DBWT

D.B. Western Texas, Inc.

New Business Development, Design, Engineering, EPC Contractor
ASME Fabrication, Finite Analysis, ASPEN Heat Exchanger, API Tanks
Technology, Chemical Process Development, Chemical Production

October 27, 2016

COOS BAY CITY COUNCIL

The Coos Bay estuary is classified by EPA for "Recreation and Shellfish" and is listed as 303 (d) "Impaired" primarily due to three waste treatment plants discharging effluents containing infectious virus waste from the community. Oysters, clams, mussels, scallops, are filter-feeders and are known to be a measurement of pollution by EPA and the FDA. Viruses found in filter-feeders reveals that we have a serious viral health problem. DEQ is incorrect, stating that fecal coliform is the pollutant of concern. The oyster meat tested by the FDA shows 20 times the number of viruses than fecal coliform (Exhibit 16). High virus accumulation is the problem as shown in Exhibits 14 & 15. ISSC and FDA have already published viral testing recommendations for shellfish harvesting areas. In 2017, EPA will draft new criteria for viral testing regulations for shellfish harvesting areas (Exhibit 20). The City's current plan for Empire (CB2) will not resolve virus pollution. City's management's answer is to wait until they are told to add a membrane and UV system, which will happen in the next 10-15 years at over 35 million dollars. DBWT's Plan A, which solves the virus issue now, is a comparison to city's current CB2 project (City's Plan A)

If the Coos Bay City Council chooses to proceed with DBWT's wastewater services plan, then a letter of intent will allow further details to be worked out with council, staff, and attorneys. DBWT is prepared to provide performance bonding for both completion and performance.

If the Coos Bay City Council chooses to proceed with their plan, will this become the same 13-year path for the downtown plant (CB1)? CB1 is 2.7 times the size and will be required to be rebuilt or replaced in the next 10-15 years. Does DEQ and City management have a plan for these rebuilds and related costs for the next 10-15 years? DBWT presents the cost projections for the expected upgrades in the City's Plan C and DBWT's alternate Plan C.

Privatization of wastewater services has been used negatively; however, please consider that all of our city's wastewater services including plant operations, maintenance, design, engineering, and consulting are provided by private companies. Even metering and payments are managed by the CB/NB Water Board. Garbage collection and disposal is managed by Waste Management, a private Chicago, IL company. Contracting with DBWT for wastewater services will keep the jobs and money within our community, and also provides health and environmental benefits.

DEQ has clouded the issue by threats of fines if the City does ***not hurry up*** (DEQ has allowed 13 years on CB2's MAO) and long delays for DBWT to implement an alternate plan. DBWT will present drawings and application requirements to DEQ within 4 months after a letter of intent from the City is received. CB2 can be operational within 1.5 years from approved permits to proceed. DEQ even states there are no statues preventing this path. The city will still own the wastewater inflow, and DBWT is merely processing this wastewater to a DEQ Class A product and returning this product to the ownership of the City. This Class A product can be beneficially reused or flow through the City's owned NPDES permitted outfall. DEQ fines received by the City for any NPDES noncompliance will be reimbursed to the city by DBWT. DEQ's policy goal is clean Class A water, so why would they fine a city who has the same mission?

INTRODUCTION

Coos Bay's wastewater treatment plants (CB2 and CB1) will be required by EPA and DEQ to be replaced due to bypassing and EPA's viral testing requirements for coastal estuaries classified for "Recreation and Shellfish" use. DEQ's 2013 MAO required the City to replace CB2. Replacement of CB1 will be required in 10-15 years due to new EPA NPDES policy. The City's CB2 (Plan A) will stop bypassing waste, however this will only minimally reduce wastewater pollutants from entering the bay. This plan does not stop virus contamination of the bay (Exhibit 5). Effective virus kill requires a membrane process to filter out fecal solids and viruses and only then can a highly efficient UV kill (Exhibit 12) be accomplish. The City announced they would add this membrane process later when required by DEQ. We offer DBWT's Plan A which uses a GE Membrane Bioreactor or MBR which removes 99% of the viruses through filtering then we use ATS's high efficiency UV system to kill 99.9999% of the 1% remaining viruses. The GE MBR process is also better at removing nutrients, which create destructive algae growth in the bay. The City's plan, using SBR, has demonstrated inconsistent performance and poor efficiency at higher flows. This inconsistency can be seen easily on the log sheets from Coquille's new SBR plant, which is the same technology the City plans to use for CB2. (Exhibit 6)

DBWT's Wastewater Services Optional Plan C provides a long range and transitional plan for replacing CB1 and CB2 using the same GE MBR process producing DEQ Class A water effluent. DBWT's Plan A and C will help the commercial oyster growers now by installing the membrane process (GE MBR) at the beginning for a lower cost to ratepayers. We propose planning for the future rather than waiting for DEQ to make the City (MAO) go through the same 13-year process like CB2 which increased the price tag over 2 times. We will provide this wastewater service at a lower cost and produce results sooner, which will improve water quality in our estuary, and benefit business and tourism.

DBW and DBWT are both Oregon corporations, located out on the North Spit of Coos Bay, and owned by the Beetham family since 1975. DBW manages the design/build of plants (licensed Oregon Contractor) and is ASME code certified. DBWT manages the training and 24-hour operations of the company's heavy industry, and is ISO 9001 certified.

SUMMARY PROPOSAL TO THE CITY'S RFP

DBWT is presenting two proposals, DBWT Plan A and an optional DBWT Plan C, in response to the City's RFP. DBWT's Plan A is a direct alternative to the current city plan for CB2 (City Plan A). DBWT's Plan C replaces both CB2 and CB1 in a step wise plan, along with additional wastewater services for the city. We have also provided projected cost for a City Plan C as a comparison to demonstrate all the rebuilds expected for Coos Bay in the next 10-15 years.

Plan A Summary

DBWT is presenting DBWT's Plan A in comparison to the City's proposed new CB2 and upgrades to CB1's anaerobic digester system (City's Plan A). DBWT's Plan A is in response to the RFP directly and is summarized as follows:

1. Replace CB2 with a new GE MBR technology plant with full management, Operations and Maintenance (O&M) responsibility producing Class A water effluent and be **in operation 2019.**
2. DBWT's lower costs are presented in Exhibit 3, and supported by spreadsheet detail in Exhibit 8.
3. DBWT's Plan A versus City's current plan (City Plan A) are presented in Exhibit 3 and spreadsheet detail in Exhibit 7.
4. Provide a new Class A Fertilizer plant on the North Spit to process all waste sludge from both CB1 and CB2, thus providing savings to the city as follows:
    a. Eliminate all Anaerobic Digestion
    b. Eliminate pumping sludge from CB2 to CB1
    c. Eliminate pumping to the Eastside Lagoon
    d. Eliminate need for Eastside lagoon
    e. Eliminate costs for transporting and spreading Class B solids on farms
    f. Be in **operation 2019.**
5. Major differences between DBWT and City Plans are shown in Exhibit 5, DBWT is providing:
    a. Virus removal
    b. Class A fertilizer
    c. Design for Cascadia Tsunami inundation.
    d. Promote tourism, commercial oyster growing, and economic recovery
6. A comparison of DBWT's GE MBR technology to the City's SBR process is shown in (Exhibit 5).
7. Our services should result in a significant reduction of the City's administrative cost for wastewater, and will reduce the projected 378% increase (Exhibit 11) for administration cost presented in the City management's projected waste water budget through 2034. These savings are the following:
    a. City will no longer have capital cost, management, operations, maintenance, upgrade responsibilities, and liabilities for CB2.
    b. City will no longer have upgrade capital cost, management, operations, maintenance, upgrade responsibilities, or cost for anaerobic digestion, sludge piping from CB2 to CB1, pumping sludge to Eastside lagoons, transporting and application of sludge to farmlands and forests, and liabilities. DBWT will transport all raw sludge to DBWT's new plant on the North Spit and process to EPA Certified Class A fertilizer.

8. City will have option to purchase all facilities after 20 years.
9. Guarantees DBWT's cost to the City through 2034 and savings of approximately $18,000,000 (Exhibit 8)
10. City will lease necessary property and equipment to DBWT for minimum costs during the term of DBWT providing Wastewater Services.
11. Under Plan A, DBWT will own only the CB2 facilities and the Class A fertilizer plant. The City will have option to purchase all facilities after 20 years.
12. DBWT will provide a performance bond to guarantee completion and performance.
13. DBWT will provide and install a new lift station for CB2 and demolish the old CB2 plant.
14. At its own cost DBWT will acquire all permits for facilities under it's control.
15. City will remain responsible for the DEQ NPDES permit and own the outfall.
16. DBWT will transfer ownership of the Class A product to the City and deliver to the existing outfall owned by the City.
17. Wastewater Services agreement shall be for 20 years with 20-year renewable options.
18. City's Plan A costs are directly from city management's own projected budget and are not guaranteed.

Plan C Summary

Coos Bay, in the next 10-15 years, must rebuild CB1 and CB2 to new EPA standards which include no bypassing, virus removal, and improved tertiary treatment. The GE MBR process technology provided by DBWT will provide all the above. The current path by the city will do none of the above. The cost for the city to accomplish these goal over the next 10-15 years will be staggering, thus we are presenting DBWT Plan C and are projecting the city's cost and the basis, in City's Plan C.

Our Wastewater Services Plan C is financed by DBWT, provides ***a step wise lower cost plan through 2055, and guarantees costs presented through 2034.*** We will also ***guarantee costs presented though 2055 and beyond,*** providing EPA or DEQ do not require major effluent changes. In order to provide these services DBWT will provide the following:

1. Replace CB2 with a new GE MBR technology CB2 plant with full management, Operations and Maintenance (OM) responsibility producing Class A water effluent and be ***in operation 2019.***
2. Provide a new Class A Fertilizer plant on the North Spit to process all waste sludge from both CB1 and CB2, thus removing all Anaerobic Digestion, pumping sludge from CB2 to CB1, pumping to the Eastside Lagoon, eliminating need for Eastside lagoon, and transporting Class B solids to farm and forest, and **in operation 2019.**
3. Provide full (OM) service for existing CB1 and collections to replace CH2M ***starting in 2020.***
4. Replace CB1 with a new GE MBR plant with full management and O&M responsibility producing Class A water effluent and be ***in operations in 2022.***

5. Provide full ***management of wastewater for the city in 2024 with city oversight.***
6. Costs for these Wastewater Services are provided in spreadsheets Exhibits 9 & 10 and Graphed in Exhibit
7. Comparative Costs for the City to provide the same services are presented in Exhibit 9.
8. Please note the lower cost to ratepayers and the slower rate of growth past 2050.
9. Two major difference between the two plans is DBWT is providing Class A fertilizer, CB1 and CB2 are designed for Cascadia Tsunami inundation, and virus removal.
10. The savings of $168,000,000 for our long-range plan C with step wise implementation eases ratepayer costs gradually without sudden spikes due to DEQ's MAOs. "Doing it right the first time" generally provides a better result.
11. A comparison of GE MBR over a SBR process is shown in Exhibit 5.
12. DEQ is short of money for other cities upgrades and can use the Coos Bay and Charleston loan funds to help other cities. Should the decision be on use of government loan funds or lower cost to ratepayers and environmental quality?
13. Our services should result in reduction of the high cost of city government administration in Coos Bay for wastewater, and should reduce the projected 378% increase in administration presented in the city management's projected waste water budget through 2035.
14. City will lease necessary property and equipment to DBWT for minimum costs during the term of DBWT providing Wastewater Services.
15. DBWT will own the CB1 and CB2 facilities and the Class A fertilizer plant. City will have option to purchase all facilities after 20 years.
16. DBWT will provide a performance bond to guarantee completion.
17. DBWT will provide and install a new lift station for CB2
18. DBWT will demolish both CB1 and CB2 old plants
19. DBWT will acquire all building permits.
20. City will be responsible for all items listed for City in Plan A.

Basis of City's Plan C

City's Plan C includes projections of cost which are escalated to the projected years shown in the Exhibits above. These projected costs for the City's plan C are as follows:

1. New CB1 in 10-15 years will cost $98,000,000 which will require full secondary treatment at 21-22 MGD, high efficiency UV virus removal, and addressing their Class B sludge issues.
2. CB2 in 10-15 years to add membrane filtering and high efficiency UV to meet EPA's virus removal which will cost $ $35,000,000. These upgrades will still not achieve the efficiency of the GE MBR with ATS high efficiency UV virus kill provided now by DBWT.
3. As DBWT's Plan C is implemented and DBWT assumes larger management responsibilities, the City's administration costs should decrease.

For purposes of comparing all plans of both parties, see Exhibit 21.

VIRUSES

Infectious human viruses are the primary pollution issue and health threat to the Coos Bay estuary and the community. Bi-valve mollusks which include oysters, clams, mussels, scallops are used as a measurement of pollution as they filter waste pollutants including bacteria and viruses from the estuary water. Shellfish are also a food source for humans, fish, crabs, birds, animals, and most other marine life in and around this estuary. Commercial oyster harvesting is a major business supporting our economy along with recreational shellfish and crab harvesting. The health of our estuary greatly effects tourism and the economy of this area.

EPA has designated our Estuary for "Recreation and Shellfish." FDA's study (Exhibits 15,16,17) and testing of the bay shows shocking viral accumulation in oysters as a direct result of the effluents from our wastewater treatment plants. Their recommendations for 21-day prohibition from harvesting on bypassing and upset events are not being followed (Exhibit 17), as it would eliminate the oyster industry. Current testing for pollution is for fecal coliform counts, which has little relationship to viruses, as now acknowledged by both EPA and FDA. Fecal coliform has been used for years as an assumed marker for viruses and has now been proven to be invalid in wastewater effluents. Normal disinfection of chlorine and low mJ/cm2 UV effectively kill fecal coliform but not viruses (Exhibit 17). DEQ continues to push the invalid notion that fecal coliform is the problem! Please look at Exhibit 16 showing what the main toxic pollution in our bay and in our oysters, is human viruses, not fecal coliform! The proof is in the meat of the oysters which FDA found contains 20 times more virus units (Exhibit 16) than fecal coliform! FDA only tested for 3 viruses and there are thousands more that are entering our food chain!

DEQ's misunderstanding of the real toxic pollution to our estuary has guided the design of City's plan for Empire CB2. EPA has advised DEQ of their pending viral testing policy and DEQ still threatens and pushes the city forward to build a plant knowing it should be upgraded within 10-15 years at a higher cost than the original plant.

TSUNAMI

Mayor Shoji wrote a very good article in the World about her planning knowledge and experience. She presented the recommendation that cities need to start considering their infrastructure vulnerability to a Cascadia Tsunami. We believe she was correct, and designed both CB1 and CB2 for a Cascadia Tsunami. Unfortunately, the City management followed DEQ's allowances stating that waste treatment plants have an exception from the rules. DBWT has listened to Mayor Shoji and has designed for a Cascadia Tsunami. This means that all equipment, including the emergency generator and fuel storage must be built within a wall structure a minimum of 40 ft above low tide. Our design is shown in a design rendering in Exbibits 1 and 2 and are shown in drawings enclosed with our proposal

DRAWINGS and TECHNOLOGYS

We have been working with GE on their MBR membrane bioreactor technology and ATS with their high efficiency UV technologies for more than a year. We have access to their proprietary drawings and technologies and have included the GE Biological design in Exhibit 14. We also have enclosed proprietary design drawings in Exhibit 12. These include proprietary drawing information from GE and ATS. These drawings are stamped with a requirement for honoring the confidentiality of this information and is not allowed to be copied or reproduced without DBWT's written permission. These drawings are provided to the city to exhibit DBWT's professional approach to solving wastewater issues and our progress over the past year. DBWT, General Electric and ATS are ready to proceed quickly.

We have secured an agreement with PE Dale Richwine to be a project engineer, who is immensely qualified (Exhibit 20).

CONCLUSION

This toxic viral pollution to our bay has led DBWT's scientists and engineers to find the best technological solutions and present this proposal to the city council. DBWT's wastewater services will provide a lower cost to ratepayers and protect the health of our estuary and our community.

If the Coos Bay City Council chooses to proceed with DBWT's wastewater services plan, then a letter of intent will allow further details to be worked out with council and staff. DBWT is prepared to provide performance bonding for both completion and performance.

Thank you

Dennis Beetham, family, and employees.

INDEX OF EXHIBITS

Exhibit 1 – CB2 Visual Drawing

Exhibit 2 – CB1 Visual Drawing

Exhibit 3 – Graph Comparison Sewer Rates City's Plan vs DBWT Plan A

Exhibit 4 - Graph Comparison Sewer Rates City's Plan vs DBWT Plan C

Exhibit 5 – Comparison GE MBR vs City's Sanitaire

Exhibit 6 – Coquille Sanitaire Plant Log Sheets

Exhibit 7 – City Plan A - Spreadsheet Costs for CB2 and CB1 Sludge Processing

Exhibit 8 – DBWT Plan A - Spreadsheet Costs for CB2 and processing CB1 and CB2 Sludge

Exhibit 9 – City Plan C – Spreadsheet Cost to Replace CB1 & CB2 + Upgrade CB2

Exhibit 10 – DBWT Plan C – Spreadsheet Costs to Replace CB1 & CB2

Exhibit 11 – Bar Chart Graph on City's Projected Cost thru 2035

Exhibit 12 – Norovirus and Adenovirus % Kill Comparison City vs DBWT

Exhibit 13 – Simplified Flow of GE MBR

Exhibit 14 – GE MBR Biological Design and Proposal

Exhibit 15 – FDA Red Map of Prohibited Shellfish Growing due to WWTP

Exhibit 16 – FDA Bar Graph of Virus and Fecal Coliforms in Coos Bay Oysters

Exhibit 17 – FDA Quotes on Coos Bay Study

Exhibit 18 – Email - EPA - Ambient Water Quality Criteria

Exhibit 19 – EPA Viral Testing using MSC

Exhibit 20 – Dale Richwine Bio

Exhibit 21 – Graph Comparison Sewer Rates for City's Plans A + C and DBWT's Plans A + C

Exhibit 22 – FDA Full Study

Exhibit 23 – DBWT Brochure

Exhibit 1
DBWT's Vision for CB2 in Empire

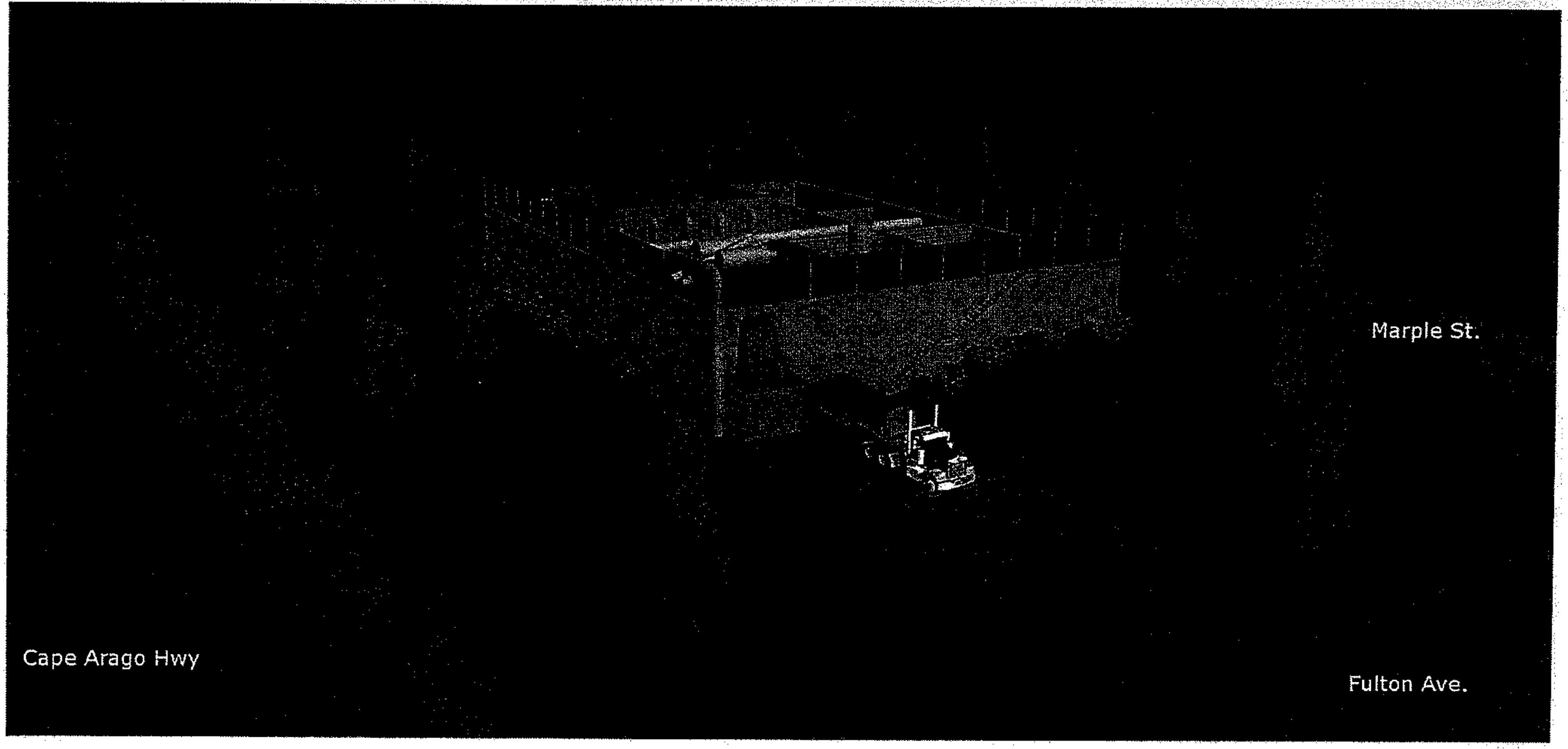


Exhibit 2

DBWT's Vision for CB1 in Downtown Coos Bay

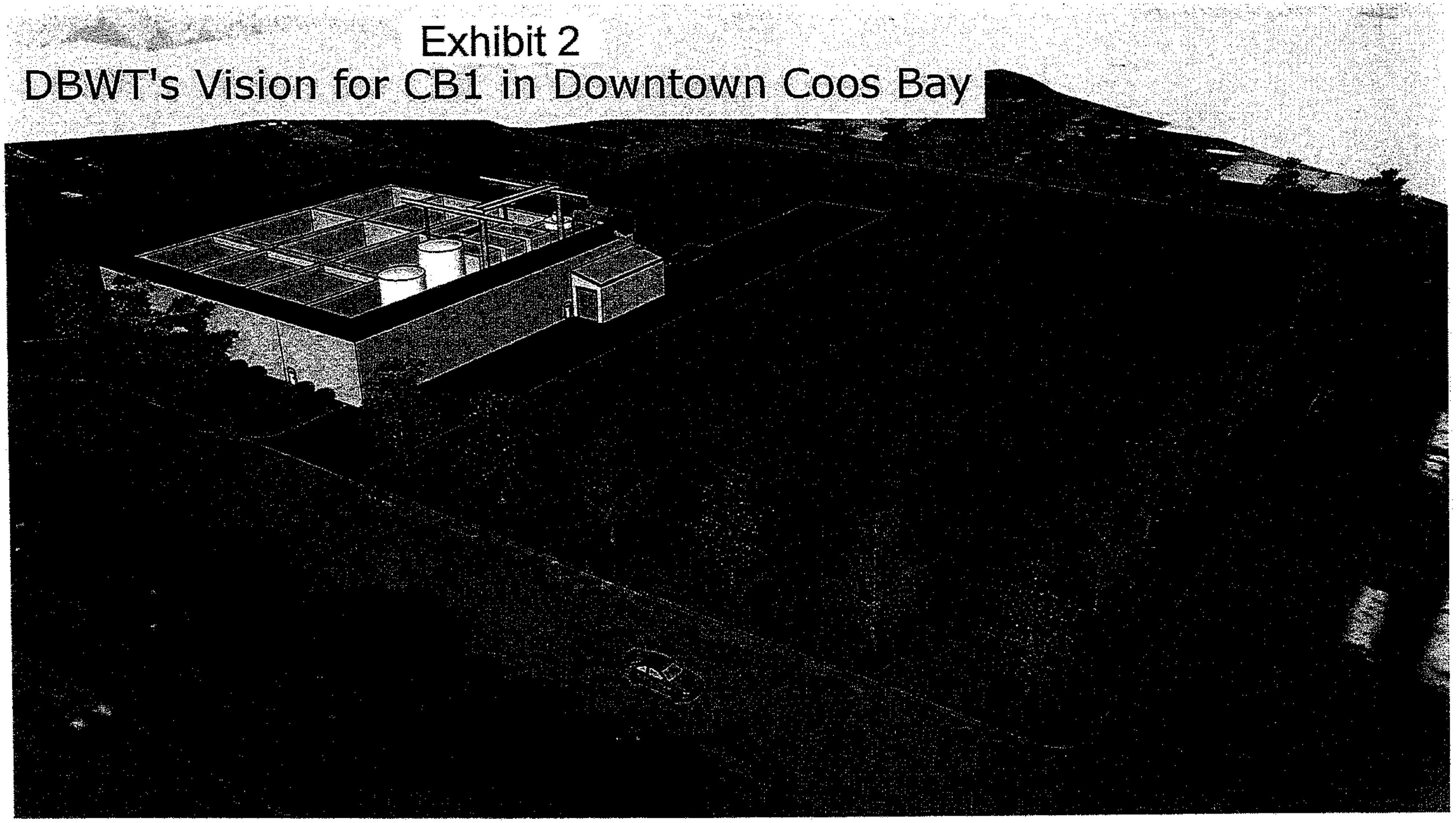


EXHIBIT 3

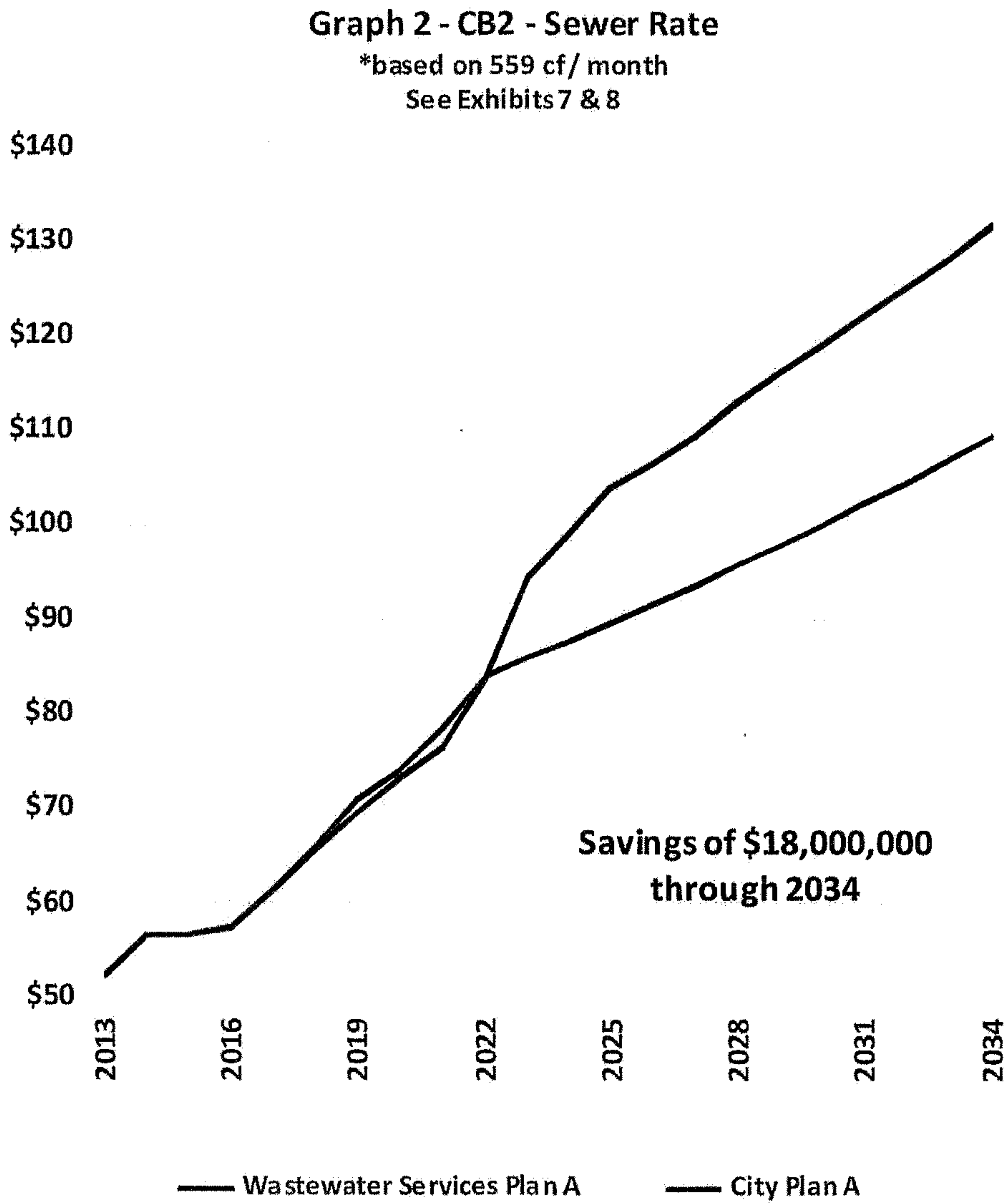

Graph 2 - CB2 - Sewer Rate
*based on 559 cf/ month
See Exhibits 7 & 8
$140
$130
$120
$110
$100
$90
$80
$70
$60
$50
2013
2016
2019
2022
2025
2028
2031
2034
Savings of $18,000,000 through 2034
Wastewater Services Plan A
City Plan A

EXHIBIT 4

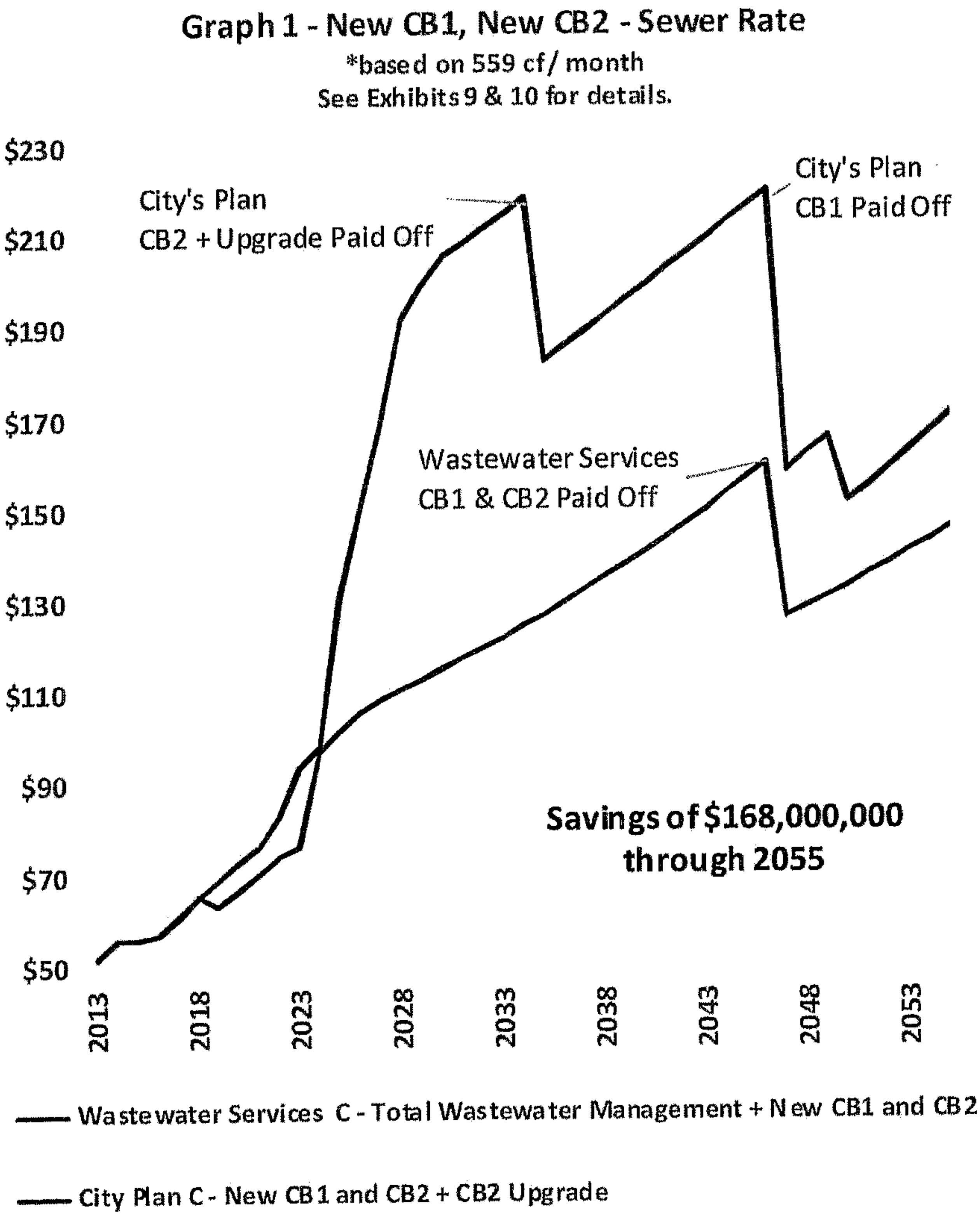

Graph 1 - New CB1, New CB2 - Sewer Rate
*based on 559 cf/ month
See Exhibits 9 & 10 for details.
$230
$210
$190
$170
$150
$130
$110
$90
$70
$50
City's Plan
CB2 + Upgrade Paid Off
City's Plan
CB1 Paid Off
Wastewater Services
CB1 & CB2 Paid Off
Savings of $168,000,000
through 2055
2013
2018
2023
2028
2033
2038
2043
2048
2053
Wastewater Services C - Total Wastewater Management + New CB1 and CB2
City Plan C - New CB1 and CB2 + CB2 Upgrade

EXHIBIT 5

Table 1

GE's MBR vs City Sanitaire Process		
	Wastewater Services	City
Engineering		
Biological Design	GE	Sanitaire
Equipment	GE	Sanitaire
Project Engineer	Dale Richwine	Jan Kerbo
Experience	43 years	?
Wastewater Projects	> 20	?
Operations Certification	Level 4	?
Quality Certification	ISO 9001	?
Tsunami Protection	Yes	No
Effluent		
Process	GE MBR 500D	Sanitaire
Membranes	.04 microns	None
Quality Classification	Class A	None
Beneficial Reuse	Yes	No
Solids TSS - mg/l	< 1	3 - 51 *
Solids - lbs/day	< 60	3400
BOD5	< 1	3 - 7 *
Norovirus Units / Day	< 100	1.2 billion
Adenovirus Units / Day	< 100	546 million
Clarity	Clear	Tan
Potential for Drinking	Yes	None
Biosolids		
Sludge Process	FKC	Anaerobic
Quality	Class A	Class B
Pathogens	No	Yes
Cost To City		
Guarantee	Guaranteed	None
Ratepayer Rate	Lower	Higher

* Based upon Data from Coquille Sanitaire Plant Log Sheets, Dec 2015 and Jan 2016, showing average of 6 samples in 24 hrs

** FDA Coos Bay Study (2011) and EPA Certification

EXHIBIT 6

Dec 15 — Coquille Plant — (Phone # 541-396-[illegible]) — (Population 4275) — Dec 15

Day	Inf. flow mgd	Eff. flow mgd	Inf. pH	Inf. BOD mg/l	Inf. BOD lbs.	Inf. SS mg/l	Inf. SS lbs.	Inf. temp C	Eff. pH	Eff. D.O. mg/l	Eff. temp C	Eff. CBOD mg/l	% CBOD red	lbs. CBOD disc	Eff. SS mg/l	% SS red	lbs. SS disc	UVT %	mw/cm2 UV Light Dose
1	.57	.55	7.1	137	651	180	856	11.0	6.5	7.2	11.5	4	92	5.3	29	78	85	71.0	95.21
2	1.17	.80	7.1					13.0	6.5	7.0	13.0							73.3	166.6
3	3.54	2.33		91	415	49	2923	14.0	6.4	5.4	14.0	5.7	92	11.8	12	88	354	76.2	56.2
4	3.68	3.75																52.9	71.9
5	1.62	1.61																53.1	45.06
6	1.85	1.88																40.5	41.79
7	1.97	2.01	6.5					15	6.7	8.2	14.0							46.6	43.57
8	2.29	2.08	6.6	37	[illegible]	62	1179	15	6.4	6.6	14	7	81	133	3	95	57	86.9	50.17
9	3.48	2.85	6.7					15	6.3	8.2	14							82.8	55.35
10	4.40	3.43	6.4	21	771	45	1651	13	6.5	7.2	14	2.2	90	81	15.5	66	569	80.9	65.67
11	4.75	3.56	6.5					11	6.3	8.9	12							83.4	49.83
12	4.87	3.46																86.0	42.97
13	4.83	3.39																88.9	42.6
14	4.59	3.50	6.2					11	6.4	8.4	11							85	42.4
15	4.65	3.49	6.3	116	5166	37	1327	11	6.4	7.0	10	3.6	75	4140	11.6	67	450	88	41.9
16	4.70	3.43	6.4					[illegible]	6.3	[illegible]	[illegible]							83.6	42.38
17	4.60	3.14	6.3	15	583	23	894	12.0	6.5	8.6	11.5	4	73	155	11	52	427	83.7	48.27
18	4.82	4.28	6.2					13.0	6.2	8.4	13.5							88.2	41.79
19	4.71	4.22																84.7	65.35
20	4.54	4.25																88.2	35.46
21	4.65	4.25	6.2					13	6.4	8.0	12							53.4	72.68
22	4.54	4.22	6.4	8	306	159	6087	13	6.8	7.6	13	1.1	86	42	27	83	1034	75.4	59.9
23	4.50	4.40	6.3					12	6.9	5.1	12							56.3	27.4
24	4.40	4.10	6.3	94	3449	18	661	11	6.4	9.1	11	6	67	220	51	46	1871	56.6	21.94
25	4.62	4.34	6.3					10	6.4	8.9	10							39.0	10.61
26	4.12	4.12																38.0	9.75
27	2.58	2.56																65.0	52.57
28	2.11	2.16	6.4					11	6.7	8.3	11							65.0	75.7
29	2.07	2.11	6.8	14.1	[illegible]	48	829	11	6.7	7.8	12	3	77	57	4	71	242	67.2	74.3
30	1.87	1.96																61.4	46.6
31	1.33	1.37	6.7	43	477	51	566	11	6.5	8.5	10	5	88	55	29	43	322	70.8	113.1
	117.11								6.9			7		440	51		1871		
	4.89								6.2			1.1		92	3		57		
	.57											5		409	39		1453		
	4.75											4	84	169	35	69	551		
	3.49																		

Day	Inf. Alk mg/L	Eff. fecal (mpn)	Eff. [illegible]	SBR % TSS	SBR % VSS	SBR to Digester %VSS red	Aerobic Dig % TSS	Aerobic Dig % VSS	SBR Basin SVI	SBR Basin MLSS	SBR Basin pH	SBR Basin D.O.	Basin #	WAS gpd	Fan Press GPD	Rainfall inches
1	132			.42	80	5	.38	59	63	4170	6.3	5.2	1	1901	Ø	.01
2			0.26						55	4145	6.3	4.6	1	1907	7113	.21
3									111	1080	6.4	4.5	2	1868	Ø	.96
4														2098	Ø	1.53
5														[illegible]	Ø	[illegible]
6													1	[illegible]	Ø	.51
7		78.2							48	305	6.4	5.5	1	1517	7462	.45
8	41.6			.38	59	Ø	3.7	59	68	1470	6.4	4.9	2	1928	Ø	.23
9			0.20						65	2370	6.4	3.3	1	1963	7490	1.22
10									75	1325	6.4	4.0	2	1454	Ø	.60
11									57	3677	6.1	3.3	1	1971	Ø	1.22
12														1970	Ø	.05
13														1929	Ø	2.18
14		34.9							64	1235	6.2	4.4	2	2138	7156	1.00
15	373			.36	54	Ø	3.6	60	59	2585	6.0	3.5	1	2011	Ø	.36
16			.65						57	1020	6.4	5.8	2	1570	7201	.01
17									53	2280	6.0	3.1	1	2006	Ø	1.57
18									57	878	6.3	7.1	2	1989	Ø	1.75
19														1496	Ø	.29
20														1987	Ø	.12
21		32.4							54	1665	6.2	3.9	1	1992	7437	.95
22	52.7		.54						45	1100	6.5	5.6	2	2009	Ø	1.29
23									44	1128	6.6	5.4	1	1979	6062	.58
24									90	445	6.9	9.1	2	1772	Ø	1.17
25				.1	36	Ø	3.5	58	44	918	6.3	7.3	1	2168	Ø	.41
26													2	1741	Ø	.35
27													1	2188	Ø	Ø
28		7.5							37	2150	6.5	7.2	2	2829	7247	.56
29	83.4			.19	43	Ø	3.9	56	53	1719	6.6	7.2	1	2229	Ø	.12
30													2	2645	3069	.53
31									39	1600	6.5	8.0	1	2573	Ø	0.
		78.2													60237	20.82
		7.5														
		73.2														
		38														

	Phosphorus mg/L Influent	Phosphorus mg/L Effluent		Nitrogens mg/L Nitrite	Nitrogens mg/L Nitrate	Nitrogens mg/L T.K.N
12/2	9.27	3.38	12/1	6.55	2.72	138
12/9	3.39	2.46	12/10	.043	2.10	3.59
12/16	1.64	.96	11/17	.626	2.17	1.48
11/23	1.25	.69	12/24	.084	.387	1.35
			12/31	.037	3.14	3.71

Wkly. Avg. Flow 4.75
x 8.34= 39.62
Wkly Max Temp (-64) 57.2
x .252= Ø
Excess Thermal Load Ø

...with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based upon my inquiry of the person or persons wh...

EXHIBIT 6

Coquille Plant — Phone # 541-396-4296 — Population: Jan '16

Date	Inf Flow mgd	Eff Flow mgd	Inf pH	Inf BOD mg/l	Inf BOD lbs.	Inf SS mg/l	Inf SS lbs.	Inf temp C	Eff pH	Eff D.O. mg/l	Eff temp C	Eff CBOD mg/l	% CBOD red	lbs. CBOD disc	Eff SS mg/l	% SS red	lbs. SS disc	UVT %	UV Light Dose	Inf Alk mg/l	Eff Fecal Coli	UV hrs	SSR % TSS	SSR % VSS	SSR to Digester	Aerobic Dig % TSS	Aerobic Dig % VSS	SVI	MLSS	pH	D.O.	Basin #	WAS gpd	Fan press gpd	Rain inches
1	1.29	1.28	6.9					11	6.5	8.6	10							79.5	192.0			.57						45	3115	6.4	6.9	1	3257	Ø	0
2	1.13	1.15																81.7	184.3														3264	Ø	0
3	.67	.71																82.0	197.7											6			3235	Ø	.05
4	1.14	1.09	6.5					11	6.8	8.7	11							72.2	304.1		Ø							50	3380	6.8	8.2	2	3642	6609	.11
5	.86	.88	6.9	38	275	91	653	12	6.7	7.9	12	1	97	7	3.4	96	24	83.9	241.2	69.6			.38	35	Ø	3.2	57	45	3545	6.7	5.9	1	3880	Ø	.12
6	.81	.41	7.0					11	6.7	8.7	11							83.5	238.5									54	3690	6.8	6.3	2	3633	7293	.01
7	.72	.72	7.0	59	354	78	468	11	6.9	8.6	11	2	97	12	10	87	60	80.3	258.2			4.4						47	3620	6.3	5.1	1	2875	Ø	.03
8	.32	.30																78.5	263.7														3635	7696	.08
9	.79	.80																84.7	[illegible]														3759	Ø	.24
10	.70	.68																79.1	77.1														2873	Ø	.04
11	.74	.74	6.9					12	6.5	8.2	12							70.1	265.6		1.0							51	3895	6.3	5.8	1	3256	6978	.06
12	1.51	1.24	7.0	26	327	126	1587	13	6.6	8.3	12	.4	98	5	9	93	113	72.8	82.7	98.7			.43	40	Ø	4.0	55	51	4135	6.9	5.2	2	3549	Ø	.73
13	2.15	1.95	6.6					12	6.7	7.1	13							82.5	227.8									54	3885	6.3	6.4	1	3948	7639	.86
14	2.91	2.57	6.5	34	805	64	1516	11	6.4	7.5	12	4	88	95	25	56	663	80.0	63.5									52	3685	6.6	6.8	2	3046	Ø	.30
15	2.58	2.61	6.0					11	6.2	8.8	11							88.6	123.1			.77						51	3915	6.3	6.0	1	3965	Ø	1.16
16	2.08	1.99																84.6	154.6														3565	Ø	.25
17	4.39	4.16																89.9	103.8														3646	Ø	.86
18	3.51	3.19	6.4					10.5	6.4	7.8	10.5							88.1	48.58		2.0							50	4830	6.3	5.8	2	3773	Ø	.75
19	4.55	4.21	6.4	51	193	48	1821	11	6.3	8.7	12	1	80	38	6	88	228	88.9	95.9	40.9			40	45	Ø	3.9	54	45	3980	6.0	5.9	1	3637	Ø	.87
20	4.39	4.29	6.4					11	6.7	7.9	12							91.9	78.4									53	3765	6.4	6.9	2	3628	7505	1.09
21	4.07	4.01	6.2	20	679	93	3157	12	7.0	7.8	12	1	95	34	13	86	441	72.9	59.8									61	1960	6.3	6.7	1	3639	Ø	.01
22	3.69	3.81																70.4	50.8			.99											3556	8029	1.11
23	3.75	3.79																78.1	72.9														3432	Ø	.84
24	3.11	3.21																81.3	93.5														3648	Ø	.45
25	2.14	2.20	6.4					11	6.4	8.7	11							84	265.1		12.4							35	1423	6.2	5.8	1	2579	6317	.23
26	1.60	1.72	6.5	28	374	44	587	13	6.9	8.0	12	2	93	27	28	36	374	72.3	48.6	54.2			.43	36	Ø	4.0	51	45	4205	6.8	6.3	2	2456	Ø	.02
27	1.38	1.33	6.8					13	6.1	8.1	12							88.8	325.7									48	2684	6.5	5.4	1	2627	Ø	.01
28	2.34	2.25	6.6	21	410	48	937	13	6.4	8.0	13	1.7	92	33	6	88	117	86.5	93.1									51	3550	6.3	5.6	2	2431	Ø	.84
29	2.06	2.13																86.4	131.5			.88											2577	7723	.50
30	2.26	2.25																71.9	90.4														2353	Ø	.41
31	1.79	1.90																90.6	296														7622	Ø	.35
TOTAL	65.81																																		
MAX	4.55								7.0			4		95	28		663																		
MIN	.67								6.1			.4		5	3.4		24																		
Wkly avg max	4.04											2		50	19		388																		
AVE	2.12											2	.94	31	13	.79	252																		
Weekly limits												90.0		530	90		336																		
Monthly limits												60		610	60		570																		
Monthly limits	1.9								6-9			45.0	0.85	438	45	0.85	250																		

Date	Phosphorus mg/L Influent	Phosphorus mg/L Effluent	Date	Nitrogens mg/L Nitrite	Nitrate	T.K.N
1/1	2.78	1.02	1/7	.02	4.6	1.29
1/8	5.1	.62	1/14	.06	3.1	1.92
1/15	2.35	.97	1/21	.07	2.4	2.38
1/22	1.58	.68	1/28	.09	.36	6.15
1/24	1.71	.39				

Wkly. Avg. Flow 4.04

x 8.34= 33.69

Wkly Max Temp (-64) 57.6

x .252= Ø

Excess Thermal Load Ø

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based upon my inquiry of the person or persons...

