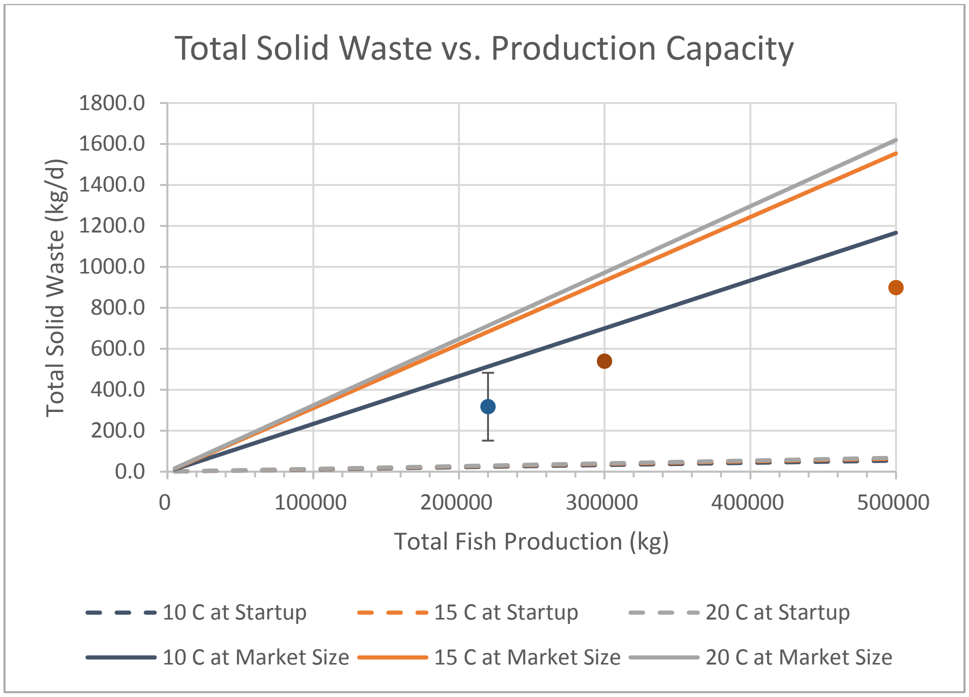


Figure 6. Daily total solid wastes produced by steelhead at various production capacities at startup of operations and at harvest, under three water temperature regimes

Note: It is assumed that none to negligible fish mortality occurs through the production cycle. Symbols represent data from other studies; blue symbol is data from Roque D'Orbcastel et al. (2008), and the other two symbols are estimates derived from Azevedo et al. (1998), corroborating that waste production estimated in this study falls within the ranges presented in other studies.

3.3.2 Daily NH_4-N Wastes and Fish Production Capacity

The relationship between production of NH_4-N wastes and fish production capacity is shown in Figure 7. At a production capacity of 5,000 kg of steelhead (10,000 fish), NH_4-N waste production is 0.06 kg/d at 10 ^{0}C at startup and increases to 1.8 kg/d at 20 ^{0}C at harvest, reflecting an increase in waste produced as fish grow through the production cycle. At 500,000 kg of steelhead produced (1,000,000 fish), total NH_4-N waste production ranges from 5.9 kg/d at 10 ^{0}C at startup, to 178.2 kg/d at 20 ^{0}C at harvest size, and represents a significant increase in waste production as fish production capacity increases. The waste load of 178.2 kg/d also reflects the maximum daily load of NH_4-N waste under the scenarios examined (Appendix, Table A-5, Figure 7).

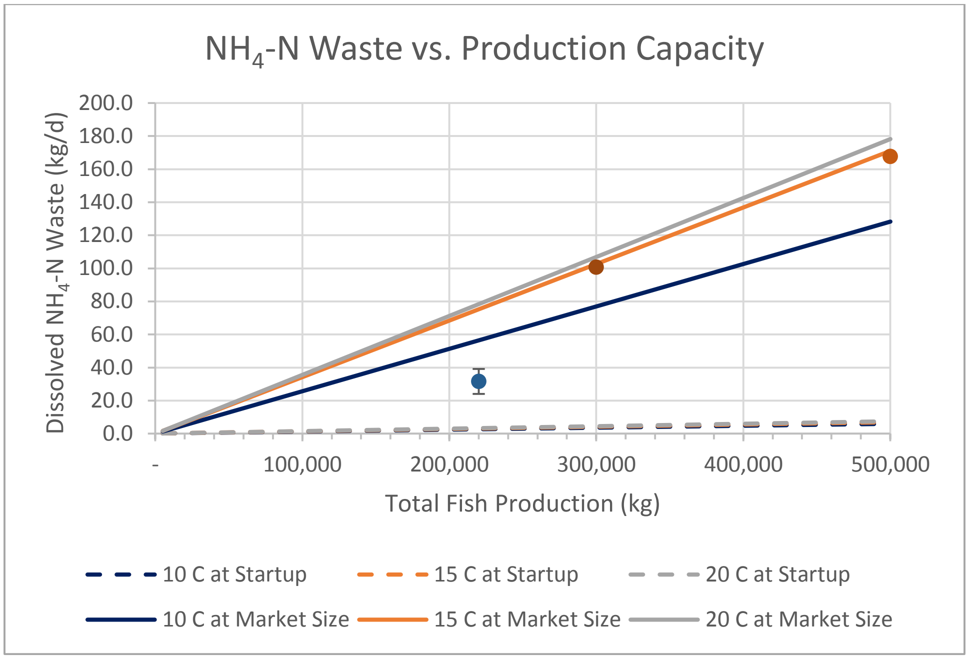


Figure 7. Daily NH_4-N wastes produced by steelhead at various production capacities at startup of operations and at harvest, under three water temperature regimes