EXHIBIT 7

City A - City Plan - New CB2 and CB1 Anaerobic Digestion (From City Projected Wastewater Budget 2013-2034)									
	City Costs				Revenue	Sewer Rates			
	Personal Services	Material and Services	Debt Service	Total Services[1]	Existing Budget[4]	SFR[3]	HSU[5]	EDU[2]	EDUs[2]
Year	$ / Year					$ / Month			No. of Units
2013	652,521	2,259,188		2,911,709	4,977,901	52.39	60.81	34.79	11,925
2014	876,696	2,338,925	23,019	3,238,640	5,376,852	56.60	65.70	37.26	12,025
2015	1,108,031	2,662,900	261,649	4,032,580	5,248,612	56.60	65.70	36.07	12,126
2016	1,163,047	2,740,727	718,119	4,621,893	5,336,297	57.55	66.80	36.37	12,228
2017	1,221,434	2,822,949	1,641,449	5,685,832	5,696,694	61.43	71.31	38.50	12,330
2018	1,283,455	2,907,637	2,235,169	6,426,261	6,124,642	66.05	76.67	41.05	12,434
2019	1,349,397	2,994,866	2,468,696	6,812,959	6,457,205	69.63	80.83	42.92	12,538
2020	1,419,576	3,084,712	2,698,683	7,202,971	6,802,104	73.35	85.15	44.84	12,642
2021	1,494,336	3,177,254	2,995,537	7,667,127	7,125,547	76.84	89.19	46.58	12,747
2022	1,574,055	3,272,571	3,311,620	8,158,246	7,759,715	83.68	97.13	50.31	12,854
2023	1,659,149	3,370,749	3,507,441	8,537,339	8,758,361	94.45	109.63	56.31	12,961
2024	1,750,072	3,471,871	3,742,519	8,964,462	9,169,796	98.89	114.78	58.47	13,069
2025	1,847,323	3,576,027	3,790,843	9,214,193	9,642,335	103.98	120.70	60.98	13,177
2026	1,951,451	3,683,308	3,830,785	9,465,544	9,899,863	106.76	123.92	62.09	13,287
2027	2,063,060	3,793,807	3,921,007	9,777,874	10,157,271	109.53	127.14	63.18	13,398
2028	2,182,812	3,907,621	3,970,459	10,060,892	10,485,663	113.08	131.26	64.68	13,509
2029	2,311,438	4,024,850	3,997,000	10,333,288	10,776,485	116.21	134.90	65.93	13,622
2030	2,449,741	4,145,595	4,010,736	10,606,072	11,052,047	119.18	138.35	67.05	13,735
2031	2,598,606	4,269,963	4,024,473	10,893,042	11,325,410	122.13	141.77	68.14	13,850
2032	2,759,008	4,398,062	4,038,209	11,195,279	11,612,949	125.23	145.37	69.30	13,965
2033	2,932,022	4,530,004	4,048,732	11,510,758	11,915,753	128.50	149.16	70.52	14,082
2034	3,118,834	4,665,904	4,048,732	11,833,470	12,231,160	131.90	153.10	71.78	14,199
Total:	39,766,064	76,099,490	63,284,877	179,150,431	187,932,662				
% Increase	378%	107%		306%	146%	152%	152%	106%	19%
% Increase/Yr	17.2%	4.8%		13.9%	6.6%	6.9%	6.9%	4.8%	0.9%

1 - Only major categories making up 95% of projected wastewater budget by Roger Craddock

2 - EDUs from Roger Craddock 2018 projection and projected population increase

3 - SFR (Single-Family Residence) rate for 2014-2015 is exact rate from billing

4 - Revenue required (100%) from ratepayer rates from Roger Craddock's budget. SFR percent increase starts in 2016.

5 - HSU (High-Strength User)

EXHIBIT 8

Private A - Private Managed CB2 + Class A Biosolids CB1 & CB																	
	Private Costs			City Costs				Required Revenue		Sewer Rates						
										Single Family Res		HSU		EDU		
	New CB2 + O&M	CB1 Sludge	Totals	Personal Services	Materials and Services	Debt Service	Total Services	Private	City Existing Revenue	Private	City	Private	City	Private	City	EDUs ***
Year	$ / Year									$ / Month						Units
2013				652,521	2,259,188		2,911,709	4,977,901	4,977,901		52.39		60.81		34.79	11,925
2014				876,696	2,338,925	23,019	3,238,640	5,376,852	5,376,852		56.60		65.70		37.26	12,025
2015				1,108,031	2,662,900	261,649	4,032,580	5,248,612	5,248,612		56.60		65.70		36.07	12,126
2016				1,163,047	2,740,727	718,119	4,621,893	5,336,297	5,336,297		57.55		66.80		36.37	12,228
2017				1,221,434	2,822,949	1,641,449	5,685,832	5,696,694	5,696,694		61.43		71.31		38.50	12,330
2018				1,283,455	2,907,637	2,235,169	6,426,261	6,124,642	6,124,642	66.05	66.05	76.67	76.67	41.05	41.05	12,434
2019	2,700,000	600,000	3,300,000	1,296,290	1,996,406	0	3,292,696	6,592,696	6,457,205	71.09	69.63	82.52	80.83	43.82	42.92	12,538
2020	2,800,000	700,000	3,500,000	1,335,178	2,056,298	0	3,391,477	6,891,477	6,802,104	74.32	73.35	86.26	85.15	45.43	44.84	12,642
2021	3,000,000	800,000	3,800,000	1,375,234	2,117,987	0	3,493,221	7,293,221	7,125,547	78.65	76.84	91.29	89.19	47.68	46.58	12,747
2022	3,100,000	1,100,000	4,200,000	1,416,491	2,181,527	0	3,598,018	7,798,018	7,759,715	84.09	83.68	97.61	97.13	50.56	50.31	12,854
2023	3,146,500	1,116,500	4,263,000	1,458,985	2,246,973	0	3,705,958	7,968,958	8,758,361	85.94	94.45	99.75	109.63	51.24	56.31	12,961
2024	3,193,698	1,133,248	4,326,945	1,502,755	2,314,382	0	3,817,137	8,144,082	9,169,796	87.82	98.89	101.94	114.78	51.93	58.47	13,069
2025	3,241,603	1,150,246	4,391,849	1,547,838	2,383,813	0	3,931,651	8,323,500	9,642,335	89.76	103.98	104.19	120.70	52.64	60.98	13,177
2026	3,290,227	1,167,500	4,457,727	1,594,273	2,455,328	0	4,049,600	8,507,327	9,899,863	91.74	106.76	105.49	123.92	53.36	62.09	13,287
2027	3,339,580	1,185,012	4,524,593	1,642,101	2,528,988	0	4,171,088	8,695,681	10,157,271	93.77	109.53	108.85	127.14	54.09	63.18	13,398
2028	3,389,674	1,202,788	4,592,462	1,691,364	2,604,857	0	4,296,221	8,888,683	10,485,663	95.85	113.08	111.26	131.26	54.83	64.68	13,509
2029	3,440,519	1,220,829	4,661,349	1,742,105	2,683,003	0	4,425,108	9,086,456	10,776,485	97.99	116.21	113.74	134.90	55.59	65.93	13,622
2030	3,492,127	1,239,142	4,731,269	1,794,368	2,763,493	0	4,557,861	9,289,130	11,052,047	100.17	119.18	116.28	138.35	56.36	67.05	13,735
2031	3,544,509	1,257,729	4,802,238	1,848,199	2,846,398	0	4,694,597	9,496,835	11,325,410	102.41	122.13	118.88	141.77	57.14	68.14	13,850
2032	3,597,677	1,276,595	4,874,271	1,903,645	2,931,790	0	4,835,435	9,709,706	11,612,949	104.71	125.23	121.54	145.37	57.94	69.30	13,965
2033	3,651,642	1,295,744	4,947,386	1,960,754	3,019,744	0	4,980,498	9,927,883	11,915,753	107.06	128.50	124.27	149.16	58.75	70.52	14,082
2034	3,706,416	1,315,180	5,021,596	2,019,577	3,110,336	0	5,129,913	10,151,509	12,231,160	109.47	131.90	127.07	153.10	59.58	71.78	14,199
Total:	52,634,172	17,760,513	70,394,684	32,434,339	55,973,649	4,879,405	93,287,392	169,526,160	187,932,662							
% Increase	20%	20%	52%	210%	38%		76%	104%	146%	66%	152%	66%	152%	45%	106%	19%
% Increase/Yr	1.5%	1.5%	3.3%	9.5%	1.7%		3.5%	4.7%	6.6%	3.9%	6.9%	3.9%	6.9%	2.7%	4.8%	0.9%

EXHIBIT 9

City C - City Current Plan with New CB1 + New CB2 + Future CB2 Upgrade Risk												
	City Costs		Debt Service				Revenue		Sewer Rates			
	Personal Services	Material and Services	New CB2	New CB1[6]	CB2 Upgrade[7]	Total	Total Services	Projected Budget[4]	SFR[3]	HSU[5]	EDU[2]	
Year	$ / Year								$ / Month			No. of Units
2013	652,521	2,259,188				0	2,911,709	4,977,901	52.39	60.81	34.79	11,925
2014	876,696	2,338,925	23,019			23,019	3,238,640	5,376,852	56.60	65.70	37.26	12,025
2015	1,108,031	2,662,900	261,649			261,649	4,032,580	5,248,612	56.60	65.70	36.07	12,126
2016	1,163,047	2,740,727	718,119			718,119	4,621,893	5,336,297	57.55	66.80	36.37	12,228
2017	1,221,434	2,822,949	1,641,449			1,641,449	5,685,832	5,696,694	61.43	71.31	38.50	12,330
2018	1,283,455	2,907,637	2,235,169			2,235,169	6,426,261	6,124,642	66.05	76.67	41.05	12,434
2019	1,349,397	2,994,866	2,468,696			2,468,696	6,812,959	6,457,205	69.63	80.83	42.92	12,538
2020	1,419,576	3,084,712	2,698,683			2,698,683	7,202,971	6,802,104	73.35	85.15	44.84	12,642
2021	1,494,336	3,177,254	2,995,537			2,995,537	7,667,127	7,125,547	76.84	89.19	46.58	12,747
2022	1,574,055	3,272,571	3,311,620			3,311,620	8,158,246	7,759,715	83.68	97.13	50.31	12,854
2023	1,659,149	3,370,749	3,507,441			3,507,441	8,537,339	8,758,361	94.45	109.63	56.31	12,961
2024	1,750,072	3,471,871	3,742,519	2,000,000		5,742,519	10,964,462	9,169,796	98.89	114.78	58.47	13,069
2025	1,847,323	3,576,027	3,790,843	3,000,000		6,790,843	12,214,193	12,214,193	131.72	152.89	77.24	13,177
2026	1,951,451	3,683,308	3,830,785	4,000,000	500,000	8,330,785	13,965,544	13,965,544	150.60	174.82	87.59	13,287
2027	2,063,060	3,793,807	3,921,007	5,000,000	900,000	9,821,007	15,677,874	15,677,874	169.07	196.25	97.51	13,398
2028	2,182,812	3,907,621	3,970,459	6,500,000	1,300,000	11,770,459	17,860,892	17,860,892	192.61	223.58	110.18	13,509
2029	2,311,438	4,024,850	3,997,000	6,500,000	1,700,000	12,197,000	18,533,288	18,533,288	199.86	231.99	113.38	13,622
2030	2,449,741	4,145,595	4,010,736	6,500,000	2,000,000	12,510,736	19,106,072	19,106,072	206.04	239.16	115.92	13,735
2031	2,598,606	4,269,963	4,024,473	6,500,000	2,000,000	12,524,473	19,393,042	19,393,042	209.13	242.75	116.69	13,850
2032	2,759,008	4,398,062	4,038,209	6,500,000	2,000,000	12,538,209	19,695,279	19,695,279	212.39	246.54	117.53	13,965
2033	2,932,022	4,530,004	4,048,732	6,500,000	2,000,000	12,548,732	20,010,758	20,010,758	215.79	250.49	118.42	14,082
2034	3,118,834	4,665,904	4,048,732	6,500,000	2,000,000	12,548,732	20,333,470	20,333,470	219.27	254.53	119.34	14,199
2035	3,259,364	4,777,365	500,000	6,500,000	2,000,000	9,000,000	17,036,729	17,036,729	183.72	213.26	99.16	14,317
2036	3,420,628	4,901,896	521,000	6,500,000	2,000,000	9,021,000	17,343,523	17,343,523	187.03	217.10	100.11	14,436
2037	3,581,891	5,026,427	542,882	6,500,000	2,000,000	9,042,882	17,651,200	17,651,200	190.35	220.95	101.05	14,557
2038	3,743,155	5,150,958	565,683	6,500,000	2,000,000	9,065,683	17,959,795	17,959,795	193.67	224.81	101.97	14,678
2039	3,904,418	5,275,489	589,442	6,500,000	2,000,000	9,089,442	18,269,349	18,269,349	197.01	228.69	102.87	14,800
2040	4,065,682	5,400,020	614,198	6,500,000	2,000,000	9,114,198	18,579,900	18,579,900	200.36	232.58	103.79	14,923
2041	4,226,945	5,524,551	639,995	6,500,000	2,000,000	9,139,995	18,891,491	18,891,491	203.72	236.48	104.62	15,048
2042	4,388,209	5,649,081	666,874	6,500,000	2,000,000	9,166,874	19,204,165	19,204,165	207.09	240.39	105.47	15,173
2043	4,549,473	5,773,612	694,883	6,500,000	2,000,000	9,194,883	19,517,968	19,517,968	210.48	244.32	106.31	15,300
2044	4,710,736	5,898,143	724,068	6,500,000	2,000,000	9,224,068	19,832,948	19,832,948	213.87	248.26	107.13	15,427
2045	4,872,000	6,022,674	754,479	6,500,000	2,000,000	9,254,479	20,149,153	20,149,153	217.28	252.22	107.94	15,555
2046	5,033,263	6,147,205	786,167	6,500,000	2,000,000	9,286,167	20,466,636	20,466,636	220.71	256.19	108.74	15,685
2047	5,194,527	6,271,736	819,186	500,000	2,000,000	3,319,186	14,785,449	14,785,449	159.44	185.08	77.90	15,816
2048	5,355,790	6,396,267	853,592	521,000	2,000,000	3,374,592	15,126,649	15,126,649	163.12	189.35	79.04	15,947
2049	5,517,054	6,520,798	889,443	542,882	2,000,000	3,432,325	15,470,177	15,470,177	166.83	193.65	80.17	16,080
2050	5,678,318	6,645,329	926,799	565,683	300,000	1,792,483	14,116,129	14,116,129	152.23	176.70	72.55	16,214
2051	5,839,581	6,769,860	965,725	589,442	310,500	1,865,667	14,475,108	14,475,108	156.10	181.19	73.78	16,349
2052	6,000,845	6,894,391	1,006,286	614,198	321,368	1,941,851	14,837,087	14,837,087	160.00	185.72	75.00	16,486
2053	6,162,108	7,018,922	1,048,550	639,995	332,615	2,021,159	15,202,189	15,202,189	163.94	190.29	76.21	16,623
2054	6,323,372	7,143,453	1,092,589	666,874	344,257	2,103,720	15,570,544	15,570,544	167.91	194.91	77.41	16,761
2055	6,484,635	7,267,984	1,138,477	694,883	356,306	2,189,666	15,942,285	15,942,285	171.92	199.56	78.61	16,901
Total:	142,078,058	202,575,649	79,625,195	142,834,957	46,365,046	268,825,198	613,478,905	616,052,612				
% Increase	894%	222%					448%	220%	228%	228%	126%	41.73%
% Increase / Yr	20.8%	5.2%					10.4%	5.1%	5.3%	5.3%	2.9%	0.970%

1 - Only major categories making up 95% of projected wastewater budget by Roger Craddock

2 - Roger Craddock's 2018 EDU Projection and Population Growth

3 - SFR (Single-Family Residence) 2014-2015 billing. Further increase proportional to budget.

4 - Revenue required from ratepayer rates from Roger Craddock's budget

5 - HSU (High-Strength User)

6 - New CB1 projected at $98,000,000 in 2026 at new 22 MGD MBR plant

7 - Ultra-filtration projected at $40,000,000 in 2028

EXHIBIT 10

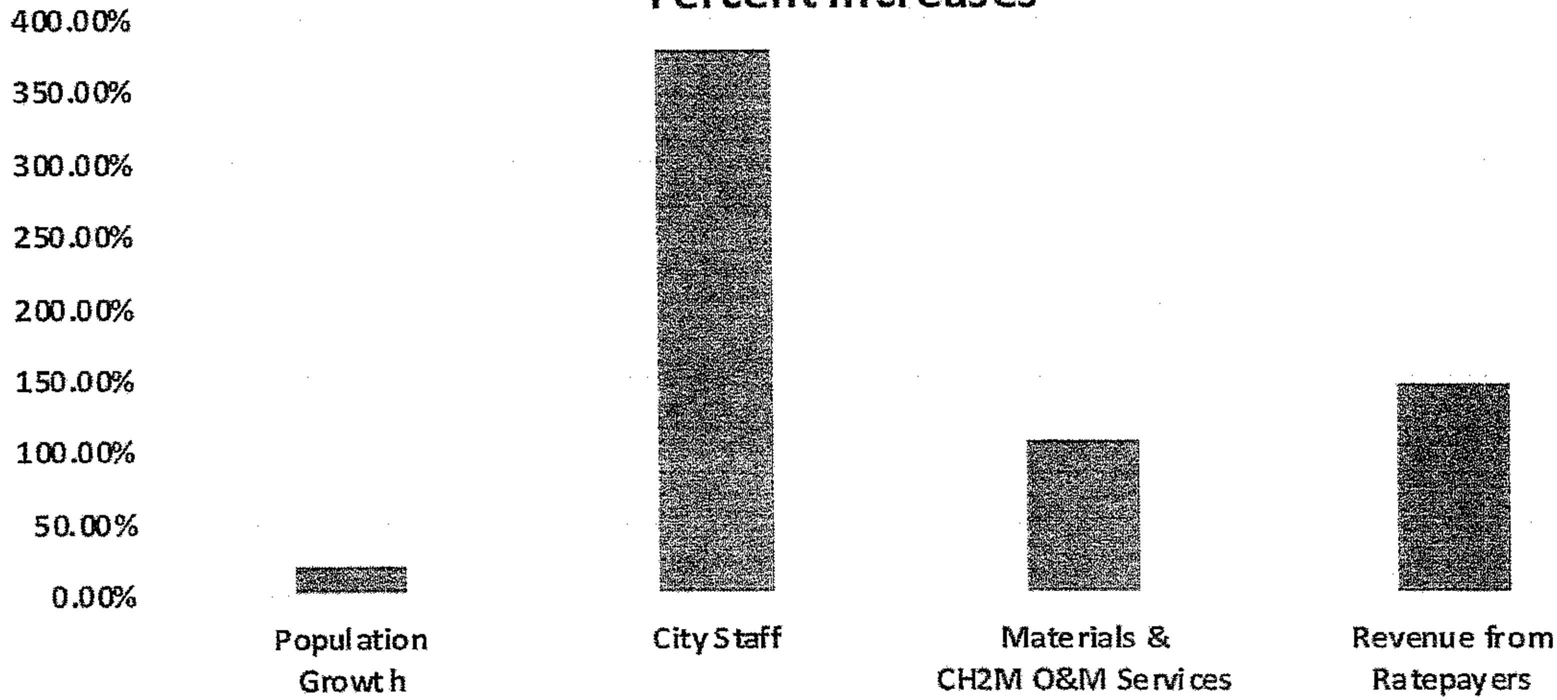
Private C - Private Wastewater Services - New CB1 & New CB2, Collections, All Sludge *																	
	Private				City Costs				Revenue		Sewer Rates						
											Single Family Res		HSU		EDU		
	New CB2 + O&M + Sludge	New CB1 + O&M + Sludge	Collections	Totals	Personal Services	Materials and Services	Debt Service	City Total Services	Private	City Existing	Private	City	Private	City	Private	City	EDUs ***
Year	$ / Year										$ / Month						Units
2013					652,521	2,259,188		2,911,709	4,977,901	4,977,901		52.39		60.81		34.79	11,925
2014					876,696	2,338,925	23,019	3,238,540	5,376,852	5,376,852		56.60		65.70		37.26	12,025
2015					1,108,031	2,662,900	261,649	4,032,580	5,248,612	5,248,612		56.60		65.70		36.07	12,126
2016					1,163,047	2,740,727	718,119	4,621,893	5,336,297	5,336,297		57.55		66.80		36.37	12,228
2017					1,221,434	2,822,949	1,641,449	5,685,832	5,696,694	5,696,694		61.43		71.31		38.50	12,330
2018					1,283,455	2,907,637	2,235,169	6,426,261	6,124,642	6,124,642	66.05	66.05	76.67	76.67	41.05	41.05	12,434
2019	2,700,000	500,040	1,497,433	4,697,473	1,233,455	0	0	1,233,455	5,930,928	6,457,205	63.96	69.63	74.24	80.83	39.42	42.92	12,538
2020	3,000,000	517,541	1,542,356	5,059,897	1,183,455	0	0	1,183,455	6,243,352	6,802,104	67.33	73.35	78.15	85.15	41.15	44.84	12,642
2021	3,300,000	535,655	1,588,627	5,424,282	1,133,455	0	0	1,133,455	6,557,737	7,125,547	70.72	76.84	82.09	89.19	42.87	46.58	12,747
2022	3,600,000	600,000	1,636,285	5,836,285	1,083,455	0	0	1,083,455	6,919,740	7,759,715	74.62	83.68	86.62	97.13	44.86	50.31	12,854
2023	3,400,000	1,000,000	1,685,374	6,085,374	1,033,455	0	0	1,033,455	7,118,825	8,758,361	76.77	94.45	89.11	109.63	45.77	56.31	12,961
2024	3,451,000	2,800,000	1,735,935	7,986,935	1,069,626	0	0	1,069,626	9,056,561	9,169,796	97.66	98.89	113.37	114.78	57.75	58.47	13,069
2025	3,502,765	3,100,000	1,788,013	8,390,778	1,107,063	0	0	1,107,063	9,497,841	12,214,193	102.42	131.72	118.89	152.89	60.06	77.24	13,177
2026	3,555,306	3,300,000	1,841,654	8,696,960	1,145,810	0	0	1,145,810	9,842,770	13,965,544	106.14	150.60	123.21	174.82	61.73	87.59	13,287
2027	3,608,636	3,400,000	1,896,903	8,905,539	1,185,913	0	0	1,185,913	10,091,453	15,677,874	108.82	169.07	126.32	196.25	62.77	97.51	13,398
2028	3,662,766	3,451,000	1,953,810	9,067,576	1,227,420	0	0	1,227,420	10,294,996	17,860,892	111.02	192.61	128.87	223.58	63.50	110.18	13,509
2029	3,717,707	3,502,765	2,012,425	9,232,897	1,270,380	0	0	1,270,380	10,503,277	18,533,288	113.27	199.86	131.48	231.99	64.25	113.38	13,622
2030	3,773,473	3,555,306	2,072,797	9,401,577	1,314,843	0	0	1,314,843	10,716,420	19,106,072	115.56	206.04	134.14	239.16	65.02	115.92	13,735
2031	3,830,075	3,608,636	2,134,981	9,573,692	1,360,863	0	0	1,360,863	10,934,555	19,393,042	117.92	209.13	136.87	242.75	65.79	116.69	13,850
2032	3,887,526	3,662,766	2,199,031	9,749,322	1,408,493	0	0	1,408,493	11,157,815	19,695,279	120.32	212.39	139.67	246.54	66.58	117.53	13,965
2033	3,945,839	3,717,707	2,265,002	9,928,548	1,457,790	0	0	1,457,790	11,386,338	20,010,758	122.79	215.79	142.53	250.49	67.38	118.42	14,082
2034	4,005,026	3,773,473	2,332,952	10,111,451	1,508,813	0	0	1,508,813	11,620,264	20,333,470	125.31	219.27	145.46	254.53	68.20	119.34	14,199
2035	4,065,102	3,830,075	2,402,940	10,298,117	1,561,621	0	0	1,561,621	11,859,738	17,036,729	127.89	183.72	148.46	213.26	69.03	99.16	14,317
2036	4,126,078	3,887,526	2,475,029	10,488,633	1,616,278	0	0	1,616,278	12,104,911	17,343,523	130.54	187.03	151.52	217.10	69.87	100.11	14,436
2037	4,187,969	3,945,839	2,549,279	10,683,088	1,672,848	0	0	1,672,848	12,355,936	17,651,200	133.24	190.35	154.67	220.95	70.73	101.05	14,557
2038	4,250,789	4,005,026	2,625,758	10,881,573	1,731,398	0	0	1,731,398	12,612,971	17,959,795	136.02	193.67	157.88	224.81	71.61	101.97	14,678
2039	4,314,551	4,065,102	2,704,531	11,084,183	1,791,997	0	0	1,791,997	12,876,180	18,269,349	138.85	197.01	161.18	228.69	72.50	102.87	14,800
2040	4,379,269	4,126,078	2,785,666	11,291,014	1,854,716	0	0	1,854,716	13,145,730	18,579,900	141.76	200.36	164.55	232.58	73.41	103.75	14,923
2041	4,444,958	4,187,969	2,869,236	11,502,164	1,919,631	0	0	1,919,631	13,421,796	18,891,491	144.74	203.72	168.01	236.48	74.33	104.62	15,048
2042	4,511,633	4,250,789	2,955,314	11,717,735	1,986,819	0	0	1,986,819	13,704,554	19,204,165	147.79	207.09	171.55	240.39	75.27	105.47	15,173
2043	4,579,307	4,314,551	3,043,973	11,937,831	2,056,357	0	0	2,056,357	13,994,188	19,517,968	150.91	210.48	175.17	244.32	76.22	106.31	15,300
2044	4,647,997	4,379,269	3,135,292	12,162,558	2,128,330	0	0	2,128,330	14,290,888	19,832,948	154.11	213.87	178.89	248.26	77.20	107.13	15,427
2045	4,717,717	4,444,958	3,229,352	12,392,026	2,202,821	0	0	2,202,821	14,594,847	20,149,153	157.39	217.28	182.69	252.22	78.19	107.94	15,555
2046	4,788,482	4,511,633	3,326,231	12,626,346	2,279,920	0	0	2,279,920	14,906,266	20,466,636	160.75	220.71	186.59	256.19	79.20	108.74	15,685
2047	2,500,000	3,500,000	3,426,018	9,426,018	2,359,717	0	0	2,359,717	11,785,736	14,785,449	127.10	159.44	147.53	185.08	62.10	77.90	15,816
2048	2,525,000	3,535,000	3,494,539	9,554,539	2,442,307	0	0	2,442,307	11,996,846	15,126,649	129.37	163.12	150.17	189.35	62.69	79.04	15,947
2049	2,550,250	3,570,350	3,564,430	9,685,030	2,527,788	0	0	2,527,788	12,212,818	15,470,177	131.70	166.83	152.88	193.65	63.29	80.17	16,080
2050	2,575,753	3,606,054	3,635,718	9,817,524	2,616,261	0	0	2,616,261	12,433,785	14,116,129	134.08	152.23	155.64	176.70	63.90	72.55	16,214
2051	2,601,510	3,642,114	3,708,433	9,952,057	2,707,830	0	0	2,707,830	12,659,886	14,475,108	136.52	156.0967	158.47	181.1935	64.53	66.30	16,349
2052	2,627,525	3,678,535	3,782,601	10,088,661	2,802,604	0	0	2,802,604	12,891,265	14,837,087	139.02	160.0002	161.37	185.7246	65.16	60.48	16,486
2053	2,653,800	3,715,321	3,858,253	10,227,374	2,900,695	0	0	2,900,695	13,128,069	15,202,189	141.57	163.9374	164.33	190.2949	65.81	54.66	16,623
2054	2,680,338	3,752,474	3,935,418	10,368,230	3,002,219	0	0	3,002,219	13,370,450	15,570,544	144.18	167.9097	167.37	194.9058	66.47	48.84	16,761
2055	2,720,543	3,789,998	4,014,127	10,524,669	3,107,297	0	0	3,107,297	[illegible]	[illegible]	147.00	171.9185	170.64	199.5591	67.22	43.03	16,901
Total:	133,388,691	123,763,550	97,705,717	354,857,958	73,298,929	15,732,326	4,879,405	93,910,660	448,768,618	616,052,612							
% Increase	1%	56%	109%	159%	226%	-100%		-27%	133%	308%	133%	319%	103%	191%	66%	109%	36%
% Increase/Yr	0.0%	2.7%	4.2%	6.1%	8.7%			-1.0%	5.1%	14.0%	5.1%	14.5%	3.1%	6.8%	3.9%	3.9%	0.9%

* CB1 and Collections would be the same operations and maintenance as is currently being done by CH2M Hill per the services contract with the City. Provides for new CB2, and sludge from CB1 and CB2 to be processed at new North Spit location.

Savings $168,000,000 thru 2055

EXHIBIT 11

Graph 2
City's Projected Wastewater Revenue Budget 2013-2034
Percent Increases



City staff costs for wastewater are projected to rise 378% through 2034.

That is *20 times greater* than the projected population growthrate.

EXHIBIT 12

Table 1: Norovirus Kill for CB1 & CB2 using UV Technology Planned by City vs DBWT's MBR Plus UV Disinfection

Loc.	Date	FDA Test Data Inflow		City Plan Virus Kill	DBWT MBR Removal	DBWT Total MBR Virus Removal (Log 2) and UV Kill (Log 5.85 & Log 5.11)	
		units/100mL	units/day	Log 1 90%	Log 2 99%	Log 7.85 99.9999999%	Log 7.11 99.999999%
CB1	2/10/2011	5,580					
	2/11/2011	3,310					
	2/11/2011	780					
	2/12/2011	13,610					
	2/12/2011	77,000					
	2/13/2011	840					
	2/13/2011	2,007					
Average Viruses		14,732	15,262,796,000	1,526,279,600	152,627,960	15	153
CB2							
Average Viruses		11,575	11,992,196,857	1,199,219,686	119,921,969	12	120

Table 2: Norovirus Kill Currently With Chlorine

Loc.	Date	FDA Test Data Effluent with Chlorine Kill	
		units/100mL	units/day
CB1	2/10/2011	2,810	
	2/11/2011	1,140	
	2/11/2011	130	
	2/12/2011	82	
	2/12/2011	600	
	2/13/2011	17	
	2/13/2011	17	
Average Viruses		685	709,808,000
CB2			
Average Viruses		538	557,706,286

Table 3: Adenovirus Kill for CB1 & CB2 using UV Technology Planned by City vs DBWT's MBR Plus UV Disinfection

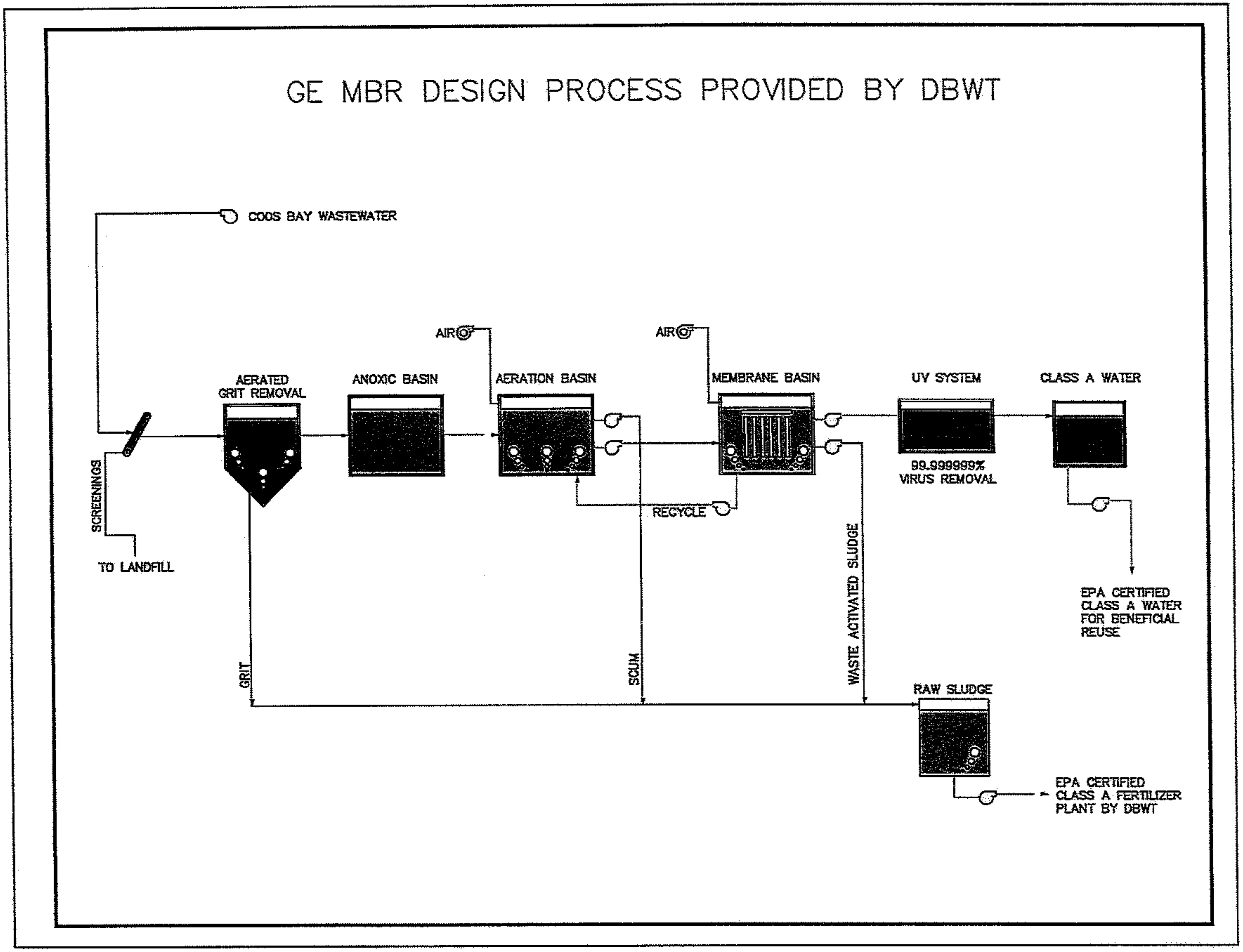
Loc.	Date	FDA Test Data Inflow		City Plan Virus Kill	DBWT MBR Removal	DBWT Total MBR Virus Removal (Log 2) and UV Kill (Log 5.85 & Log 5.11)	
		units/100mL	units/day	Log 1 90%	Log 2 99%	Log 7.85 99.9999999%	Log 7.11 99.999999%
CB1	2/10/2011	4,580					
	2/11/2011	2,731					
	2/11/2011	6,260					
	2/12/2011	5,600					
	2/12/2011	25,900					
	2/13/2011	990					
	2/13/2011	890					
Average Viruses		6,707	6,948,748,000	694,874,800	69,487,480	7	69
CB2							
Average Viruses		5,270	5,459,730,571	545,973,057	54,597,306	5	55

Table 4: Adenovirus Kill Currently With Chlorine

Loc.	Date	FDA Test Data Effluent with Chlorine Kill	
		units/100mL	units/day
CB1	2/10/2011	720	
	2/11/2011	2,360	
	2/11/2011	560	
	2/12/2011	430	
	2/12/2011	460	
	2/13/2011	146	
	2/13/2011	10	
Average Viruses		669	693,528,000
CB2			
Average Viruses		526	544,914,857

DBWT Log 5.85 is at Beginning of UV bulb life (BOL), and Log 5.11 is the end of bulb life (EOL). Therefore, we add MBR Log 2 plus the BOL, and the EOL to achieve Log 7.85 and Log 7.11

EXHIBIT 13



GE MBR DESIGN PROCESS PROVIDED BY DBWT
COOS BAY WASTEWATER
SCREENINGS
TO LANDFILL
AERATED GRIT REMOVAL
ANOXIC BASIN
AIR
AERATION BASIN
AIR
MEMBRANE BASIN
UV SYSTEM
99.999999% VIRUS REMOVAL
CLASS A WATER
RECYCLE
GRIT
SCUM
WASTE ACTIVATED SLUDGE
RAW SLUDGE
EPA CERTIFIED CLASS A WATER FOR BENEFICIAL REUSE
EPA CERTIFIED CLASS A FERTILIZER PLANT BY DBWT

EXHIBIT 14

GE
Water & Process Technologies

Budget Proposal for

City of Coos Bay WWTP No.2

ZeeWeed* Membrane Bioreactor System

Submitted to:

DB Western Inc.
North Bend, OR 97459, United States

Attention: Dennis Beatham

September 30, 2016

Proposal Number : 195842 – Rev 02

ZENON Environmental Corporation
d/b/a GE Water & Process Technologies
Chris Allen, P.E. - Regional Manager
Tel: 208-319-3512
Cell: 503-307-2238
Email: Chris.Allen@ge.com

Local Representation By:
APSCO, LLC
Shawn Clark, P.E.
Tel: (541) 754-7292
Email: sclark@apsco-llc.com

EXHIBIT 14

GE
Water & Process Technologies

GE Water & Process Technologies
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1 Basis of Design

The proposed ZeeWeed Membrane Bioreactor System for City of Coos Bay WWTP No.2 project is offered based on the design parameters summarized in the following sections.

1.1 Influent Flow Data

The influent design flows are summarized in the table below. The system, as proposed, has been designed to treat the flows shown below within four membrane trains, with a fifth train installed for standby purposes.

Average Day Flow, (ADF)	1.25	mgd
Maximum Month Flow, (MMF)	2.10	mgd
Maximum Week Flow, (MWF)	3.51	mgd
Maximum Day Flow, (MDF)	6.31	mgd
Peak Hour Flow, (PHF)	5,694.45	gpm

- (ADF) – The average flow rate occurring over a 24-hour period based on annual flow rate data.
- (MMF) – The average flow rate occurring over a 24-hour period during the 30-day period with the highest flow based on annual flow rate data.
- (MWF) – The average flow rate occurring over a 24-hour period during the 7-day period with the highest flow based on annual flow rate data.
- (MDF) – The maximum flow rate averaged over a 24-hour period occurring within annual flow rate data.
- (PHF) – The maximum flow rate sustained over a 1-hour period based on annual flow rate data.

1.2 Influent Quality

The design solution proposed is based on the wastewater characteristics detailed below. The below concentrations are specific for the flow used for the biological design (MMF) as listed in section 2.1 below.

Influent Parameters	Concentration	Unit
Minimum Design Influent Temperature	12	°C
BOD_5	223	mg/L
TSS	280	mg/L
VSS [1]	224	mg/L
TKN [1]	35	mg/L
NH_3-N	23	mg/L
TP [1]	8	mg/L
Alkalinity [1,2]	250	mg/L as $CaCo_3$

Note 1: Parameter value assumed

Note 2: GE is assuming that sufficient influent alkalinity is available to ensure proper performance of the biological system. If influent alkalinity level is not sufficient, chemical addition by Buyer will be required.

1.3 Effluent Quality

The following performance parameters are expected upon equipment startup and once the biological system has stabilized based on the data listed in sections 1.1 and 1.2.

BOD_5	<1	mg/L
TSS	<1	mg/L
TN [1]	<6.5	mg/L
NH_3-N	<1	mg/L
TP	<1	mg/L
Turbidity	< 0.2 (95% of time) <0.5 (100% of time)	NTU

Note 1: TN ≤ 6.5 mg/L corresponds to a minimum design temperature of 10°C and <1.5 mg/L recalcitrant dissolved organic nitrogen in the influent.

1.4 Influent Variability

Influent wastewater flows or loads in excess of the design criteria defined above must be equalized prior to entering the MBR tankage. In the event that the influent exceeds the specifications used in engineering this proposal, or the source of influent changes, the ability of the treatment system to produce the designed treated water quality and/or quantity may be impaired. Buyer may choose to continue to operate the system, but assumes the risk of damage to the system and/or additional costs due to increased membrane cleanings, potential for biological upset and/or increased consumable usage.

2 System Design and Scope

The ZeeWeed Membrane Bioreactor (MBR) process consists of a suspended growth biological reactor integrated with a membrane filtration system, using the ZeeWeed hollow fiber ultrafiltration membrane. The membrane filtration system essentially replaces the solids separation function of secondary clarifiers and sand filters used in a conventional activated sludge process.

ZeeWeed ultrafiltration membranes are directly immersed mixed liquor. Through the use of a permeate pump, a vacuum is applied to a header connected to the membranes. The vacuum draws the treated water through the hollow fiber membranes. Permeate is then directed to downstream disinfection or discharge facilities. Air, in the form of large bubbles, is introduced below the bottom of the membrane modules, producing turbulence that scours the outer surface of the hollow fibers to keep them clean.

The proposed MBR design utilies LEAPmbr, GE's latest technology for wastewater treatment, which offers the lowest cost of ownership in the industry. LEAPmbr incorporates several innovations, including the latest ZeeWeed 500 module with increased membrane surface area, increased productivity through proven MBR design flux improvements, an optimized membrane tank design, along with a more efficient membrane aeration system (known as LEAP Aeration Technology) that simplifies the aeration system and reduces aeration requirements. These innovations combine to offer:

- 15% productivity improvement
- 20% footprint reduction
- 50% reduction in membrane aeration equipment
- 30% membrane aeration energy savings

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The use of LEAPmbr offers some of the most important benefits of ZeeWeed MBR systems – simplicity, reliability, and lowest life-cycle cost.

Simplicity

Over the years, GE has continually improved the design of ZeeWeed MBR systems, making them the simplest MBR systems in the industry to operate and maintain. The system is fully automated, with operators having the ability to review operation, adjust set points, or schedule operating tasks through the easy-to-understand HMI graphical display.

Membrane cleaning procedures are automated and do not require any manual handling or removal of the membranes from the tanks.

The LEAPmbr system uses no moving parts within the membrane aeration system. A single air pipe and a single permeate pipe (per membrane train) provide the connection between the immersed membranes and the ancillary pumps and blowers that comprise the rest of the ZeeWeed system.

Reliability

GE's reinforced ZeeWeed hollow fiber membrane incorporates a patented internal support to which the membrane is bonded, creating the most robust membrane in the industry. In addition, GE's automated manufacturing processes ensure a consistent membrane product meeting the highest standards of workmanship and quality. This exceptionally strong and reliable membrane forms the backbone of ZeeWeed MBR systems, which consistently meet and exceed the toughest regulatory standards around the world.

GE is the world leader in MBR technology, with the majority of the industry's largest and longest-operating MBR plants. GE now has over two decades of experience with the well-proven ZeeWeed membrane. The earliest MBR plants using the ZeeWeed-500D membrane, GE's current standard for MBR applications, have now been in operation for almost 10 years. GE's long-term and wide-ranging MBR experience ensures that plant operators can count on many years of successful operation of proposed ZeeWeed MBR plant operation.

Lowest Lifecycle Cost

LEAP Aeration is a significant innovation for ZeeWeed MBR technology that offers a 30% reduction in air flow versus GE's previous air cycling technology. When combined with LEAPmbr's other features, membrane aeration energy savings are almost 50% compared with the previous generation of ZeeWeed MBR. In addition to the substantial energy savings, LEAPmbr requires fewer membrane modules and cassettes, smaller membrane tanks, fewer valves and pipes, and lower connected horsepower. In many cases, using LEAPmbr technology, a ZeeWeed MBR system has an equivalent lifecycle cost to conventional treatment options.

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2.1 Biological System Design

Flow Basis for Biological Design (MMF)	2.10	MGD
Total Pre-Anoxic Tank Working Volume [1]	230,000	US gallons
Total Aerobic Working Volume (excluding membranes) [1]	658,000	US gallons
Total Reactor Working Volume (excluding membranes) [1]	888,000	US gallons
Total Design HRT (excluding membranes)	10	hours
Total Design SRT	17	days
Waste Sludge	46,000	gpd
Design MLSS Concentration in Bioreactor	8,000	mg/L
Minimum Design Water Depth	18	ft
Alum Dosing	400	gal/day
AOR	4,900	lb O_2/ day

Note 1: Tank volumes are preliminary only (GE recommended based on the feed information) and may change once final detail design commences.

Note 2: The biological system is designed for installation within concrete tanks supplied by Buyer

2.2 Ultrafiltration System Design

Number of Membrane Trains	5
Number of Cassettes Installed Per Train	5
Number of Cassette Spaces Per Train	5
Number of Modules per Cassette	48 x 4 + 26 x 1
Total Number of Cassettes Installed per Plant	25
Total Number of Modules Installed per Plant	1090
Spare Space	9.2%
Membrane Tank Internal Dimensions (L x W x H)	35 x 9 x 12 ft

Note 1: Tank dimensions and volumes are preliminary only and may change slightly once final detail design commences.

Note 2: The ultrafiltration system is designed for installation within concrete tanks supplied by Buyer

2.3 Scope of Supply by GE

ZeeWeed Membranes and Associated Equipment

- ZeeWeed 500 membrane cassettes and modules
- Membrane tank cassette mounting assemblies
- Permeate collection & air distribution header pipes
- Membrane tank level transmitters
- Membrane tank level switches

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Permeate Pumping System

- Permeate pumps supplied loose (VFD by Others), complete with required isolation valves, pressure gauges, and flow meters
- Vacuum ejectors and associated air release valves
- Trans-membrane pressure transmitters
- Turbidimeters

Membrane Air Scour Blowers

- Membrane air scour blowers supplied loose, complete with required isolation valves, pressure gauges and flow switches

Backpulse System

- Backpulse pumps supplied loose (VFD by Others), complete with required isolation valves, flow meters,
- Backpulse water storage tank, with isolation valves and level transmitter

Mixed Liquor Recirculation

- Mixed liquor recirculation pumps (VFDs by Others) used to transfer mixed liquor from aerobic zone to membrane tanks, supplied loose, complete with required isolation valves, pressure gauges, and flow meters

Membrane Cleaning Systems

- Sodium hypochlorite chemical feed system
- Citric acid chemical feed system

Electrical and Control Equipment

- PLC complete with touch screen HMI

Miscellaneous

- Air compressors and refrigerated air dryers for ejectors and pneumatic valve operation

General

- Equipment general arrangement and Process and Instrumentation Drawings
- Operating & Maintenance manuals
- Field service and start-up assistance[2] - 42 days support over 3 site visits from GE Water field-service personnel for installation assistance, commissioning, plant start-up and operator training
- Membrane warranty – 2 year cliff
- Equipment mechanical warranty – 1 year or 18 months from shipment of equipment
- InSight Pro – Process Consulting Service and 24/7 Emergency Telephone Technical Support Service – 1 year

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Notes:

1 Additional man-hours will be billed separately from the proposed system capital cost at a rate of $1,300 per day plus living and traveling expenses. Detailed GE Water service rates are available upon request.

2 All GE supplied equipment is designed for installation in an unclassified area.

3 A further customized package of post-commissioning Field Service support can be provided upon request. The package may include additional years of GE's Insight Remote Monitoring & Diagnostics or 24/7 services or site visits by GE Field Service personnel.

4 To receive complete 24/7 Emergency Telephone Technical Support Service a suitable, secure remote internet connection, by Buyer, is required.

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3 Buyer Scope of Supply

The following items are for supply by Buyer and will include but are not limited to:

- ☐ Overall plant design responsibility
- ☐ Review and approval of design parameters related to the biological process and/or membrane separation system
- ☐ Review and approval of GE-supplied equipment drawings and specifications
- ☐ Detail drawings of all termination points where GE equipment or materials tie into equipment or materials supplied by Buyer
- ☐ Design, supply and installation of lifting devices including overhead traveling bridge crane and/or monorail crane able to lift 5,000 kg for membrane removal, lifting davit crane and guide rails for submersible mixers and pumps, hoists, etc...
- ☐ Civil works, provision of main plant tank structures, buildings, equipment foundation pads etc. including but not limited to:
  - ☐ Common channels, Housekeeping pads, Equipment access platforms, walkways, Handrails, stairs etc.
  - ☐ Equalization tank – as required
  - ☐ Bioreactor tank – complete with pre-anoxic and aerobic zones
  - ☐ Membrane tanks c/w tank covers or grating, and their support over membrane tanks. Note: cassette beams provided by GE are designed to provide structural support for tank grating/covers.
  - ☐ Treated water storage tank, as required
- ☐ HVAC equipment design, specifications and installation (where applicable)
- ☐ UPS, power conditioner, emergency power supply and specification (where applicable)
- ☐ 2-mm Pretreatment fine screens
- ☐ Biological process equipment – including process blowers, diffusers and mixers
- ☐ Acoustical enclosures for membrane and process blowers
- ☐ VFDs and MCC for all GE supplied equipment
- ☐ Plant SCADA system
- ☐ Process and utilities piping, pipe supports, hangers, valves, etc. including but not limited to:
  - ☐ Piping, pipe supports and valves between GE-supplied equipment and other plant process equipment
  - ☐ Piping between any loose-supplied GE equipment
  - ☐ Process tank aeration system air piping, equalization tank system piping, etc.

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- ☐ Interconnecting pipe between GE-supplied skids and tanks (as applicable)
- ☐ Electrical wiring, conduit and other appurtenances required to provide power connections as required from the electrical power source to the GE control panel and from the control panel to any electrical equipment, pump motors and instruments external to the GE-supplied enclosure
- ☐ Supply and installation of suitable, secure remote internet connection for 24/7 Emergency Telephone Technical Support Service and InSight Remote Monitoring & Diagnostics Service
- ☐ Design, supply and installation of equipment anchor bolts, brackets, and fasteners for GE supplied equipment. Seismic structural analysis and anchor bolt sizing.
- ☐ Receiving (confirmation versus Packing List), unloading and safe storage of GE-supplied equipment at site until ready for installation
- ☐ Installation on site of all GE supplied skids and loose-shipped equipment
- ☐ Alignment of rotating equipment
- ☐ Raw materials, chemicals, and utilities during equipment start-up and operation
- ☐ Disposal of initial start-up wastewater and associated chemicals
- ☐ Supply of seed sludge for biological process start-up purposes
- ☐ Laboratory services, operating and maintenance personnel during equipment checkout, start-up and operation
- ☐ Touch up primer and finish paint surfaces on equipment as required at the completion of the project
- ☐ Weather protection as required for all GE-supplied equipment. Skids and electrical panels are designed for indoor operation and will need shelter from the elements.

EXHIBIT 14

4 Commercial

4.1 Pricing

Pricing for the proposed equipment and services, as outlined in Section 2.3, is summarized in the table below. All pricing is based on the design operating conditions and influent characteristics detailed in Section 1. The pricing herein is for budgetary purposes only and does not constitute an offer of sale. No sales, consumer use or other similar taxes or duties are included in the pricing below.

4.2 Freight

The following freight terms used are as defined by INCOTERMS 2010.

All pricing is CIP designated **City of Coos Bay WWTP No.2 project site.** Delivery to the project site is conditional upon provision of access roads of a nature that will permit access by tractor-trailers. Off-loading and positioning of equipment at the job site is not included.

4.3 Bonds

Performance or Payment Bonds are not included in the system price. These bonds can be purchased on request but will be at additional cost.

4.4 Annual Power & Chemical Consumption Estimates

The data presented below is for information purposes only and is based on the design information provided by the Buyer and presuming that the equipment is operated according to the design basis and in accordance with Seller's Operations and Maintenance manuals.

Annual power consumption estimate [1]

Equipment	kWh/year
Permeate Pumps [2]	24,100
Membrane Blowers	319,500
Recirculation Pumps	210,100
Air Compressors	30,400
Total	584,100

Note1: Annual Power consumption estimate is calculated at ADF condition

Note2: Assumes membrane relaxation mode used

Annual chemical consumption estimate

Chemical	USgal/year
Sodium Hypochlorite (10.3% w/w, SG: 1.168)	4,060
Citric Acid (50.0% w/w, SG: 1.24)	3,210

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Note: Cleaning chemical consumption estimates are based on the frequencies and concentrations summarized in the table below. Frequencies are typical for ZW-MBR operation, actual frequency of maintenance and recovery cleans may change with final design, or may change once system is in operation.

Basis of chemical consumption estimates

Chemical		Maintenance Clean	Recovery Clean
Sodium Hypochlorite solution (10.3% w/w, SG: 1.168)	Frequency	2 times per week	2 times per year
	Concentration	200 mg/L	1,000 mg/L
Citric Acid Solution (50.0% w/w, SG: 1.24)	Frequency	1 time per week	2 times per year
	Concentration	2,000 mg/L	2,000 mg/L

4.5 Equipment Shipment and Delivery

Equipment Shipment is estimated at 26 to 35 weeks after order acceptance. The Buyer and Seller will arrange a kick-off meeting after contract acceptance to develop a firm shipment schedule.

Typical Drawing Submission and Equipment Shipment Schedule

		8-12 weeks	2-3 weeks	16-20 weeks		2 weeks
Acceptance of PO						
Submission of Drawings						
Drawings Approval						
Equipment Manufacturing						
Equipment Shipment						
Plant Operations Manuals						

The delivery schedule is presented based on current workload backlogs and production capacity. This estimated delivery schedule assumes no more than 2 weeks for Buyer review of submittal drawings. Any delays in Buyer approvals or requested changes may result in additional charges and/or a delay to the schedule.

4.6 Pricing Notes

- ☐ All prices quoted are in **US Dollars**
- ☐ Any applicable sales or value added tax is not included,
- ☐ The Buyer will pay all applicable Local, **State**, or **Federal** taxes and Duties
- ☐ The equipment delivery date, start date, and date of commencement of operations are to be negotiated.
- ☐ Commercial Terms and Conditions shall be in accordance with Seller's Standard Terms and Conditions of Sale.

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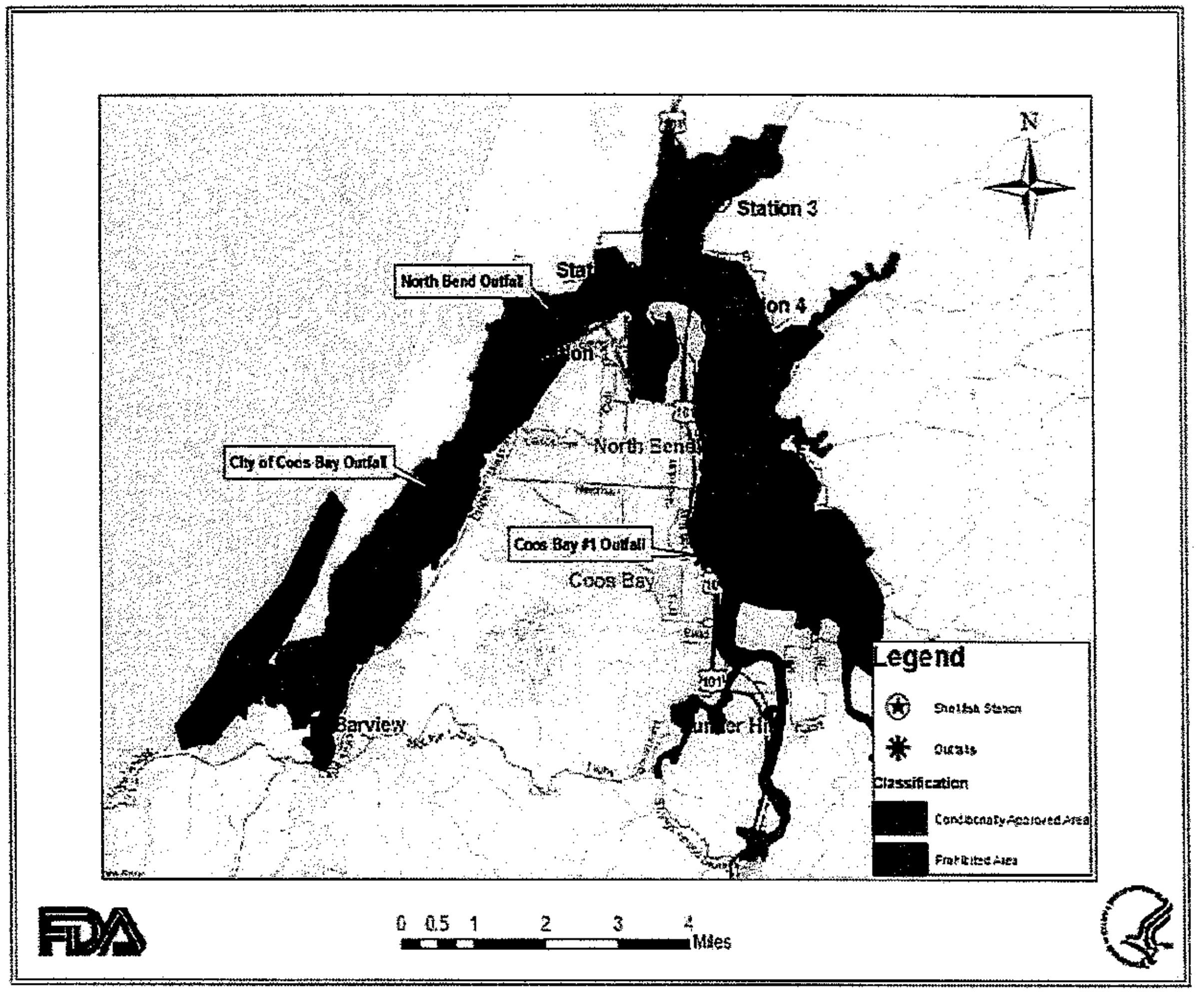
4.7 Conditional Offering

Buyer understands that this proposal has been issued based upon the information provided by Buyer, and currently available to Seller, at the time of proposal issuance. Any changes or discrepancies in site conditions (including but not limited to system influent characteristics, changes in Environmental Health and Safety ("EH&S") conditions, and/or newly discovered EH&S concerns, Buyer's financial standing, Buyer's requirements, or any other relevant change, or discrepancy in, the factual basis upon which this proposal was created, may lead to changes in the offering, including but not limited to changes in pricing, warranties, quoted specifications, or terms and conditions. Seller's offering in this proposal is conditioned upon a full Seller EH&S, and Buyer financial review.

EXHIBIT 15

Figure 3
Coos Bay Prohibited Shellfish Growing Areas (2011)
--Prohibited due to proximity to waste treatment effluent
Finalized 2015



Station Location, WWTP Outfalls, and Classified Growing Areas in Coos Bay

EXHIBIT 16

Figure 15: Indicator Microorganism and Human Virus Levels in Oyster Sentinels Vs. Estimated Dilution Values Based on Impact from Both WWTPs in Combination at Stations 1 – 6

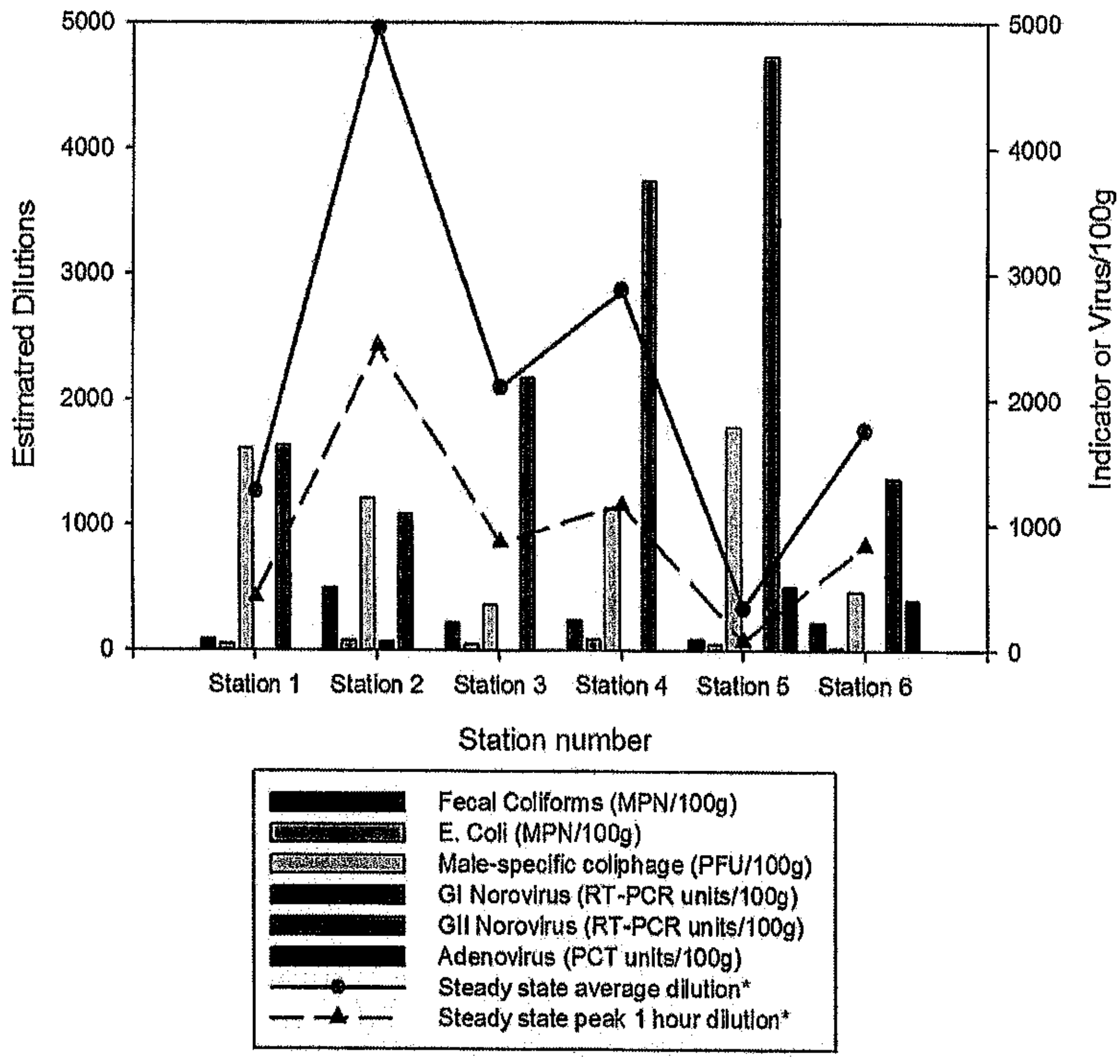


EXHIBIT 17

Quotes from FDA Report

"***The oysters were deployed on February 4, 2012 and retrieved on February 28, 2012. A three week deployment time was used to allow time for virus and microbiological contaminant...***" – Page 15

"It is recommended that anytime that either the Coos Bay #1 or North Bend Wastewater Treatment Plant (WWTP) ***goes into bypass or split flow event or experiences a malfunction, including a loss of disinfection, the entire Conditional growing area, encompassing the area east of station 2 and north of station 6, shall immediately close for a recommended 21days.***" – Page 4

Note: ODA only requires 5 days of closure.

"However, ***human enteric viruses such as noroviruses and hepatitis A virus are more resistant to disinfection and thus are not reduced to the same degree as the coliform bacteria group.***" – Page 6

"***The results of the shoreline survey did not indicate any major contributing source of pollution to the growing area other than the WWTPs.***" – Page 25

"***However, the ability of shellfish to bioaccumulate viruses up to 100-fold*** (Seraichekas et al., 1968; Maalouf et al., 2011)..." – Page 27

"Based on these findings, ***FDA recommends that either Coos Bay be re-classified to conditionally restricted, with conditional management based on the WWTPs' performance***, or as conditionally approved with the following conditions as recommended in FDA FY-2014 and 2015 PEER:"

Table 3 - Coos Bay #1 WWTP Influent Data

Date	Time	GI RT-PCR units/100 ml	GII RT-PCR units/100 ml	Adenovirus units/100 ml	MSC/100 ml	EC/100 ml	FC/100 ml
2/10/2011	1:00 to 6:00	<17	5,580	4,580	92,000	925,000	955,000
2/11/2011	1:00 to 6:00	<17	3,310	2,731	154,000	850,000	865,000
2/11/2011	13:00 to 18:00	<17	780	6,260	128,000	1,185,000	1,190,000
2/12/2011	1:00 to 6:00	<17	13,610	5,600	108,000	105,000	115,000
2/12/2011	13:00 to 18:00	<17	77,000	25,900	128,000	ND	ND
2/13/2011	1:00 to 6:00	<17	840	990	136,000	1,600,000	1,700,000
2/13/2011	13:00 to 18:00	<17	2,007	890	76,000	2,400,000	2,800,000
2/15/2011	7:28 (grab)	ND	ND	ND	25,400	300,000	360,000
2/15/2011	12:08 (grab)	ND	ND	ND	62,000	1,500,000	1,650,000

ND- Not Determined

Note: The varying levels of viruses in the influent are a direct reflection on Viral Infections in the community.

EXHIBIT 17

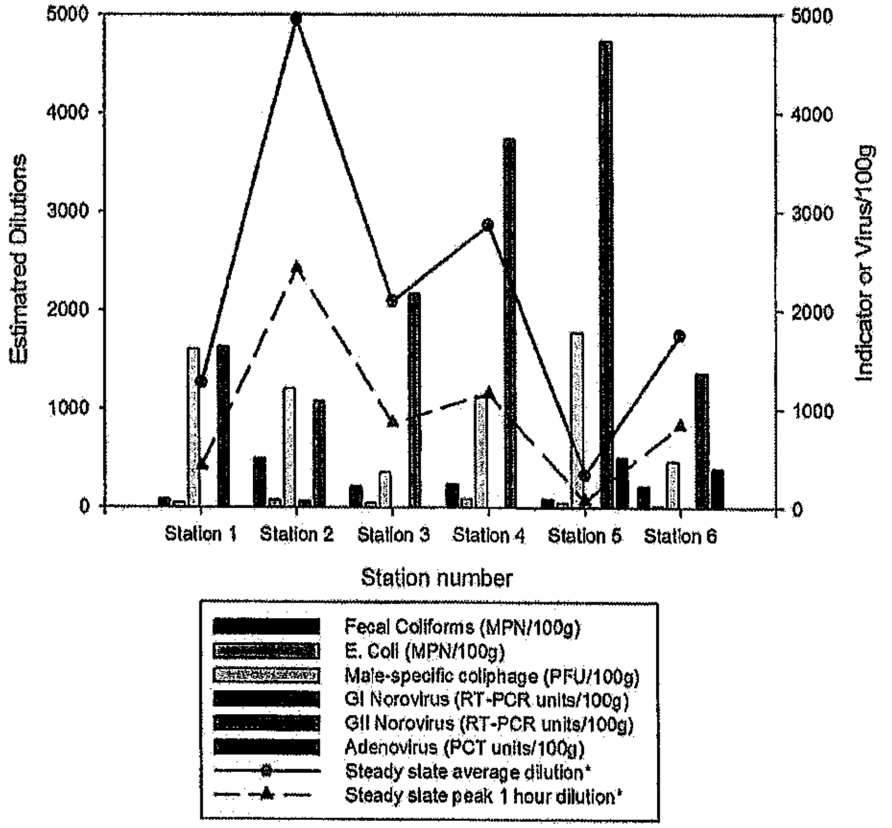
Table 4 - Coos Bay #1 WWTP Effluent Data

Date	Time	GI RT-PCR units/100 ml	GII RT-PCR units/100 ml	Adenovirus units/100 ml	MSC/100 ml	EC/100 ml	FC/100 ml
2/10/2011	1:00 to 6:00	<17	2,810	720	8,600	<0.5	<0.5
2/11/2011	1:00 to 6:00	<17	1,140	2,360	12,400	1.50	1.50
2/11/2011	13:00 to 18:00	<17	130	560	8,000	0.50	0.50
2/12/2011	1:00 to 6:00	<17	82	430	9,200	<0.5	<0.5
2/12/2011	13:00 to 18:00	<17	600	460	10,400	ND	ND
2/13/2011	1:00 to 6:00	<17	<17	<10	12,800	1.50	2.50
2/13/2011	13:00 to 18:00	<17	<17	146	17,200	1.50	1.50
2/15/2011	7:28 (grab)	ND	ND	ND	4,400	<0.5	<0.5
2/15/2011	12:08 (grab)	ND	ND	ND	2,200	3.50	3.50

ND- Not Determined

Note: Fecal Coliform is easily killed, Viruses are not.

Figure 15: Indicator Microorganism and Human Virus Levels in Oyster Sentinels Vs. Estimated Dilution Values Based on Impact from Both WWTPs in Combination at Stations 1 – 6



Note: This graph shows how Fecal Coliform levels can be low while Infectious Virus levels are dangerously high.

EXHIBIT 18

From:
To:
Subject: Fwd: EPA - Ambient Water Quality Criteria
Date: Tuesday, October 25, 2016 12:18:16 PM

-------- Original message --------
From: "Nappier, Sharon" <Nappier.Sharon@epa.gov>
Date: 10/25/2016 11:38 AM (GMT-08:00)
To:
Subject: RE: EPA - Ambient Water Quality Criteria

We are hoping to publish DRAFT Recreational Water Quality Criteria for Coliphage (for public comment) in late 2017. The ISSC/FDA have published recommendations that use coliphage for shellfish harvesting areas.

Hope this helps.

Sharon

From:
Sent: Tuesday, October 25, 2016 1:12 PM
To: Nappier, Sharon <Nappier.Sharon@epa.gov>
Subject: RE: EPA - Ambient Water Quality Criteria

Good morning Sharon,

EXHIBIT 18

Do you expect EPA to adopt a requirement for viral testing of recreation and oyster growing waters that receive effluent discharge by 2018?

Hope all is well…

From: Nappier, Sharon [mailto:Nappier.Sharon@epa.gov]
Sent: Friday, July 22, 2016 7:34 AM
To:
Subject: Re: EPA - Ambient Water Quality Criteria

EPA just published a fact sheet outlining the overall conclusions from our Coliphage Experts Workshop. We plan to publish a meeting proceedings report in early 2017. The draft criteria will likely not be available until 2018.

Fact Sheet:

https://www.epa.gov/wqc/microbial-pathogenrecreational-water-quality-criteria

I will also forward you information on an upcoming (free) webcast where I will be discussing the criteria development updates on August 3rd.

Thanks,

Sharon

EXHIBIT 19

United States Environmental Protection Agency

Office of Water
EPA 823-F-16-001
July 2016

2016 Coliphage Experts Workshop: Discussion Topics and Findings

Summary

EPA is developing Clean Water Act §304(a) Recreational Water Quality Criteria (RWQC) for coliphage, a viral indicator, to ensure public health protection when recreating in water bodies that may be affected by human fecal contamination. On March 1-2, 2016, EPA convened the Coliphage Experts Workshop to engage twelve internationally recognized experts on the state of the science of coliphages and their usefulness as viral indicators in recreational waters. Experts represented a spectrum of perspectives from academia, the wastewater industry, and other federal agencies including the Centers for Disease Control and Prevention and the Food and Drug Administration. Experts addressed charge questions related to five topic areas over the course of the two-day meeting.

Background

Viruses cause the majority of illnesses associated with primary contact recreation in surface waters impacted by human sources. While EPA recommends coliphage as an option for evaluating fecal contamination in groundwater, the Agency does not currently have a recommended indicator of viruses in surface waters that is protective of human health for primary contact recreation. Coliphages, viruses used to indicate the presence of a health risk, are not themselves dangerous to human health. Coliphages are useful for evaluating surface water quality because they exhibit numerous desirable indicator characteristics. For example, they:

- are of fecal origin and present in high numbers in sewage;
- are physically similar to viruses causing illnesses associated with primary contact recreation;
- do not re-grow in surface waters, thus their presence specifically indicates fecal contamination;
- are non-pathogenic;
- can be counted cheaply, easily, and quickly;
- show correlations to gastrointestinal illness; and
- are similarly resistant to sewage treatment and environmental insults as enteric viruses of concern.

Discussion Topics

- **Topic 1: The Need for a Viral Indicator** - Workshop participants were asked to comment on EPA's conclusion that the literature (including epidemiological, risk assessment, outbreak, and microbiological) indicates that viruses are an important cause of illnesses associated with exposure to ambient recreational waters and that coliphages can be used as an indicator of fecal contamination. The participants also identified the most important advantages and disadvantages of using coliphage for assessing fecal contamination in surface waters compared to traditional fecal indicator bacteria (FIB).
- **Topic 2: Coliphage as a Predictor of Gastrointestinal Illnesses** - Workshop participants were asked to comment on the overall strength of the association between coliphage and human health illness in epidemiological studies conducted in ambient recreational waters, identify specific characteristics that influence the association between coliphage and human health illness, and identify specific conditions under which traditional FIB are not adequate to protect public health.

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- **Topic 3: Coliphage as an Indicator of Wastewater Treatment Performance** - Workshop participants were asked to comment on EPA's conclusion that human pathogenic viruses are entering surface waters via wastewater treatment effluent. Participants summarized the most important reasons coliphages are useful models of the behavior of enteric viruses in wastewater treatment and disinfection processes.
- **Topic 4: Male-specific versus Somatic Coliphage** - The participants identified the most important advantages and disadvantages of using these two types of coliphages as predictors of human health illness in recreational waters and as indicators of wastewater treatment performance.
- **Topic 5: Systematic Literature Review of Viral Densities** - EPA has conducted systematic literature reviews to understand and document densities of key viral pathogens (norviruses and adenoviruses) and coliphages in raw wastewater. Participants reviewed the approach and information collected to date.

Workshop Findings

Topic 1: Need for a Viral Indicator

- Individual experts agreed that viruses are a source of illness in recreational water exposures.
- Viruses can enter surface waters via wastewater treatment plant (WWTP) effluent. Especially during wet weather and when WWTPs exceed design flows.
- Coliphages are more similar to human pathogenic viruses than the traditional FIB and they mimic the persistence of human pathogenic viruses.
- Coliphages have been shown to be useful in evaluating individual wastewater treatment processes, disinfection efficacy, and shellfish harvesting waters.
- Currently available, inexpensive coliphage test methods could be developed into simple kits. Rapid, commercial methods (results under eight hours) exist, which could be useful for swimming advisories at beaches.

Topic 2: Predictor of Gastrointestinal Illness

- Future epidemiological studies should specifically include coliphages as measured indicators.

Topic 3: Indicator of WWTP performance

- Coliphages are consistently present in municipal sewage and provide a baseline for looking at different WWTP processes under varied conditions. Experts indicated the literature suggests coliphage and human viruses have more similar log-reductions during wastewater treatment, compared to traditional FIB.

Topic 4: Male-specific vs Somatic Coliphages

- Opinions ranged on whether somatic, male-specific coliphage, or both would be better for various applications. There is evidence for both showing relationship to gastrointestinal illness. Male-specific coliphage behave more similarly to RNA viruses under some conditions and are currently used successfully by the Interstate Shellfish Sanitation Conference and Food and Drug Administration for shellfish waters. Somatic coliphage may persist longer than male-specific coliphage and may be present in greater concentrations in raw sewage. Laboratory bacterial hosts exist that can detect both coliphage types.

Topic 5: Review of Viral Densities

- Individual experts supported how the systematic analysis was structured and conducted.

Where can I find more information?

EPA plans to publish more detailed outcomes of the workshop in a peer-reviewed workshop proceedings document in early 2017. For additional information on EPA's efforts to develop recreational water quality criteria for coliphage, please visit EPA's water quality criteria website at: https://www.epa.gov/wqc/microbial-pathogenrecreational-water-quality-criteria or email Sharon Nappier at nappier.sharon@epa.gov.

EXHIBIT 20

richwine

Reynold "Dale" Richwine, P.E.
President, Principal Engineer

EDUCATION
Master Business Administration, Portland State University, 1995
M.S. Engineering Management, Portland State University, 1992
B.S. Civil-Structural Engineering, Portland State University, 1980
A.A.S. Wastewater Technology, Linn-Benton Community College, 1974
Oregon State University, 1971 – 1972

PROFESSIONAL REGISTRATIONS
Oregon, Washington – Civil Engineering
Oregon – Environmental Engineering
Oregon, Washington – Group IV Wastewater Treatment Plant Operator

CAREER SUMMARY
Dale began his career as a service representative for Neptune Microfloc in 1974 where he provided startup services for package water and wastewater treatment plants, installed mixed media filters and provided startup services for redwood media biofilters. During that time he worked in over 50 treatment systems throughout the United States.

Dale then worked as a plant operator for Clean Water Services (then Unified Sewerage Agency) where he participated in the startup of the new Rock Creek AWWT. During this period of time, Dale attended Portland State University and received his degree in Civil Engineering in 1980.

Dale then went to work for CH2M HILL as an operations and process engineer, following the receipt of his engineering degree. During his time with CH2M HILL he worked on the design, startup and troubleshooting of treatment plants throughout the US. Some of these projects included the startup of the original Tri-City WPCP, Anchorage Pt. Woronzof WWTP, Edmond, OK WTP, Wilsonville WWTP, Tillamook WWTP and Woodburn WWTP. He also worked on a number of plant designs including the Rock Creek AWWT Tertiary Complex, Seattle West Point secondary expansion and the San Francisco Oceanside WWTP.

Dale then worked for Clean Water Services (then Unified Sewerage Agency) as their Operations Manager. During this time he provided operations oversight of the design and construction of over $200M of new infrastructure at the Rock Creek, Durham, Forest Grove and Hillsboro Facilities. Dale also managed over 110 employees consisting of the operations for the four treatment facilities, the biosolids utilization, effluent reuse and technical services.

Dale returned to CH2M HILL as a Principal Engineer where he completed facility plans for the City of Portland Columbia Boulevard WWTP, Eugene-Springfield WWTP and Tri-City WPCP. He left CH2M HILL to work for MWH (then Montgomery Watson) as their Wastewater Manager for the Pacific Northwest. Following two years with MWH, Dale started his own firm of Richwine Environmental, Inc. where he provided engineering services to a number of clients throughout the Pacific Northwest, including Water Environment Services. He then returned to MWH for a 5-year period where he was the Wastewater Technical Lead for the Northern US as well as the Office Manger for the Portland, Oregon Office. During this time, he was the project manager for the planning, permitting and design of the Tri-City WPCP Phase I Expansion. He was also the project manager for the design and construction of the

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richwine environmental

Lower Tualatin Pump Station for Clean Water Services and assisted with facility plans for the City of Nampa, ID; Eagle Sewer District, ID; and Las Vegas, NV.

Dale has been with Richwine Environmental, Inc. for the past seven years where he has provided process-engineering services for Clackamas County Water Environment Services, Clean Water Services, City of Astoria, City of Sutherlin and City of Canby, OR; Columbia Biogas, OR; Port of Bremerton, Alderbrook Resort, and Kitsap PUD, WA; Whitefish and Missoula, MT; Slayden Construction Group, OR and McClure and Sons Construction, WA as well as other consulting firms and private confidential clients.

PROFESSIONAL EXPERIENCE
Service Representative, Neptune MicroFloc, Corvallis, OR, 1974 - 1976
Plant Operator, Unified Sewerage Agency (USA), Hillsboro, OR, 1976 - 1980
Process/Operations Engineer, CH2M HILL, Portland, OR, 1980 - 1990
Operations Division Manager, USA, Hillsboro, OR, 1990 - 1994
Project Manager, CH2M HILL, Portland, OR, 1994 - 1995
NW Wastewater Manager, Montgomery Watson, Portland, OR, 1995 - 1997
President, Richwine Environmental, Inc., Beaverton, OR, 1997 – 2003
NW Regional Wastewater Director/Portland Office Manager, MWH, Portland, OR, 2003 – 2005
Portland Office Manager, MWH, Portland, OR, 2005 – 2007
North Division Wastewater Director, MWH, Portland, OR, 2007 - 2009
President, Richwine Environmental, Inc., Beaverton, OR, 2009 - Present

ADJUNCT PROFESSOR
Portland State University School of Engineering
Water Resources Management: Spring 1994 - 1996
Unit Processes in Environmental Engineering: Fall 1995 - 1999
Civil Engineering Design Spring: 1997 - 1999

PROFESSIONAL SOCIETIES
Water Environment Federation (WEF)
Pacific Northwest Clean Water Association (PNCWA)
Montana Water Environment Association (MWEA)
Alaska Water and Wastewater Management Association (AWWMA)
Oregon Association of Clean Water Agencies (ACWA)

AWARDS AND HONORS
PNCWA – President's Award – 2012
PNCWA – Individual Distinguished Achievement Award – 2011
WEF Water Hero – 2008
WEF Quarter Century Operator – 2003
WEF Authur Sidney Bedell Award – 2000
PSU Chapter Tau Beta Pi Honor Society – 2000
PSU School of Engineering Academy of Distinguished Alumni – 1997
Boy Scouts District Award of Merit - 2001

PROFESSIONAL ACTIVITIES
Pacific Northwest Clean Water Association
President, 2006 - 2007
Secretary-Treasurer, 2001 - 2004
Water Environment Federation
WEF Board of Directors, 1998 – 2001

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richwine

WEF Student and Young Professionals Committee – Chairman – 2003 - 2006
WEF Student and Young Professionals Committee – Vice Chairman – 2001 - 2003
PSU School of Engineering Civil Engineering Advisory Council, 1999 - 2006

Oregon Association of Clean Water Agencies
Biosolids Management Committee, 1990 – Present
Water Quality Committee, 1992 - Present

Oregon Department of Environmental Quality
Biosolids Advisory Committee, 1991 - 2002

EXHIBIT 21

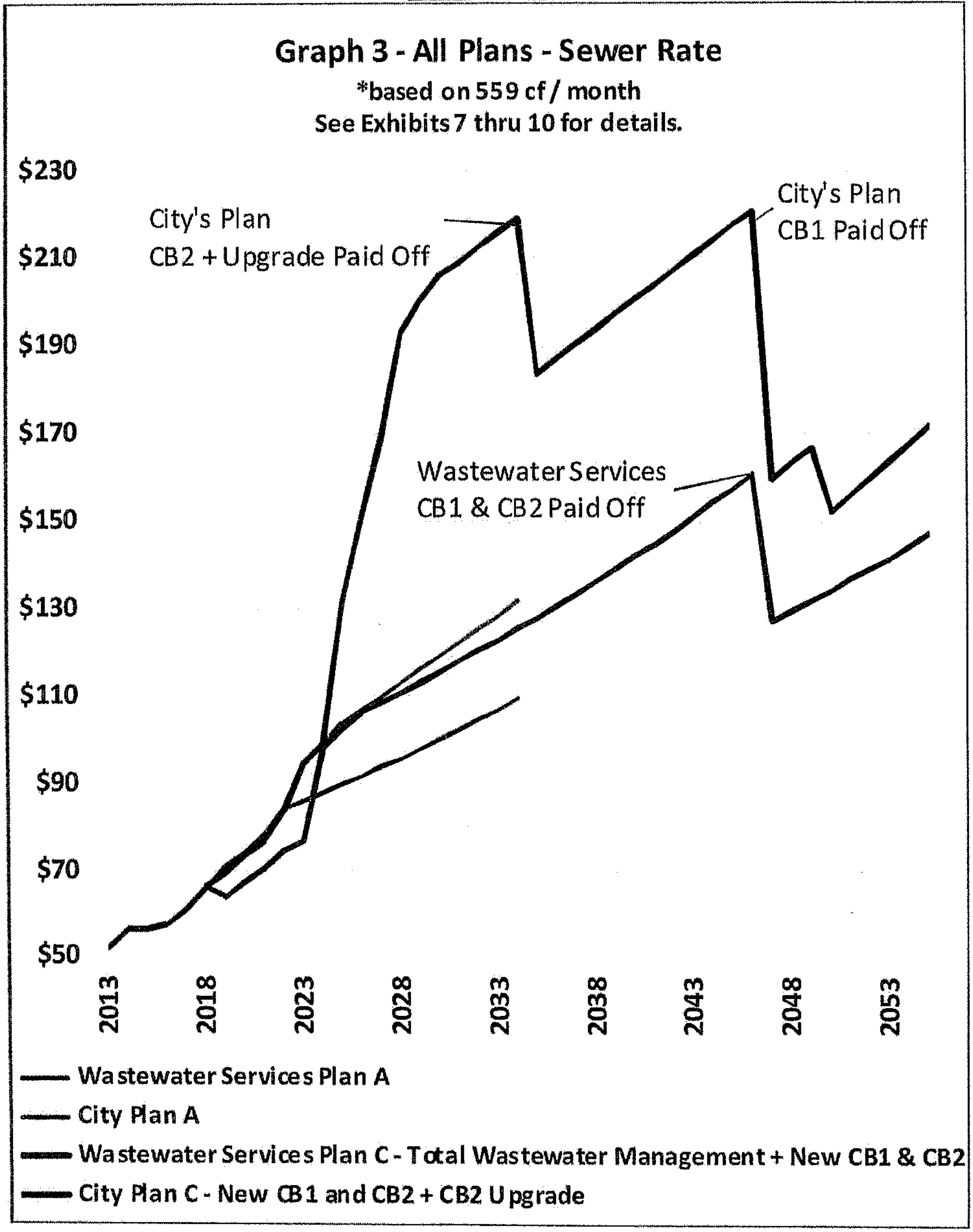

Graph 3 - All Plans - Sewer Rate
*based on 559 cf / month
See Exhibits 7 thru 10 for details.
$230
$210
$190
$170
$150
$130
$110
$90
$70
$50
City's Plan
CB2 + Upgrade Paid Off
City's Plan
CB1 Paid Off
Wastewater Services
CB1 & CB2 Paid Off
2013
2018
2023
2028
2033
2038
2043
2048
2053
Wastewater Services Plan A
City Plan A
Wastewater Services Plan C - Total Wastewater Management + New CB1 & CB2
City Plan C - New CB1 and CB2 + CB2 Upgrade

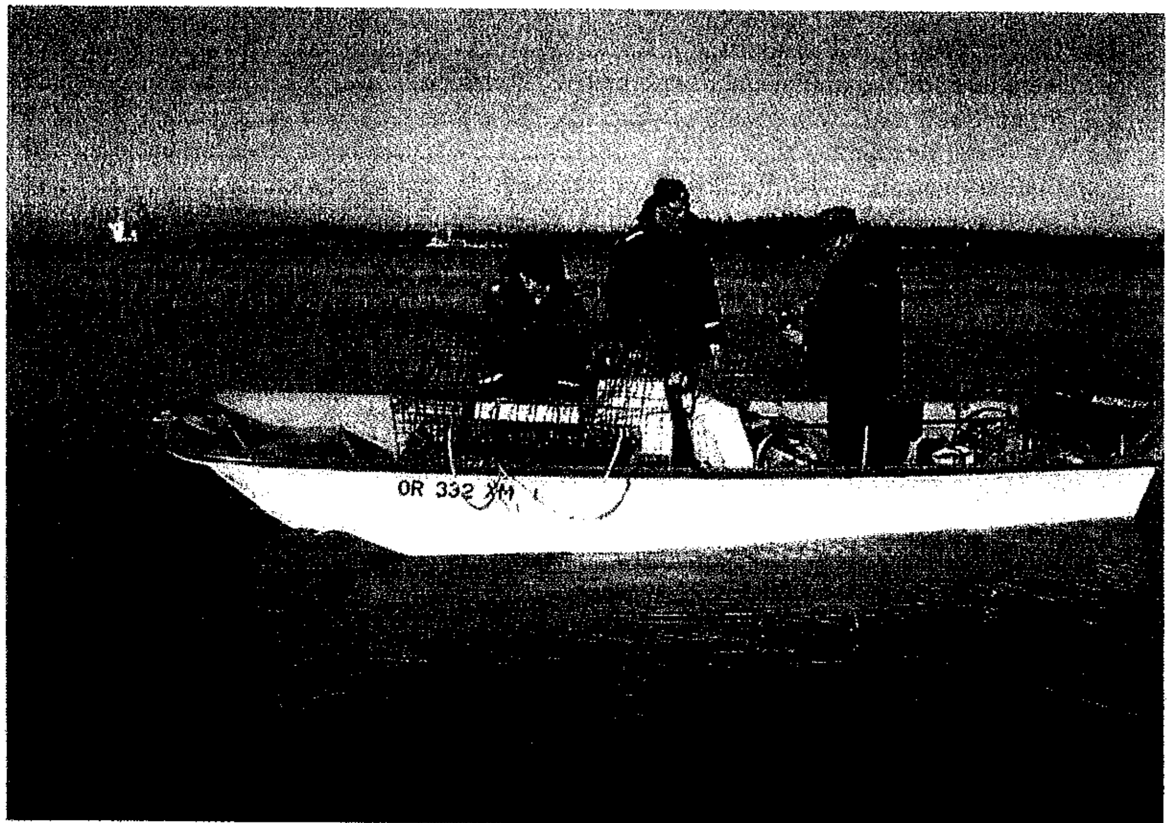
EXHIBIT 22

U.S. Food and Drug Administration
U.S. Department of Health and Human Services
CENTER FOR FOOD SAFETY AND APPLIED NUTRITION

Hydrographic Studies of Wastewater Treatment Plant Discharges in Coos Bay, Oregon

Study Conducted: February 2011

FDA Technical Assistance and Research Project



Reported by:
U.S. Food and Drug Administration
Center for Food Safety and Applied Nutrition
Office of Food Safety
Shellfish and Aquaculture Policy Branch
College Park, MD 20740-3835

September 2015

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LIST OF FIGURES (APPENDIX)

1.0 EXECUTIVE SUMMARY

FDA and the Oregon Department of Agriculture conducted two studies in February 2011 in Coos Bay, OR – one at the North Bend wastewater treatment plant (WWTP) and one at the Coos Bay #1 WWTP. Cages filled with oyster sentinels were deployed between the two plants and fluorometers were attached to the cages. Rhodamine WT dye was injected into the effluent of the North Bend WWTP on February 7, 2011 and into the effluent of the Coos Bay WWTP on February 15, 2011. The cage-attached fluorometers measured the dye-tagged effluent received by each cage. Boat tracking fluorometers were also used to measure the level of dye-tagged effluent near each cage and in other parts of Coos Bay. A new mobile geographic information system (GIS) tool was employed to assist in collecting the boat tracking data in real-time. Microbiological analyses of fecal coliforms (FC), *E. coli* (EC), male-specific coliphage (MSC), norovirus (NoV) genogroup I (GI) and genogroup II (GII), and adenovirus (AdV) were conducted in the WWTPs' effluent and in the oyster sentinels. Extensive shoreline survey work was conducted with microbial indicator analysis performed on potential pollution sources. The results of the microbiological analyses and the dye study are presented in this report.

Based on the findings of this study it is recommended that ODA reevaluate the 1000:1 and 100,000:1 WWTP dilution zones for these areas, as well as collect bypass information from WWTP operators. If Conditionally Approved areas are determined to be within the affected area of the 100,000:1 recommended dilution zone, then those areas should be closed during bypass events. WWTP operators should report any bypasses of primary or secondary treatment, to include any split flow or flow blending events as well as exceedances of design flow for sustained periods. Procedures for timely notification of WWTP upsets need to be sufficient to ensure those areas can be placed in a closed status prior to the pollution reaching the harvest area.

It is recommended that anytime that either the Coos Bay #1 or North Bend Wastewater Treatment Plant (WWTP) goes into bypass or split flow event or experiences a malfunction, including a loss of disinfection, the entire Conditional growing area, encompassing the area east of station 2 and north of station 6, shall immediately close for a recommended 21days. If another bypass event occurs during the 21 day closure, it is recommended that the growing area will be closed for an additional 21days from that event. However, the growing area could potentially be re-opened sooner through sample collection, where the analytical sample results shall not exceed background levels or a level of 50 male-specific coliphage (MSC) per 100 grams from shellfish samples collected no sooner than 7 days after contamination has ceased and from representative locations in each growing area potentially impacted.

1.1 INTRODUCTION

Two hydrographic dye studies of treated wastewater effluent from the North Bend WWTP facility and the Coos Bay #1 WWTP facility, as well as a shoreline survey of the area, were conducted between the dates of February 2 - 18, 2011 in Coos Bay, OR. The hydrographic dye studies assessed the dilution, time of travel, and dispersion of effluent from the two tested WWTPs. In addition to the hydrographic dye studies, the microbiological impacts of the wastewater on molluscan shellfish were assessed by testing oyster sentinels placed in cages located along the anticipated paths of both WWTPs' effluents. Levels of FC, EC, MSC, NoV GI & GII, and AdV were determined. The Oregon Department of Agriculture (ODA) requested technical assistance and training from the FDA and the Coos Bay site was chosen because of mutual interest. These studies were led by FDA in conjunction with the ODA. FDA was interested in assessing the combined impact from multiple WWTPs, and Coos Bay has three WWTPs impacting the same growing areas; the two with the impacts of most concern were chosen for this study. As sanctioned under the Public Health Act, FDA provides technical assistance to State Shellfish Control Authorities (SSCAs). For over 30 years, FDA has assisted SSCAs by conducting hydrographic dye-dilution studies, such as the studies conducted in Coos Bay, as a means to assess the impact of WWTPs on shellfish growing areas.

1.2 Study Objectives

The general objective of this study was to provide highly technical applied field training to a cadre of federal and state shellfish specialists. Other objectives of this study were to: 1) determine the sanitary water quality conditions in the estuary that could arise under a short term lapse in treatment and disinfection; 2) determine the steady state bacterial conditions in the shellfish growing waters that could arise in the event of a long term elimination or lapse in disinfection; 3) provide guidance to the ODA regarding WWTP closure zones; and 4) establish the necessary minimum zone of dilution of wastewater needed to achieve a sufficient reduction in viruses to ensure the safety of shellfish. The findings of these objectives are intended to inform FDA's recommendations for growing area management in Coos Bay and its dilution guidance for establishing prohibited zones around WWTP outfalls. Finally, an additional goal of this research was to determine the impact of combined effluents from different WWTPs on microbial bio-accumulation in shellfish.

1.3 FDA Guidance on Establishing Closure Zones for WWTP Discharges

In consideration of Section II, Chapter IV @.03 E(5) (Prohibited Classification – Wastewater Discharges) of the National Shellfish Sanitation Program Model Ordinance, which notes that the determination of the size of a prohibited zone around a WWTP outfall shall include "the wastewater's dispersion and dilution, and the time of waste transport to the growing area where shellstock may be harvested" (iii), FDA has provided guidance to state shellfish control authorities to size prohibited zones around WWTP outfalls according to the following scenarios:

Scenario 1: In consideration of effluent discharged from a WWTP under **failure conditions** (such as a loss of disinfection), the prohibited zone should provide a sufficient amount of dilution to dilute the effluent discharged under failure conditions to the fecal coliform standard of 14 MPN/100 ml within the prohibited zone

OR

Scenario 2: In order to reduce the size of the prohibited zone, a conditionally approved zone may be operated **if** a factor of at least a 1000:1 dilution of effluent is achieved within the prohibited area to mitigate the impact of viruses, **and** there is a sufficient amount of time to close the conditional area to the harvesting of shellfish **before** the effluent discharged at the onset of a failure can travel to the boundaries of the prohibited zone

Note: the additional area beyond the prohibited zone to be closed under WWTP failure conditions should provide a sufficient amount of dilution to dilute the effluent discharged under failure conditions to the fecal coliform standard of 14 MPN/100 ml within the closed (due to failure) zone (consistent with Scenario 1).

Over the years, wastewater treatment technologies have improved. However, FDA has maintained a conservative position recognizing that a WWTP may still be subject to failure regardless of the type of treatment system used. FDA does recognize that with the advancement of technologies such as improved monitoring and alarm systems, it may be possible to operate a conditional area as outlined in Scenario 2 above. This allows additional shellfish growing areas to be harvested under certain conditions.

When a WWTP is operating normally, disinfection has been shown to be effective in reducing the coliform bacteria groups (fecal coliform and total coliform) to levels below shellfish harvesting standards as can be seen in WWTP permit records kept in accordance with the Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System (NPDES) Program. However, human enteric viruses such as noroviruses and hepatitis A virus are more resistant to disinfection and thus are not reduced to the same degree as the coliform bacteria group. In an effort to mitigate the risk of contaminating shellfish with viruses, FDA has recommended a 1000:1 dilution as described in Scenario 2 as the minimum zone of dilution needed when the WWTP is operating under normal conditions.

1.4 Description of North Bend WWTP and Coos Bay #1 WWTP

Figure 1 shows a map of Coos Bay with the locations of the three WWTP outfalls. Growing area classifications are also shown on the map, with approved areas delineated in green and prohibited areas delineated in red.

The North Bend WWTP was constructed in 1954 and was last renovated in 2008. It serves a population of 9855 in the North Bend, OR area. It has primary and secondary treatment with activated sludge and gas fed chlorine disinfection. The design flow is 2.0 MGD and the hydraulic capacity is 8.3 MGD. The average daily dry flow is 1.0 MGD, and the average daily wet flow is 2.5 MGD. The peak hourly dry flow is 2.0 MGD and the peak hourly wet flow can be up to 8.5 MGD. The WWTP has a 27" outfall with a 128 ft. multi-port diffuser that is 10 feet deep. According to a 1991 mixing zone study, the estimated dilution at the outfall was predicted to be in the range of 53:1 – 107:1.

The Coos Bay #1 WWTP serves a population of approximately 11,000 in the Coos Bay, OR and surrounding areas. It has primary and secondary treatment with activated sludge and chlorine disinfection. Flows up to 7 MGD receive both primary and secondary treatment, but flows in excess of 7 MGD bypass primary treatment and receive secondary treatment only. The design year peak flow is 20 MGD. Data provided in a May 2008 facilities plan indicated that the average daily dry flow is 1.6 MGD, and the average daily wet flow is 3.2 MGD. The peak daily flow is 10.0 MGD and the peak wet weather flow is 15.0 MGD. The WWTP has a 42" outfall with a 715 ft., 5-port diffuser.

1.5 General Description of Study Design

Prior to the comprehensive dye study, a drogue study was conducted with oranges. The GPS coordinates of the drogues were marked in a new mobile GIS application developed for FDA's Shellfish and Aquaculture Policy Branch called the Real-Time Application for Tracking and Mapping (RAFT-MAP). The drogue study provided information about tidal cycles, tidal velocity, and wind speed and direction in Coos Bay. The drogue study was also used to assist in the placement of oyster sentinel cages in order to maximize the oysters' exposure to the effluent plumes and to viruses.

The six oyster sentinel cages were equipped with submersible WET Labs fluorometers (WET Labs, Inc., Philomath, OR) and were placed at various distances between the North Bend WWTP and the Coos Bay #1 WWTP along the path of the effluent plumes from both plants for a three week period. Figure 1 shows the locations of the six cage stations. Each cage was also equipped with a Star-Oddi miniature CTD (Star-Oddi Ltd., Iceland) to monitor conductivity/salinity, temperature, and depth/pressure during the course of the comprehensive dye study.

The dye for each of the two comprehensive studies was injected over half a tidal cycle (12.4 hours) and was tracked by boat in the Coos Bay system for at least two days. Boat tracking with towed fluorometers was conducted to find the edges of the dye plume during daylight hours, in addition to the continuous dye readings recorded by the cage-attached submersible fluorometers. The submersible fluorometers were collected from the cages on February 18, after dye readings had fallen below detectable levels.

The oyster sentinels from the six cages were shipped to FDA's Gulf Coast Seafood Laboratory (GCSL) in Dauphin Island, AL to test for FC, EC, MSC, NoV (GI and GII), and AdV. Water samples taken from the influent, final effluent, and post-disinfected flows at the North Bend and Coos Bay #1WWTPs were also analyzed for FC, EC, MSC, NoV (GI and GII) and AdV to compare with the levels found in the oyster sentinels. The results of these microbiological analyses were compared with the level of dilution of the dye found at each of the cages to determine the relationship between effluent dilution and viral impacts on shellfish.