Note: It is assumed that none to negligible fish mortality occurs through the production cycle. Symbols represent data from other studies; blue symbol is data from Roque D'Orbcastel et al. (2008), and the other two symbols are estimates derived from Azevedo et al. (1998), corroborating that waste production estimated in this study falls within the ranges presented in other studies.

3.3.3 Daily Dissolved P Waste and Fish Production Capacity

The relationship between production of dissolved P wastes and fish production capacity is shown in Figure 8. At a production capacity of 5,000 kg of steelhead (10,000 fish), dissolved P waste production is 0.006 kg/d at 10 ^{0}C at startup and increases to 0.18 kg/d at 20 ^{0}C at harvest, reflecting an increase in dissolved P waste generated as fish grow through the production cycle. At 500,000 kg of steelhead produced (1,000,000 fish), dissolved P waste production ranges from 0.58 kg/d at 10 ^{0}C at startup, to 17.6 kg/d at 20 ^{0}C at harvest size. The latter also reflects the maximum daily load of dissolved P waste, most of it as orthophosphate, under the scenarios examined (Appendix, Table A-6, Figure 8).

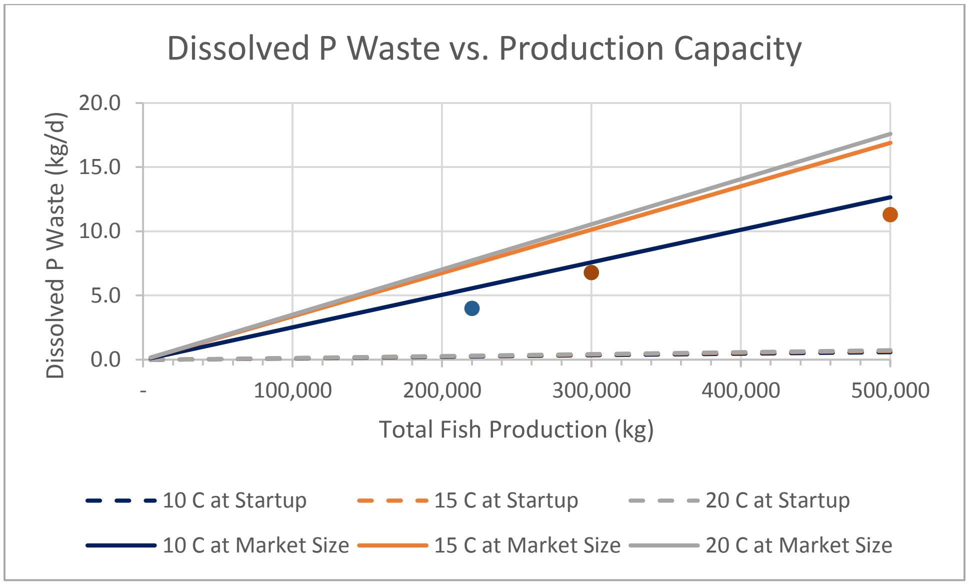


Figure 8. Daily dissolved P wastes produced by steelhead at various production capacities at startup of operations and at harvest, under three water temperature regimes

Note: It is assumed that none to negligible fish mortality occurs through the production cycle. Symbols represent data from other studies; blue symbol is data from Roque D'Orbcastel et al. (2008), and the other two symbols are estimates derived from Azevedo et al. (1998), corroborating that waste production estimated in this study falls within the ranges presented in other studies.

3.3.4 Daily Total N Waste and Fish Production Capacity

The relationship between daily total N wastes (dissolved N + solid N) is shown in Figure 9. At a production capacity of 5,000 kg of steelhead (10,000 fish), total N waste production is 0.1 kg/d at 10 ^{0}C at startup and increases to 2.9 kg/d at 20 ^{0}C at harvest. This reflects an increase in total N waste generated as fish grow through the production cycle. At 500,000 kg of steelhead produced (1,000,000 fish), total N waste production ranges from 9.8 kg/d at 10 ^{0}C at startup, to a maximum of 294.5 kg/d at 20 ^{0}C at harvest size under the scenarios examined (Appendix, Table A-7, Figure 9).