2.0 METHODS

2.1 Dye Standard Preparation and Fluorometer Calibration

The dye tracer used in this study, Rhodamine WT, was purchased from the Keystone Aniline Corporation and had a specific gravity of approximately 1.12 (20% as dry dye). Ten (10) standards were prepared from the stock solution of Rhodamine WT dye and distilled water by serial dilution, ranging from 100,000 parts per million (ppm) to 0.1 part per billion (ppb).

The Rhodamine WT dye was detected and its concentrations in Coos Bay were obtained using a combined total of nine fluorometers. Six of these were WET Labs FLRHB submersible fluorometers (WET Labs, Inc., Philomath, OR) that were attached to the shellfish cages deployed at stations along the anticipated path of the effluent throughout the course of the study. Two were WET Labs FLRHRT fluorometers that were pulled behind a boat and used for tracking the dye on the ebb tide for each day of the study. The final instrument was a WET Labs FLRHB fluorometer with a built-in pressure (depth) sensor that was used for taking depth profiles to determine the vertical distribution of the dye within Coos Bay. This instrument was on loan from Mr. Mark Toy of the Washington Department of Health, who received training during the study and was an active participant of this study.

The dye standards were used to develop calibration curves for FDA's WET Labs FLRHRT-586 and 2040 tracking fluorometers, the six moored, submersible fluorometers – WET Labs FLRHB units 585, 913, 915, 1730, 1731, and 2032, and the profiling fluorometer – WET Labs FLRHB 2153 - in distilled water. With the subtraction of background fluorescence levels in Coos Bay, these curves were used to calculate part per billion (ppb) levels of dye based on the WET Labs' measured fluorescent units (FUs).

The y-intercept of the calibration curve was adjusted so that a "0.1 ppb" result read as a perfect "0.1" on the curve. The slope and x-axis values for the curve remained the same, but this adjustment introduced only a slight addition of error to the higher concentrations on the curve, such as 1, 10 and 100 ppb standards. For example, for the 585 unit calibrated for the North Bend study, the intercept was increased from 0.025 to 0.047 to produce a 0.1 ppb reading for the 0.1 ppb standard. The increase of 0.022 in the intercept would mean that a 1 ppb reading would increase to 1.022 (2.2% difference) and a 10 ppb reading would read 10.022 (0.22% difference) and a 100 reading would read 100.022 (0.022% difference). Thus, the accuracy at the lower end of the curve, 0.1 ppb, is more vital in order to optimize accuracy in dye concentration readings at low concentrations, as important data tends to fall within the 0.1 – 1 ppb range during FDA dye studies. Using a calibration curve adjusted in this manner is necessary when converting raw FU readings to ppb values if sensitivity in the 0.1 – 1 ppb range is critical for the study.

On February 6, 2011, background fluorescence levels in Coos Bay were assessed using the WET Labs FLRHRT-586 tracking fluorometer and WET Labs FLRHB-2153 profiling fluorometer. Background levels were subtracted from the calibration equation when performing the conversion from fluorescent units to ppb.

2.2 Drogue Study

Approximately thirty drogues (oranges) were used on Feb. 4, 2011 to access the timing of tidal cycles (i.e., slack high/start of ebb tide), tidal velocity, and the influence of wind to estimate the velocity and direction of the effluent leaving the outfall of the Coos Bay #1 WWTP. The drogues were released on the surface of the water, and were influenced in part by surface winds.

A portion of the drogues were thrown in a horizontal line near the outfall just prior to the turning of the tide from flood to ebb tide. The timing of the turn to ebb tide was noted and used to help plan the timing for the dye studies. The drogues were marked with drop points in FDA's new RAFT-MAP GIS mobile application, and the time at which each drogue was released was recorded. After the tide switched to ebb, the movement of the drogues was tracked and the new locations of the drogues were marked in RAFT-MAP about 41 minutes after the initial release. This information was used to determine the velocity and direction of the tidal movement in ArcGIS 10.0. To calculate the general velocity of the drogues, the median values for the times of release and the times of re-marking were used, as well as the central locations for the first drogue cluster and the second drogue cluster.

2.3 Dye Tracer Injection

For the first study at the North Bend WWTP, a total of 4.4 Gallons of dye was injected into the WWTP effluent over a 12.4 hour period at a constant rate. The injection began around 1:16 AM on February 7, 2011. To facilitate the pumping of dye, 4.4 Gallons of deionized water was added creating a 1:2 dye dilution mixture (~9 Gallons). A Masterflex model 7553-20 variable speed peristaltic pump (Cole-Palmer Instrument Co.) was used to withdraw the tracer dye solution from a large plastic holding bin, using Masterflex Tygon L/S-16 tubing. A pump head size 7016 was used with a constant pumping rate of 46 ml/min which was maintained at about 58 revolutions/minute (rpm) head speed. The tracer dye mixture was fed continuously into the effluent following the chlorine detention tank over the half tidal day period. The initial concentration of the dye in the effluent was determined using the WWTP's flow average over the course of the dye injection period.

For the second study at the Coos Bay #1 WWTP, a total of 10 Gallons of dye was injected into the WWTP effluent over a 19.5 hour period at a constant rate. The period of the dye injection should have been 12.4 hours, but a problem with the tubing (discussed more below) resulted in a lengthening of the overall injection period. The injection started at 4:00 AM on February 15, 2011. To facilitate the pumping of dye, 10 Gallons of deionized water was added creating a 1:2 dye dilution mixture (20 Gallons). A Masterflex model 7553-20 variable speed peristaltic pump (Cole-Palmer Instrument Co.) was used to withdraw the tracer dye solution from a large plastic holding bin, using Masterflex Tygon L/S-16 tubing. A pump head size 7016 was set at a 121 revolutions/minute (rpm) head speed which maintained a constant pumping rate of 101.88 ml/min (38.6 gal/day). The tracer dye mixture was fed continuously into the effluent following the chlorine detention tank. The initial concentration of the dye in the effluent was determined using the WWTP's flow average as described below.

During the second study at the Coos Bay #1 WWTP, the dye injection pump was placed inside a cooler to protect it from heavy winds and rain from a strong storm. A piece of foam was placed under the cooler lid to elevate it so that the Masterflex Tygon L/S 16 tubing could be threaded under the lid and into the final effluent chamber of the WWTP. However, the lid of the cooler crimped down on the foam and the tubing and thereby decreased the rate of the dye flow. Because the dye was still flowing (albeit at a much lower rate than 101.88 ml/min) and was still visible in the final effluent, and it was initially picked up at low concentrations of 0.1 ppb near the outfall, this problem was not discovered until hours later at 12:50 PM. At that time, the lid of the cooler was lifted and the dye flowed through the tubing freely at the proper rate. The dye injection continued until 11:33 PM on February 15, at which time the entire dye/water mixture of 20 Gallons had been injected. Therefore, the bulk of the dye injection actually took place over 10.7 hours from 12:50 PM to 11:33 PM. The WWTP flows from this time period were averaged and used to determine the initial concentration of dye injected into Coos Bay. However, the low levels of dye injected prior to 12:50 PM were still detected and recorded by the submersible fluorometers located closest to the outfall and were factored into the calculations when determining the dye levels at those stations.

2.4 Dilution Analysis - Dye Readings from Submersible Fluorometers

The fluorescence readings recorded by the submersible fluorometers at each of the six oyster sentinel stations were downloaded, converted to ppb using each fluorometer's calibration curve chart, and plotted in SigmaPlot alongside tidal depth charts and salinity readings from the Star-Oddi CTD for the period of the study.

A five-point moving average was applied to the dye concentration data to smooth out any false high or low readings in the data. Dilution was calculated by dividing the initial concentration of dye injected at the WWTP by the final (five-point moving average) concentrations detected in the estuary.

Since only half tidal day dye injections were conducted – rather than full tidal day injections – an improved variation on the superposition method (Kilpatrick, 1993) was used to estimate the steady state condition for dye at each of the cage stations using data collected during the two study periods, from 2/7/2011 – 2/10/2011 and from 2/15/2011 – 2/17/2011, respectively. In the past, FDA would typically conduct a 2 – 3 day injection of dye to determine the build-up of WWTP effluent in a system and to determine the steady state condition, in which the rate of effluent flowing into a system is equal to that being flushed out by tides. However, Kilpatrick (1993) demonstrated using the superposition principle that a shorter dye injection period could be used and the steady state condition estimated if remaining dye in the system on the second tidal day after an injection is added to the dye detected on the first tidal day, and if the remaining dye detected on the third tidal day is added to the dye found on both the first and second tidal days, and so on. FDA has successfully employed the superposition method, even with only a half tidal day (12.4 hour) injection, and used this method in the Coos Bay study.

For example, for the day of the injection for the North Bend study, 2/7/2011, the superposition dye concentration was plotted based on the first half-tidal day. For the second day of the study, 2/8/2011, the remaining dye level in the system from the first day was added to the levels detected on day 2. Following the superposition principle, remaining dye levels found in the system on days 3 and 4 of the study were also used to determine the steady state condition at each cage station.

To determine the combined impact of the effluents from the both the North Bend WWTP and the Coos Bay #1 WWTP, FDA applied a new method to calculate the "combined dilution" at each cage station, factoring in the decrease in dilution combining the impact caused by both WWTPs based on the area under the concentration-time curve method described in Goblick, et al.,2011). Dilution of effluent from each WWTP can be determined separately considering the impact from a single WWTP described as follows:

$$D_1 = \frac{A_1}{SA_1}$$

Where:

D_1 = Dilution of effluent discharged from WWTP 1
A_1 = Area under the concentration-time curve produced by injecting dye into WWTP 1 effluent
SA_1= Area under the concentration-time curve measured at Station in growing area in response to the area under the concentration-time curve A_1

Similarly, the dilution of effluent discharged from WWTP 2 can be determined as follows:

$$D_2 = \frac{A_2}{SA_2}$$

Where:

D_2 = Dilution of effluent discharged from WWTP 2
A_2 = Area under the concentration-time curve produced by injecting dye into WWTP 1 effluent
SA_2= Area under the concentration-time curve measured at Station in growing area in response to the area under the concentration-time curve A_2

Both the steady state average dilution as well as the steady state peak 1 hour dilution may be determined based on the area analysis as described in more detail in Goblick, et al. (in press). The steady state average is based on the cumulative area under the concentration-time curve for each half tidal day whereas the steady state peak 1 hour is based on the cumulative area under the concentration-time curve for each half tidal day during the peak 1 hour timeframe which produces the highest concentrations.

However, in consideration of the impact from both WWTPs the area under the concentration-time curve method can also be utilized to determine the dilution of effluent relative to WWTP 1 and WWTP 2 and considering the combined impact from both WWTPs. It should be noted that FDA's long standing minimum dilution recommendation of 1000:1 is with respect to a "single" WWTP discharge. Thus, the "combined" dilution analysis method presented below is made relative to one WWTP discharge (and adding the impact of the second discharge) such that the dilution results can be compared against the FDA minimum dilution recommendation based on a single discharge. This will enable the determination if adequate dilution is achieved at each state with respect to the recommended 1000:1.

Thus, to find the dilution with respect to with respect to either WWTP 1 or WWTP 2 but combining the impacts from both, the dilution can be presented as follows:

<u>Dilution relative to WWTP 1 (and adding the impact from WWTP 2):</u>

$$D = \frac{A_1}{SA_1 + SA_2(\frac{A_1}{A_2})}$$

Where:

D = Dilution with respect to WWTP 1 but combining the impact of both WWTP 1 and WWTP 2
A_1 = Area under the concentration-time curve produced by injecting dye into WWTP 1 effluent
SA_1= Area under the concentration-time curve measured at Station in growing area in response to the area under the concentration-time curve A_1
A_2 = Area under the concentration-time curve produced by injecting dye into WWTP 2 effluent
SA_2= Area under the concentration-time curve measured at Station in growing area in response to the area under the concentration-time curve A_2

Thus, in the equation above, the additional impact of (SA_2) caused by WWTP 2 are added to the Station. However, in order to make the impact of SA_2 relative to the impact of SA_1 a scaling factor A_2/A_1 is needed such that they can be combined.

The dilution equation could also be expressed relative to WWTP 2 which would yield similar results. If expressed relative to WWTP2 the dilution equation can be expressed as:

$$D = \frac{A_2}{SA_2 + SA_1(\frac{A_2}{A_1})}$$

Where:

D = Dilution with respect to WWTP 2 but combining the impact of both WWTP 2 and WWTP 1
SA_1 = Area under the concentration-time curve produced by injecting dye into WWTP 1 effluent
SA_1= Area under the concentration-time curve measured at Station in growing area in response to the area under the concentration-time curve A_1
A_2 = Area under the concentration-time curve produced by injecting dye into WWTP 2 effluent
SA_2= Area under the concentration-time curve measured at Station in growing area in response to the area under the concentration-time curve A_2

Dilution analysis using either equation will produce results that make relative the impacts from both WWTP 1 and WWTP 2 such that the impact from both WWTPs can be combined. However, it is important to note that the dilution analysis is made relative to one discharge (although combining the impact from both) such that the dilution result can be compared against the FDA recommended minimum dilution of a 1000:1 which was in consideration of a single discharge.

2.5 Dye Tracking Via Boat

The dye was tracked and the outer edges of the dye plume were located via boat using FDA's WET Labs FLRHRT-586 and FLRHRT-2040 fluorometer units linked to either a Trimble GPS unit operating with Terrasync software or an Itronix DuoTouch II operating FDA's new custom-made mobile GIS software RAFT-MAP.

RAFT-MAP allowed FDA and ODA to see the dye concentration results plotted in real-time on a GIS map with colors like red, yellow, and green representing high, medium, and low concentrations, respectively. The slope and intercept values of the calibration curves for the WET Labs FLRHRT units were programmed into RAFT-MAP so that the program could automatically convert the fluorescence units recorded by the WET Labs into part per billion (ppb) concentration values, which were the values plotted on the map in real-time. RAFT-MAP was also able to identify maximum and minimum detected concentrations and calculate estimates of dye dilution as well. RAFT-MAP was field tested for the very first time in Coos Bay, and the results of this beta test with the new tracking system are discussed more in Section 2.7 below.

The dye plume was followed during the beginning of the North Bend WWTP study on 2/7/2011 as it moved through Coos Bay on an ebb tide using FDA's WET Labs FLRHRT-586 and FLRHRT-2040 tracking fluorometers and with the FLRHB-2153 profiling fluorometer. Three boats were used, with each instrument on a different boat. Dye readings were also taken on successive days (2/8/2011 and 2/9/2011) for high and low tides. Traverses were done on all the days of study from west to east and east to west, and dye readings were also recorded at each of the station locations (via boat and with the submersible fluorometers fixed to the stationary cage stations) to show changes in dye concentration and build-up with time at the fixed locations. The same boat tracking methods were used for the Coos Bay #1 study on 2/15/2011 – 2/17/2011.

A five-point moving average was applied to the dye concentration data to normalize the range and variability of the readings. Dilution was calculated by dividing the initial concentration of dye injected at the WWTP by the final (five-point moving average) concentrations detected in the estuary. As previously noted, since the injection only lasted a half tidal day, the build-up and steady state concentration of pollutants at the station locations were estimated using the superposition principle (Kilpatrick, 1993).

For data recorded with the Trimble GeoXM data logger, the fluorometer dye readings (in fluorescent units) with the associated GPS readings were later downloaded and converted into ppb units using the calibration curve for WET Labs FLRHRT-586. These values were then imported into a geodatabase in ArcGIS v.10.0 (ESRI, Inc., Redlands, CA) to create a color-coded map representing the presence of different dye concentrations along the path of the effluent during the North Bend study. The concentrations in ppb were converted to dilution values by dividing the initial concentration of dye in the effluent with the final concentration of dye in the estuary. The dilution values were also plotted in a color-coded GIS map using ArcGIS v.10.0.

For data recorded with FDA's new RAFT-MAP program, concentrations in ppb were automatically plotted on a GIS map in real-time on the boat.

2.6 Beta Testing of FDA's Real-Time Application for Tracking and Mapping (RAFT-MAP)

During the studies in Coos Bay in February 2011, FDA beta tested for the first time a new mobile GIS application called RAFT-MAP, which was developed with ESRI, Inc. RAFT-MAP allowed FDA to plot the dye concentration results in real-time on an electronic map tagged with latitude and longitude coordinates. High levels of dye were mapped with red points, average levels were mapped with yellow points, and low levels were mapped with green points. In this way, it was easy to visualize the concentrated center of the dye plume and find the edges of the plume.

RAFT-MAP also performed calculations in real-time, including the conversion of fluorescent units (FUs) from the WET Labs fluorometer into parts per billion (ppb) dye concentrations and then the calculation of dilution levels (e.g., 1000:1 dilution). The conversion of FUs into ppb units was performed by subtracting out background FU levels and by using the slope and intercept of the calibration curve for the instrument. The dilution calculation was determined by using an estimate of the initial concentration of dye injected into the effluent based on a theoretical calculation; the estimate used was 1000 ppb. Once the actual WWTP flows for the dye injection period were known, the accurate initial concentration was determined and the dilution values were re-calculated after the study. However, by using an estimate of 1000 ppb, FDA was able to show ODA in RAFT-MAP approximately where the 1000:1 dilution line could be found.

Errors observed in RAFT-MAP during the beta test (discussed in section 3.9) were noted and reported to ESRI, Inc. for correction.

2.7 Shoreline Survey

A shoreline survey of the growing area was conducted during wet weather at every identified potential pollution source that was accessible by land. Pollution source water samples were collected and poured into 3.0 ml Whirl-pak bags, with a new bag for each sample. The sample number, date, and time were written on the bags. This date was also recorded in a notebook along with a description of the location that the sample was collected and the GPS coordinates. The GPS coordinates were recorded with a Trimble GeoXM data logger. A photograph of each sample site was taken and the number of the photograph was recorded in the notebook as well.

Pollution source samples were analyzed for FC, EC, and MSC in the same manner that WWTP influent and effluent samples were assessed for these criteria as described in Section 2.8 below. Sample sites for which FC or EC were high or for which MSC was above the limit of detection were re-sampled to confirm results and investigate the source waters further up the catchment if possible. Since MSC is used as a microbiological tool that indicates the presence of human sewage, whereas FC and EC can be attributable to other sources as well, particular attention was paid to samples that had detectable levels of MSC.

2.8 Microbiological Analysis of Wastewater and Oysters

Shellfish Sentinels at Station Locations

Local oysters (relocated from Netarts Bay) up to 3 inches in size were used as sentinels at each of the six station locations. A total of 200 oysters were used in the study. There were approximately 30 oysters per cage for each of the six FDA station locations with the other oysters used as controls. The oysters were distributed evenly throughout the cages in a mono-layer. The cages were weighed down with cement and stationary on the bottom of the estuary.

The oysters were deployed on February 4, 2012 and retrieved on February 28, 2012. A three week deployment time was used to allow time for virus and microbiological contaminant accumulation and to cover the span of both the North Bend WWTP dye study and the Coos Bay #1 WWTP dye study. Each sample set was analyzed for FC, EC, MSC, NoV GI and GII, and AdV.

Indicator Microorganisms

FC and EC densities in the shellfish and in the WWTP influent and effluent were determined using a conventional five-tube, three-dilution MPN procedure. In the case of the shellfish, the procedure was done with minimal modifications to the FDA *Bacteriological Analytical Manual* (BAM) and American Public Health Association (APHA) (1970) recommended procedures for the examination of shellfish. Modifications to this procedure included blending of the shellfish meats and liquors without dilution buffer; this was necessary due to the multiple microbial analyses performed on each shellfish sample. Following homogenization, a 1:10 dilution of homogenate (10 g) was prepared with phosphate-buffered solution (PBS). Ten ml of this dilution, a 1-g equivalent, was transferred to five tubes of 10 ml of double-strength lauryl tryptose broth (LST; Difco Laboratories, Sparks, MD). One-milliliter aliquots (0.1-g equivalent) were also transferred to five tubes of single-strength LST, while five 1-ml aliquots of a 1:100 dilution were also transferred to single-strength LST. Presumptive positive tubes were confirmed for FC and EC using EC-MUG (Difco, Sparks, MD) medium.

MSC densities were determined by using a modified double-agar-overlay method initially described by Cabelli (1988); the *E. coli* strain HS(pFamp)R (ATCC 700891) was utilized as the bacterial host strain.

Virus concentration and RNA extraction

Viral analysis for the sewage utilizes elution with an alkaline buffer followed by ultracentrifugation (Williams-Woods, et al., 2011). Concentrates were extracted for RNA with RNeasy Mini Kit (Qiagen, Valencia, CA) utilizing 6M guanidium isothiocyanate as a lysis solution. Extracted RNA and DNA was tested by real-time reverse transcription (RT)-qPCR and qPCR respectively.

For the shellfish concentration and extraction, a modified protocol was used (Williams-Woods, et al., 2011). Four to six whole oysters were shucked and the digestive diverticula were removed to obtain a 4 gram sample. An aliquot of murine norovirus was added as an extraction control prior to homogenization of the digestive diverticula with 40 ml of sterile milli-Q water. Viruses were absorbed onto the particulates and were then centrifuged at 4°C on low speed. The pellet was eluted with 0.75M glycine and 0.5 M threonine. The eluates were ultracentrifuged at 170, 000 x g for 1 hr at 4°C. The pellet was resuspended in tissue culture grade phosphate buffered saline (tcPBS) and extracted first with chloroform, and 0.5 M-threonine. Both aqueous phases were combined and 50ml of tcPBS was added to each sample, balanced, and ultracentrifuged at 1 hr at 4°C. Concentrates were extracted for RNA with RNeasy Mini Kit (Qiagen, Valencia, CA) utilizing 6M guanidium isothiocyanate as a lysis solution. Extracted RNA and DNA was tested by real-time RT-qPCR and qPCR as described below.

RT-qPCR

Positive controls used for NoV GI and GII were *in vitro* RNA transcripts of sequences cloned from positive clinical samples previously identified as NoV (Burkhardt, et al., 2006). Primers and probes for NoV GI and GII targeted the most conserved region of the open reading frame 1 (ORF1)-ORF2 junction. Real-time RT-qPCR for detection of NoV GI and NoV GII with an RNA IAC was performed in a 25-µl reaction volume by using a one-step RT-PCR kit (Qiagen). The primer concentrations for the NoV targets were 300 nM each, and the concentrations for the IAC primers (46F and 194R) were 75 nM each. The 5' nuclease probe concentrations for NoV and the IAC target were 100 and 150 nM each, respectively. The final concentration of $MgCl_2$ in the real-time RT-qPCR was 4 mM. Thermal cycling was run using the SmartCycler II system with the following conditions: 50°C for 3,000 s and 95°C for 900 s followed by 50 cycles of 95°C for 10 s, 53°C for 25 s, and 62°C for 70 s. Fluorescence was read at the end of the 62°C elongation step. Default analysis parameters were used, except that the manual threshold fluorescence units were set to 10. Samples positive with the initial primer and probe sets for NoV GI and/or NoV GII were subjected to a secondary detection assay. Amplification of the original RNA extract was performed with primers from the B region by conventional RT-PCR (see Table 1 in DePaola, et al., 2010). Amplification of a second region of the genome is non-contiguous to the first and serves as an indication that the RNA was not degraded.

Adenovirus

The positive control used for Adenovirus (AdV) was serotype 41 isolated from a clinical stool sample, propagated in-house by utilizing the A-549 cell line. Real-time PCR for the detection of AdV was performed in a 25-mL reaction volume by using Platinum TAQ DNA Polymerase (Life Technologies, Grand Island, NY) as previously described with slight modifications (Williams-Woods, et al., 2011). A DNA IAC utilizing the 46F and 194R primers and the TxRed-labeled probe as previously described was added with final primer and probe concentrations of 0.75 mM and 1.5 mM, respectively (DePaola et al., 2010). Cycle parameters were slightly adjusted as follows: 95°C for 120 s followed by 50 cycles of 95°C for 3 s, 53°C for 10 s, and 65°C for 70 s. AdV primers and probe were previously described with slight modifications to the probe (Heim, 2003) whereby probe was FAM-ZEN labeled as a fluorescent dye on the 5' end and an Iowa Black quencher dye labeled on the 3'end. Fluorescence was read at the end of the 72°C elongation step. Default analysis parameters were used except that the manual threshold fluorescence units were set to 10.

Murine norovirus

The positive control used for murine norovirus was purchased from ATCC PTA-5935 and propagated using the RAW264.7 cell line. Real-time RT-qPCR was utilized for the detection of murine norovirus (the extraction control virus) with an RNA IAC in a 25-µl reaction volume by using a one-step RT-PCR kit (Qiagen). Primers and probes were utilized as described in Hewitt, et al., 2009. Thermal cycling was run using the SmartCycler II system. Fluorescence was read at the end of the elongation step and the default analysis parameters were used except that the manual threshold fluorescence units were set to 10.

3.0 RESULTS AND DISCUSSION

3.1 Drogue Study

The orange drogues were released on the flood tide shortly before the predicted change of the tide from flood to ebb based on NOAA's Crescent City, CA tide station. However, the movement of the drogues indicated that the tide did not actually turn from flood to ebb until over an hour later than predicted. This observation assisted with the timing for the dye injection.

The drogues were tracked using RAFT-MAP and the locations of the drogues were tagged with GPS markers. The results were uploaded into ArcGIS Desktop 10.0, and the distance and travel time between the drogue clusters was ascertained. Figure 2 shows the movement and velocity of the drogues. The drogues traveled north from the Coos Bay #1 outfall site, moving 0.42 miles in 41 minutes (0.68 hours), moving at a velocity of 0.62 mph or 1.0 km/hr.

3.2 Background Readings

Background levels of fluorescent units (FUs) for the WET Labs FLRHRT-586 tracking fluorometer were measured as 82.8 FUs on average. A background level of 82.8 FUs is typical of average background levels for other estuary systems that have been evaluated with the FLRHRT-586 fluorometer. This background level was subtracted from the fluorescence readings during the dye studies.

Background levels were also assessed with the WET Labs FLRHB-2153 profiling fluorometer and for that instrument were determined to be 50.2 FUs on average. The background levels remained the same from the surface down to 10 foot depths in the water column. Background levels recorded in air were higher than those recorded in water, but this was thought to possibly be due to radio signal interference from the nearby North Bend airport.

3.3 Dye Injections

The dye injection began at the North Bend WWTP on February 7, 2012 at 1:16 AM and ended at approximately 1:40 PM. The injection was continuous for a total of 12.4 hours. The average WWTP effluent flow rate during the injection was 1.27 MGD, with a high flow of 1.75 MGD from 8:00 AM - 9:00 AM. Based on the continuous flow rate out of the dye container, 17.65 gal/day, a 1×10^8 ppb concentration factor for the Rhodamine WT dye, and an effluent flow rate of 1.27 MGD, the average dye concentration in the effluent was calculated to be 1393 ppb using a mass balance equation. The initial dye concentration of 1393 ppb was used for calculating the dilutions for the readings taken on each day of the dye study.

The dye injection began at the Coos Bay #1 WWTP on February 15, 2012 at 4:00 AM and ended at 11:33 PM. The injection was continuous for a total of 19.5 hours, but due to a crimp in the tubing that was not discovered and repaired until 12:50 PM, the bulk of the injection took place over 10.7 hours from 12:50 PM – 11:33 PM. The average WWTP effluent flow rate during this 10.7 hour injection period was 5.82 MGD with a high flow of 7.52 MGD from 1:00 PM – 2:00 PM. Based on the continuous flow rate out of the dye container, 38.80 gal/day, a 1×10^8 ppb concentration factor for the Rhodamine WT dye, and an effluent flow rate of 5.82 MGD, the average dye concentration in the effluent was calculated to be 667 ppb using a mass balance equation. The initial dye concentration of 667 ppb was used for calculating the dilutions for the readings taken on each day of the dye study.

3.4 Travel Time

Travel time of the dye on the ebb tide of the first day of the North Bend WWTP study (2/7/2012) was determined. The dye injection began at 1:16 AM on a flood tide but did not reach Station 1 until the following flood tide. Based on data obtained from the submersible fluorometers (Figures 3 – 8), the dye first reached Station 1 around 9:17 AM and first reached Station 2 around 10:12 AM (55 minutes later). Stations 1 and 2 were approximately 1.7 km apart, so the dye travel time from Station 1 to Station 2 was about 1.9 km/hr or 1.2 mph. The distance from the North Bend WWTP outfall to the nearest border of the approved growing area is 1.9 km, so it would take approximately one hour for effluent to travel from the outfall to the growing area. This is a just slightly longer than the 55 minutes it took the dye to travel from Station 1, which was close to the WWTP outfall, to Station 2, which was just south of the area border.

Travel time of the dye on the ebb tide of the first day of the Coos Bay #1 WWTP study (2/15/2012) was also determined. Based on data obtained from the submersible fluorometers (Figures 9 – 14), the dye first reached Station 6 (nearest the WWTP) around 2:24 PM and first reached Station 5 around 3:58 PM (94 minutes later). Stations 6 and 5 were approximately 2.2 km apart, so the dye travel time from Station 6 to Station 5 was about 1.4 km/hr or 0.87 mph. This compares fairly well with the travel time determined by the drogue study (1.0 km/hr), since the drogues were released in the same vicinity as the Coos Bay #1 WWTP and traveled in the same direction as the dye-tagged effluent from the plant. However, dye typically travels faster than drogues, and the more conservative value of 1.4 km/hr based on the velocity of dye movement should be used for determining the response time needed for a WWTP failure. The Coos Bay #1 WWTP outfall is 1.3 km away from the nearest border of the approved growing area, so it would take about 56 minutes for effluent to travel from the outfall to the growing area.

3.5 Dye Readings at Cage Stations

One significant advantage of the submersible fluorometers attached to the cage stations was that they could detect dye every ten minutes over the entire multi-day period of the study and could pick up dye readings during hours when boat tracking was not possible. These continuous dye readings could then be used for a steady state analysis as discussed below.

Dye readings recorded by the submersible WET Labs units at each of the station locations for the North Bend study (2/7/2011 – 2/10/2011) are shown in Figures 3 – 8 and for the Coos Bay #1 study (2/15/2011 – 2/17/2011) in Figures 9 - 14. The tidal depth in feet is also plotted, and the peaks in the Rhodamine WT dye concentration follow closely with the tidal cycles. Any readings at or below background levels, such as readings measured by the submersible WET Labs units prior to the dye injection, were removed from the graphs. Steady state conditions were estimated using the superposition method (Kilpatrick, 1993) described in the "Methods" section. Superposition dye concentrations at each station are also plotted in Figures 3 – 14.

Figure 3 shows the dye concentration levels at Station 1 over the course of the North Bend study. As expected, the peak dye concentration occurred during the low tide following the dye injection period on 2/7/2012. The 5-point moving average concentration at the peak was 3.78 ppb, which equated to a dilution of 369:1. During the North Bend study, the maximum 5-point moving average concentration detected near Station 1 via boat tracking (not including depth profiles) was 27 ppb, with a dilution of 52:1. The majority of the dye during the study was detected right near the surface of the water, whereas the cages were placed at various depths of about 10 – 30 feet deep. Therefore, Station 1 and the other cages received much lower concentrations of dye than those levels detected by boat tracking at the surface. However, unlike the boat tracking data, the build-up of dye at the stations could be assessed using the superposition method to determine steady state dilution values. The maximum dye concentrations at Station 1 for successive study days were added to ascertain the superposition concentrations, and the (half tidal day) steady state dilution was determined to be 319:1. The peak one hour steady state dilution was 1080:1, and the average steady state dilution was 2731:1.

Figures 4 – 8 show the dye concentration levels and steady state dilution values for Stations 2 – 6 over the course of the North Bend study. For Station 2, the peak one hour steady state dilution was 17415, which represents a 16-fold increase in dilution from Station 1. The peak one hour steady state dilution for Station 3 was 13930, which was actually lower than the dilution at Station 2. The maximum and average steady state dilution values were also lower at Station 3 than at Station 2. This indicates that there was some build-up of dye at Station 3, which was stationed within Haynes Inlet. Even though Station 3 was located farther away from the North Bend outfall than Station 2, it had lower levels of dilution, because dye-tagged effluent was not well flushed from the inlet.

Station 4 had higher levels of dilution than both Station 2 and Station 3, with a peak one hour steady state dilution of 10715:1. As seen in Figure 6, significant levels of dye were detected at Station 4 over a two day period from 2/7/2011 – 2/9/2011. On the other hand, Stations 5 and 6 had very high levels of dilution save for a single high peak that occurred at each station over two days after the start of the dye injection. Even with consideration of these peaks, the steady state peak one hour dilution levels at Stations 5 and 6 were 139300:1 and 1906478:1, respectively.

Figures 9 – 14 show the dye concentration levels and steady state dilution values for Stations 1 – 6 over the course of the Coos Bay #1 WWTP study, which took place a week after the North Bend WWTP study. Station 6 was actually the station closest to the Coos Bay #1 WWTP outfall, and Station 1 was the station farthest away.

As previously noted, the dye injection at the Coos Bay #1 WWTP started at 4:00 AM on 2/15/2011, but a crimp in the dye tubing impinged the free flow of dye into the final effluent and prevented dye from reaching Station 6 at significant levels. Although Station 6 was located very close to the outfall, the first peak at Station 6 was not observed until after the crimp in the tubing was resolved at 12:50 PM. Thereafter, dye reached Station 6 at significant levels, with the maximum steady state, peak one hour steady state, and average steady state dilution levels calculated as 526:1, 834:1, and 1754:1, respectively (see Figure 14).

Although Station 6 was located close to the outfall, the dye reached Station 5 at much greater levels – the peak dye concentration at Station 5 was over 300 times higher than the peak dye concentration at Station 6. For this reason, the dilution values at Station 5 were very low, with the steady state peak one hour dilution calculated to be only 74:1 (see Figure 13).

Dilution levels varied from Station 4 to Station 1. Dilution did not increase with increasing distance from the outfall in a linear fashion. As shown in Figures 12 – 9, the steady state peak one hour dilution values at Stations 4, 3, 2, and 1 were 1332:1, 933:1, 2880:1, and 807:1, respectively. Once again, there appeared to be a build-up of dye at Station 3 in Haynes Inlet, as was observed during the North Bend study. This same trend was observed via boat tracking, and it appeared that dye gathered within the inlet and was not flushed as well from the inlet as from other parts of the estuary. However, it is not clear why the dye built up at Station 1 and why dilution was lower at this station than at Stations 2, 3, and 4, which were closer to the Coos Bay #1 WWTP outfall.

During the Coos Bay #1 study, Stations 2, 3, 4, and 6 received more dye on the third day of the study, 2/17/2011, than on any of the preceding days. These findings further indicate that significant concentrations of dye-tagged effluent can remain in the Coos Bay system and build up, even after the input has stopped. It's possible that effluent from the North Bend and Coos Bay #1 WWTPs may be insufficiently flushed from the bay on the ebb tide and may return back to the bay on flood tide.

Since dilution did not increase in a linear fashion with increasing distance from the outfall during either study, a linear regression analysis to estimate the location of the 1000:1 dilution line could not be performed. However, it was possible to combine the dye concentration levels from both the North Bend and Coos Bay #1 WWTPs to determine the combined half tidal day peak one hour dilution and average dilution at each station. The maximum dilution values could also be determined, but this value was considered to be overly conservative for a comparison with the microbial data collected at each station. Figure 15 shows levels of NoV GII, and MSC in comparison to the combined dilution values from both studies at Stations 1 through 6. The NoV GII and MSC results will be discussed in more depth later in this report, but it is important to note that the highest levels of dilution were seen at Station 2, where the NoV GII levels were the lowest, whereas the lowest levels of dilution were seen at Station 5, where the NoV GII and MSC levels were the highest. These findings demonstrate that dilution is a more significant factor in regards to the impact of viruses than the distance of shellfish from the WWTP outfalls.

Figure 15 also shows that at levels of 1000:1 dilution or less at Stations 1, 3, 5, and 6, NoV GII levels were higher than 1000 RT-PCR/100g. The reason for this finding will be discussed later in the report, but this result demonstrates that the establishment of a 1000:1 dilution line for growing area classification purposes may be insufficient to mitigate the impact of viruses in Coos Bay, unless used in conjunction with other mitigation strategies.

3.6 Dye Readings by Tracking Fluorometers during the North Bend Study

While the submersible fluorometers determined the dye levels reaching the oyster cages, boat tracking was conducted with two towed fluorometers (the WET Labs FLRHRT-586 and

FLRHRT-2040) and one profiling fluorometer (WA State's WET Labs FLRHB-2153 fluorometer) to track the dye past the cages and to determine the shape and edges of the dye as it traveled through Coos Bay. Figures 16 and 17 represent the 5-point moving average concentration values and the corresponding dilution levels for the first and second day of the North Bend study (2/7/2012 and 2/8/2012). Data collected with the Trimble and the FLRHRT-586 fluorometer on one boat was combined with data collected using RAFT-MAP and the FLRHRT-2040 fluorometer on a different boat to create these figures. The raw data used to create these figures (in Excel sheets) can be provided upon request.

The WET Labs FLRHB-2153 instrument was used to conduct profiles of the dye at different depths in order to determine the vertical distribution of dye in the water column. It was observed that the dye primarily remained near the surface of the bay as it moved farther away from the WWTP diffuser, with less dye detectable at depth. This observation makes sense in that the wastewater effluent with the dye consisted of freshwater, which floated on top of the salt water. There were no other obvious freshwater inputs that could create a salt water wedge and push the dye towards the bottom of the water column. However, very close to the diffuser, which was located near the bottom of the bay, the dye levels were far higher as detected by the profiling WET Labs at depth than by the other fluorometers near the surface.

It was observed after the study that the depth data collected with the FLRHB-2153 fluorometer did not match the observations of the profiles made during the study. For example, some profiles recorded negative or very low depth readings (based on the WET Labs conversion equation for the sensor) when the profiler instrument was suspended deep in the water column or recorded high depth readings when the profiler was at the surface. There was no correlation between increasing or decreasing values recorded by the profiler and the notes/ observations made of the depth of the instrument during particular profiles. Based on the values recorded by the profiler, FDA was unable to determine the depth of the fluorometer at any given point in time. Further, there did not appear to be any relationship between increasing or decreasing dye concentration data and the pressure values recorded by the profiler. Therefore, the profiler data described in this report are based on field notes written during the study as profiles were being taken.

The highest 5-point moving average concentration of dye detected by the WET Labs FLRHB-2153 right over the WWTP diffuser on the first day of the North Bend study was 727 ppb. Since the initial concentration of dye at the WWTP was 1393 ppb, this equates to a very low dilution factor of 1.92:1. At least 40 dye readings in the area were over 450 ppb as determined with the profile data. However, the tracking WET Labs FLRHRT-2040 fluorometer used near the surface only detected a maximum dye concentration of 27 ppb. This indicates that the diffuser might not have diluted the dye significantly but that dilution did increase significantly as the dye traveled up from the bottom to the surface of the bay.

As can be seen in Figure 17, dye concentrations in the range of 1.0 – 5.0 ppb were detected as far away from the North Bend diffuser as Station 6 on the second day of the study. Comparing Figure 16 with Figure 17, it can be seen that the dye traveled farther and at higher levels to Station 3, 4, 5, and 6 on February 8th than on February 7th.

Figure 18 shows the locations of <=1000:1 dilution based on boat tracking data for both days. Because the initial concentration of dye at the North Bend WWTP outfall was 1393 ppb, a dye concentration in the bay of 1.393 ppb would represent a 1000:1 dilution of the North Bend WWTP's effluent. Dye concentrations in the bay greater than 1.393 ppb represent levels of dilution less than 1000:1. This observation is important when viewing the boat tracking data and assessing instantaneous dilution, but it does not factor in the steady state dilution analysis or build-up of dye over time that was discussed earlier. In fact, the submersible fluorometers attached to the stations showed that some were still receiving dye on 2/10/2012 – three days after the dye injection – and that two of the stations (Stations 5 and 6) received more dye in the days after the injection than on the day of the injection.

3.7 Dye Readings by Tracking Fluorometers during the Coos Bay #1 Study

Figures 19 and 20 represent the 5-point moving average concentration values and the corresponding dilution levels for each day of boat tracking for the Coos Bay #1 study (2/15/2011 and 2/16/2011). The raw data used to create these figures (in Excel sheets) can be provided upon request. The GIS data shown in Figures 19 and 20 was taken solely from the RAFT-MAP program.

As can be seen in Figure 19, dye concentrations were in the range of 1.0 – 50.0 ppb between Stations 6 and 5, but decreased below 1.0 ppb around Stations 2 to 4. The concentrated dye plume tended to stay close to the shoreline. Dye was not tracked around Stations 1 and 3 on this day, but was detected at these stations on the second day of the study as discussed below.

Figure 20 shows the RAFT-MAP data gathered on the second day of the Coos Bay #1 study, 2/16/2011. As shown on the map, dye levels in the range of 0.50 – 1.0 ppb were detected from Station 6 up to Station 4. Lower levels of dye, in the range of 0.10 – 0.50 ppb, were detected at the stations farther from the Coos Bay #1 outfall – Stations 3, 2, and 1, but dye levels of 0.50 – 1.0 ppb were also detected north and south of Station 3 within Haynes Inlet. Since the initial concentration of dye at the outfall was 667 ppb, a dye concentration of 0.667 ppb in the estuary would equate to a 1000:1 dilution. Even on the second day of the study, 84.5% of the dye levels recorded throughout the estuary were > 0.8 ppb, including dye levels detected near Station 1. The lowest dye level recorded in RAFT-MAP on 2/16/2011 was 0.32 ppb. The dye levels detected in RAFT-MAP using the boat tracking fluorometers compared well with the dye levels detected by the submersible fluorometers attached to the cage stations, e.g. dye levels recorded by both the boat tracking fluorometers and submersible fluorometers were in the range of 0.1 – 1.0 ppb at all the stations. Overall though, dye levels tended to be higher at the surface, where all dye concentration readings were greater than 0.32 ppb, than at the bottom of Coos Bay, where many dye readings were less than 0.32 ppb.

Figure 21 shows the locations of ≤1000:1 dilution based on boat tracking data for both days. Because the initial concentration of dye at the Coos Bay #1 WWTP outfall was 667 ppb, a dye concentration in the bay of 0.667 ppb would represent a 1000:1 dilution of the Coos Bay #1 WWTP's effluent. Dye concentrations in the bay greater than 0.667 ppb represent levels of dilution less than 1000:1. As seen in Figure 21, ≤1000:1 dilution levels were seen from Station 6 all the way to Station 2 and a little past that station.

3.8 Overall Boat Tracking Results for Both WWTP Studies

Figure 22 shows the boat tracking results for both the North Bend WWTP study and the Coos Bay #1 WWTP study combined. This map demonstrates that significant levels of dye-tagged effluent from one or both WWTPs reached all six stations and other parts of the bay, such as locations east of Stations 4, 5, and 6. The dye mostly concentrated along the shoreline, but also reached Station 3 at high levels (1.0 – 5.0 ppb) and accumulated in Haynes Inlet.

This map only shows dye readings taken at a single point in time at the surface level at each GPS location (or in some cases 2 or 3 points in time if the same location was traversed by the boat more than once). It does not represent a continuous stream of data from a stationary location like the data recorded by the submersible fluorometers. It's important to note that the dye-tagged effluent from both WWTPs would have a cumulative effect on the locations in between the plants. This map does not show the effect of adding effluent levels from the North Bend WWTP to effluent levels from the Coos Bay #1 WWTP, but the map does show the *minimum* level of dye-tagged effluent that could be expected to reach each station and location in Coos Bay by simultaneously displaying the boat tracking data for both studies.

Figure 23 shows the ≤1000:1 dilution estimates based on both studies' boat tracking data in relation to the conditionally approved growing area in between the WWTPs. As can be seen in the figure, levels of ≤1000:1 occur near all the shellfish stations and throughout much of the growing area. It's also important to reiterate that the ≤1000:1 dilution estimates shown in Figure 23 (and in Figures 18 and 21) and determined using daily boat tracking data do not represent the steady state dilution condition. In other words, this data does not show the build-up of dye that occurs over time, typically two to three days, before the steady state condition is reached, whereby the rate of effluent entering Coos Bay from one of the WWTPs is being flushed out of the bay by tides at the same rate, so that no further build-up of effluent occurs. This principle was demonstrated by the analysis of the station fluorometer data using the superposition method. The maps with the boat tracking data show where locations of ≤1000:1 are known to occur, but there could be even more locations within the bay where ≤1000:1 dilution occurs if the build-up of effluent from both WWTPs and the steady state condition are factored.

3.9 RAFT-MAP Beta Test

Having the ability to both map the GPS-tagged dye results electronically and perform calculations for concentration and dilution in real-time using RAFT-MAP proved to be a valuable asset. For the North Bend WWTP study, Figures 16 to 18 show data collected using RAFT-MAP. This data can be directly compared to data collected the past way of using Trimble units and post-processing the results. During the North Bend study, the Trimble was attached to a different fluorometer operating on a different boat that did not traverse the same locations at the same times as the boat operating with RAFT-MAP, but the RAFT-MAP results compare very well to the Trimble results. Whereas it took months to create the GIS maps with the Trimble results, the RAFT-MAP results were obtained in real-time out on the boat. Then post-processing with ArcGIS Desktop could be conducted back at the office.

One immediate benefit from the use of RAFT-MAP was that FDA and ODA noticed on the map that Station 1 was originally positioned outside the most concentrated portion (centerline) of the dye plume during the North Bend WWTP study. Because of this observation using the RAFT-MAP system, Station 1 was picked up and moved to a better position directly within the dye plume's centerline. This ensured that the station would detect the highest levels of dye in the area and that oysters in the cage would have the highest exposure to the dye-tagged effluent.

Figure 22 shows the RAFT-MAP results from a geodatabase for the entire Coos Bay project, including both the North Bend and Coos Bay #1 WWTP studies, over the entire time span that boat tracking data was collected. Data for each individual day of the study is located in ArcGIS "layers" within the collective map. When viewing the ArcGIS .mxd file for this project, each layer can be turned on and off to see how the dye-tagged effluent behaved on a particular day or how it behaved for the entire length of the study.

While the RAFT-MAP program performed very well during the beta test in Coos Bay, there were a few features that were noted for improvement. The program shut down a few times in the middle of data collection. This was thought to be due to a memory cache issue, since it tended to happen towards the end of the day after a lot of data had been collected. However, data collected prior to the shut downs was not lost. A related issue was that each track file took longer and longer to save towards the end of a day of data collection. These issues were partly resolved by saving data in multiple projects within RAFT-MAP, rather than trying to save all the data from Coos Bay in a single project. There were also other issues related to exporting files, re-loading calibrations, labeling markers, and error messages. Due to the calibration issue, many data readings had to be post-processed and corrected in ArcGIS Desktop after the study. All of the observations made during the beta test were discussed with ESRI, Inc. to improve the RAFT-MAP system. Once further improvements are made, FDA plans to distribute RAFT-MAP at no cost to state shellfish control authorities who are interested in using this new technology.

3.10 Wastewater Treatment Plant Flows and Performance During the Studies

The studies were conducted in February 2011 during a time of high flows and cold temperatures, which are conditions conducive to viruses. For the North Bend WWTP, the average flow during the 12.4 hour dye injection period on 2/7/2012 was 1.27 MGD based on flow data provided by the plant. The maximum flow rate during the dye injection period was 1.75 MGD. The North Bend WWTP performed within its design capacity during the study and did not experience any bypasses, loss of disinfection, or other interruptions.

The average daily wet flow for the North Bend WWTP is 2.5 MGD, with a peak hourly flow up to 8.5 MGD – close to the hydraulic capacity of 8.3 MGD – and a design flow of 2.0 MGD. Since flows of 2.5 – 8.5 MGD can be expected at the North Bend WWTP in the winter months, such flows would be 2.0 – 6.7 times higher than the average recorded during the dye study. This would result in lower dilutions of effluent, approximately 2.0 – 6.7 times lower, than those previously discussed in this report using the study data.

For the Coos Bay #1 WWTP, the average flow during the dye injection period on 2/15/2012 (after the problem with the tubing was fixed) was 5.8 MGD based on flow data provided by the plant. The maximum flow rate during that period was 7.52 MGD. It should be noted that earlier in the day, prior to detection of the tubing problem, a WWTP flow level as high as 11.61 MGD was recorded.

The average daily wet flow for the Coos Bay #1 WWTP is 3.2 MGD, with a peak daily flow up to 10.0 MGD and a peak wet weather flow up to 15.0 MGD (values obtained from document "City of Coos Bay Facilities Plan for Wastewater Treatment Plant No. 1", May 2008). The average daily wet flow is lower than the average flow calculated for the dye injection period (5.8 MGD). In fact, a significant rainstorm event occurred during the dye injection period for the Coos Bay #1 study and this event not only resulted in higher flows at the WWTP, but it also caused a bypass of primary treatment to occur. The higher flows and the bypass of treatment resulted in the detection of high levels of enteric viruses and MSC in the effluent, as discussed more below. This is believed to be the reason that even stations that experienced greater than 1000:1 dilution during the studies, as determined based on the steady state combined dilutions, still had shellfish sentinels test high for levels of viruses and indicator microorganisms.