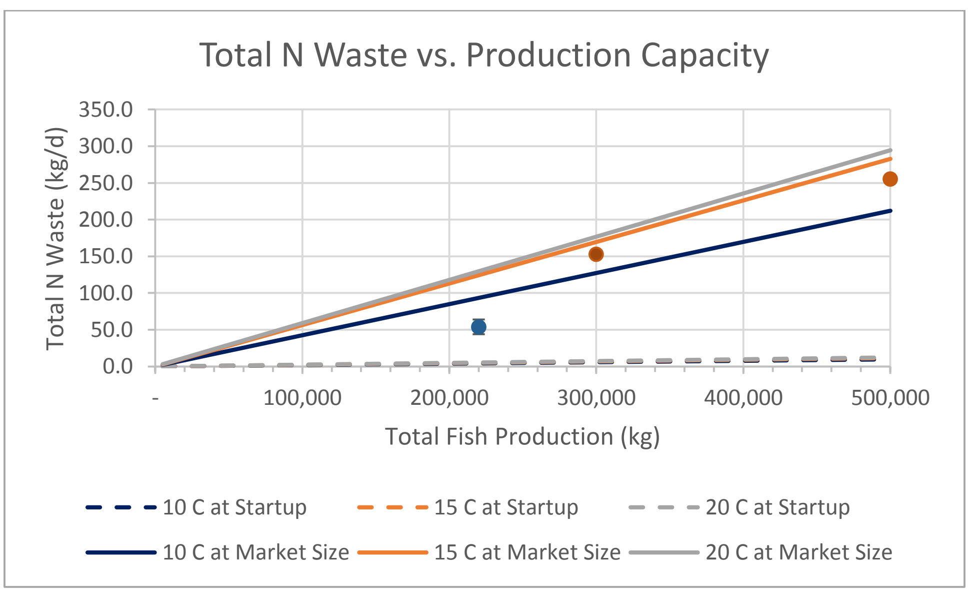


Figure 9. Daily total N wastes produced by steelhead at various production capacities at startup of operations and at harvest, under three water temperature regimes

Note: It is assumed that none to negligible fish mortality occurs through the production cycle. Symbols represent data from other studies; blue symbol is data from Roque D'Orbcastel et al. (2008), and the other two symbols are estimates derived from Azevedo et al. (1998), corroborating that waste production estimated in this study falls within the ranges presented in other studies.

3.3.5 Daily Total P Waste and Fish Production Capacity

The relationship between daily total P wastes (dissolved P + solid P) is shown in Figure 10. At a production capacity of 5,000 kg of steelhead (10,000 fish), total P waste production is 0.02 kg/d at 10 ^{0}C at startup and increases to 0.47 kg/d at 20 ^{0}C at harvest. This reflects an increase in total P waste generated as fish grow through the production cycle. At 500,000 kg of steelhead produced (1,000,000 fish), total P waste production ranges from 1.57 kg/d at 10 ^{0}C at startup, to a maximum of 47.16 kg/d at 20 ^{0}C at harvest size, under the scenarios examined (Appendix, Table A-8, Figure 10).

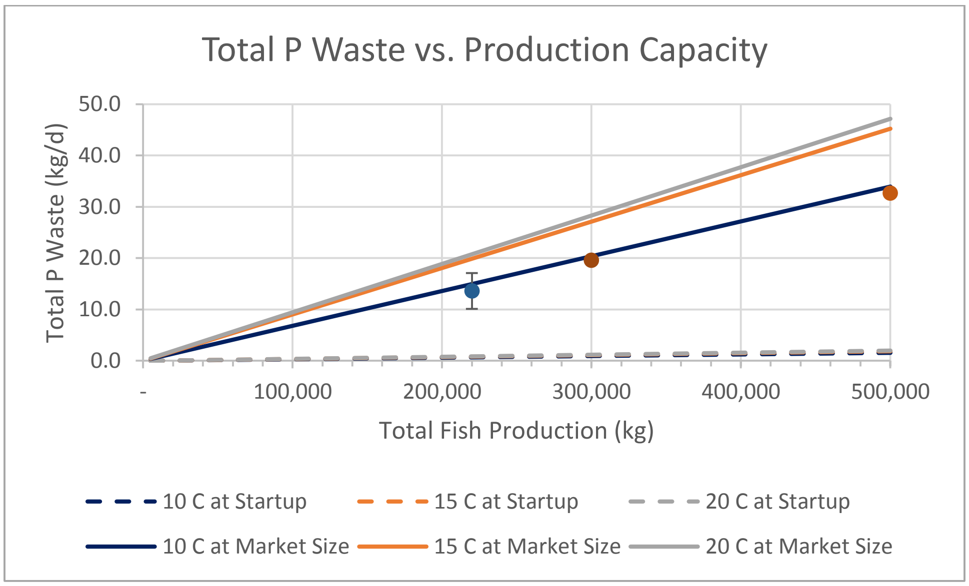


Figure 10. Daily total P wastes produced by steelhead at various production capacities at startup of operations and at harvest, under three water temperature regimes

Note: It is assumed that none to negligible fish mortality occurs through the production cycle. Symbols represent data from other studies; blue symbol is data from Roque D'Orbcastel et al. (2008), and the other two symbols are estimates derived from Azevedo et al. (1998), corroborating that waste production estimated in this study falls within the ranges presented in other studies.

3.4 Annual Waste Loads Generated by Steelhead Aquaculture

Annual waste loads generated per metric ton of fish produced are estimated for a single cycle of steelhead aquaculture that grows fish from 5 g at startup to 500 g market size over a 30 week (210 day) period. The average water temperature is assumed to be 15 ^{0}C during this production cycle, which is within the optimal water temperature range for growth of *O. mykiss* in aquaculture operations (Hinshaw 1999).

Total solid wastes formed the bulk of the total wastes generated at 306.5 kg per metric ton of fish produced, followed by N and P wastes (Figure 11).

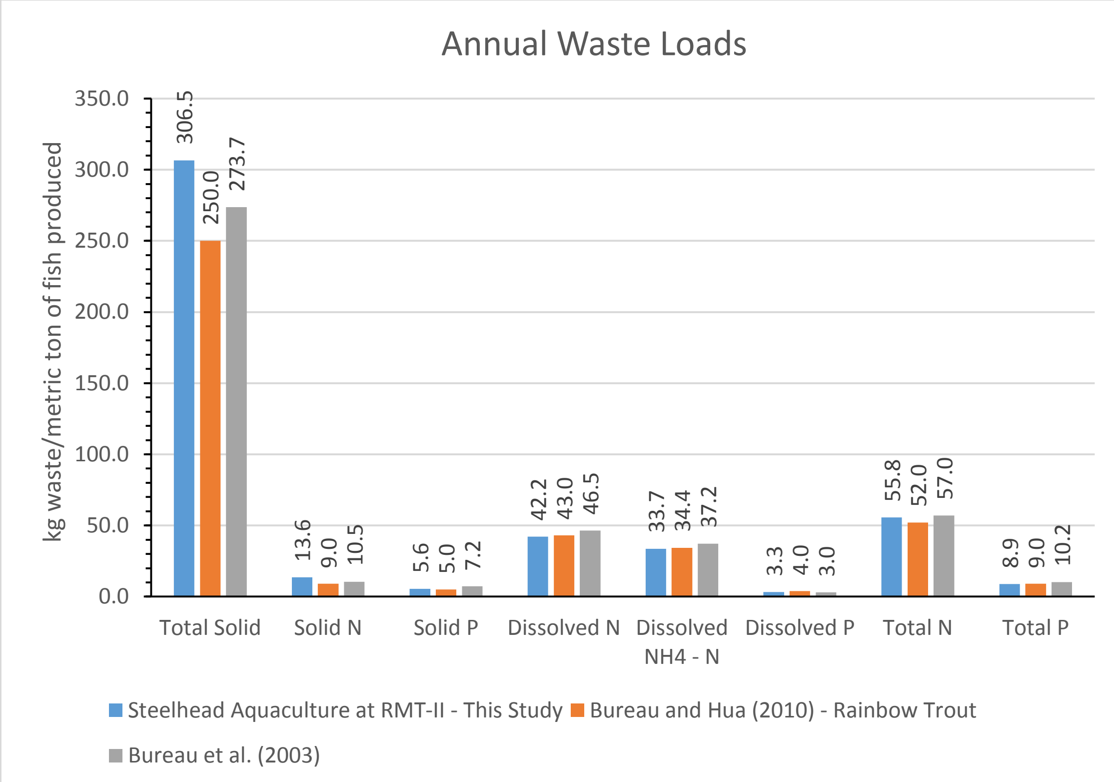


Figure 11. Total waste loads generated per metric ton of steelhead produced over a 30 week production period, compared to waste production estimates from other studies.

Table 4 further provides a breakdown of these waste loads based on various total fish production capacities of the steelhead aquaculture operations.

Table 4. Total waste loads generated by steelhead aquaculture over a 30 week production period at various fish production capacities.

	Total Fish Production (kg)			
Waste Load (kg)	**5,000**	**50,000**	**250,000**	**500,000**
Total Solid Waste (SW)	1,532	15,324	76,622	153,244
Solid N Waste (SW_N)	68	679	3,396	6,792
Solid P Waste (SW_P)	28	280	1,399	2,799
Dissolved N Waste (DW_N)	211	2,108	10,542	21,084
NH4 - N Waste (DW_{NH4-N})	169	1,687	8,433	16,867
Dissolved P Waste (DW_P)	17	167	833	1,666
Total N Waste (TW_N)	279	2,788	13,938	27,876
Total P Waste (TW_P)	45	446	2,232	4,464

4.0 References

Azevedo, P. A., C. Y. Cho, S. Leeson, D. P. Bureau. 1998. Effects of feeding level and water temperature on growth, nutrient and energy utilization and waste outputs of rainbow trout (*Onchorhynchus mykiss*). Aquatic Living Resources 11: 227-238.

Bureau, D. P. and K. Hua. 2010. Towards effective nutritional management of waste outputs in aquaculture, with particular reference to salmonid aquaculture operations. Aquaculture Research 41: 777-792.