3.11 Shoreline Survey Assessment

The results of the shoreline survey did not indicate any major contributing source of pollution to the growing area other than the WWTPs. Most of the samples collected had low levels of FC, EC, and MSC. Two of the samples, collected in the same location, had MSC levels above the limit of detection. This area was re-sampled, but the results were not replicated. The samples were collected near large homes with run-off. Soap bubbles were seen in the run-off, which are consistent with laundry detergents or other household items often present in gray water. The homes were far from the location of the growing area and the run-off flows were very small. This source was not deemed to have any significant impact on the growing area. ODA indicated that it would follow up with the home-owners about the run-off issue. Thus, the shoreline survey results indicate that the most dominant and significant source of MSC comes from the WWTPs.

3.12 Microbiological Analysis of WWTP Influent and Effluent

Tables 1 – 4 show the FC, EC, MSC, NoV GI and GII, and AdV results for the North Bend and Coos Bay WWTPs' influent and final effluent for both study periods.

Table 1 - North Bend WWTP Influent Data

Date	Time	GI RT-PCR units/100 ml	GII RT-PCR units/100 ml	Adenovirus units/100 ml	MSC/100 ml	EC/100 ml	FC/100 ml
2/6/2011	1:00 to 6:00	<17	14,400	1,270	76,800	1,500,000	2,000,000
2/6/2011	13:00 to 18:00	<17	71,860	7,380	1,176,000	1,500,000	1,500,000
2/7/2011	1:00 to 6:00	24	47,330	1,120	212,000	600,000	600,000
2/7/2011	13:00 to 18:00	80	6,910	1,540	306,000	660,000	695,000
2/8/2011	1:00 to 6:00	<17	6.570	4,680	346,000	785,000	845,000
2/8/2011	13:00 to 18:00	<17	13,000	15,590	280,000	745,000	750,000

ND- Not Determined

Table 2 - North Bend WWTP Effluent Data

Date	Time	GI RT-PCR units/100 ml	GII RT-PCR units/100 ml	Adenovirus units/100 ml	MSC/100 ml	EC/100 ml	FC/100 ml
2/6/2011	1:00 to 6:00	<17	1,970	1,560	3,840	7.0	8.5
2/6/2011	13:00 to 18:00	ND	ND	ND	ND	<0.5	<0.5
2/7/2011	1:00 to 6:00	<17	3,260	530	ND	<0.5	<0.5
2/7/2011	13:00 to 18:00	<17	1,890	63	12,200	12.0	17.0
2/8/2011	1:00 to 6:00	<17	2,500	470	4,000	2.5	3.0
2/8/2011	13:00 to 18:00	<17	<10	1,680	2,000	<0.5	<0.5

ND- Not Determined

Table 3 - Coos Bay #1 WWTP Influent Data

Date	Time	GI RT-PCR units/100 ml	GII RT-PCR units/100 ml	Adenovirus units/100 ml	MSC/100 ml	EC/100 ml	FC/100 ml
2/10/2011	1:00 to 6:00	<17	5,580	4,580	92,000	925,000	955,000
2/11/2011	1:00 to 6:00	<17	3,310	2,731	154,000	850,000	865,000
2/11/2011	13:00 to 18:00	<17	780	6,260	128,000	1,185,000	1,190,000
2/12/2011	1:00 to 6:00	<17	13,610	5,600	108,000	105,000	115,000
2/12/2011	13:00 to 18:00	<17	77,000	25,900	128,000	ND	ND
2/13/2011	1:00 to 6:00	<17	840	990	136,000	1,600,000	1,700,000
2/13/2011	13:00 to 18:00	<17	2,007	890	76,000	2,400,000	2,800,000
2/15/2011	7:28 (grab)	ND	ND	ND	25,400	300,000	360,000
2/15/2011	12:08 (grab)	ND	ND	ND	62,000	1,500,000	1,650,000

ND- Not Determined

Table 4 - Coos Bay #1 WWTP Effluent Data

Date	Time	GI RT-PCR units/100 ml	GII RT-PCR units/100 ml	Adenovirus units/100 ml	MSC/100 ml	EC/100 ml	FC/100 ml
2/10/2011	1:00 to 6:00	<17	2,810	720	8,600	<0.5	<0.5
2/11/2011	1:00 to 6:00	<17	1,140	2,360	12,400	1.50	1.50
2/11/2011	13:00 to 18:00	<17	130	560	8,000	0.50	0.50
2/12/2011	1:00 to 6:00	<17	82	430	9,200	<0.5	<0.5
2/12/2011	13:00 to 18:00	<17	600	460	10,400	ND	ND
2/13/2011	1:00 to 6:00	<17	<17	<10	12,800	1.50	2.50
2/13/2011	13:00 to 18:00	<17	<17	146	17,200	1.50	1.50
2/15/2011	7:28 (grab)	ND	ND	ND	4,400	<0.5	<0.5
2/15/2011	12:08 (grab)	ND	ND	ND	2,200	3.50	3.50

ND- Not Determined

FC and EC levels in the final effluent were low, in accordance with the WWTPs' discharge permits, but average MSC levels in the final effluent ranged from 2,000 to 12,200 MSC/100 ml for the North Bend WWTP and from 2,200 to 17,200 MSC/100 ml for the Coos Bay #1 WWTP. NoV GI was not detected in the final effluent of either plant during the studies.

NoV GII levels detected in the North Bend WWTP influent ranged from 6,570 to 71,860 RT-PCR units/100 ml. In one case, NoV GII levels were reduced to <10 RT-PCR units/100 ml in the final effluent after treatment by the WWTP. However, in most cases virus levels detected in the WWTP final effluent remained high – ranging from 1,890 to 3260 NoV GII RT-PCR units/100 ml.

For the Coos Bay #1 WWTP influent, levels of NoV GII in the influent ranged from 780 to 77,000 RT-PCR units/100 ml. In two cases, NoV GII levels were reduced to <17 RT-PCR units/100 ml in the final effluent, but as with the North Bend WWTP, the majority of final effluent samples tested had detectable levels of viruses, ranging from 82 to 2810 NoV GII RT-PCR units/100 ml.

Adenovirus was found in all North Bend influent samples and ranged from 1,120 to 15,590 units/100ml. The effluent samples ranged from 63 to 1,680 units/100ml. As with the North Bend WWTP, the Coos Bay # 1 WWTP had AdV positive results for all influent samples, with AdV values ranging from 890 to 25,900 unit/100ml. The effluent had one sample below the detection limit of <10 units /100ml and the rest ranged from 146 to 2,360 units/100ml. The AdV removal through treatment seemed consistent with the other virus analyzed.

A 1000:1 dilution of the WWTPs' outputs in the bay would reduce the highest NoV GII levels detected in the North Bend and Coos Bay #1 final effluent down to 3.3 and 2.8 NoV GII RT-PCR units/100 ml, respectively. However, the ability of shellfish to bioaccumulate viruses up to 100-fold (Seraichekas et al., 1968; Maalouf et al., 2011) should be considered in determining whether a 1000:1 dilution is sufficient, particularly since the viral impacts from both WWTPs on the approved growing area is cumulative. The elevated levels of NoV GII in the shellfish indicate that the combined impact from both WWTPs and bioaccumulation play a critical role.

3.13 Microbiological Analysis of Oysters at Cage Stations

Figure 15 shows the FC, EC, MSC, NoV GII, NoV GII, and AdV results from the oyster sentinels at the station locations.

These stations are located within the approved area

Some overall trends seen in Figure 15 are: FC, EC, and NoV GI levels were generally low and did not appear to be directly correlated to the distance from the WWTP outfall, the level of dilution, or the NoV GII results; the stations positioned in between the two WWTP outfalls but closer to the Coos Bay #1 outfall (Stations 5, 4, and 3) had the highest NoV GII results; and MSC levels increased and decreased in a similar manner to NoV GII levels. MSC and NoV GII results were also related to dilution levels, as shown in Figure 15 and previously discussed.

For the North Bend WWTP study, Station 1 was closest to the diffuser and Station 6 was farthest away. Dye concentrations were highest near Station 1, up to 27 ppb, and were still detected at significant levels (1.0 – 5.0 ppb) near the other stations (see Figures 17 and 18). For comparison with the microbiological findings, levels of MSC and NoV GII at Station 1 were high (1630 NoV GII RT-PCR units/100g), but decreased at Station 2 (1080 NoV GII RT-PCR units/100g). The level of NoV GII (but not MSC) increased at Station 3 and Station 4, but this finding may also be due to the influence of the Coos Bay #1 WWTP on these stations. Based on the microbiological results in Figure 15, it appears that Stations 3 and 4 were more impacted by NoV GII from the Coos Bay #1 WWTP than from the North Bend WWTP. However, dye detected by the submersible fluorometers at these stations during the North Bend study (2/7/2011 – 2/10/2011) indicates that effluent from the North Bend WWTP reached Stations 3, 4, and 5 at levels up to 0.4 ppb, 0.12 ppb, and 0.4 ppb, respectively. Therefore, the NoV GII levels in the shellfish are partly representative of inputs from the North Bend WWTP, even though the Coos Bay #1 WWTP appeared to have a larger impact on the results. The viral impacts from the effluent from both WWTPs on all six stations were cumulative.

For the Coos Bay #1 WWTP study, Station 6 was closest in proximity to the WWTP outfall and Station 1 was farthest away. Interestingly, as shown in Figure 15, Station 6 had lower levels of NoV GII than Stations 5, 4, and 3 and lower levels of MSC than Stations 5 and 4, even though it was positioned closer to the WWTP outfall. Dilution was lower at Station 5 than at Station 6, so this could explain why NoV GII levels were higher at Station 5, i.e. Station 6 was closer to the outfall but was not as well positioned within the concentrated dye plume. However, it does not explain why virus levels were higher at Stations 3 and 4 than at Station 6, since those stations had higher dilution levels. One possible explanation for the observations about Station 6 is that the station was positioned so closely to the Coos Bay #1 WWTP outfall that the freshwater effluent may have adversely affected the pumping ability of the oyster sentinels at that station and hindered the uptake of NoV GII and MSC. During the North Bend WWTP study, Station 6 has normal salinity levels relative to the other stations (~18 – 24 ppt). However, after the major rainfall event that occurred during the Coos Bay #1 study, the salinity levels at Station 6 dropped below 8 ppt on 2/15 and 2/16 (see Figure 14). The salinity levels at the other stations also dropped during the second study, but Station 1 was the only other station that experienced a salinity level less than 8 ppt for a brief period on 2/16 (see Figure 9). All the other stations maintained salinities greater than 10 ppt throughout both studies. Station 6 was so close to the Coos Bay #1 WWTP outfall that the shellfish were likely impacted by the freshwater influent.

NoV GII levels in shellfish at Stations 5, 4, 3, 2 decreased in a stepwise fashion as the stations moved farther away from the Coos Bay #1 WWTP outfall. MSC levels increased from Station 3 to Station 2, which can most likely be attributed to the contribution of MSC from the North Bend WWTP. However, NoV GII levels were lower and dilution levels were higher at Station 2 than at Station 3. Therefore, we are unable to determine which WWTP had the biggest impact on Station 2.

Adenovirus was detected at Station 6 (395 adenovirus PCR units/100 g) and at Station 5 (498 adenovirus PCR units/100 g), but was not detected at the other four stations farther away from the outfall. Adenovirus was only present in oyster sentinels near the Coos Bay #1 outfall, and not in sentinels near the North Bend diffuser.

In summary, the Coos Bay #1 WWTP appeared to have a greater viral impact on Stations 6, 5, 4, and 3, whereas the North Bend WWTP appeared to have a greater viral impact on Station 1 and possibly Station 2. Nevertheless, based on dye tracking results recorded in RAFT-MAP and results from the submersible fluorometers, all six stations were impacted by effluent from both WWTPs. The cumulative estimated dilution values from both WWTPs are shown in Figure 15, along with the microbiological findings at each of the oyster sentinel stations. NoV GII levels ranged from 1080 GII RT-PCR units/100 g (at Station 2) to 4730 RT-PCR units/100 g (at Station 5). These levels are very high and should be considered in conjunction with the dye study results.

3.14 Short Term Failure Scenario – Dilution and Anticipated Fecal Coliform Concentrations in Surface Water

A short-term raw sewage failure at either the North Bend WWTP or the Coos Bay #1 WWTP could result in deteriorated water quality in a single ebb tide. Dilution is physical and is computed by dividing the dye concentration added to the WWTP effluent by the dye concentrations found at locations in the estuary. The initial concentration at the North Bend WWTP was 1393 ppb and at the Coos Bay #1 WWTP was 667 ppb. Once dilution is calculated in this manner, the FC counts detected in the influent can be divided by the dilution level achieved at a certain location within Coos Bay to estimate the FC counts that would occur at that location in the event of a raw sewage failure. For example, we can estimate the anticipated fecal coliform concentrations at the 1.5, 1.0, and 0.5 ppb contours in Coos Bay in the event of a short-term raw sewage failure. The FC counts in the pre-chlorinated effluent can also be divided by the dilution levels to determine what would happen in the event of a loss of disinfection failure.

Tables 5 and 6. The following tables provide the dilution values for 0.5, 1.0, and 1.5 ppb concentrations in the estuary and the anticipated fecal coliform (FC) concentrations if a short term failure should occur at the North Bend WWTP or the Coos Bay #1 WWTP (single ebb tide and assuming no decay). When influent data for a WWTP is unavailable, a typical literature based value of 1.4×10^6 FC MPN/100 ml can be used to represent the anticipated fecal coliform count for untreated wastewater in the event of a worst-case, total failure scenario. However, actual influent data for the North Bend and Coos Bay #1 WWTPs is presented in Figures 22 and 23 and was used in the analysis. Average FC levels in the influent at the North Bend and Coos Bay #1 WWTPs were 1.1×10^6 and 1.2×10^6 FC MPN/100 ml, respectively. FDA testing also found FC levels as high as 2.0×10^6 FC MPN/100 ml in the North Bend WWTP influent and 2.8×10^6 FC MPN/100 ml in the Coos Bay #1 WWTP (twice the literature value).

Table 5: Dilution and Theoretical Fecal Coliform Concentrations for a Raw Sewage Failure at the North Bend WWTP

Dye Contour (ppb)	Dilution with Respect to FC with no decay	Estimated Conc. in Bay (FC/100 ml) With 1.1×10^6 FC/100 ml (average level in influent)	Estimated Conc. in Bay (FC/100 ml) With 2.0×10^6 FC/100 ml (max level in influent)
1.5	929:1	987	1794
1.0	1393:1	658	1196
0.5	2786:1	329	598
0.1	13930:1	66	120
0.01	139300:1	7	12

Table 6: Dilution and Theoretical Fecal Coliform Concentrations for a Raw Sewage Failure at the Coos Bay #1 WWTP

Dye Contour (ppb)	Dilution with Respect to FC with no decay	Estimated Conc. in Bay (FC/100 ml) With 1.2×10^6 FC/100 ml (average level in influent)	Estimated Conc. in Bay (FC/100 ml) With 2.8×10^6 FC/100 ml (max level in influent)
1.5	445:1	2247	5243
1.0	667:1	1498	3496
0.5	1334:1	749	1748
0.1	6670:1	150	350
0.01	66700:1	15	35

Since typical literature values for FC counts in raw sewage are around 1.4×10^6 FC MPN/100 ml, FDA has often recommended that a 100,000:1 dilution needs to be achieved for a raw sewage failure prior to the sewage reaching the boundary of an approved growing area, since the goal is to achieve 14 FC MPN/100 ml within the approved area. Any growing areas within the 100,000:1 dilution zone should be prohibited, restricted, or conditionally managed based on the WWTP operation.

As shown in Tables 1 and 2 above, dilution levels close to 100,000:1 would be needed to reduce FC counts to acceptable levels in the event of a raw sewage failure at either WWTP. The limit of detection of the tracking fluorometers in the Coos Bay estuary was around 0.03 ppb. Since 0.01 ppb is below the limit of detection, approved areas should not be established anywhere that dye was detectable during the first ebb tide of the study. Dye was detectable in every location that boat tracking was conducted with RAFT-MAP and at every station location in both WWTP studies. The dye tracking results are shown in Figures 16 – 23 and the station fluorometer data results are shown in Figures 3 – 14. Based on these figures, there is no location in Coos Bay where an approved growing area could be established, since significant levels of dye were detected throughout the bay.

3.15 Determination of 1000:1 Dilution

Under Scenario 2 for sizing prohibited areas (see Section 1.2), the size of the prohibited zone can be reduced and a conditional area can be established if a 1000:1 dilution zone is achieved and other conditions are met.

The 1000:1 dilution line changes throughout the course of the tidal excursion, so the steady state condition of the estuary should be assessed to estimate where the 1000:1 dilution line will be when the rate of effluent entering the system from the WWTP outfall is the same as the rate of effluent being pushed out be the tides. To do this, we need to rely on the data collected from the submersible fluorometers attached to the station cages, since this data was being recorded on a continuous basis throughout the study. The superposition concentrations and steady state dilutions were calculated from the submersible data as described in Section 2.4. These results should then be compared with dilution assessments based on the boat tracking data to determine which dilution levels are the lowest at the station locations.

As seen in Figure 4, the peak 1 hour steady state dilution at Station 1 was 1080:1. If only the submersible fluorometer data is considered, the 1000:1 dilution line for the North Bend WWTP should occur right near this location, which is about 0.14 km from the outfall. Dilution at the bottom of the bay increased rapidly past Station 1, as the peak 1 hour steady state dilution at Station 2 was 17415:1. This station was 1.9 km from the outfall. However, the dilution assessment based on the boat tracking data (Figure 18) shows that dilution levels ≤1000:1 occurred as far away as Stations 5 and 6 during the North Bend study. This is because dye concentrations were higher at the surface than at the cages down below. Although the steady state dilutions at the surface are unknown, it is known that they would be less than 1000:1 at these locations. Typically steady state dilutions at the bottom of an estuary are lower than single time point dilutions determined at the surface since they accumulate the dye readings over time, but in this case the single time point dilutions calculated based on the surface readings were lower. FDA recommends considering the lowest dilution values seen at a particular location during a dye study as part of a conservative assessment, since wastewater at the surface could potentially reach the shellfish down below on low tide, in strong currents, or in other conditions.

For the Coos Bay #1 study, the peak 1 hour steady state dilution values at Stations 1 – 6 were 807:1, 2880:1, 933:1, 1332:1, 74:1, and 834:1. Although dilution increased above 1000:1 at Stations 2 and 4, dilution was less than 1000:1 at Stations 1 and 6 which were within the prohibitive near the WWTP outfalls and at Station 5 which was located along the edge of the prohibitive conditionally approved area in the Coos Bay. Station 3 which was located within the conditionally approved area also showed dilutions slightly less than 1000:1. Station 1 was the farthest from the Coos Bay #1 WWTP but still had dilution levels less than 1000:1. Since this station is also impacted by effluent from the North Bend WWTP, the cumulative dilution would be even lower than 807:1. As seen in Figure 21, dilution levels based on boat tracking data were similarly low, with ≤1000:1 dilution levels observed from Station 6 to Station 2 within the channel along the western shoreline.

Figure 15 shows steady state dilution values based on the combined impact of effluent from both WWTPs. As shown in the figure, the peak 1 hour steady state dilution values (or "1/2 tidal day peak 1 hour dilution" values) were less than 1000:1 at every station except for Stations 2 and 4. The dilution level at Station 4 was slightly above 1000:1. Because the combined dilution levels fluctuated between the stations, it's not possible to create a regression line to estimate where the 1000:1 line may occur beyond Station 1 or Station 6. It's also not possible to factor in the impact of the Coos Bay #2 WWTP (shown in Figure 1), since a dye study was not conducted at this plant. However, the studies that were conducted at the North Bend WWTP and the Coos Bay #1 WWTP show that the dilution levels achieved in the growing area between the two plants were insufficient to mitigate the impact of viruses during the time of the study during which a bypass occurred at the Coos Bay #1 WWTP. In addition to the low peak 1 hour dilution values seen in Figure 15, the figure also shows that NoV GII levels in oyster sentinels from all six stations were greater than 1000 RT-PCR units/100 g. It should be noted that the shellfish were harvest during a period in which the conditional area was closed due to rainfall. However, shellfish were harvest on the day prior to re-opening and it is questionable whether there would be sufficient time to purge these high levels of enteric viruses to an acceptable level of risk (e.g. MSC below 50 PFU/100 g) in less than 24 hours during which the area re-opened. The high level of viruses occurring in the shellfish less than 24 hours prior to opening suggests that additional length of closure time is needed to address the high risk of enteric viruses posed by partially treated effluent during bypass events.

3.16 Bypass in Treatment at the Coos Bay #1 WWTP

Due to a large rainfall event, the Coos Bay #1 WWTP bypassed primary treatment during a portion of the study and this likely had a large impact on the NoV GII levels detected in the shellfish. However, NoV GII levels in the WWTP effluent were high prior to the bypass – 2810 RT-PCR units/100 ml on 2/10/2011 and 1140 RT-PCR units/100 ml on 2/11/2011 (see Figure 23). The large rainfall event and the bypass in primary treatment did not occur until several days later, on 2/15/2011, when the dye injection took place. Nevertheless, the oyster sentinels were still in the water during the time of the rainfall event and may have bioaccumulated virus particles that were higher in level due to the bypass in primary treatment. FDA research has found that MSC and NoV levels increase when treatment is bypassed, and in some circumstances may be higher when flows are higher than the WWTP's design capacity, or when other interruptions in treatment occur. Therefore, FDA recommends that the growing area be closed, at a minimum, during bypass events or when interruptions in full treatment occur including "split flow" events. During split flow events, in order to avoid becoming hydraulically overloaded, the waste stream entering the WWTP may receive primary treatment and bypass secondary treatment but then combined in the disinfection step. Although a disinfection step may occur during split flow events, human enteric viruses such as Norovirus and Hepatitis A are more resistant to disinfection and partial treatment further reduces the effectiveness of disinfection. Therefore any bypasses of primary or secondary treatment, to include any split flow or flow blending events as well as exceedances of design flow for sustained periods, should be considered a significant event. In addition to rainfall, these situations should be addressed in the Conditional Area Management Plan in addition established for Coos Bay.

4.0 CONCLUSIONS

Shellfish growing area considerations and recommendations are discussed in Section 5.0 below. This section discusses some general conclusions can be drawn from this study.

As previously noted, the results of the dye studies indicate that there is sufficient dilution in the southern-most conditionally approved growing area, located at the entrance of Coos Bay, with respect to effluent discharges from the North Bend and the Coos Bay #1 WWTPs. However, the Coos Bay #2 WWTP located closest to this area was not assessed due to limitations in time and resources. Although the two dye study results indicate that the rate of tidal flushing and dilution significantly increases closer to the mouth of the estuary, the level of effluent dilution in this growing area from the Coos Bay #2 WWTP is unknown. Therefore, the Coos Bay #2 WWTP may need to be assessed via a separate dye study or computer modeling assessment if ODA requires additional information for the conditional management of this growing area.

The combination of fluorometers towed by boat and moored to cages provided for a complete and extensive determination of the dispersion and dilution of effluent discharge from both the North Bend WWTP and the Coos Bay #1 WWTP into Coos Bay. In addition, new mobile GIS technology, the Real-Time Application for Tracking and Mapping (RAFT-MAP), was beta tested during this study for the first time and successfully provided dye concentration and dilution results in real-time while the data was being collected.

Significant flow data and influent and effluent microbial data was collected at the North Bend and Coos Bay #1 WWTPs during the dye studies. This data can be used to assess the WWTPs' efficiency and to contribute to FDA's research on WWTP performance. The data demonstrates the presence of NoV GII, AdV, and MSC at significant levels in the WWTPs' final effluent, both for the North Bend WWTP operating under normal conditions and for the Coos Bay #1 WWTP operating under a bypass of primary treatment. The MSC results followed the same patterns as the NoV GII results, demonstrating that MSC was a good NoV GII indicator for this study. FC, EC, NoV GI, and AdV did not follow the same patterns as NoV GII and MSC. The same observations applied to the microbiological findings in the shellfish sentinels as in the final effluent.

NoV and MSC data collected from the shellfish sentinels demonstrate that viruses in the WWTPs' effluents can be detected in shellfish located in proximity to the plants, with a trend of higher levels of viruses at sentinel stations with low dilution and lower levels of viruses at stations with high dilution. The microbiological results in the WWTP effluents and in the shellfish support the relationship between dilution and mitigation of viruses.

5.0 SHELLFISH GROWING AREA CONSIDERATIONS AND RECOMMENDATIONS

When considered collectively, the data from the hydrographic dye studies at the North Bend WWTP and the Coos Bay #1 WWTP and the microbiological assessments of WWTP effluent and shellfish supports the following conclusions and recommendations:

- Both WWTPs are very efficient at removing FC and EC bacteria but less efficient at removing MSC, AdV, and NoV GII.
- Steady state dilution values (peak 1 hour) within the vicinity of the Stations were less than 1000:1 in most circumstances. It should be noted that Stations 1 and 6 were located within the prohibited areas. Stations 2,4, and 5 were located on the edges of the prohibited area and conditional area extending along the western shoreline. Within this channel the most concentrated dye tagged effluent levels were recorded with the boat tracking collecting a significant amount of data with dilutions levels of <1000:1 within approximately ½ mile of the shoreline. Thus, based on the Station data and the Boat tracking data it is suggested that the prohibited area along this section be widen to ½ mile to account for most concentrated dye path.
- Station 3 received higher levels of dye and had a lower combined peak 1 hour steady state dilution than Stations 2 and 4. Dye levels were observed to increase near Station 3 during boat tracking as well. Dye-tagged effluent accumulated at this location, which was within Haynes Inlet. Although the peak 1 hour steady state dilution and tracking values were less than a 1000:1 they were relatively close to 1000:1 (approximately 900:1 range).

- MSC and NoV levels in the oyster sentinels were high – presumably the largest impact to sentinels was caused by primary bypass event that occurred at the Coos Bay #1 WWTP.
- FDA recommends closing the growing area when this type of bypass occurs, since it can result in an increase in viruses similar to a raw sewage of loss of disinfection failure. Any bypasses of primary or secondary treatment, should include any split flow or flow blending events as well as exceedances of design flow for sustained periods, should be considered a significant event.
- Dye-tagged effluent remained detectable in the growing areas for at least 3 days in both studies and a "build-up" of effluent was observed at some stations.
- Estimated travel time of the effluent from the North Bend WWTP was 1.9 km/hour and from the Coos Bay #1 WWTP was 1.4 km/hour. For both WWTPs, it would take approximately one hour for raw or untreated sewage from a failure to travel to the nearest border of the growing area. In the event of a failure, or bypass/split flow event, the current growing area would need to be closed within an hour. This may pose to be a considerable challenge. Although, other strategies could be explored with lease owners regarding notification and certification of any product before released to market.
- Over 100,000:1 dilution would be needed to dilute raw sewage from a failure at either WWTP down to acceptable levels for an approved growing area adjacent to the WWTP prohibited zone. FDA was unable to identify any locations within Coos Bay where this level of dilution would be achieved.
- Levels of 1000:1 dilution primarily occurred within the narrow channel that extends along the western channel of Coos Bay. As previously indicated, it is recommended that the prohibited zone within this section is expanded approximately ½ mile from shoreline to include dilutions <1000:1. Although, sporadic dilutions of <1000:1 occurred throughout the growing area during the Coos Bay #1 study it is recognized that these occurred during higher WWTP flow rates (more than double the average daily wet flow) corresponding to the bypass event when rainfall reached a level that the area closed. Under lower WWTP flows the level of dilution in the growing area would have more available water for dilution likely resulting in an increase in dilution when the WWTP is operating normally during dry weather and under average flows. Although it may be possible in theory to operate Coos Bay as a conditional area based on the dye study results alone (assuming that provisions can be made to adequately address the short time of travel/response time and close the area during any failure, bypass/split flow event) the microbiological results suggests that further shellfish collection and MSC analysis (during the open status) may help to validate if the area is of acceptable sanitary quality (including viruses) when in the open status. Currently not a requirement under the NSSP it has been recognized that Male-Specific Coliphage (MSC) is a useful indicator of enteric viral risk posed from WWTP effluents (ISSC Male Specific Coliphage Meeting Report, 2014).

Based on these findings, FDA recommends that either Coos Bay be re-classified to conditionally restricted, with conditional management based on the WWTPs' performance, or as conditionally approved with the following conditions as recommended in FDA FY-2014 and 2015 PEER:

- Each time the Coos Bay #1 or North Bend Wastewater Treatment Plant (WWTP) goes into bypass, the entire Conditional growing area, encompassing the area east of station 2 and north of station 6, shall immediately close for 21days. If another bypass event occurs during the 21 day closure, then the growing area will be closed for 21days from that event.

- The growing area may be re-opened sooner through sample collection, where the analytical sample results shall not exceed background levels or a level of 50 male-specific coliphage (MSC) per 100 grams from shellfish samples collected no sooner than 7 days after contamination has ceased and from representative locations in each growing area potentially impacted.
- Increased communication between ODA and the WWTP operators in the event of a bypass. According to the study, the time of travel to the growing area is approximately one hour. Prompt notification to ODA in the event of a bypass will allow for prompt closure of the growing area.

Based on the findings of this study it is recommended that ODA reevaluate the 1000:1 and 100,000:1 WWTP dilution zones for these areas, as well as collect bypass information from WWTP operators. WWTPs should report any bypasses of primary or secondary treatment, to include any split flow or flow blending events as well as exceedances of design flow for sustained periods. If Conditionally Approved areas are determined to be within the affected area of the 100,000:1 recommended dilution zone, then those areas should be closed during bypass events. Procedures for timely notification of WWTP upsets need to be sufficient to ensure those areas can be placed in a closed status prior to the pollution reaching the harvest area.

Additional guidance on classification of growing areas affected by WWTPs is described in ISSC Proposal 13-118 *Dilution Guidance for Prohibited Zones Associated with Wastewater Discharges*, as well as proposal 15-102 *Using Male-Specific Coliphage as a Tool to Refine Determinations of the Size of the Areas to be Classified as Prohibited Adjacent to Each Outfall.*

6.0 REFERENCES

American Public Health Association. 1970. Recommended procedures for the examination of seawater and shellfish, 4th ed. APHA. Washington, D.C.

Burkhardt, W. III, J.W. Woods, J. Nordstrom, and G. Hartman. 2006. A real-Time RT-PCR protocol for the simultaneous detection of norovirus and enteroviruses. U.S. Food and Drug Administration. Laboratory Information Bulletin #4369.

Cabelli, V.J. 1988. Microbial indicator levels in shellfish, water, and sediments from the upper Narragansett Bay conditional shellfish-growing area. Report to the Narragansett Bay Project, Providence, RI.

DePaola, A., J.L. Jones, J. Woods, W. Burkhardt III, K.R. Calci, J.A. Krantz, J.C. Bowers, K. Kasturi, R.H. Byars, E. Jacobs, D. Williams-Hill, & K. Nabe. 2010. Bacterial and Viral Pathogens in Live Oysters: 2007 United States Market Survey. Appl. Environ. Microbiol. 76(9):2754-2768.

Goblick, G.N. and J. M. Anbarchian, J. Woods, W. Burkhardt III, and K. Calci. (2011) Evaluating the Dilution of Wastewater Treatment Plant Effluent and Viral Impacts on Shellfish Growing Areas in Mobile Bay, Alabama, *Journal of Shellfish Research*, 30(3): 1–9.

Heim, A., C. Ebnet, G. Harste, P. Pring-Akerblom. 2003. Rapid and quantitative detection of human adenovirus DNA by real-time PCR. J. of Med. Virol. 70(2):228-239.

Hewitt, J., M. Rivera-Aban, G.E. Greening. 2009. Evaluation of murine norovirus as a surrogate for human norovirus and hepatitis A virus in heat inactivation studies. J. of Appl. Microbiol. 107(1):65-71.
Interstate Shellfish Sanitation Conference (ISSC) Male-Specific Coliphage Meeting Report, Charlotte, NC, August 18-19, 2014

Kilpatrick, F.A. 1993. Techniques of Water-Resources Investigations of the United States Geological Survey: Simulation of Soluble Waste Transport and Buildup in Surface Waters using Tracers. United States Geological Survey, Chapter A20, Book 3, Application of Hydraulics, Report Number: TWRI3A20.

Maalouf, F., J. Schaeffer, S. Parnaudeau, J. Le Pendu, R. Atmar, S.E. Crawford & F.S. Le Guyader. 2011. Strain-dependent Norovirus bioaccumulation in oysters. Applied and Environmental Microbiology 77(10): 3189.

Seraichekas, H. R., D. A. Brashear, J. A. Barnick, P. F. Carey & O. C. Liu. 1968. Viral deputation by assaying individual shellfish. Appl. Microbiol. 16:1865-1871.

U.S. Food and Drug Administration. 1998. Bacteriological Analytical Manual, 8th edition, Revision A.

Williams-Woods, J., N. Gonzalez-Escalona, W. Burkhardt III. 2011. J. of Virological Methods. 178(1-2):253-257.

Figure 1: Station Locations, WWTP Outfalls, and Classified Growing Areas in Coos Bay