Bureau, D. P., S. J. Gunther, and C. Y. Cho. 2003. Chemical composition and preliminary theoretical estimates of waste outputs of rainbow trout reared in commercial cage operations in Ontario. North American Journal of Aquaculture 65: 33-38.

Food and Agriculture Organization of the United States (FAO). Cultured Aquatic Species Information Programme. *Onchorhynchus mykiss*. FAO.

Hinshaw, J. M. 1999. Trout Production: Feeds and Feeding Methods. Southern Regional Aquaculture Center (SRAC). Publication number 223.

Klontz, G. W. 1991. Manual for rainbow trout production on the family-owned farm. Manual prepared by University of California – Davis. 70 pgs.

Papatryphon, E., J. Petit, H. M. G. Van der Werf, K. J. Sadasivam, and K. Claver. 2005. Nutrient-balance modeling as a tool for environmental management in aquaculture: The case of trout farming in France. Environmental Management 35: 161-174.

Roque d'Orbcastel, E., J-P Blancheton, T. Boujard, J. Aubin, Y. Moutounet, C. Przybyla, and A. Belaud. 2008. Comparison of two methods for evaluating waste of a flow through trout farm. Aquaculture 274: 72-79.

Vinci, B. 2013. Aquaculture facility planning for freshwater tissue pulp mill. Draft Memorandum, The Conservation Fund, Freshwater Institute, WV. 9 pgs.

Appendix (Tables A-1 to A-8)

Table A-1. Fish body mass, rations fed, and related food consumption.

	Feeding Rates (F_R) (% of body weight)			Feed Distributed (F_D) (g/fish/d)			Uneaten Feed (UE_F) (g/fish/d)			Feed Consumed (F_C) (g/fish/d)		
Individual Fish Mass (g)	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**
5	4.15	4.9	5.3	0.2075	0.2450	0.2650	0.0104	0.0123	0.0133	0.1971	0.2328	0.2518
50	1.8	2.3	2.4	0.9000	1.1500	1.2000	0.0450	0.0575	0.0600	0.8550	1.0925	1.1400
250	1.1	1.55	1.55	2.7500	3.8750	3.8750	0.1375	0.1938	0.1938	2.6125	3.6813	3.6813
500	0.9	1.2	1.25	4.5000	6.0000	6.2500	0.2250	0.3000	0.3125	4.2750	5.7000	5.9375

Table A-2. Solid wastes for individual fish in relation to fish body mass and water temperature.

	Total Solid Waste (SW) (g/fish/d)			Solid N Waste (SW_N) (g/fish/d)			Solid P Waste (SW_P) (g/fish/d)		
Individual Fish Mass (g)	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**
5	0.0537	0.0635	0.0686	0.0024	0.0028	0.0030	0.0010	0.0012	0.0013
50	0.2331	0.2979	0.3108	0.0103	0.0132	0.0138	0.0043	0.0054	0.0057
250	0.7123	1.0036	1.0036	0.0316	0.0445	0.0445	0.0130	0.0183	0.0183
500	1.1655	1.5540	1.6188	0.0517	0.0689	0.0718	0.0213	0.0284	0.0296

Table A-3. Dissolved wastes for individual fish in relation to fish body mass and water temperature

	Dissolved N Waste (DW_N) (g/fish/d)			Dissolved NH_4-N Waste (DW_{NH4-N}) (g/fish/d)			Dissolved P Waste (DW_P) (g/fish/d)		
Individual Fish Mass (g)	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**
5	0.0074	0.0087	0.0094	0.0059	0.0070	0.0076	0.0006	0.0007	0.0007
50	0.0321	0.0410	0.0428	0.0257	0.0328	0.0342	0.0025	0.0032	0.0034
250	0.0980	0.1381	0.1381	0.0784	0.1105	0.1105	0.0077	0.0109	0.0109
500	0.1604	0.2138	0.2227	0.1283	0.1710	0.1782	0.0127	0.0169	0.0176

Table A-4. Annual production capacity of aquaculture operations and daily solid wastes at startup and at harvest.

		Total Solid Waste (SW) (kg/d) at startup			Total Solid Waste (SW) (kg/d) at harvest		
Total Fish Production (kg)	**Total Number Fish Produced**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**
5,000	10,000	0.5	0.6	0.7	11.7	15.5	16.2
50,000	100,000	5.4	6.3	6.9	116.6	155.4	161.9
250,000	500,000	26.9	31.7	34.3	582.8	777.0	809.4
500,000	1,000,000	53.7	63.5	68.6	1165.5	1554.0	1618.8

Note: Fish size at startup is 5 g and at harvest is 500 g (market size).

Table A-5. Annual production capacity of aquaculture operations and daily NH_4-N wastes at startup and at harvest.

		NH_4-N Waste (DW_{NH4-N}) (kg/d) at Startup			NH4-N Waste (DW_{NH4-N}) (kg/d) at Harvest		
Total Fish Production (kg)	**Total Number Fish Produced**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**
5,000	10,000	0.06	0.07	0.08	1.3	1.7	1.8
50,000	100,000	0.6	0.7	0.8	12.8	17.1	17.8
250,000	500,000	3.0	3.5	3.8	64.1	85.5	89.1
500,000	1,000,000	5.9	7.0	7.6	128.3	171.0	178.2

Note: Fish size at startup is 5 g and at harvest is 500 g (market size).

Table A-6. Annual production capacity of aquaculture operations and daily dissolved P wastes at startup and at harvest.

		Dissolved P Waste (DW_P) (kg/d) at Startup			Dissolved P Waste (DW_P) (kg/d) at Harvest		
Total Fish Production (kg)	**Total Number Fish Produced**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**	**10 ^{0}C**	**15 ^{0}C**	**20 ^{0}C**
5,000	10,000	0.006	0.007	0.007	0.13	0.17	0.18
50,000	100,000	0.058	0.069	0.075	1.27	1.69	1.76
250,000	500,000	0.29	0.34	0.37	6.33	8.45	8.80
500,000	1,000,000	0.58	0.69	0.75	12.67	16.89	17.60

Note: Fish size at startup is 5 g and at harvest is 500 g (market size).

Table A-7. Annual production capacity of aquaculture operations and daily total N wastes at startup and at harvest.

		Total N Waste (TW_N) (kg/d) at Startup			Total N Waste (TW_N) (kg/d) at Harvest		
Total Fish Production (kg)	**Total Number Fish Produced**	**10 °C**	**15 °C**	**20 °C**	**10 °C**	**15 °C**	**20 °C**
5,000	10,000	0.10	0.12	0.12	2.1	2.8	2.9
50,000	100,000	1.0	1.2	1.2	21.2	28.3	29.4
250,000	500,000	4.9	5.8	6.2	106.0	141.3	147.2
500,000	1,000,000	9.8	11.5	12.5	212.0	282.7	294.5

Note: Total N = Solid N + Dissolved N.

Fish size at startup is 5 g and at harvest is 500 g (market size).

Table A-8. Annual production capacity of aquaculture operations and daily total P wastes at startup and at harvest.

		Total P Waste (TW_P) (kg/d) at Startup			Total P Waste (TW_P) (kg/d) at Harvest		
Total Fish Production (kg)	**Total Number Fish Produced**	**10 °C**	**15 °C**	**20 °C**	**10 °C**	**15 °C**	**20 °C**
5,000	10,000	0.02	0.02	0.02	0.34	0.45	0.47
50,000	100,000	0.16	0.18	0.20	3.40	4.53	4.72
250,000	500,000	0.78	0.92	1.00	16.98	22.64	23.58
500,000	1,000,000	1.57	1.85	2.00	33.95	45.27	47.16

Note: Total P = Solid P + Dissolved P.

Fish size at startup is 5 g and at harvest is 500 g (market size).

E

HWE Preliminary Analysis Dredge Spoils Processing

Memorandum

To: Mike Foget, PE / SHN Consulting Engineers and Geologists, Inc.	
From: Brian Hemphill	Project: Redwood Marine Terminal II
CC:	
Date: January 15, 2016	Job No:
Re: Preliminary Analysis Dredge Spoils Processing in Microfloc System	

INTRODUCTION

This memorandum presents a concept for managing dredge spoils in the existing Microfloc water processing facilities at the Samoa site. Details on existing treatment facilities are presented in a separate memorandum.

SYSTEM DESIGN CONCEPT

A preliminary operating scheme was developed for management of the dredge spoils. A summary of the basic system operating parameters is presented in Table 1.

Under this concept the dredge will pump directly to the treatment system site, and the slurry will be directed to one of the two clarifiers. The clarifier basins will be modified by installing a porous base/underdrain system that covers the existing floor, preventing dredged soil from entering the solids hoppers in the floor while allowing drainage of water. The drained water will be pumped away using the existing waste pumps, supplemented with new vertical can pumps equipped with telescoping valves, installed in clarifier. These will allow pumping of supernatant over soils in the event of slow drainage to the floor.

The operating clarifier will be alternated each week. While one is in service processing the pumped spoils, the other will be allowed to drain free water and then excavated using conventional mobile machinery. Spoils will be trucked to the final destination.

Free water will also be allowed to overflow the tank via the existing weirs. The overflowed water will be combined with the pumped drain water in the clarifier effluent sump in the filter building.

There appears to be sufficient storage in each clarifier basin to hold a week's production with adequate freeboard. The total depth of accumulation is estimated at just under nine feet measured at the tank center, and about 2.7 feet above the floor at the tank wall, well within the available space. Even with consideration of an 18 inch underdrain, this leaves about four feet from the top of the sediment surface to the top of the effluent launder, as depicted in Figure 3.