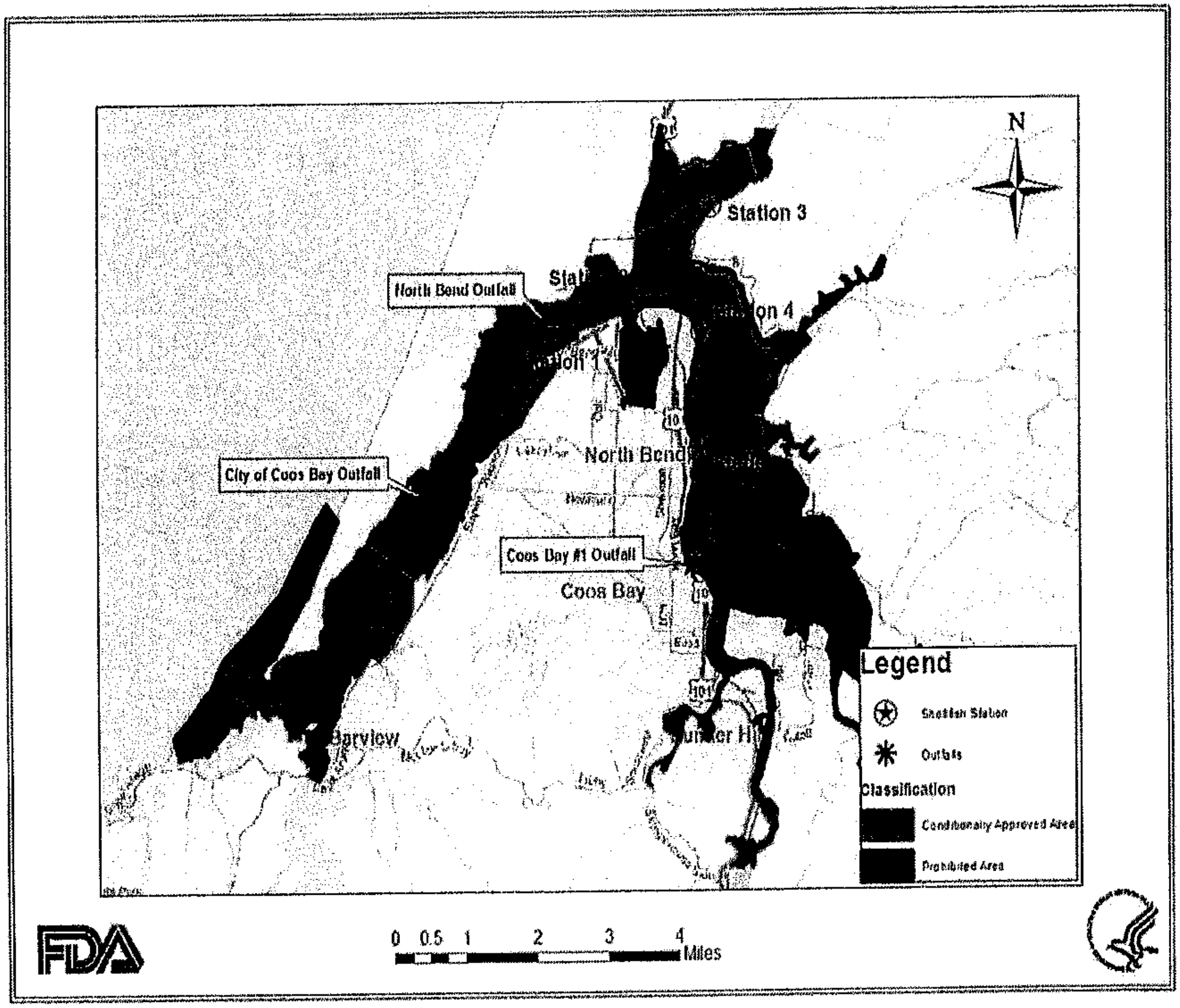


Figure 2: Drogue Study Results

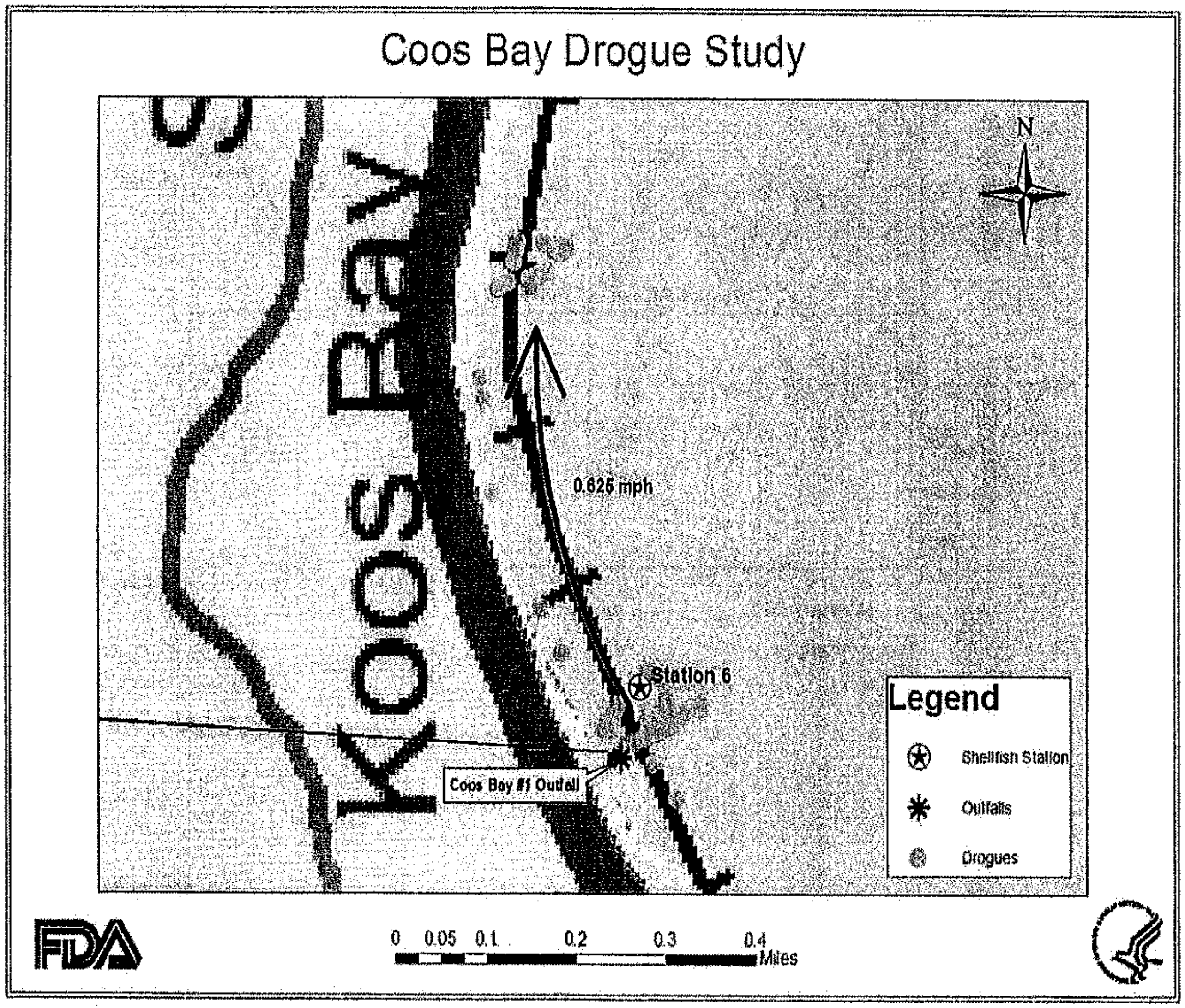


Figure 3: North Bend WWTP Study – Station 1 WET Labs Data

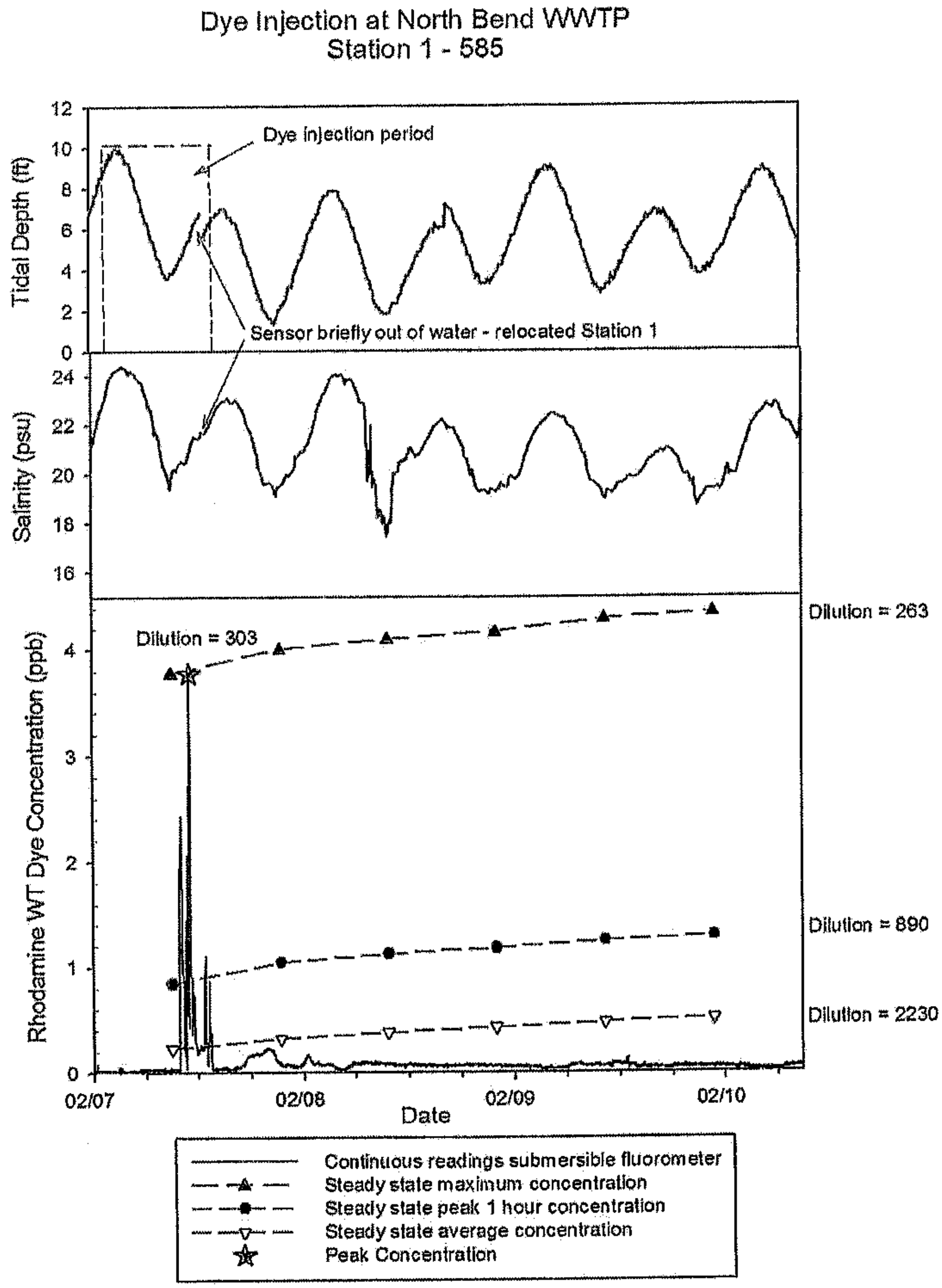


Figure 4: North Bend WWTP Study – Station 2 WET Labs Data

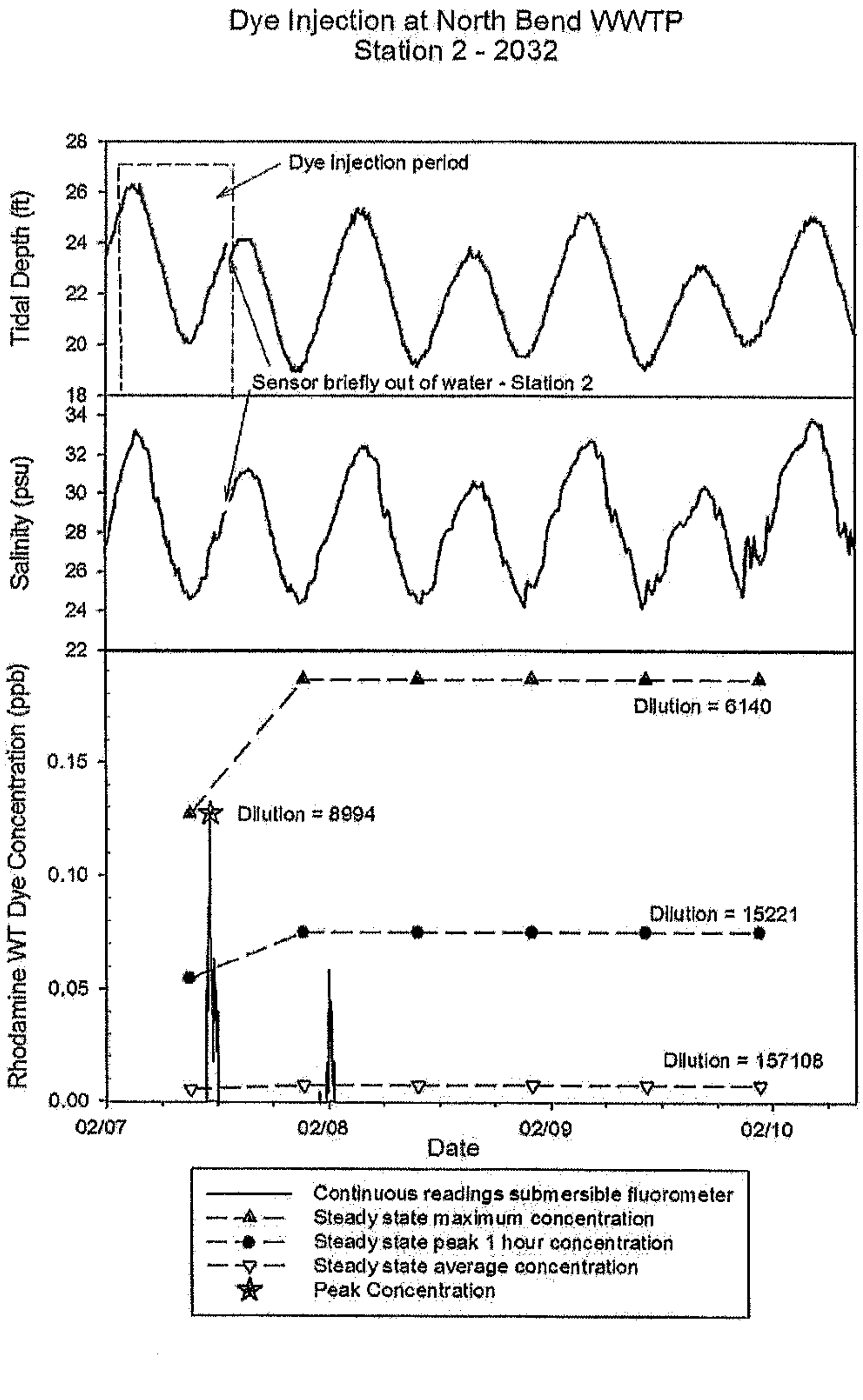


Figure 5: North Bend WWTP Study – Station 3 WET Labs Data

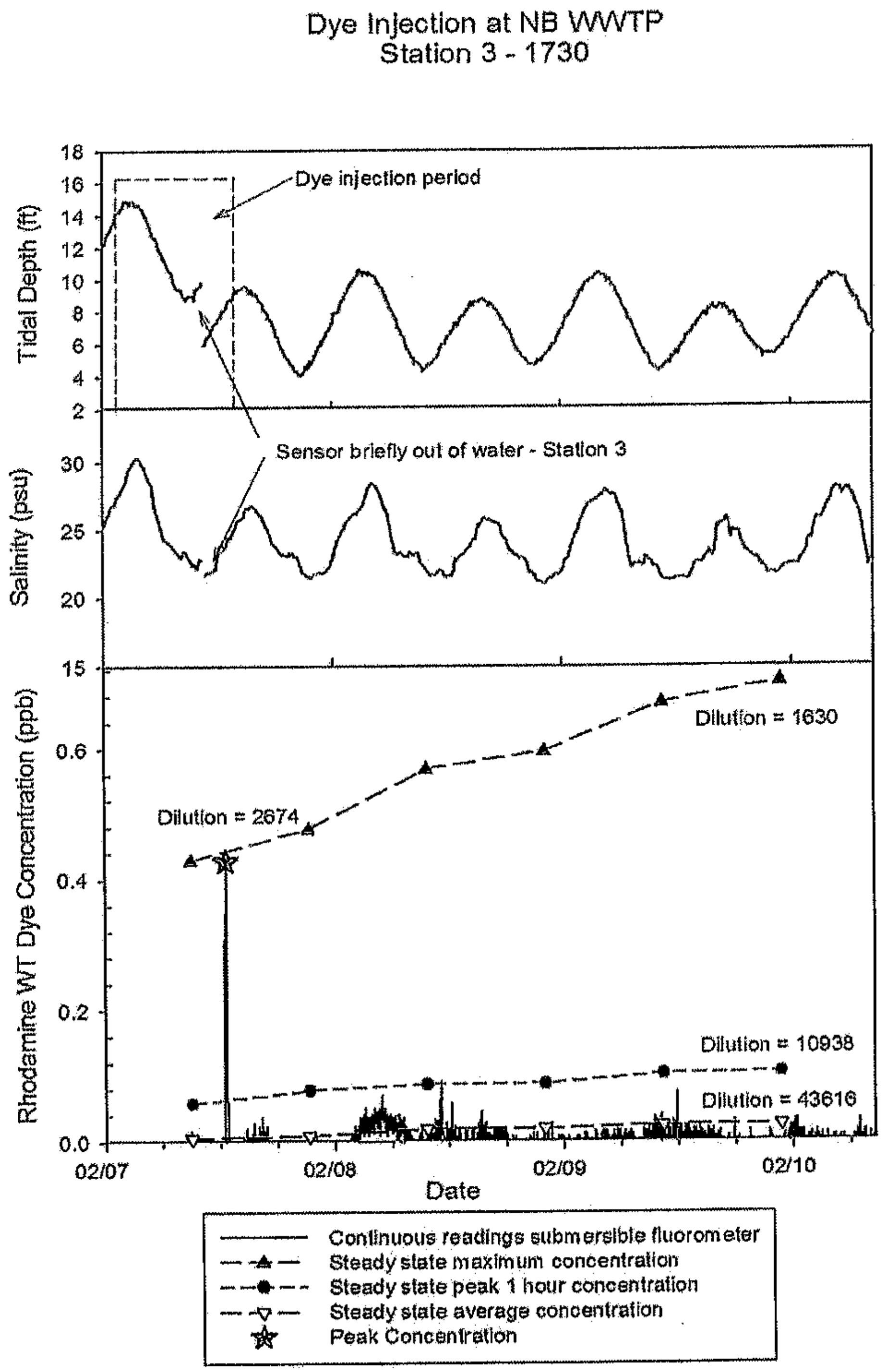


Figure 6: North Bend WWTP Study – Station 4 WET Labs Data

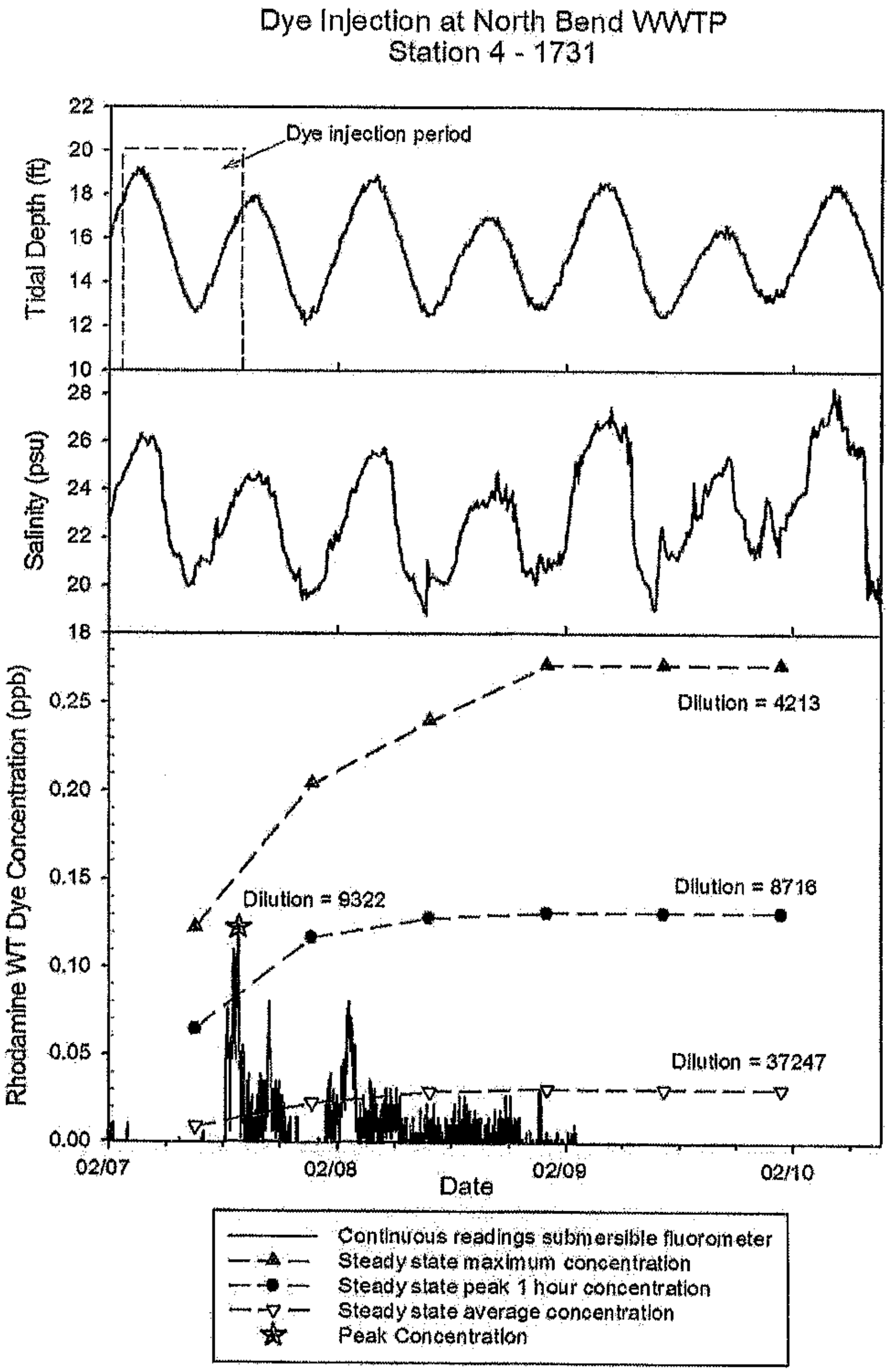


Figure 7: North Bend WWTP Study – Station 5 WET Labs Data

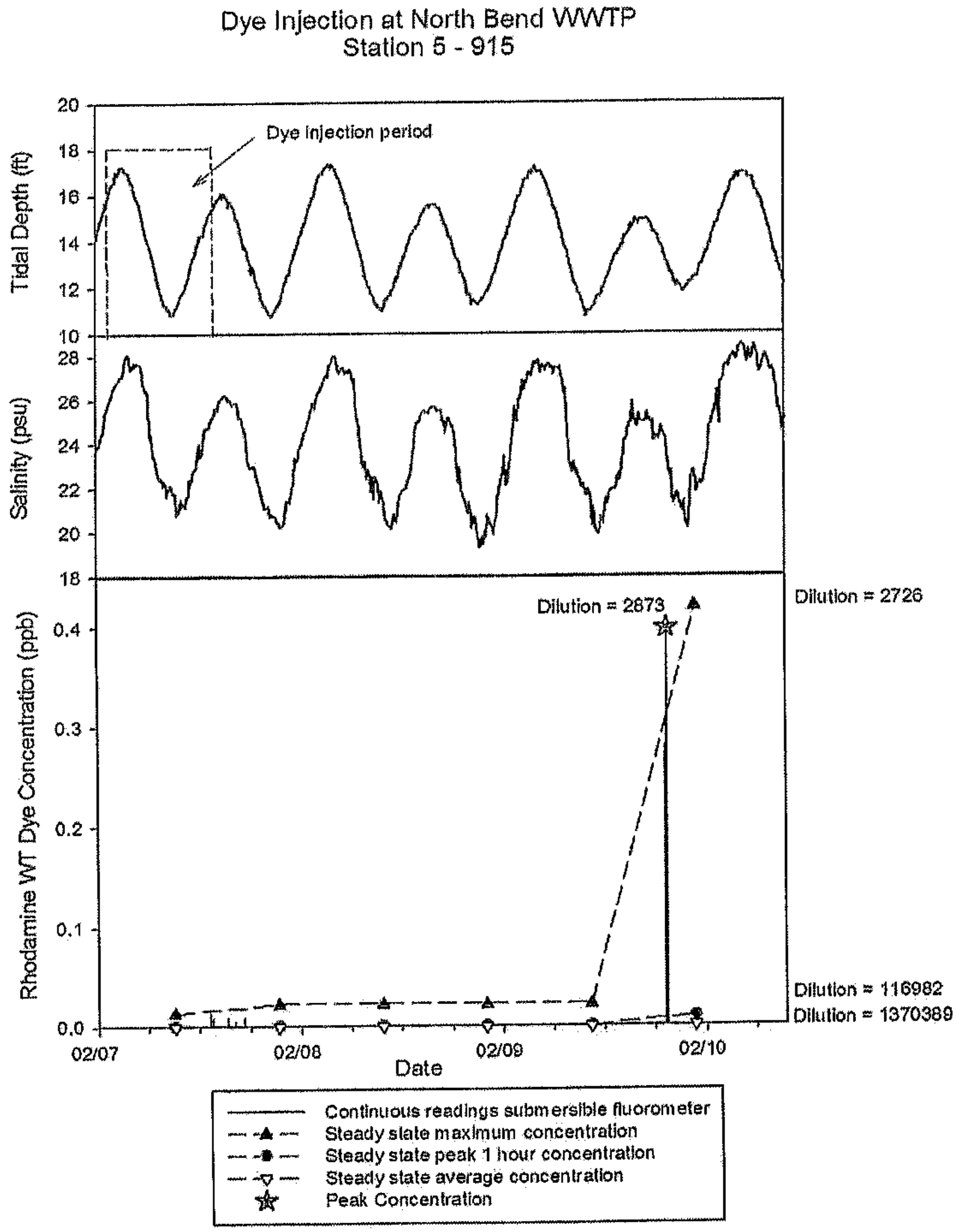


Figure 8: North Bend WWTP Study – Station 6 WET Labs Data

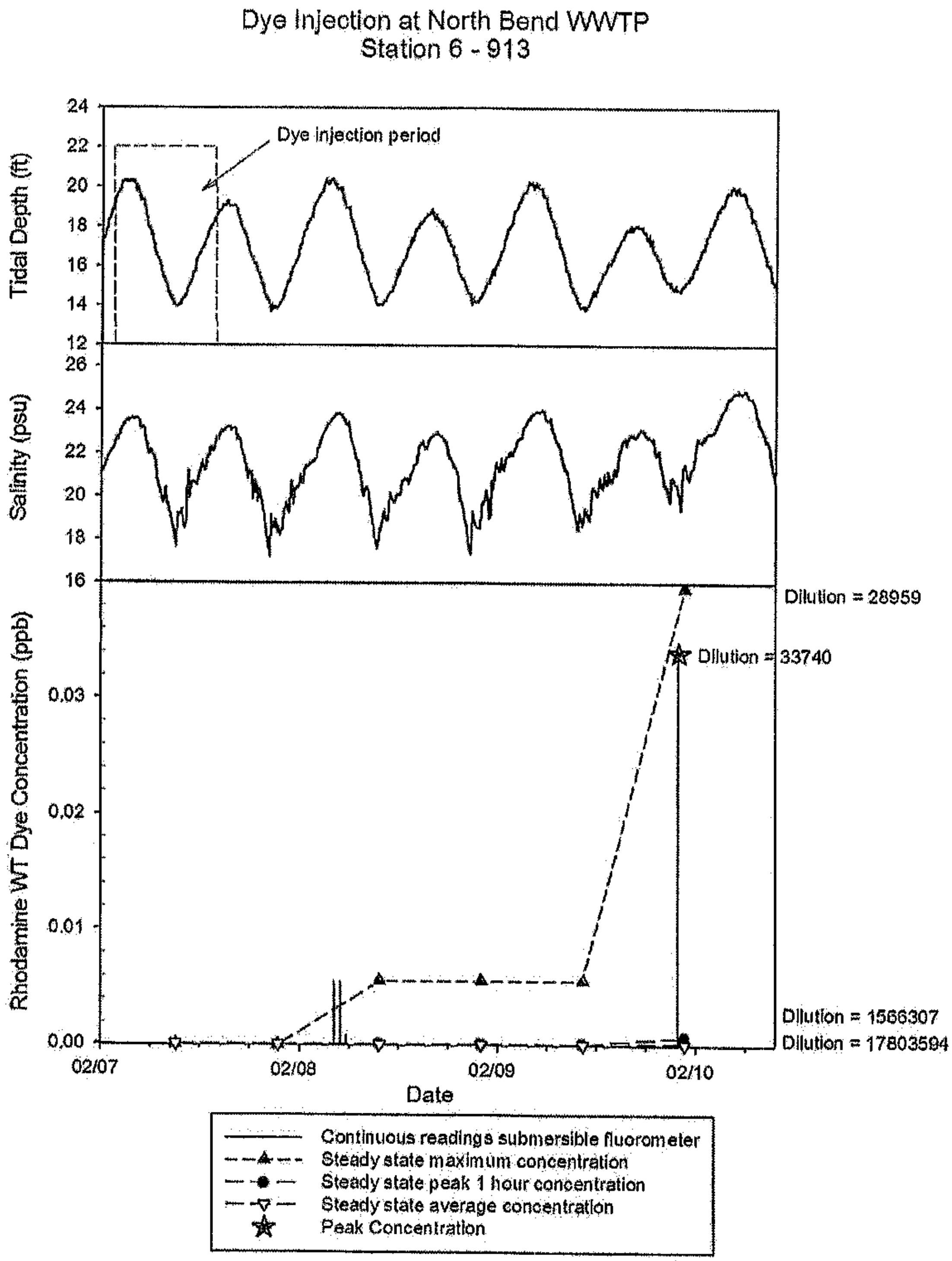


Figure 9: Coos Bay #1 WWTP Study – Station 1 WET Labs Data

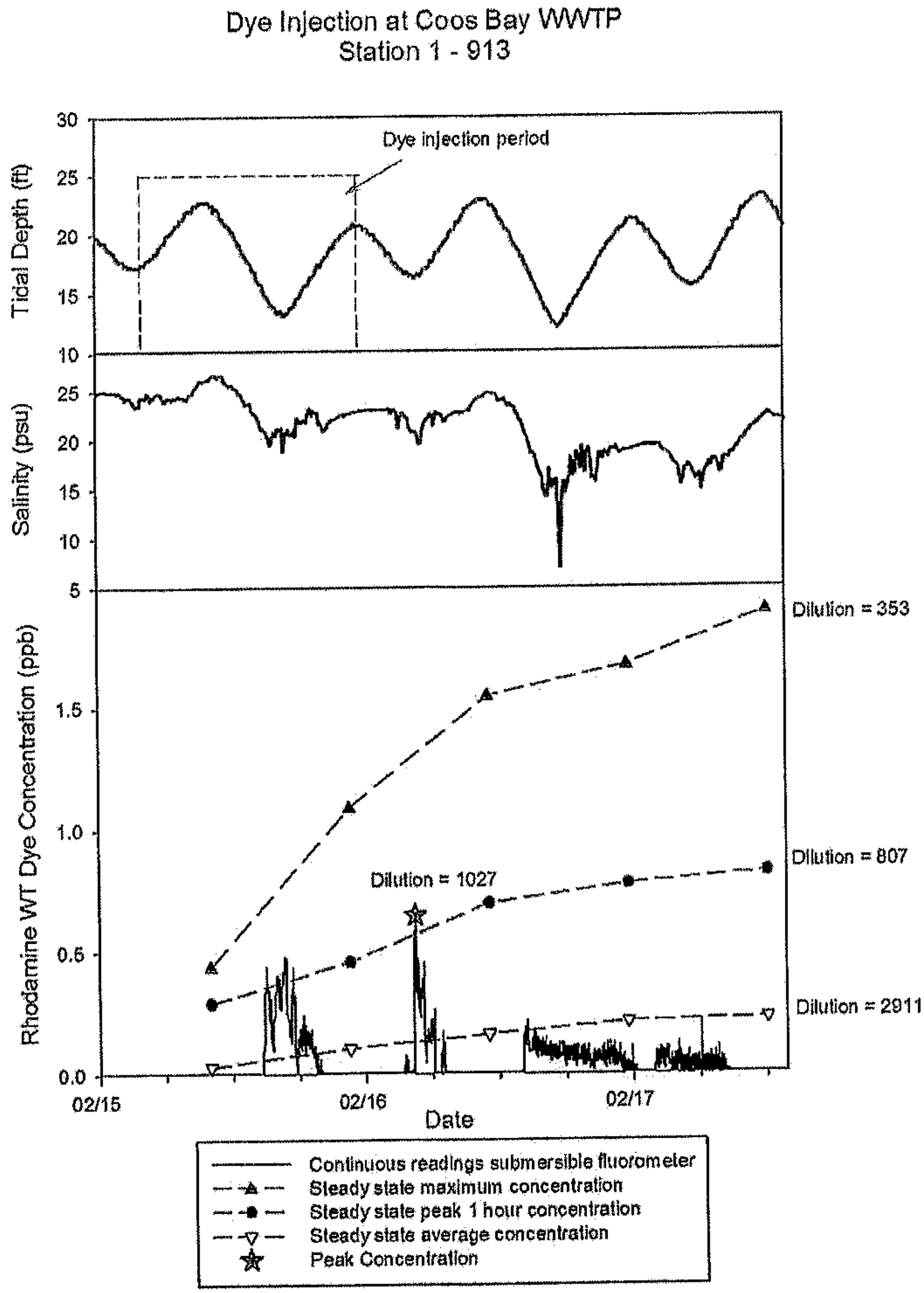


Figure 10: Coos Bay #1 WWTP Study – Station 2 WET Labs Data

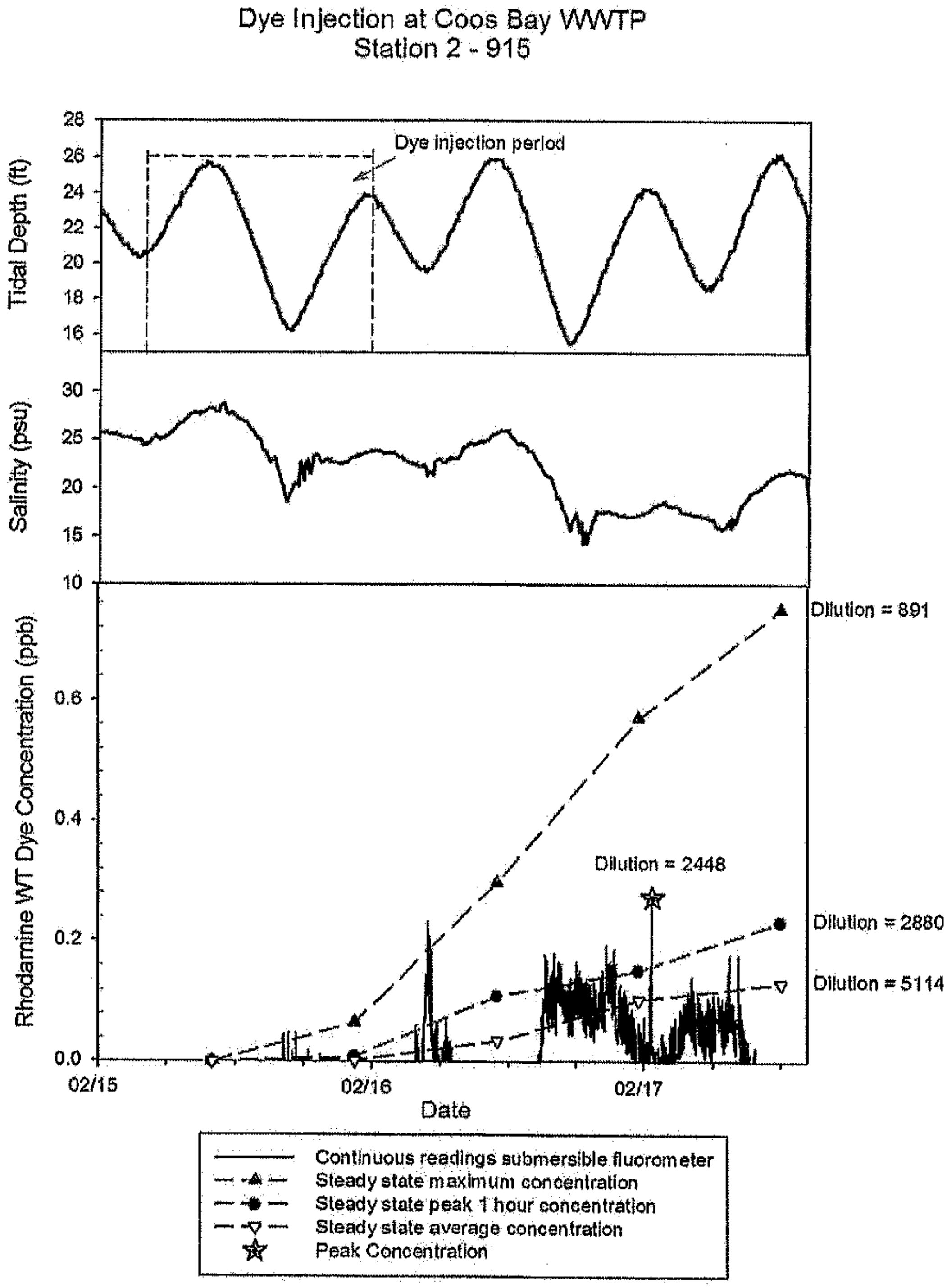


Figure 11: Coos Bay #1 WWTP Study – Station 3 WET Labs Data

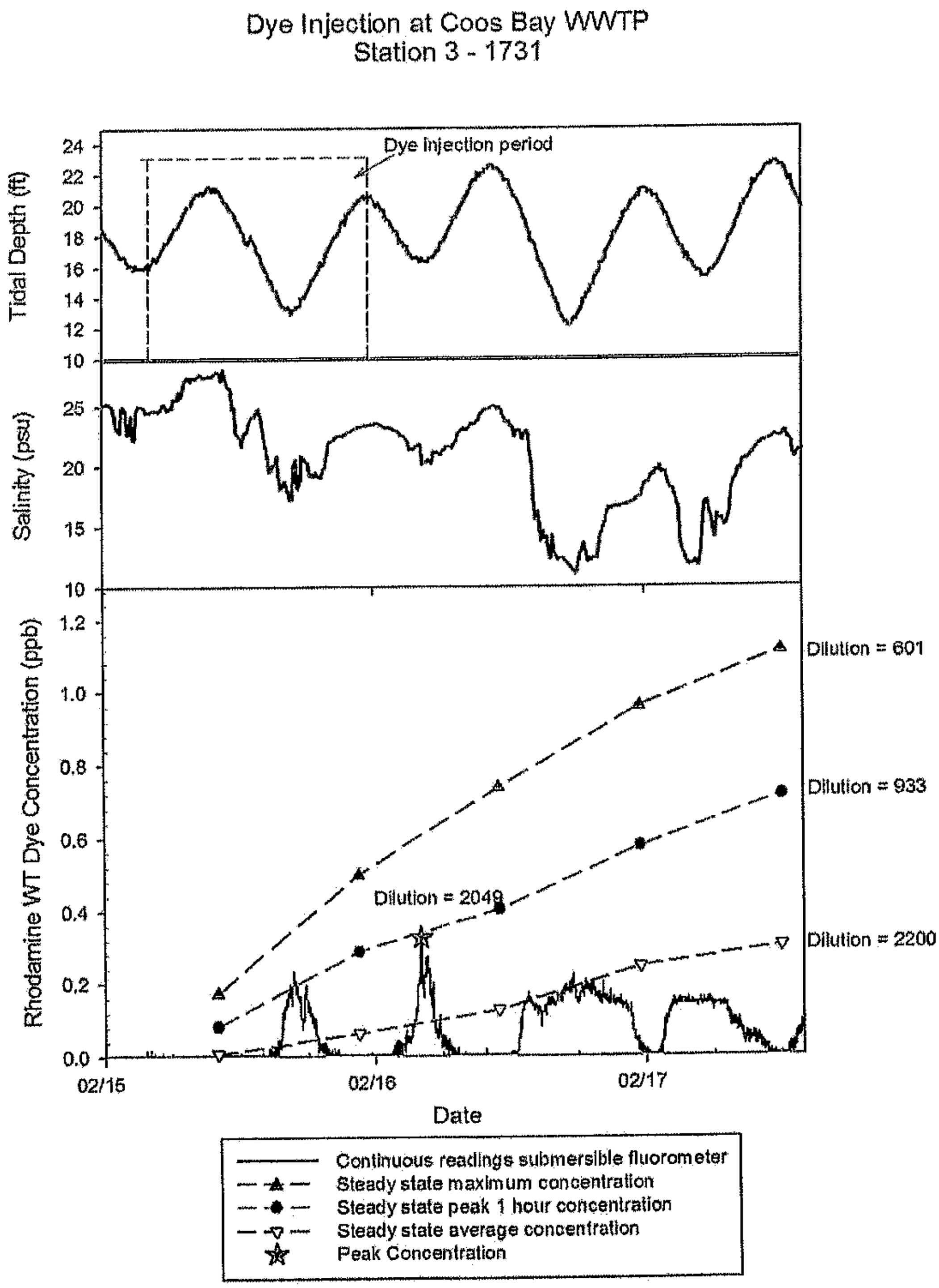


Figure 12: Coos Bay #1 WWTP Study – Station 4 WET Labs Data

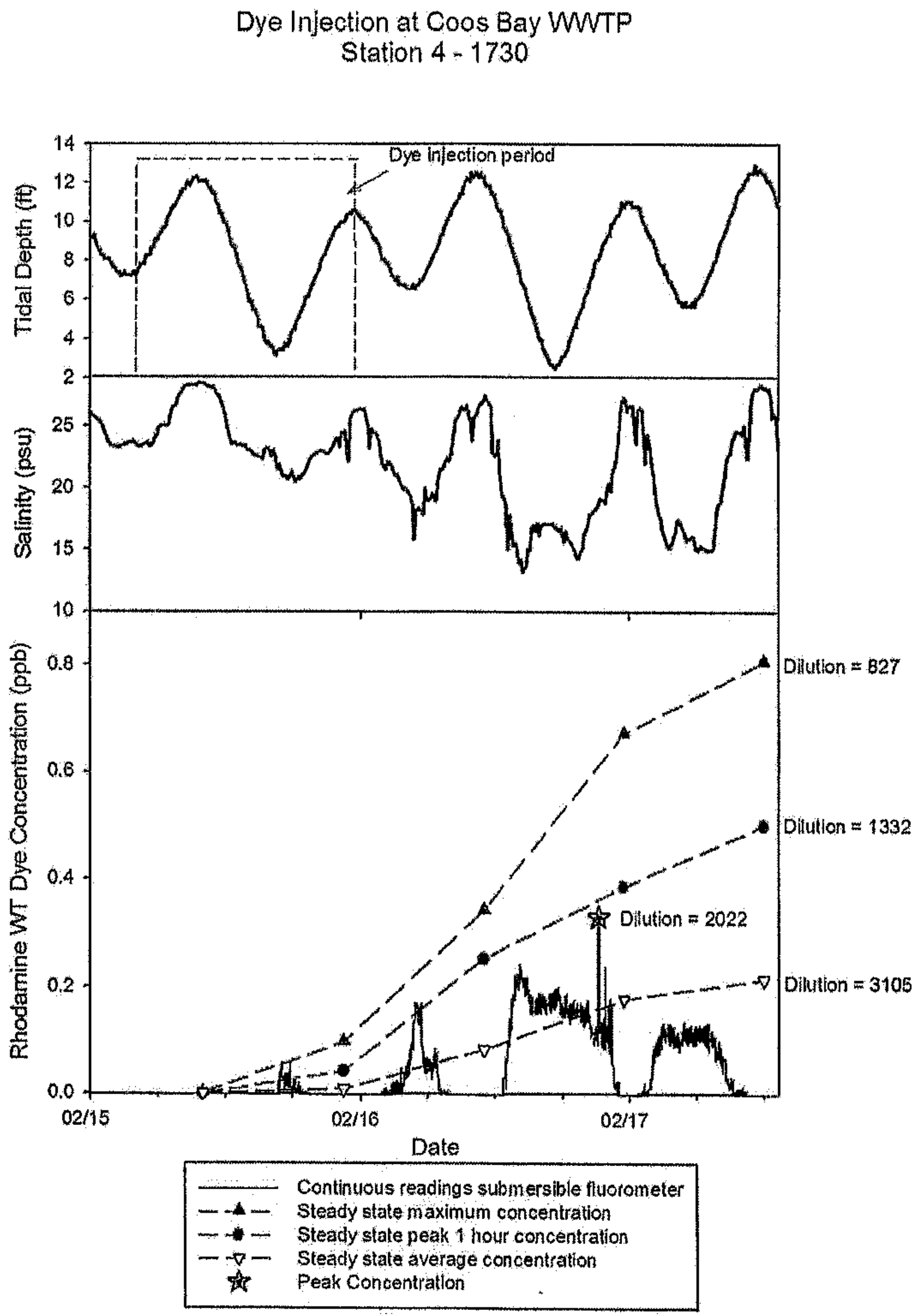


Figure 13: Coos Bay #1 WWTP Study – Station 5 WET Labs Data

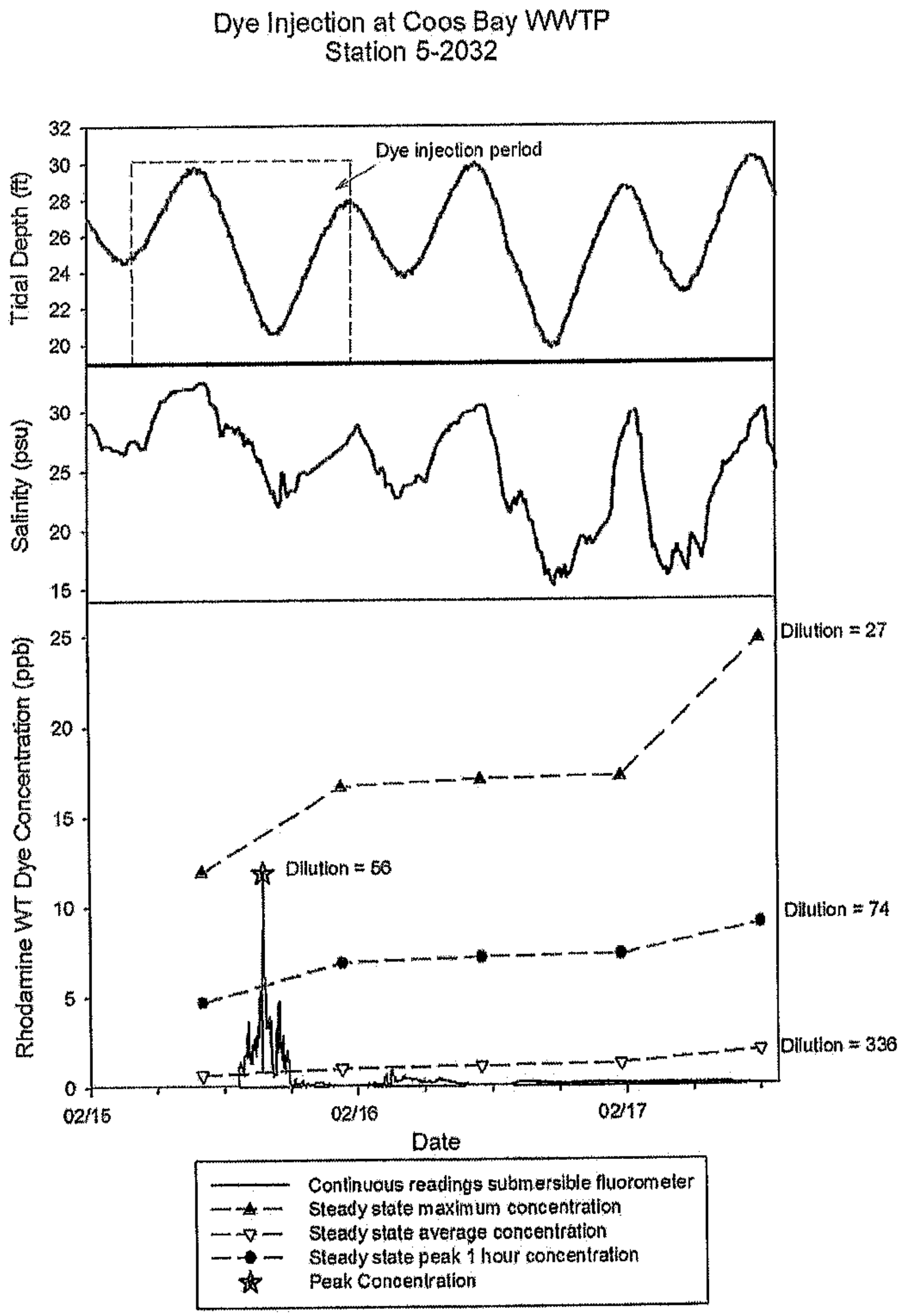


Figure 14: Coos Bay #1 WWTP Study – Station 6 WET Labs Data

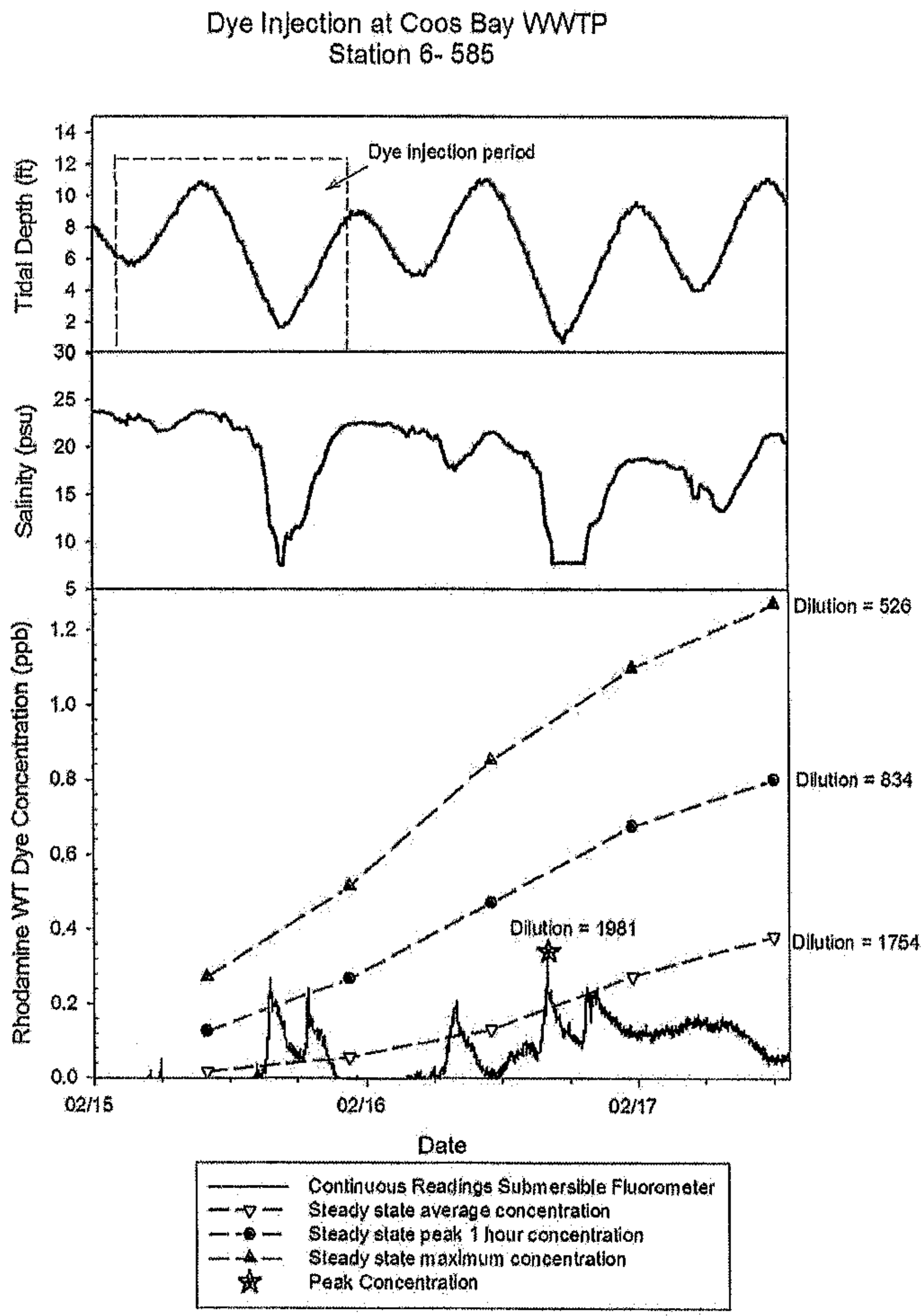


Figure 15: Indicator Microorganism and Human Virus Levels in Oyster Sentinels Vs. Estimated Dilution Values Based on Impact from Both WWTPs in Combination at Stations 1 – 6