TABLE 1. DREDGE SPOILS PROCESSING DESIGN CONCEPT	
DREDGE SPOILS	
Solids pumping rate	150 CY/hour
Solids content of pumped slurry	10%
Total slurry pumping rate	5,000 gpm
Water flow	4,500 gpm
Hours/day of pumping	5
Days/week of operation	5
Weekly solids processed	3,750 CY
SLURRY PROCESSING	
Overflow rate in one clarifier (150')	365 gpd/sf
Depth of soil in one clarifier/week	5.7 ft
Filter rate in three filters (if needed)	4.1 gpm/sf

The water quality standards for the outfall call for a maximum discharge turbidity of 75 NTU (nephelometric turbidity units). For most types of water this is roughly equivalent to 75 mg/l TSS. It's not possible to speculate whether or not the discharge from the dredge spoils tank will meet that standard without additional treatment. It is highly likely that it will if it is filtered, possibly with the aid of a low dose of coagulant. To be safe, it is prudent to plan to use three of the existing filters for this purpose.

SYSTEM MODIFICATIONS

Besides renovations needed to get the filters operable, it will be necessary to also install a new system to provide backwash water. The existing filtration system was designed to use what is known as "internal backwash", in which treated effluent is routed directly from other operating filters into the effluent/backwash supply line to the filter being backwashed. To ensure sufficient flow for backwash, this method relies on at least four filters being in operation while another is being backwashed. That will not be the case for the proposed system. The backwash requirement for each filter will be a flow rate of about 5,700 gpm and a total volume of about 56,000 gallons.

The proposed scheme for accomplishing this is to use the existing seawater filtration storage tank, which has a capacity of 100,000 gallons. New pumps would be installed to supply the required backwash flow. These will be in the range of 75-100 hp. A new line will be installed to the storage tank from the filter effluent line with an automatic valve to keep the backwash storage tank filled,

This scheme will also require modifications to the piping manifold serving the filters. An 18" backwash supply line will be installed, with automatic valves serving each filter.

Other minor modifications will be made to the treatment complex:

- A new line will be installed to direct collected underdrain water from the clarifier waste sump to the clarifier effluent sump.
- The filter backwash waste line will connected to the existing flash mix basin, which feeds both clarifiers by gravity. In this way filter backwash will be recycled to the clarifiers, where the solids will settle and be removed with the dredge material.

FIGURE 1. DREDGE SPOILS LIQUIDS PROCESSING SCHEMATIC

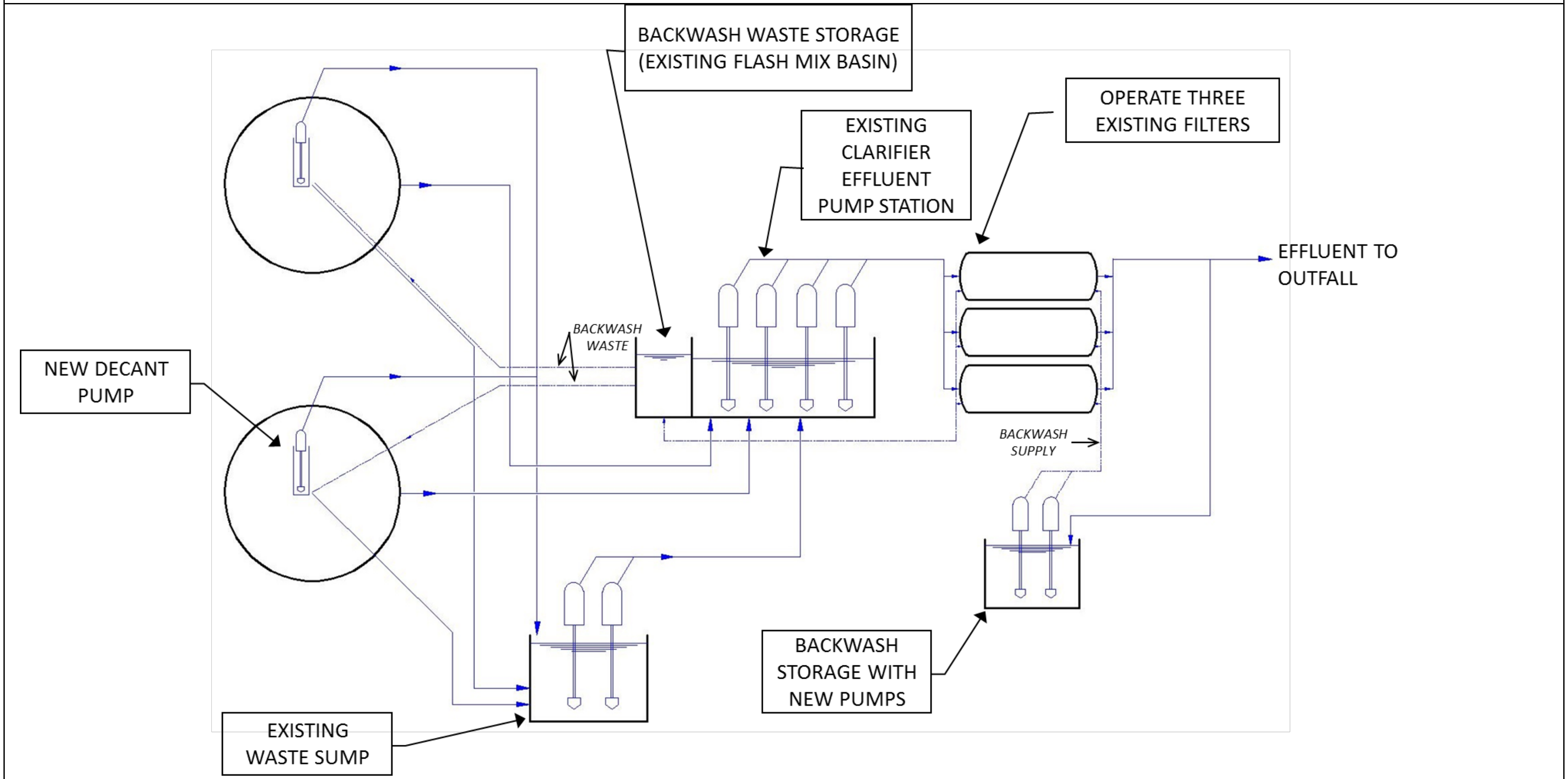


FIGURE 2. PLAN OF CONVERTED CLARIFIERS

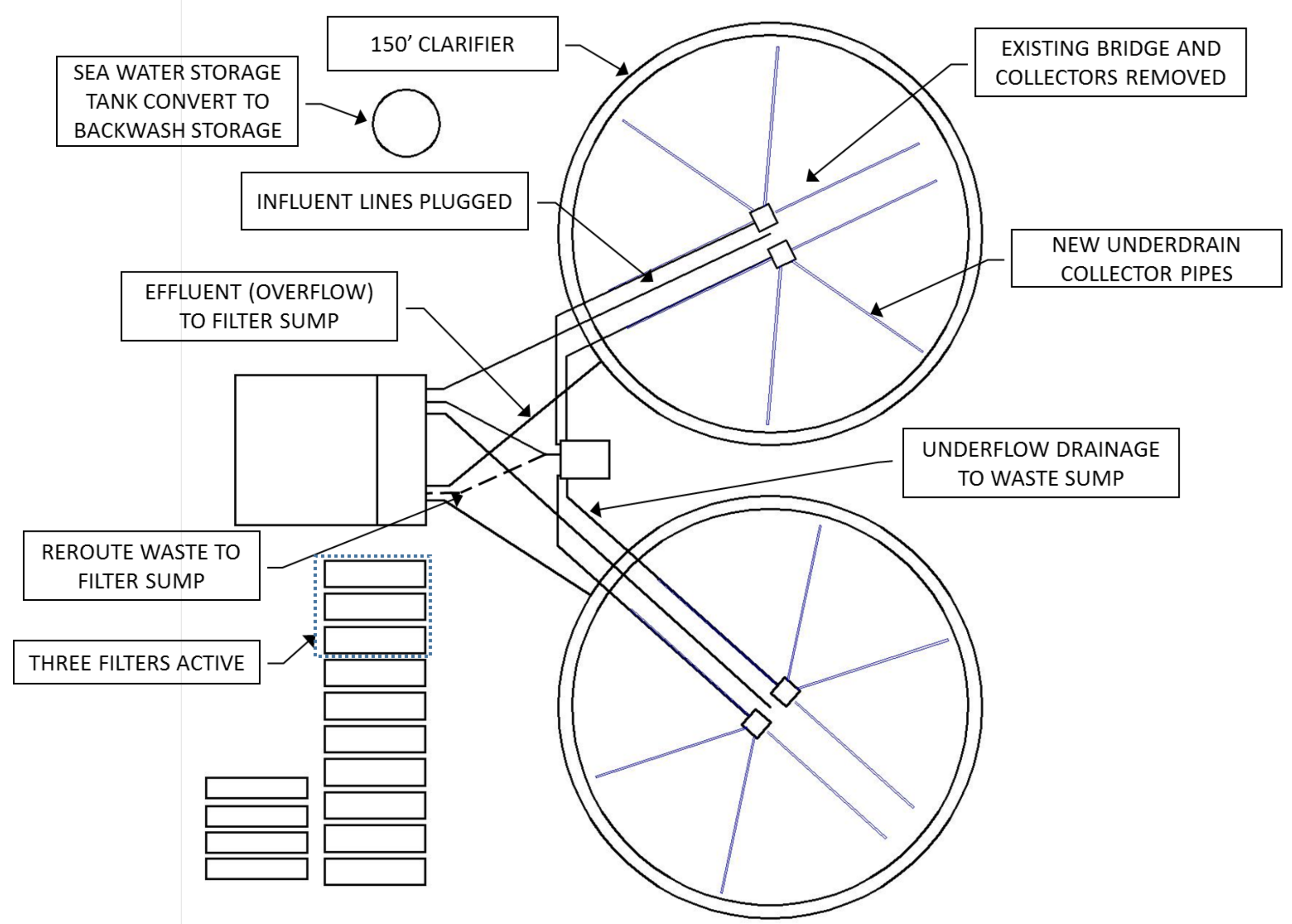


FIGURE 3. SECTION OF CONVERTED CLARIFIER