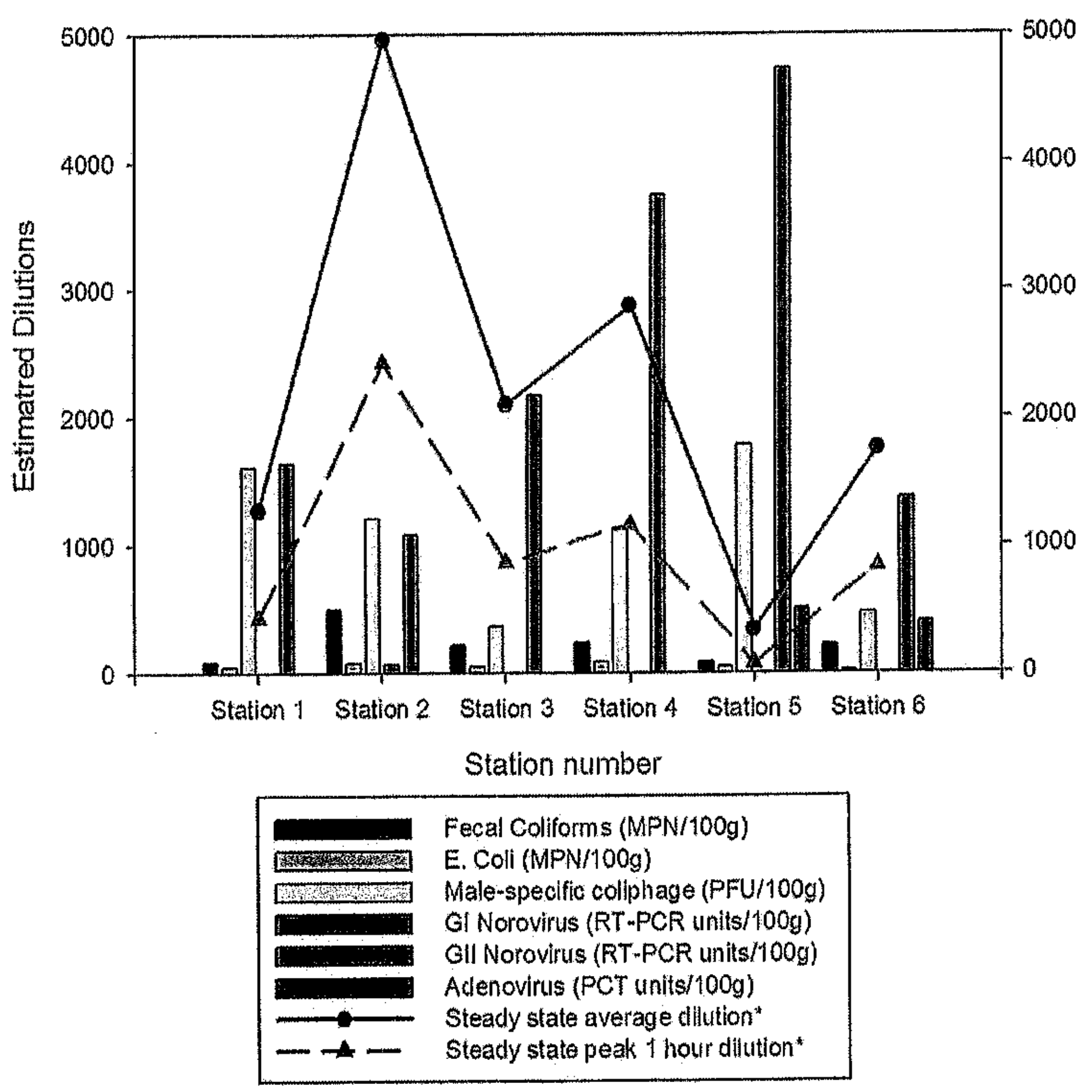


Figure 16: Dye Tracking Results on Feb. 7, 2011 for North Bend WWTP Study

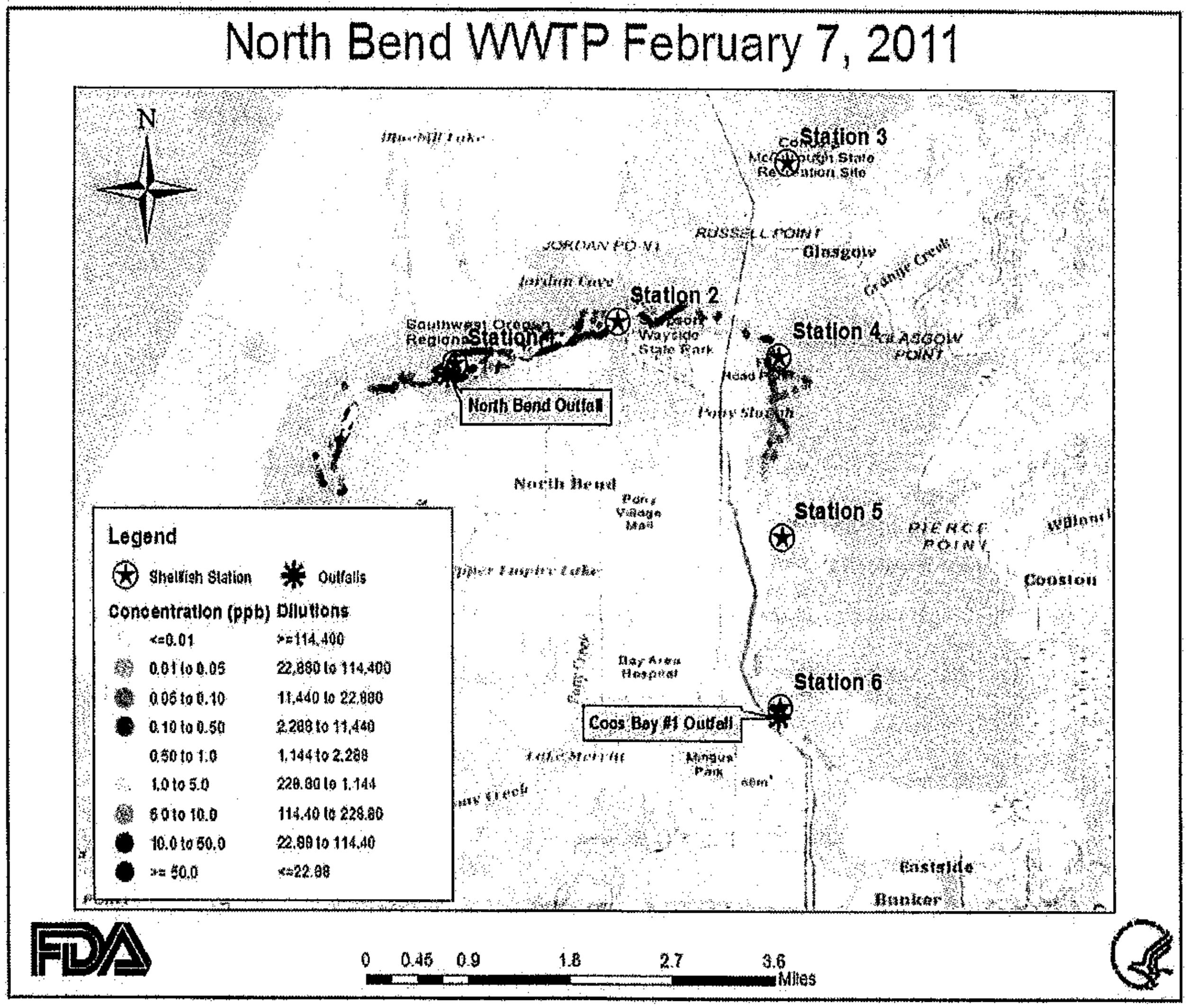


Figure 17: Dye Tracking Results on Feb. 8, 2011 for North Bend WWTP Study

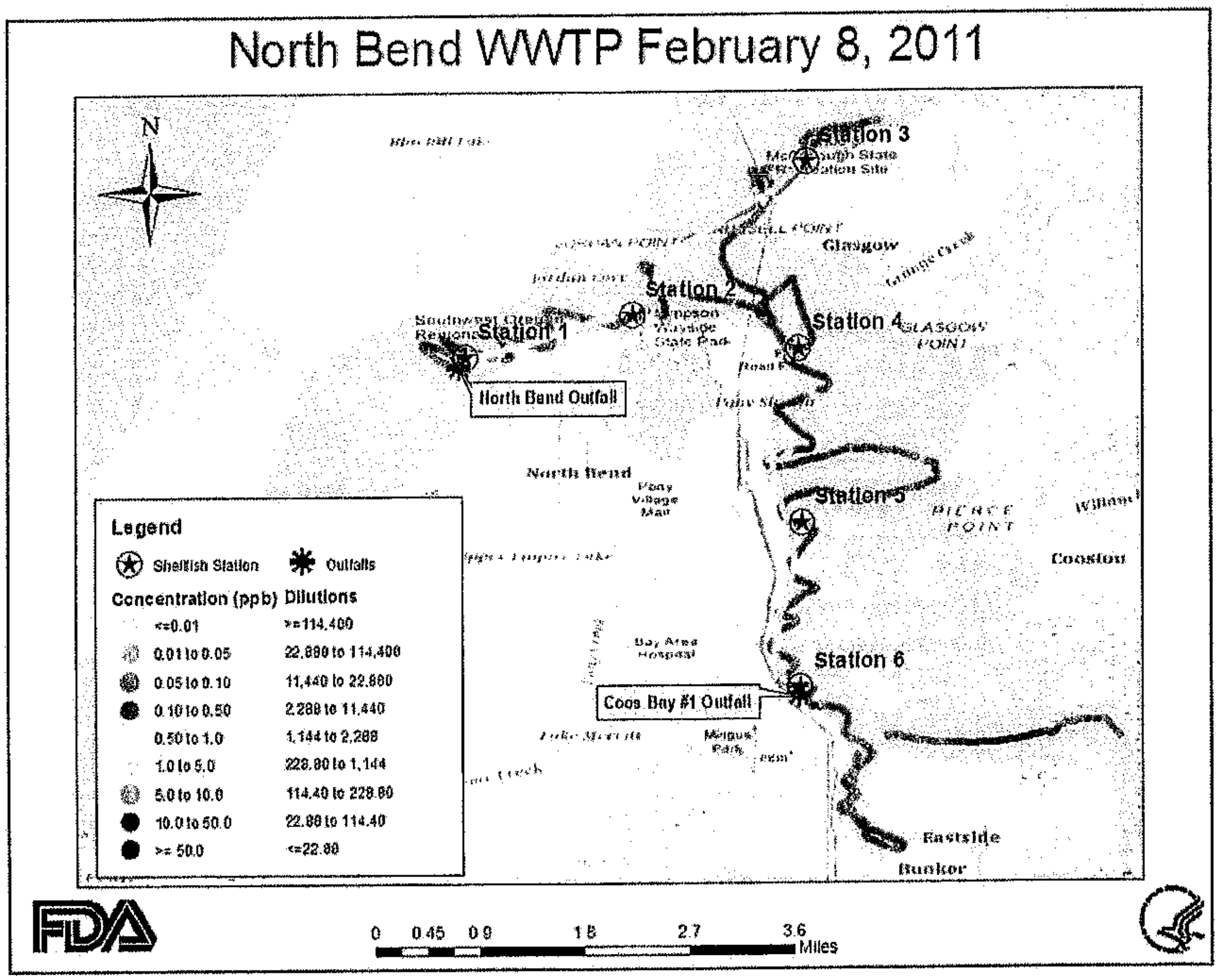


Figure 18: Dilution Assessment for North Bend WWTP Study

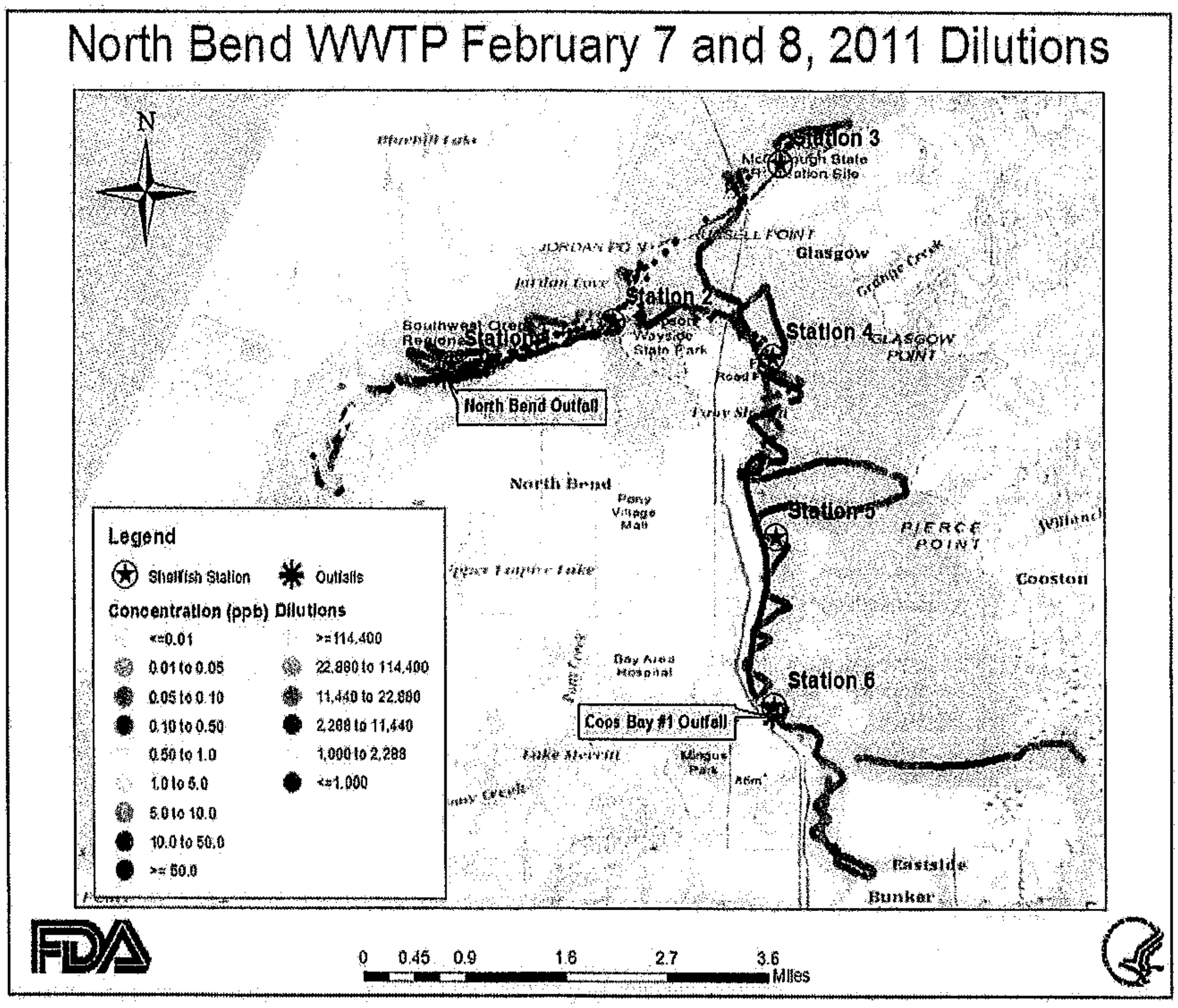


Figure 19: Dye Tracking Results on Feb. 15, 2011 for Coos Bay #1 WWTP Study

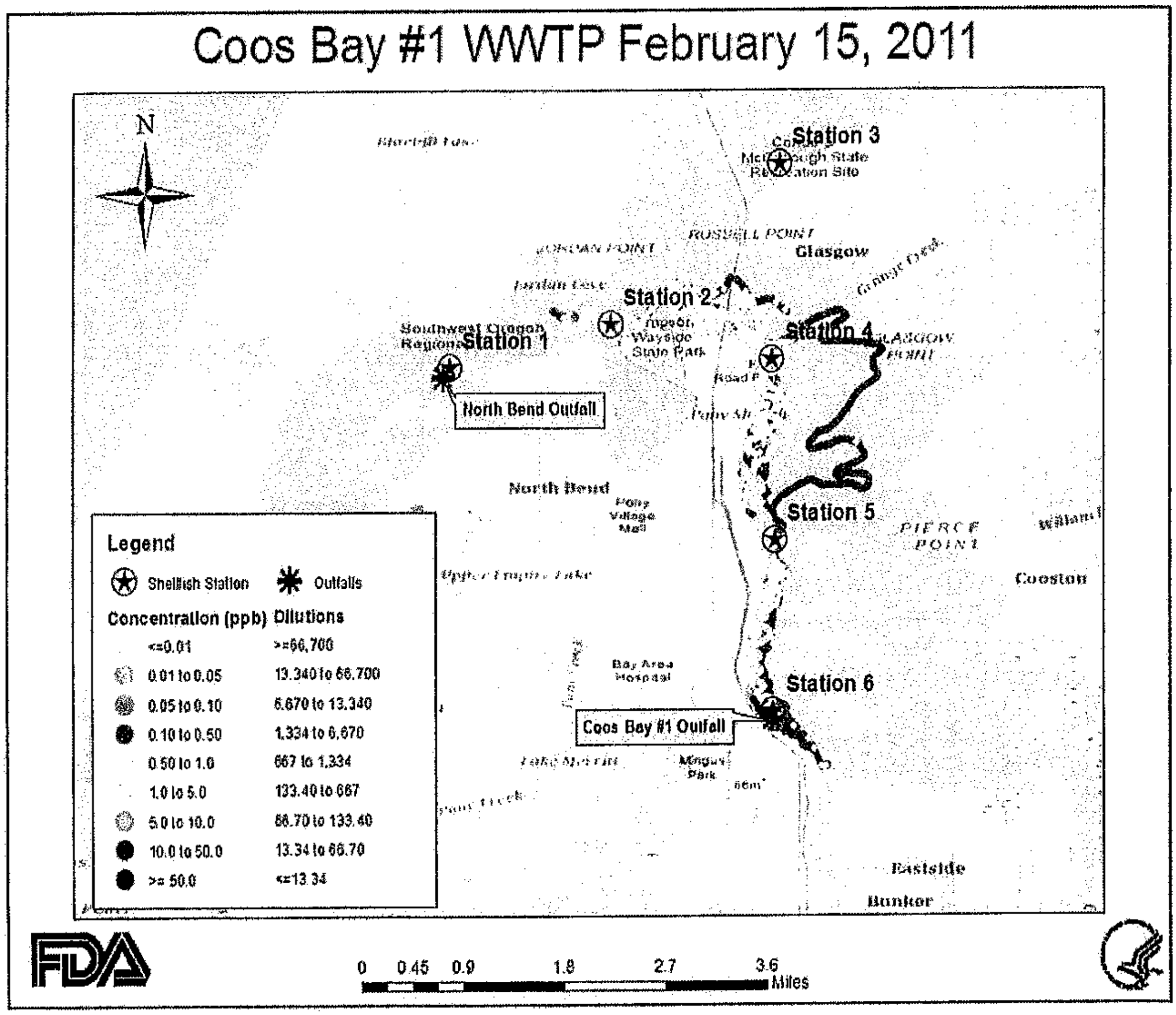


Figure 20: Dye Tracking Results on Feb. 16, 2011 for Coos Bay #1 WWTP Study

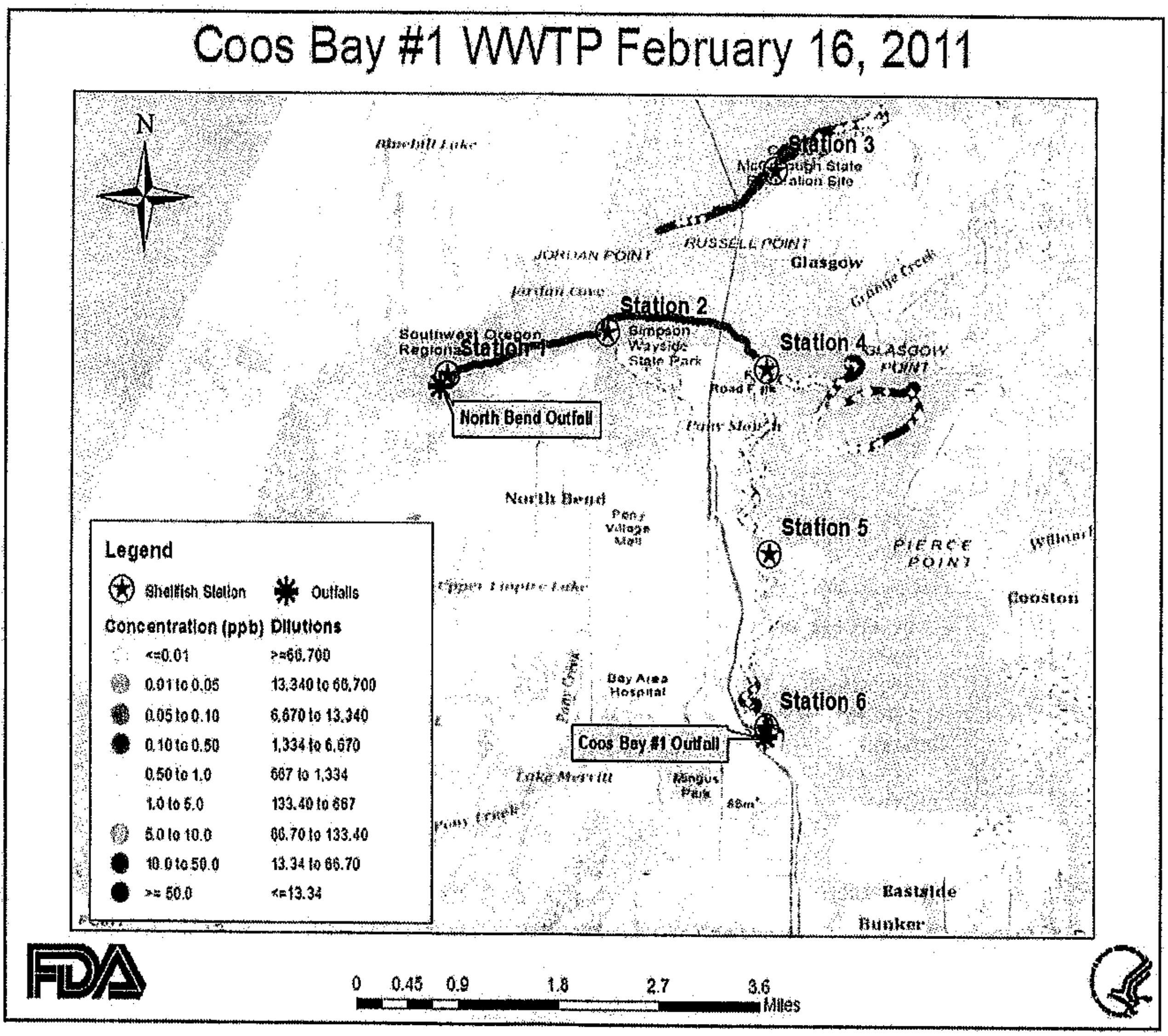


Figure 21: Dilution Assessment for Coos Bay #1 WWTP Study

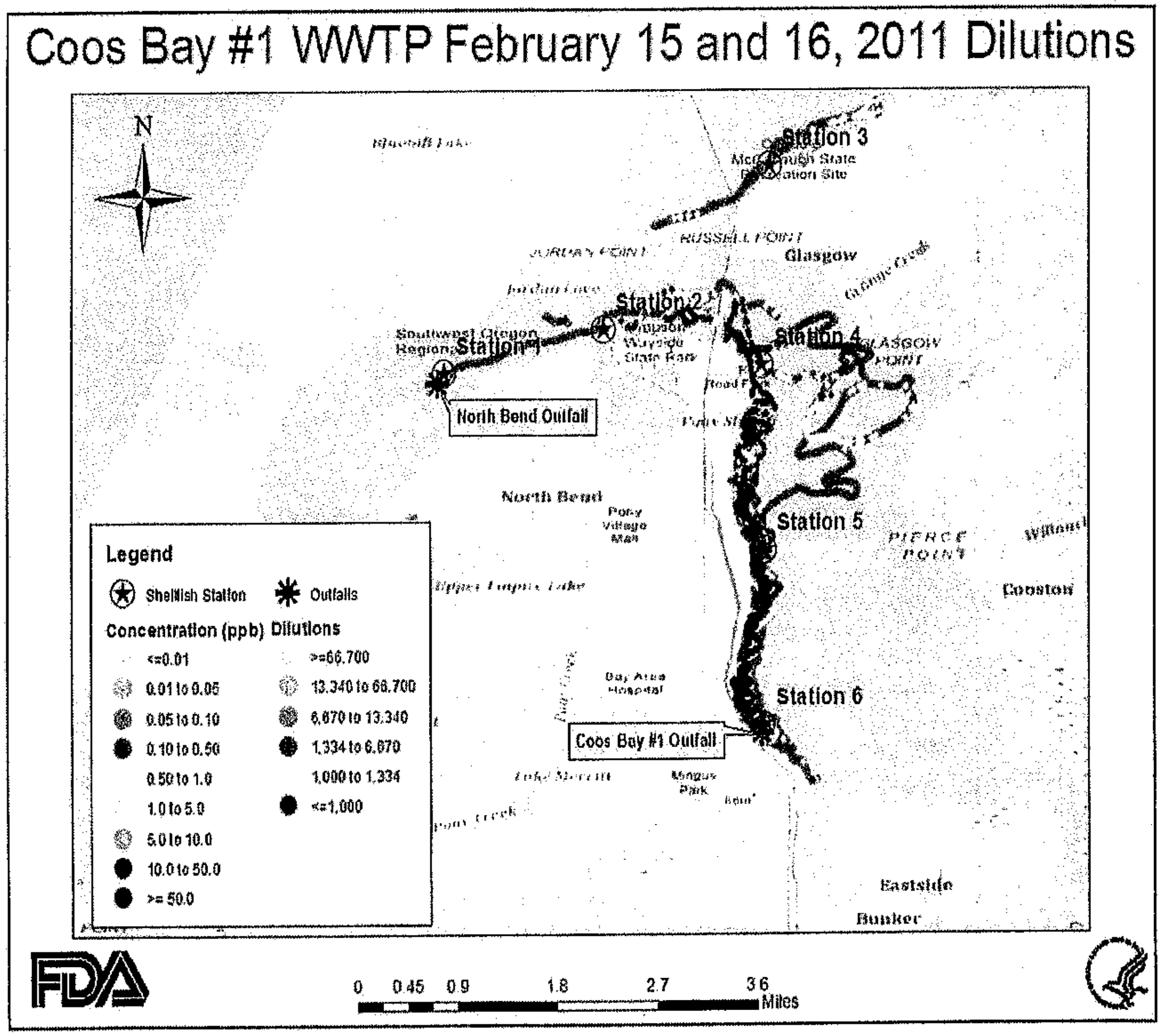


Figure 22: Overall Dye Tracking Results for Both WWTP Studies

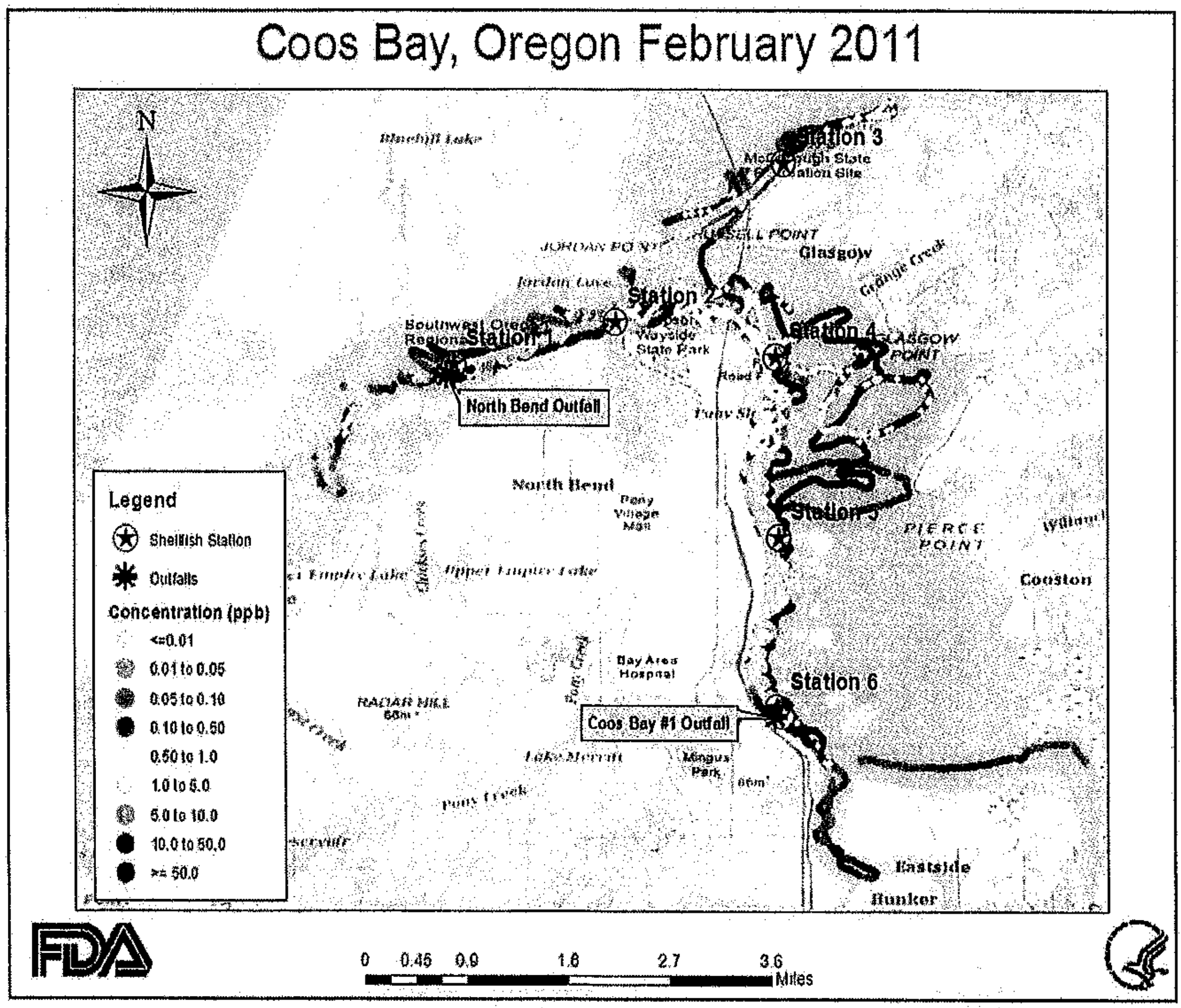


Figure 23: Dilution Assessment for Both Studies in Relation to Shellfish Growing Area Classifications

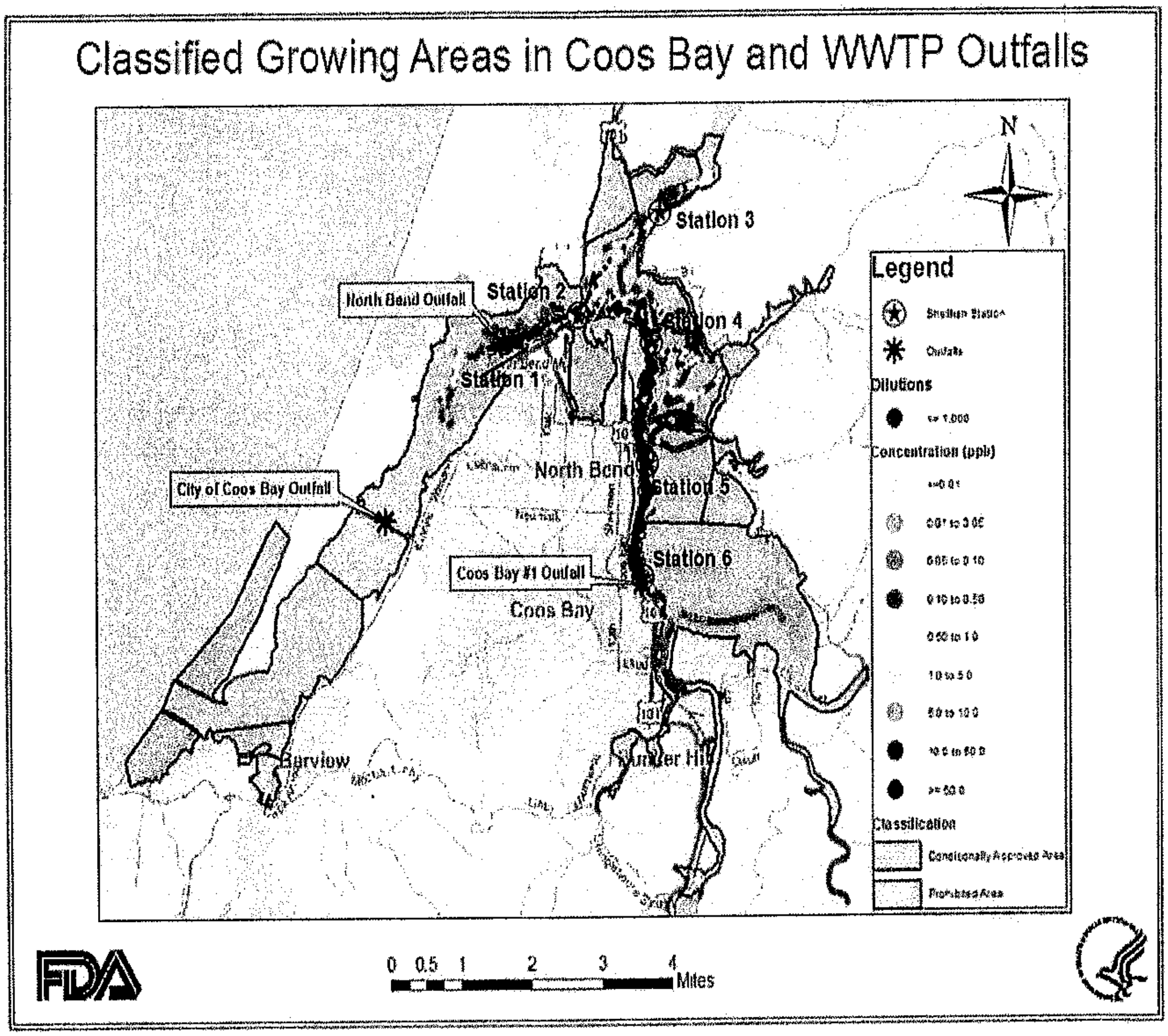
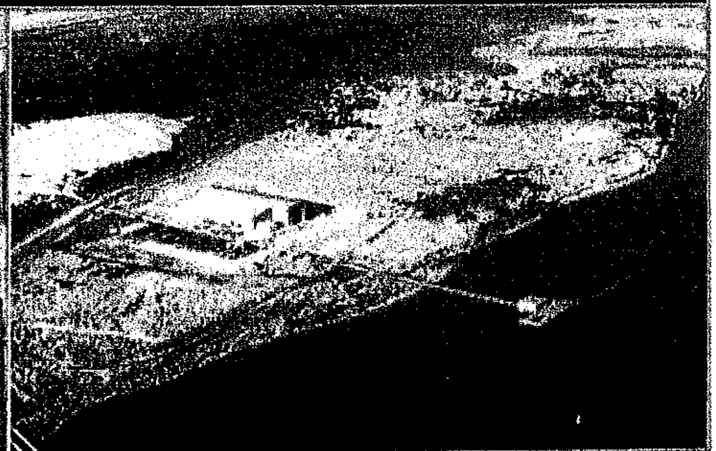


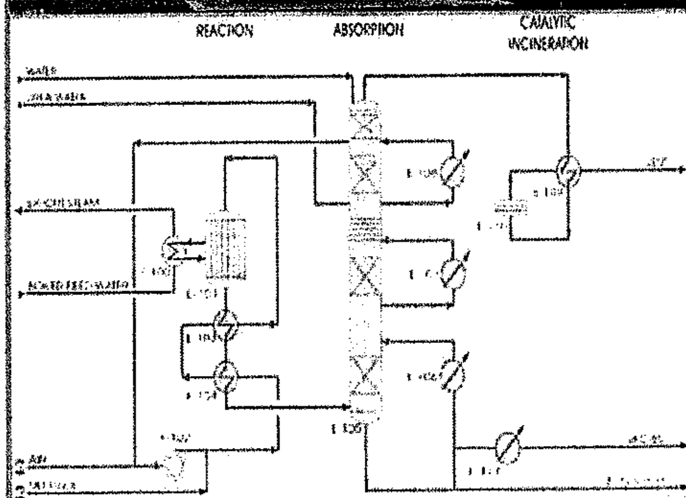
EXHIBIT 23

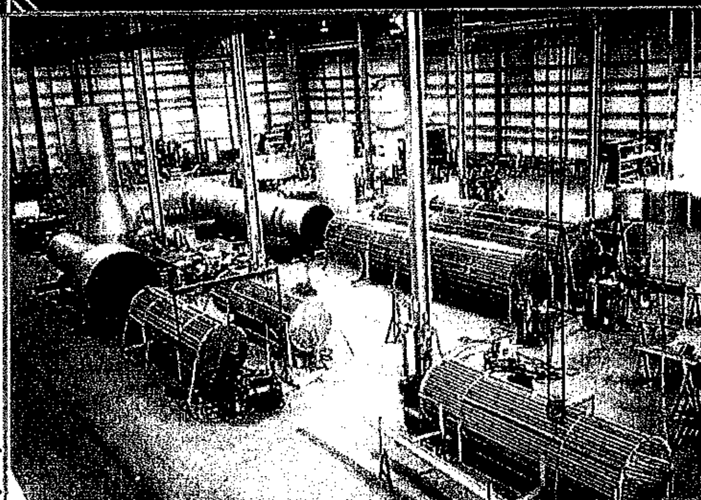
DBWT

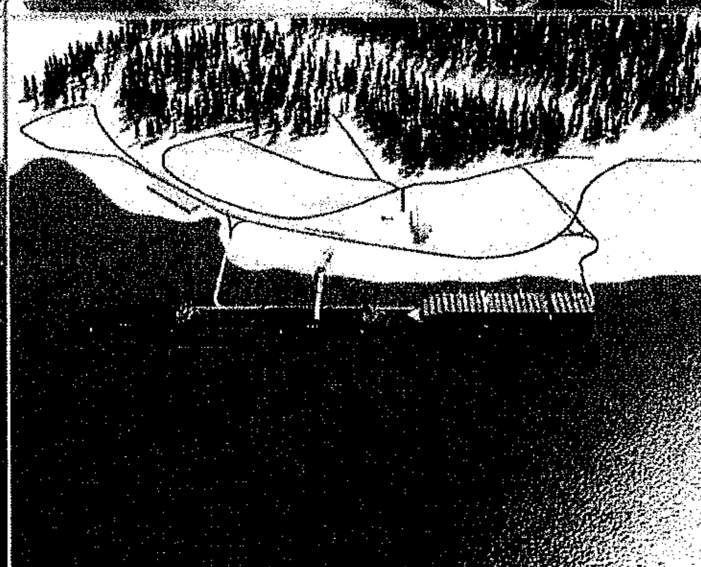
D.B. Western Inc. - Texas

New Business Development, Design, Engineering, EPC Contractor
ASME Fabrication, Finite Analysis, ASPEN Heat Exchanger, API Tanks
Technology, Chemical Process Development, Chemical Production









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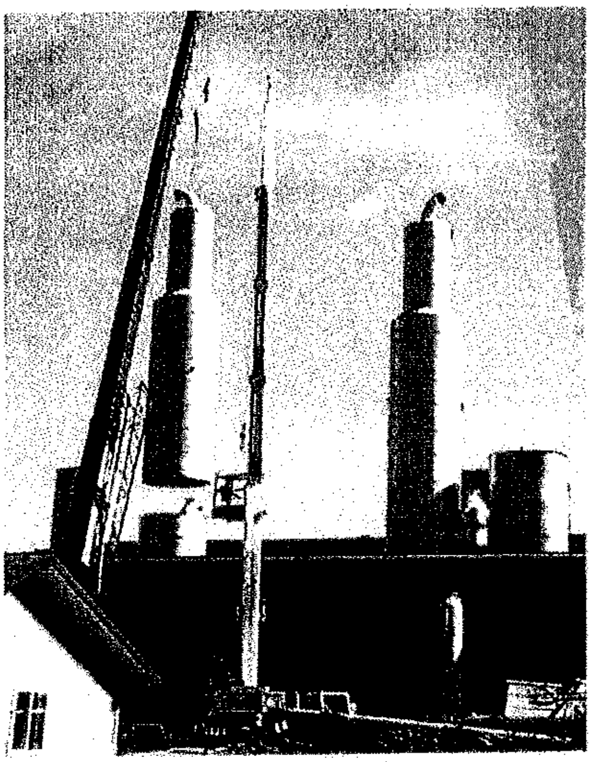
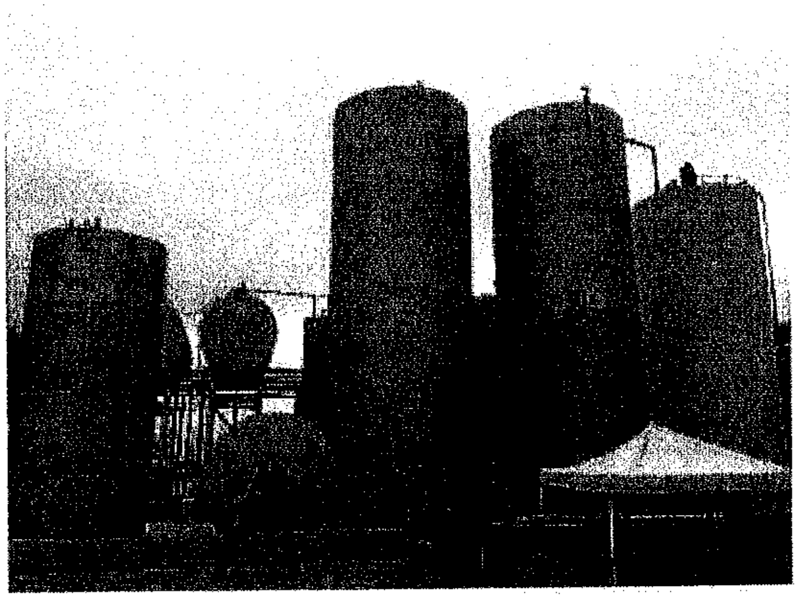
Ship to: 90418 Trans Pacific Lane ♦North Bend ♦ OR ♦ 97459 ♦www.dbwt.us ♦ mail@dbwt.us

Construction and Installation

DBWT - A recognized global business leader and chemical engineering corporation providing advanced technology and support to customers through business development, engineering design, planning, contract administration and construction.



Left - DBWT - 2 Train Plant built in New York State that produces formaldehyde used in pyridines, automotive resins and specialty plastics.



Above - DBWT - Triazine Tank assembly in Texas.

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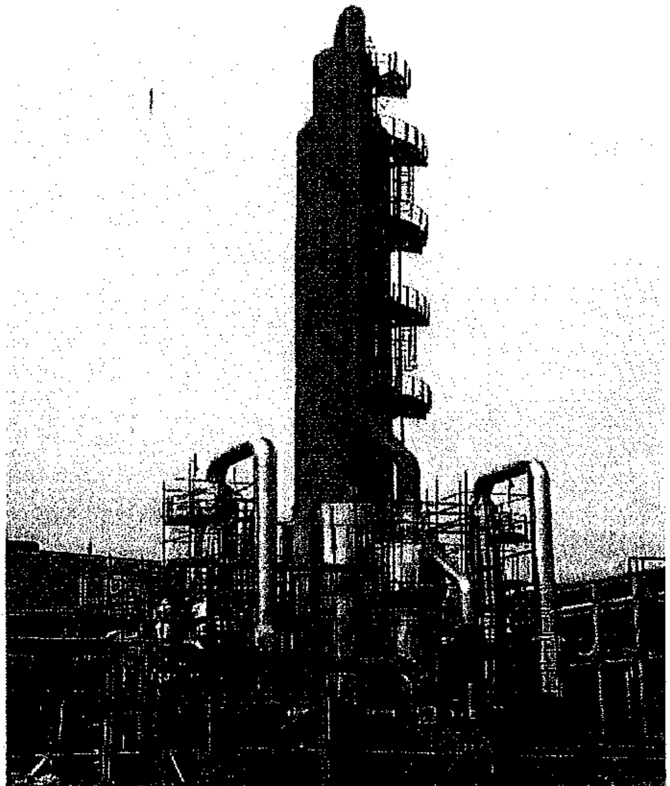
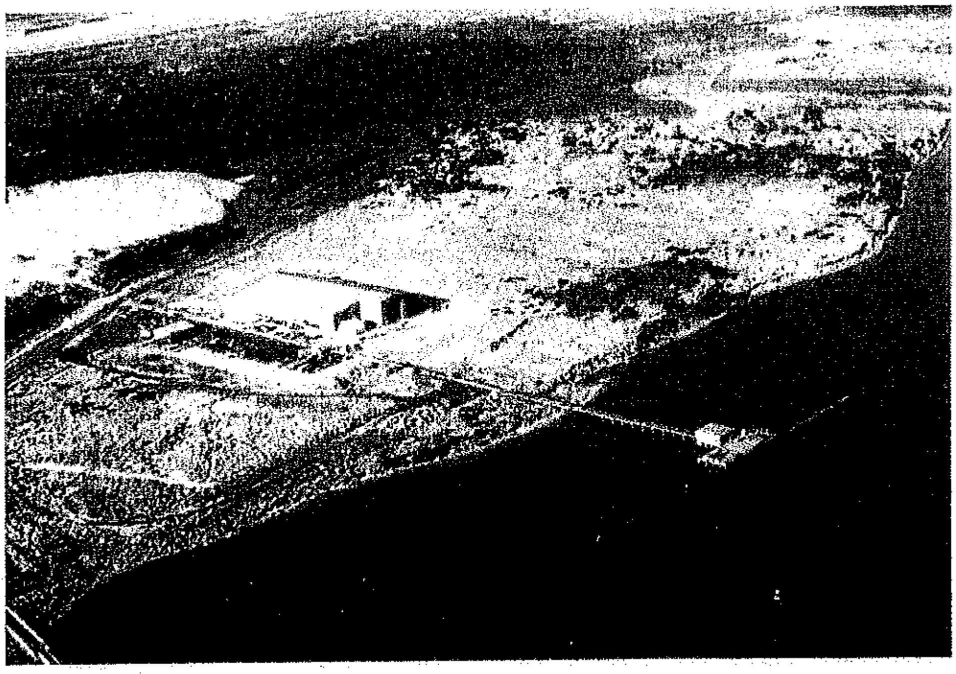


Left - DBWT - Technology, Process Design, Engineering, Training and Start-up. Tianhua, China Plant under construction.

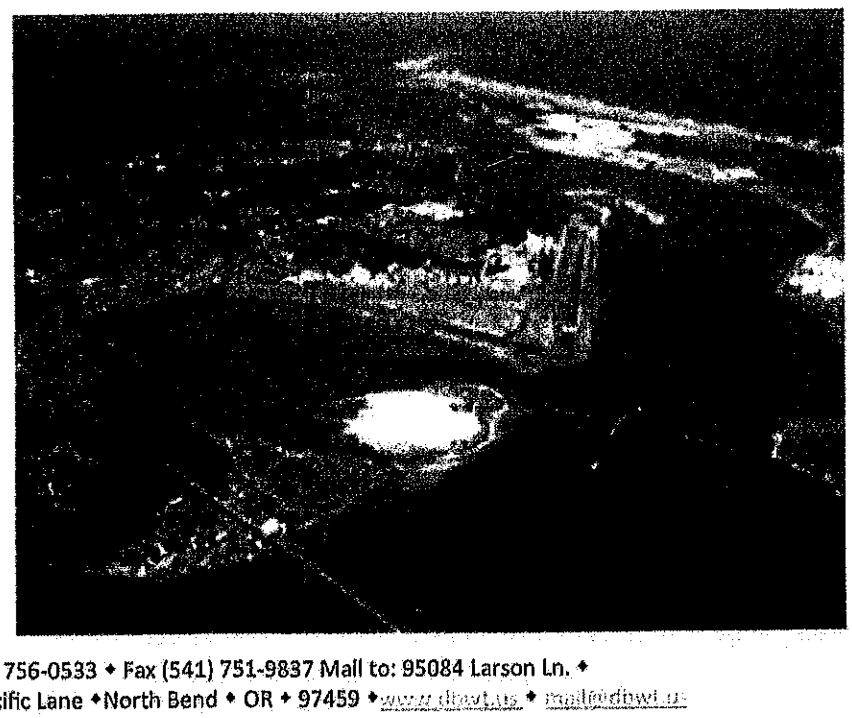
Right - Completed China Plant.

Facility



DBWT - 32 acre site located at the Oregon International Port of Coos Bay. Modern 100,000 square foot facility with advanced automated technology fabrication capability adjacent to a heavy lift dock in a deep draft port with 1,600 linear ft of water front.

Right - Aerial photo of DBWT Oregon International Port of Coos Bay.



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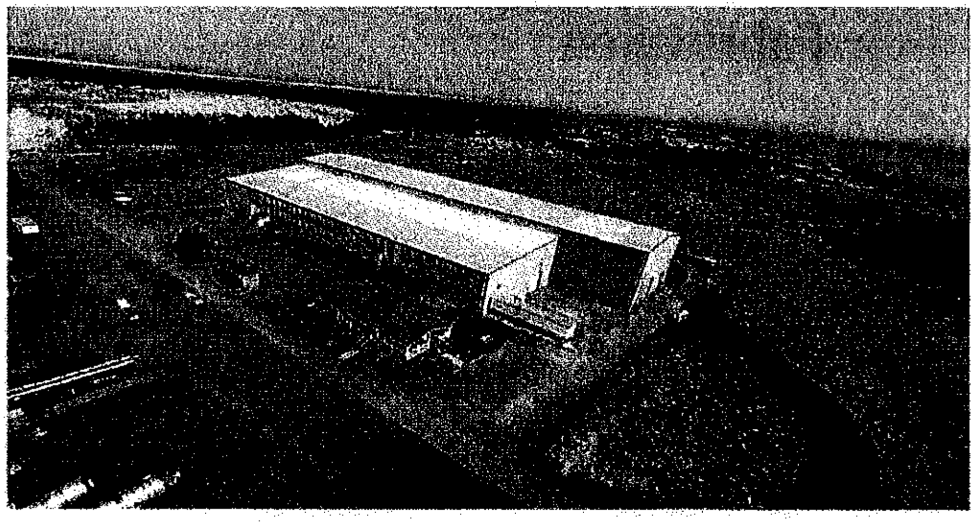
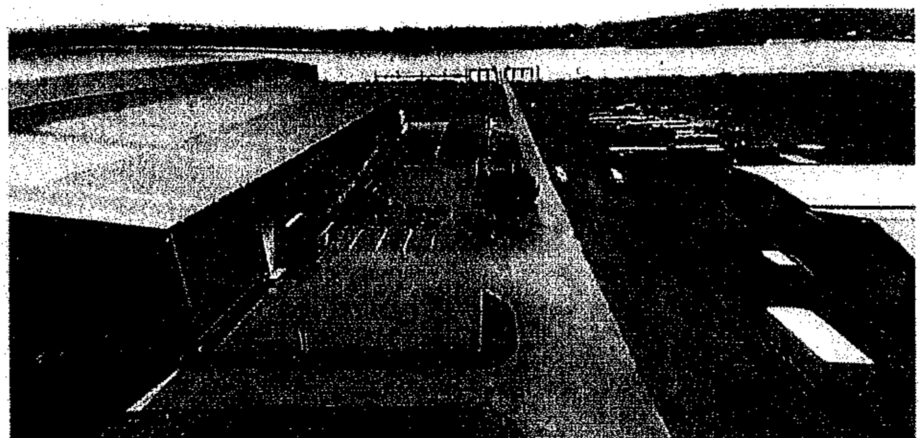
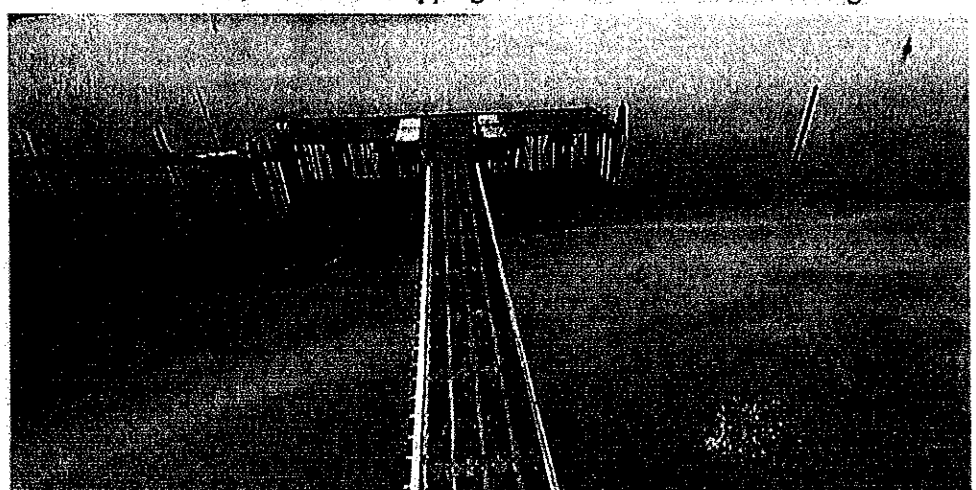


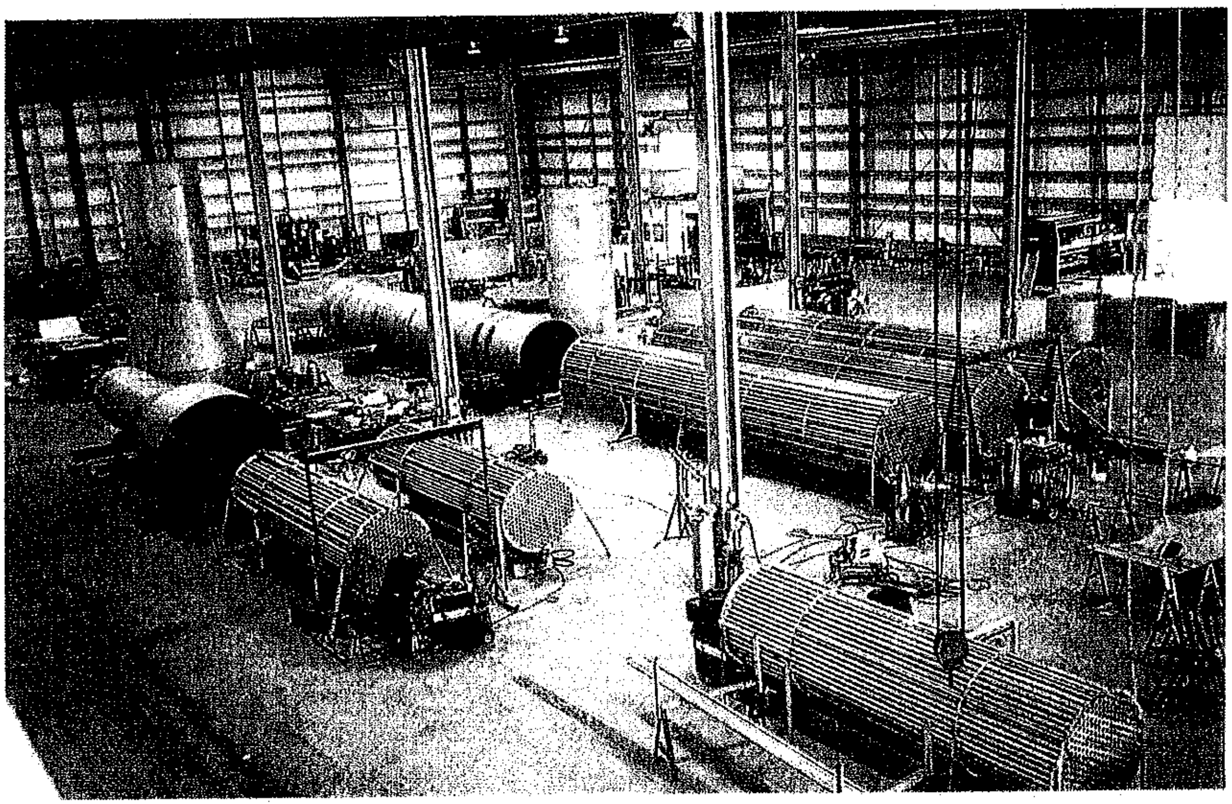
100,000 square ft. building with direct concrete heavy lift road to heavy lift dock, plus 32 acres of laydown area.



Below - 16ft wide Dock approach, 50ft x 150ft Lift Dock with a 200ft floating dock, and 2 40ft shipping containers for additional storage.



Fabrication



100,000 square foot high bay shop, ASME Code Certificates, U & R with the latest welding and manufacturing equipment. 3 Bays with overhead cranes 40 ft @ hook.

Quality Assurance

DBWT, Inc. has an excellent Quality

Assurance Program and trains its employees on the company's quality performance standards. These include:

- *A.S.M.E. Certification for Section VIII, "U" & "R" stamp for design, fabrication and repair of boilers, heat exchangers, and pressure vessels.*
- *Oregon CCB # 150463*

Major Equipment

- *CNC Control Quickmill Machining and Drilling Bridge for materials up to 16" high and 15' wide while maintaining 0.001" accuracy*
- *Radial Drill Presses: 12' capacity*
- *90-ton Piranha Iron Worker*
- *Beveler: Plate and Pipe*
- *Plasma Cutting*
- *Break: ½" x 12' using a 320-ton Hydraulic Press*
- *Shear: ½" x 12'*
- *Roll: ½" x 10'*
- *Pipe Bender: 2" diameter*
- *Pipe and Angle rolls 4" Cap.*
- *6 Automatic tube welders*
- *2" to 6" Automatic pipe welders*

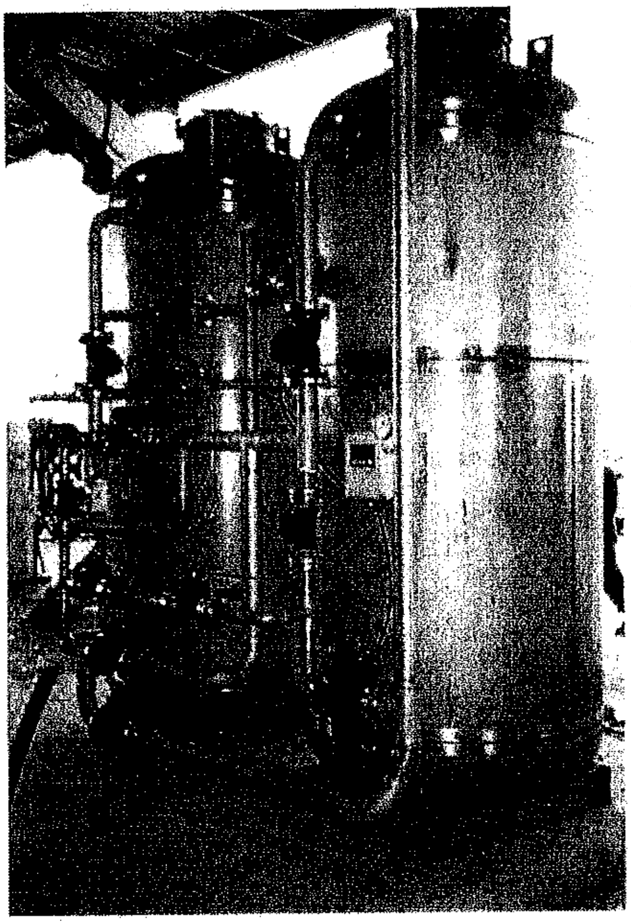
DBWT

PRESSURE VESSEL, HEAT EXCHANGER AND TANK EXPERIENCE LIST

1		**Pressure Vessels**				
2	**Materials**	Stainless - 304 and 316	Carbon - A-36, 516-70, 285			
3	**Thickness**	Gauge through 2"				
4	**Size**	Diameter - 1' 0" thru 15' 0"	Length - 1' 0" thru 130' 0"			
5	**Pressures**	0 psis thru 500 psig				
6	**Temperatures**	-20° F thru 1100° F				
7		**Heat Exchangers**				
8	**Materials**	Stainless - 304 and 316	Carbon - A-36, 516-70, 285			
9	**Thickness**	Gauge through 2"				
10	**Size**	Diameter - 1" thru 15' 0"	Length - 1' 0" thru 80' 0"			
11	**Pressures**	0 psis thru 500 psig				
12	**Temperatures**	-20° F thru 1100° F				
13		**Tanks - Shop Fabricated**	**Tanks - Field Fabricated**			
14	**Materials**	Stainless - 304 and 316 - Carbon - A-36 & 516	Stainless - 304 and 316 - Carbon - A-36 & 516			
15	**Thickness**	10 Gauge thru 5/8"	10 Gauge thru 5/8"			
16	**Size**	Diameter - 2' 0" thru 15' 0" Tall 4' 0" thru 41' 0"	Diameter - 12' 0" thru 42' 0" Tall 10' 0" thru 40' 0"			
17	**Pressures**	0 psig thru 2.5 psig	0 psig thru 2.5 psig			
18	**Temperatures**	N/A				

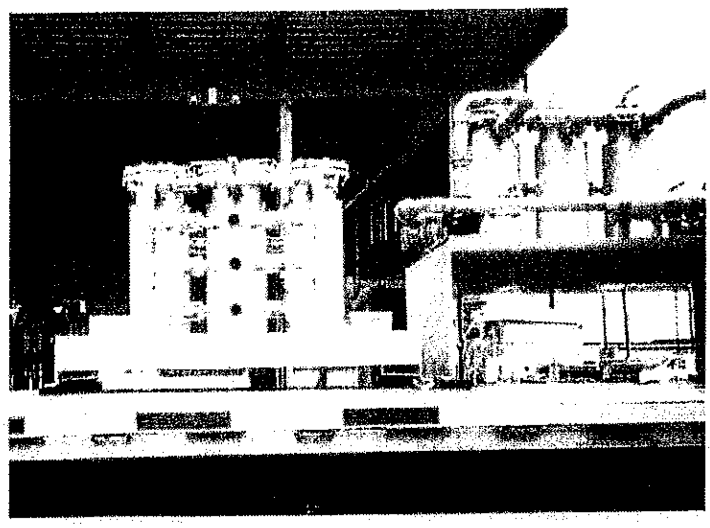
Codes and Standards used and followed: A.S.M.E. {U} Certified - National Board {R} Certified - API 650 - API 650 Designed and constructed for operating at less than 2.5 psig

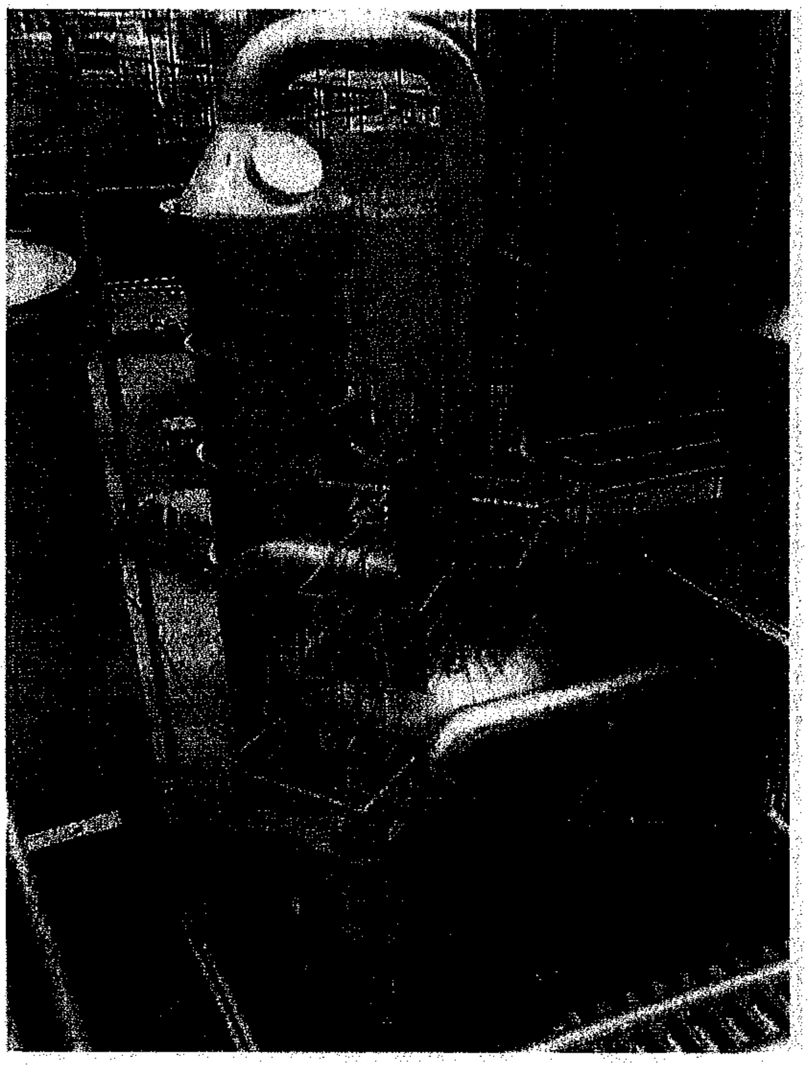
DBWT



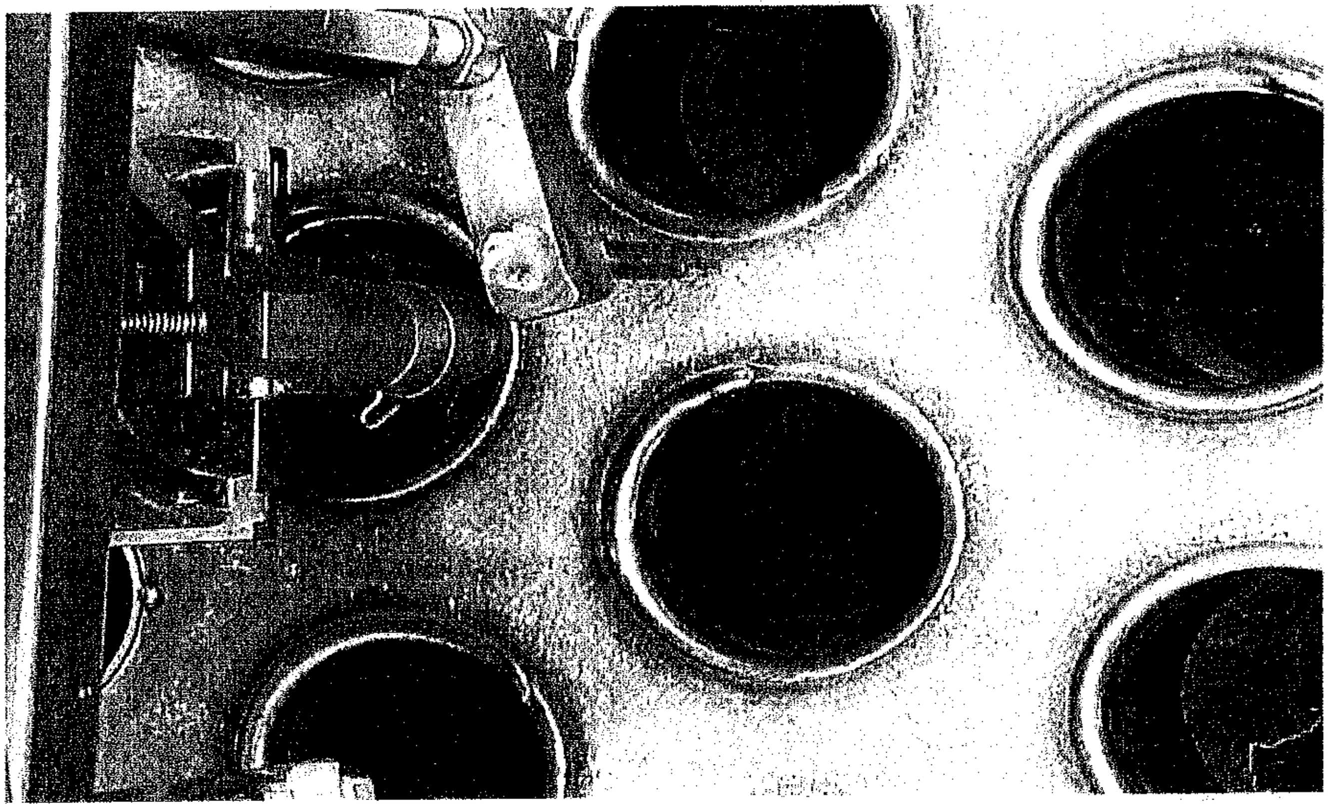
Left - DBWT - 200 GPM all stainless steel Water Softener System designed to remove calcium and magnesium.

Right - DBWT - Heavy duty stainless steel Filter Modules for the chemical industry.

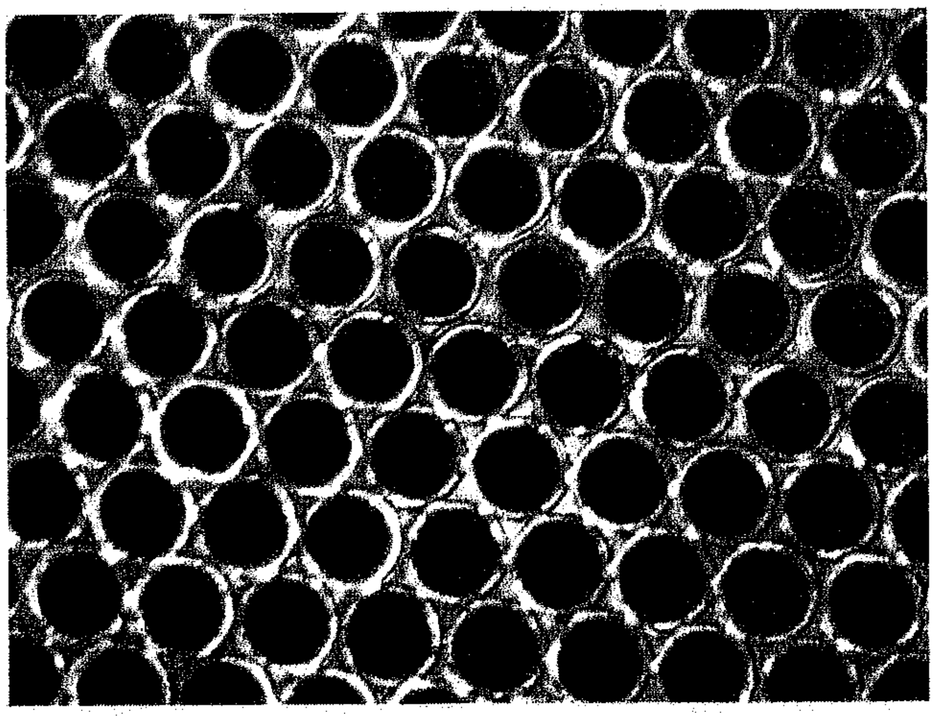


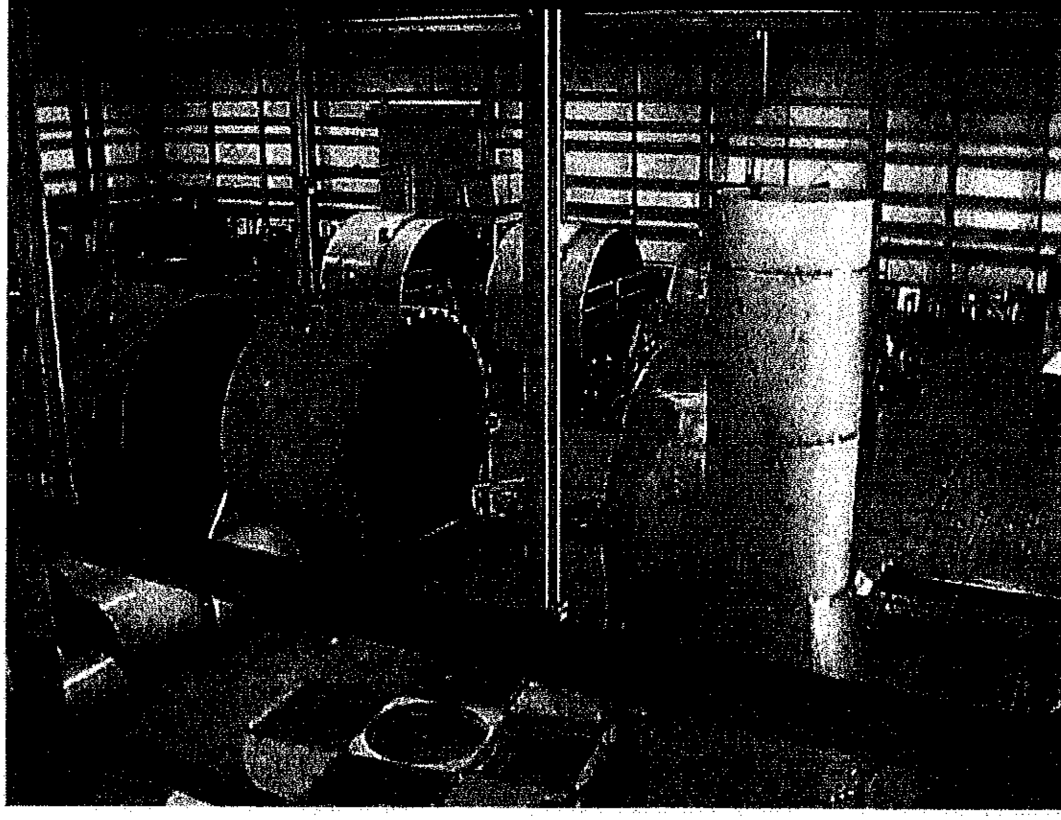


DBWT - 15,000 tube Reactor and related vessels design, engineered, fabricated and installed.

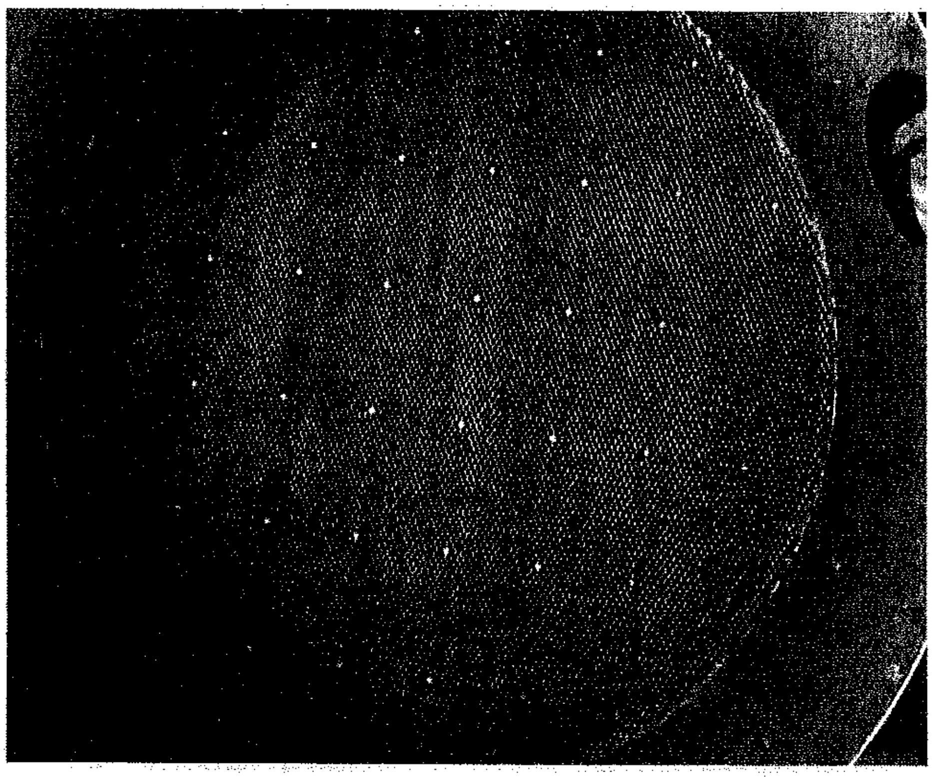


DBWT - Polysoude Pulse Tig - Computer controlled tube to tube sheet welding for fabricating Reactors and Heat Exchangers.



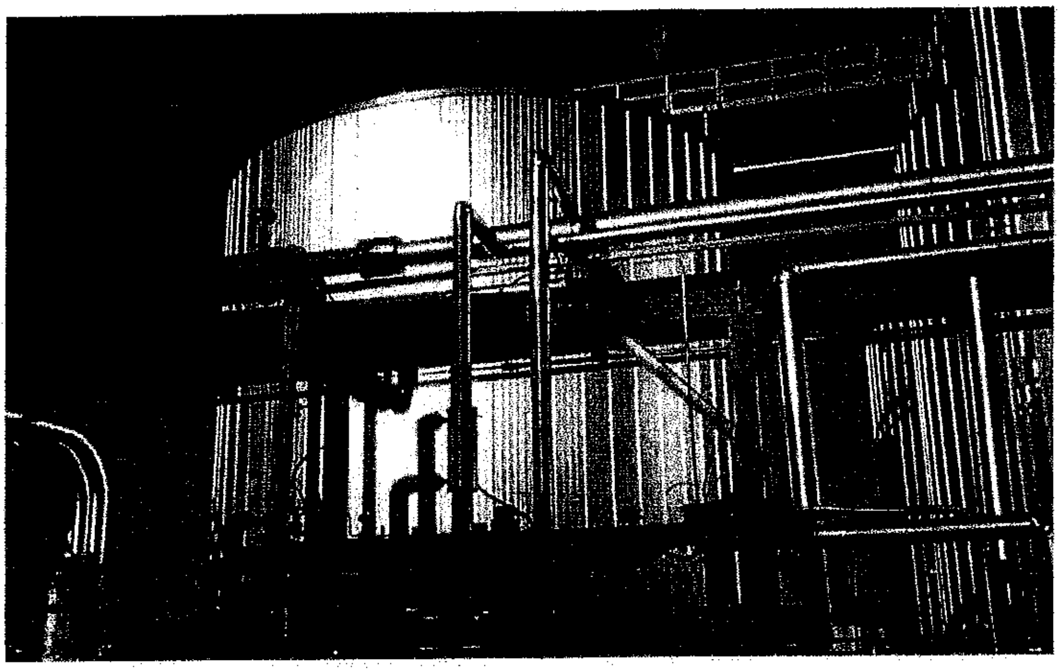


15,000 Tube Reactor Assembly

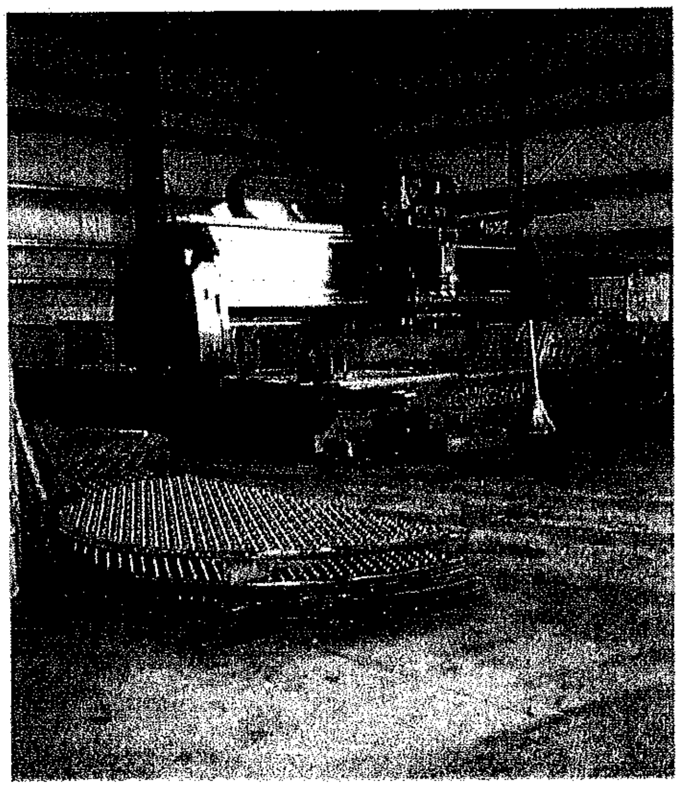


15,000 Reactor tubes in place

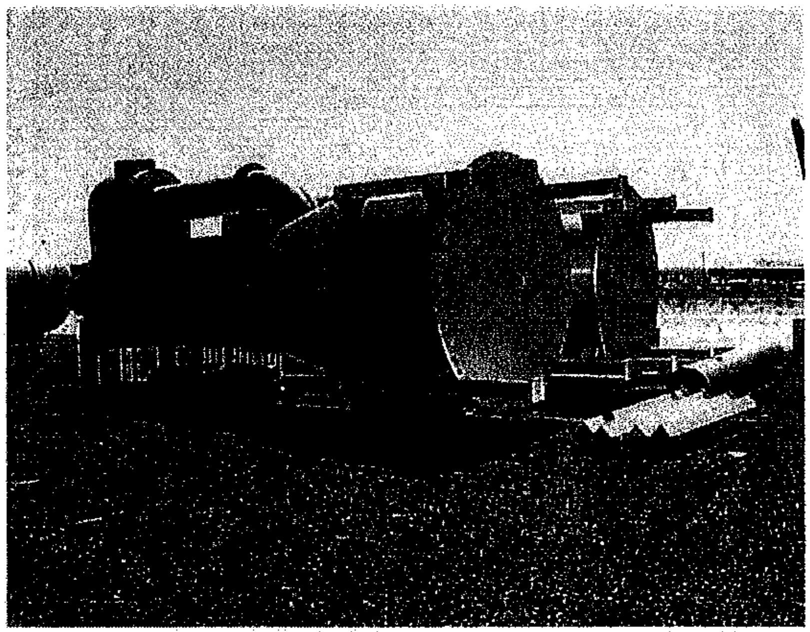
DBWT can build Reactors to 16ft diameter, 100 mt 500 psig and 750° F.



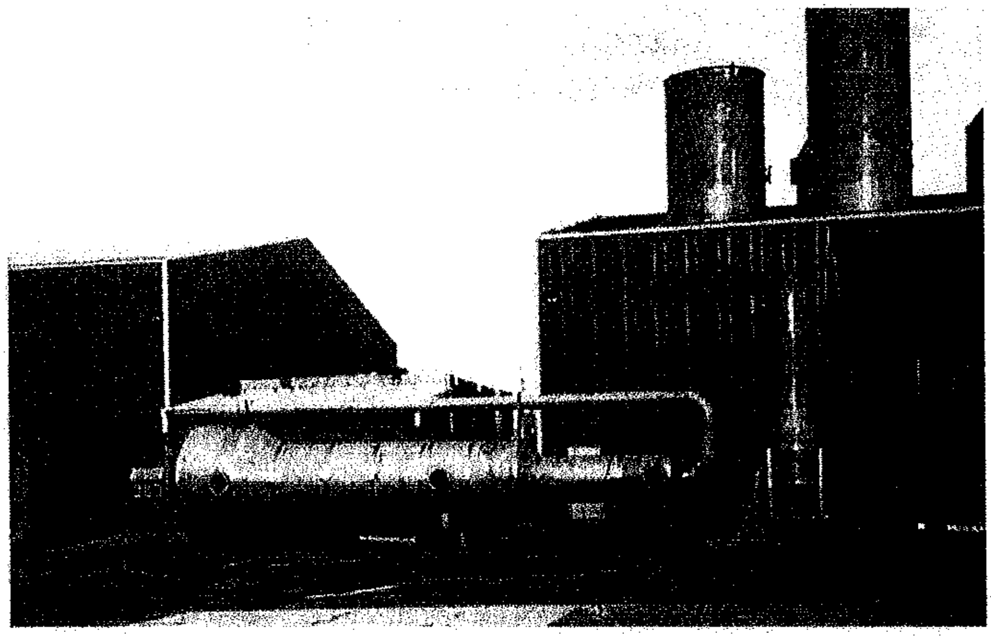
Above - DBWT - Fabrication and Installation of 45 ft Diameter Stainless Steel Tanks with insulation and piping in a chemical plant.



Left - DBWT - Cad Cam Bridge Crane drilling and milling technology producing up to15 ft diameter precision to within .001 of an inch.

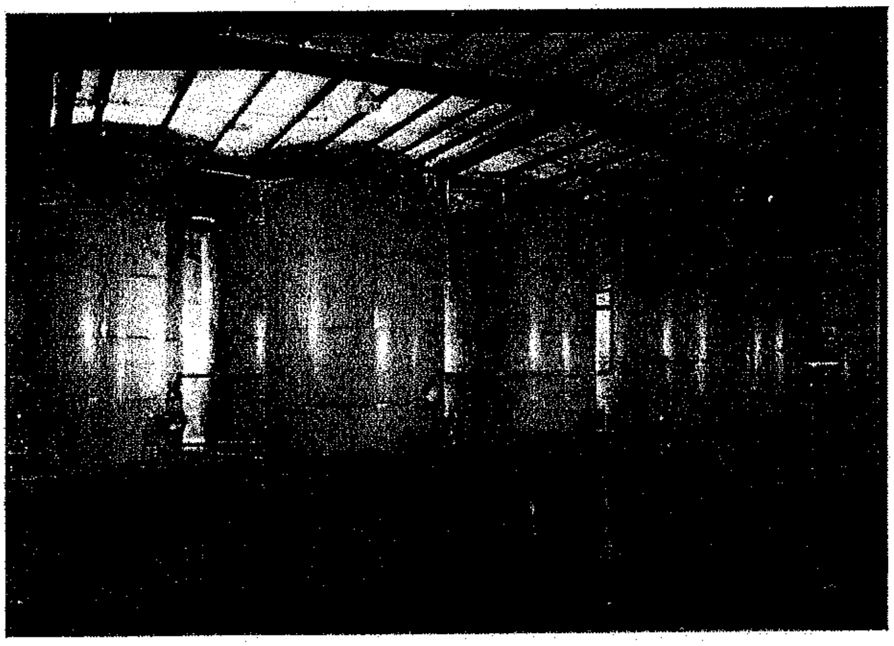


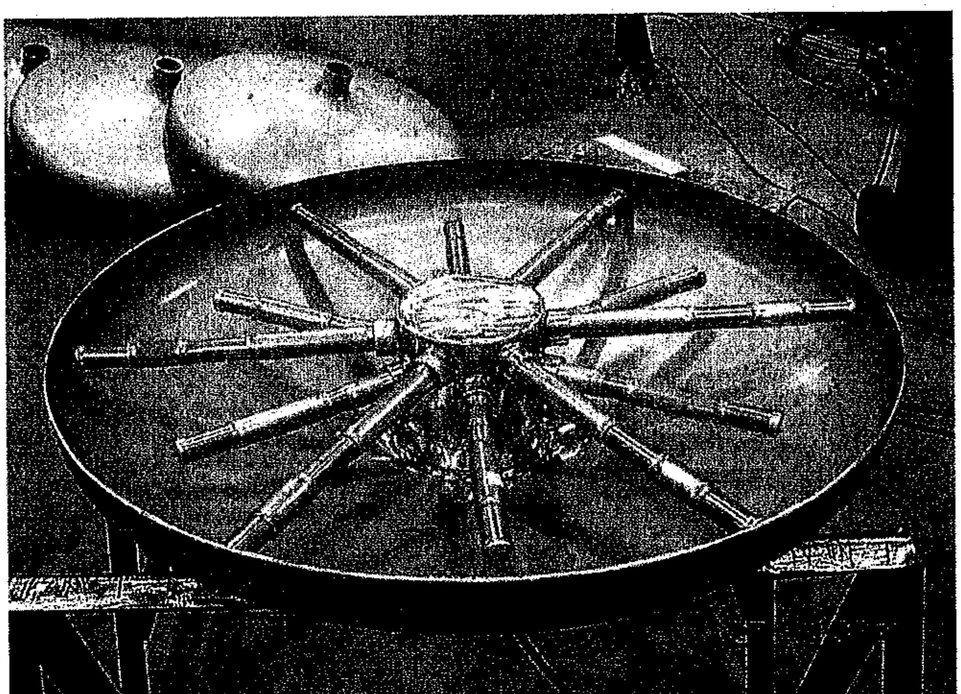
Above - DBWT - Patented and proprietary technology for Catalytic Converters with Platinum Catalyst for 99.99 % Vol. reduction with closed loop heat cycle and 15,000 SCFM.



Above - DBWT - Sections of Distillation Columns with Sulzer Structure Packing for the New York State plant construction.

Right - DBWT - 12 ft x 24 ft & 12 ft x 36 ft Diameter Stainless Steel Tanks erected within customer building.





Above - DBWT - Stainless Distributers with Johnson screen takes for polish filters used in water treatment plant construction.

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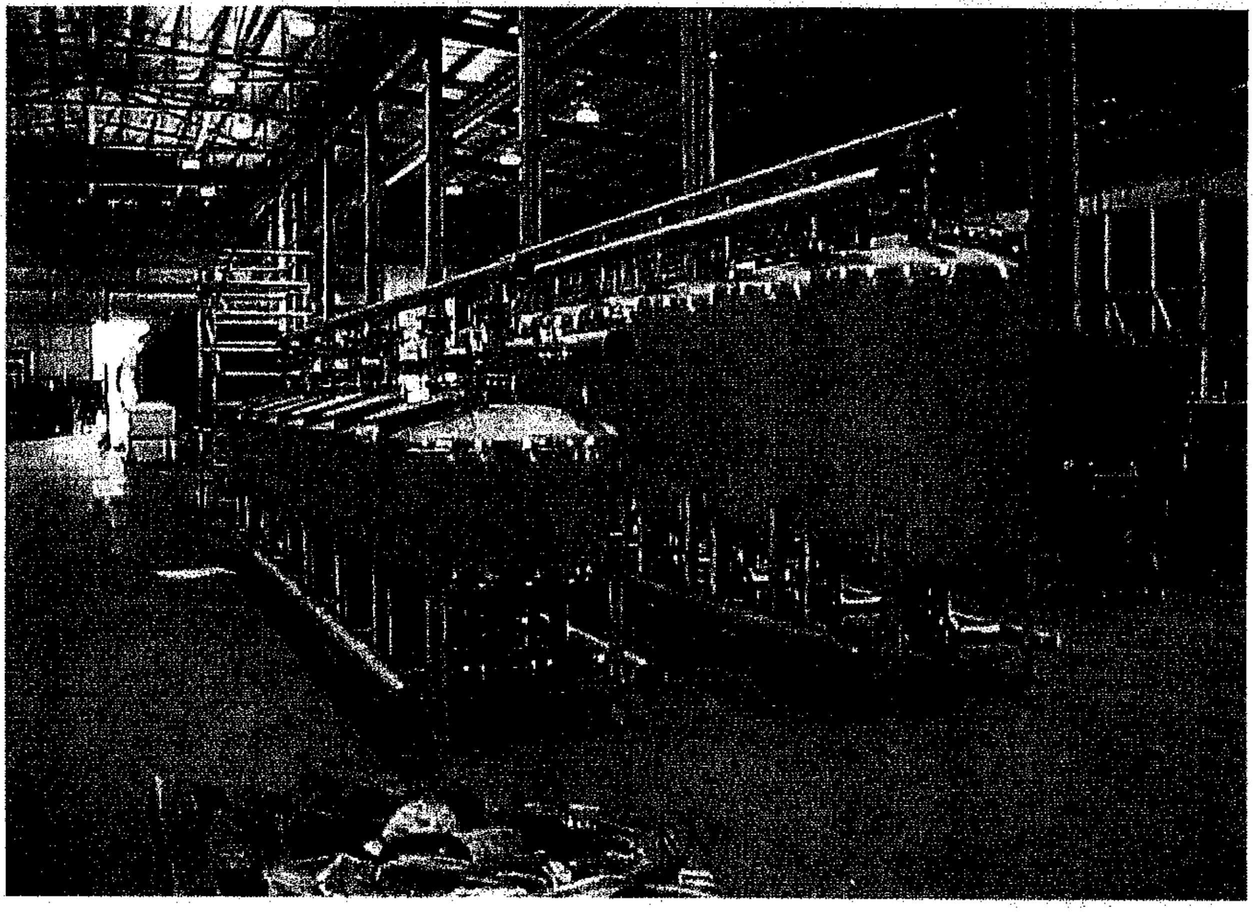
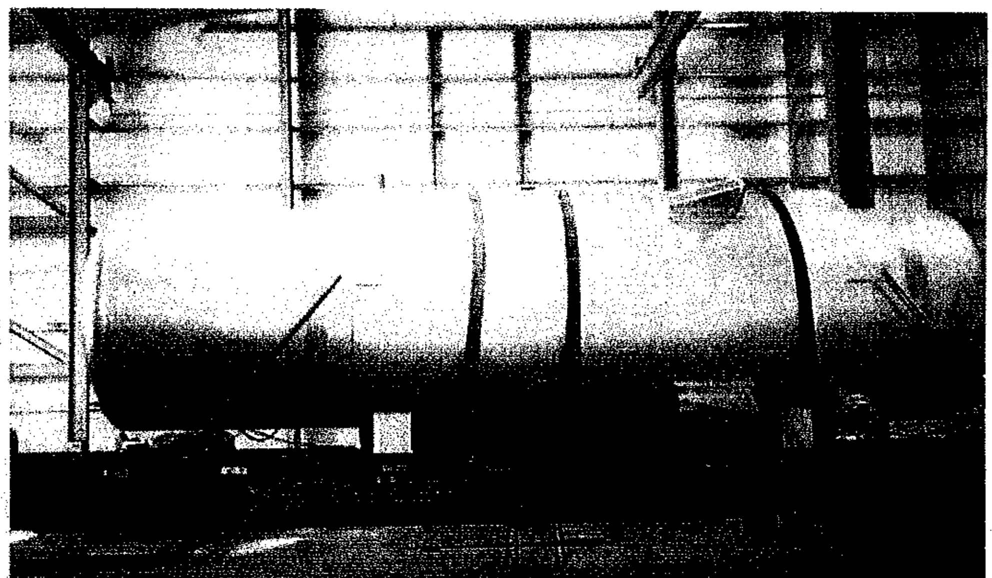
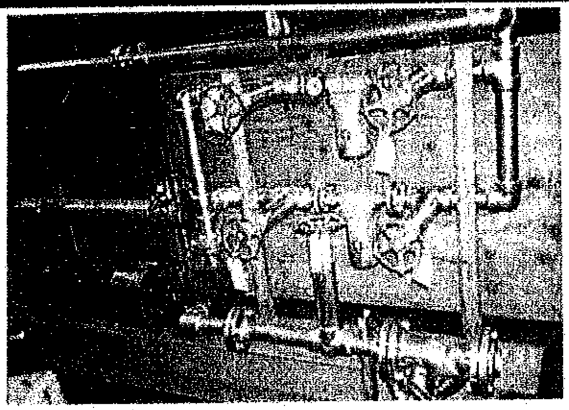


DBWT - Skid mounted sand filter and polish filter system prior to shipment.

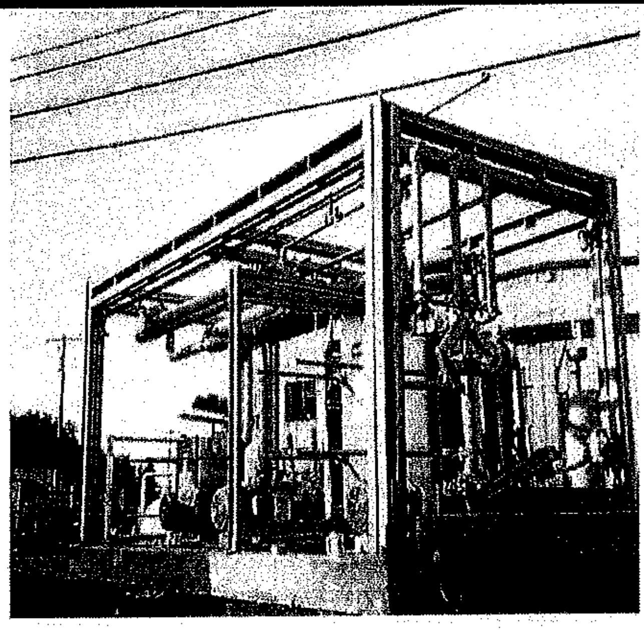


Right - DBWT - ASME 40 ton high pressure waste heat boiler @ 30,000 btu/hr.

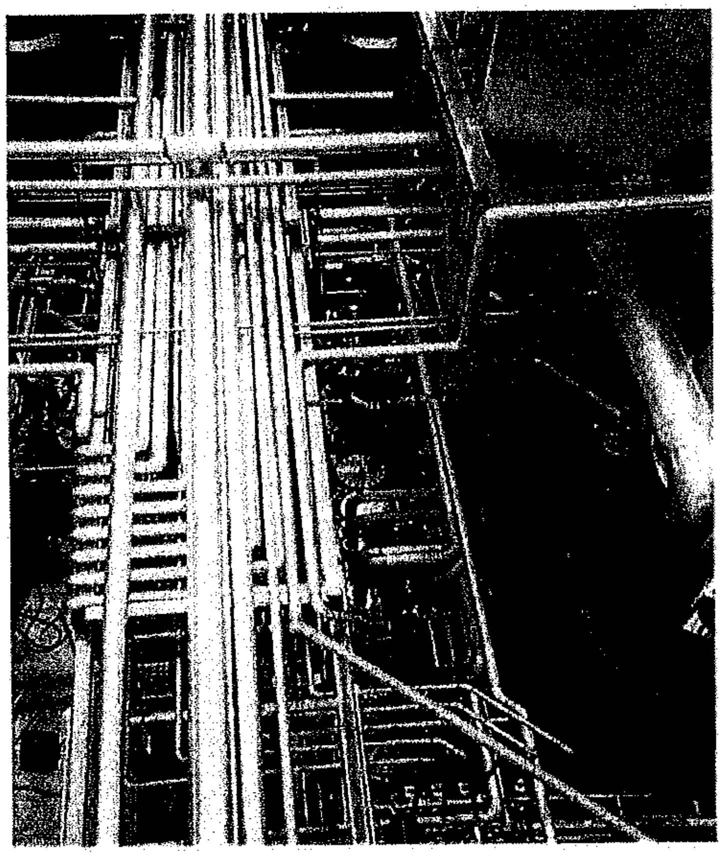
Design, engineered, fabricated and installed.



Above - DBWT - Gear pump skid for Methanol with "zero" emission valves.

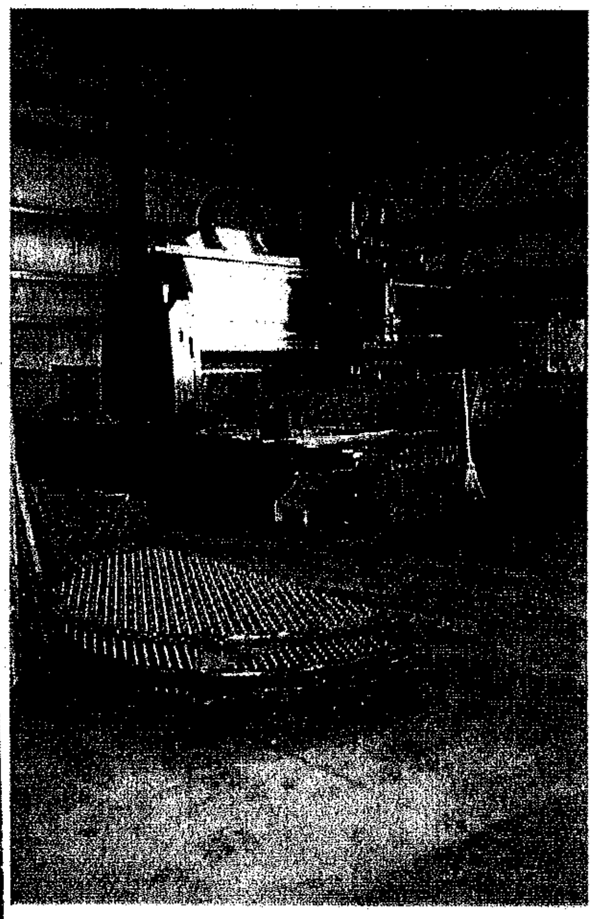


Above - DBWT - Pump modules on cast concrete skids ready for over seas shipment.

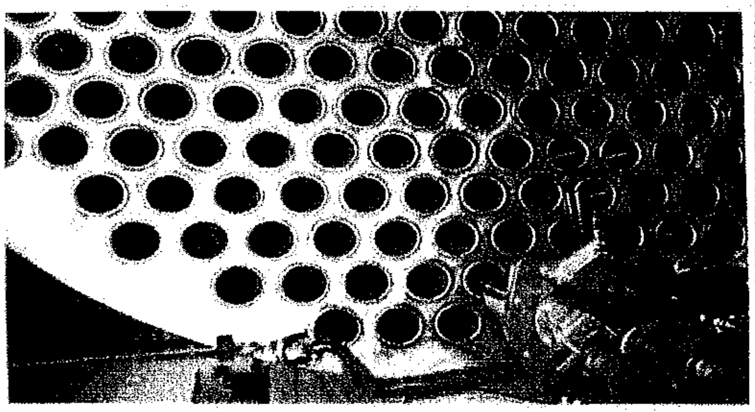


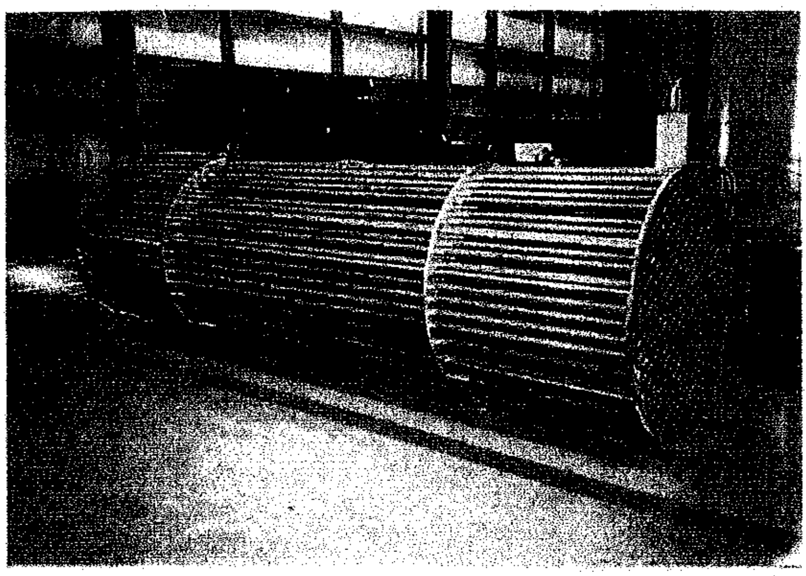
Left - DBWT - Field piping systems designed, fabricated and installed in field.

Tube Bundle Assembly



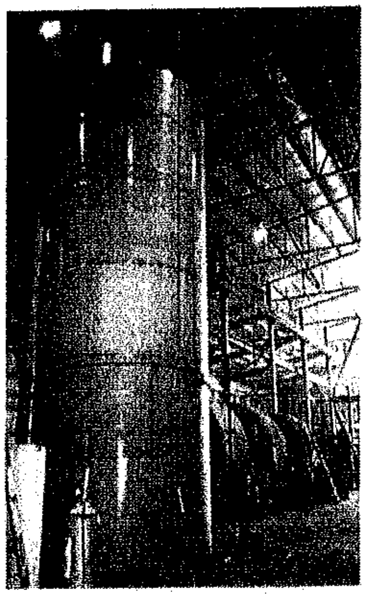
- CNC machining/drilling—the QuickMill can accommodate materials up to 15 feet in width, 16" high, while maintaining an accuracy of .001".
- Orbital, Tube-To-Tube sheet welders increased quality and speed by 200%

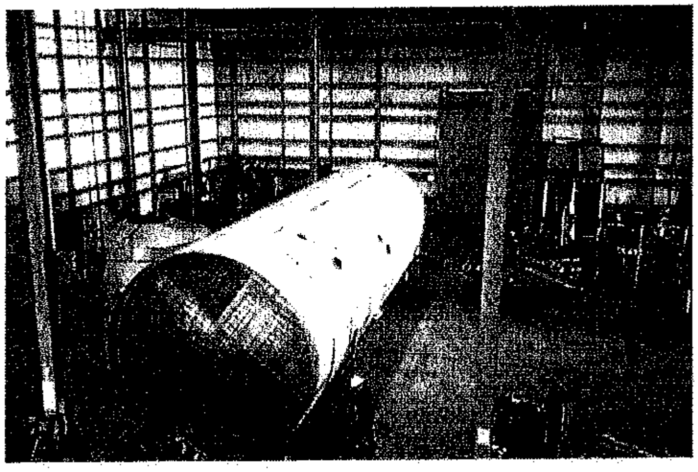




Orbital Tube-to-Tube sheet welders increased quality and speed by 200% with state of the art welding process

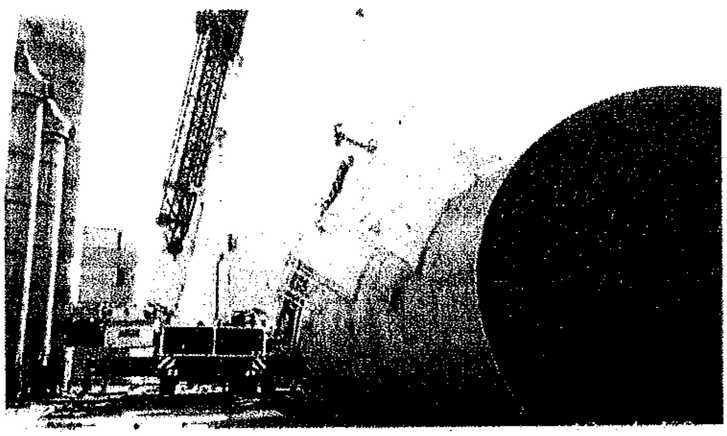
ABSORBER COLUMNS



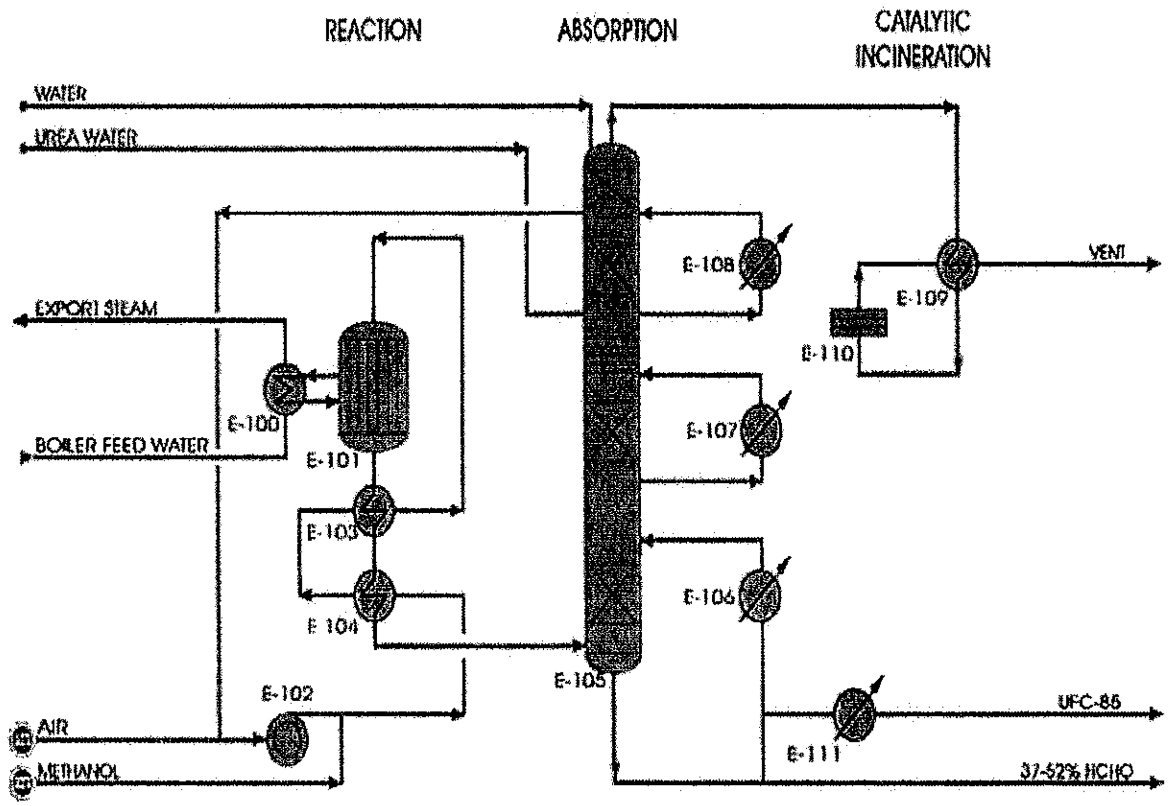


Above: Absorber Tower Assembly process

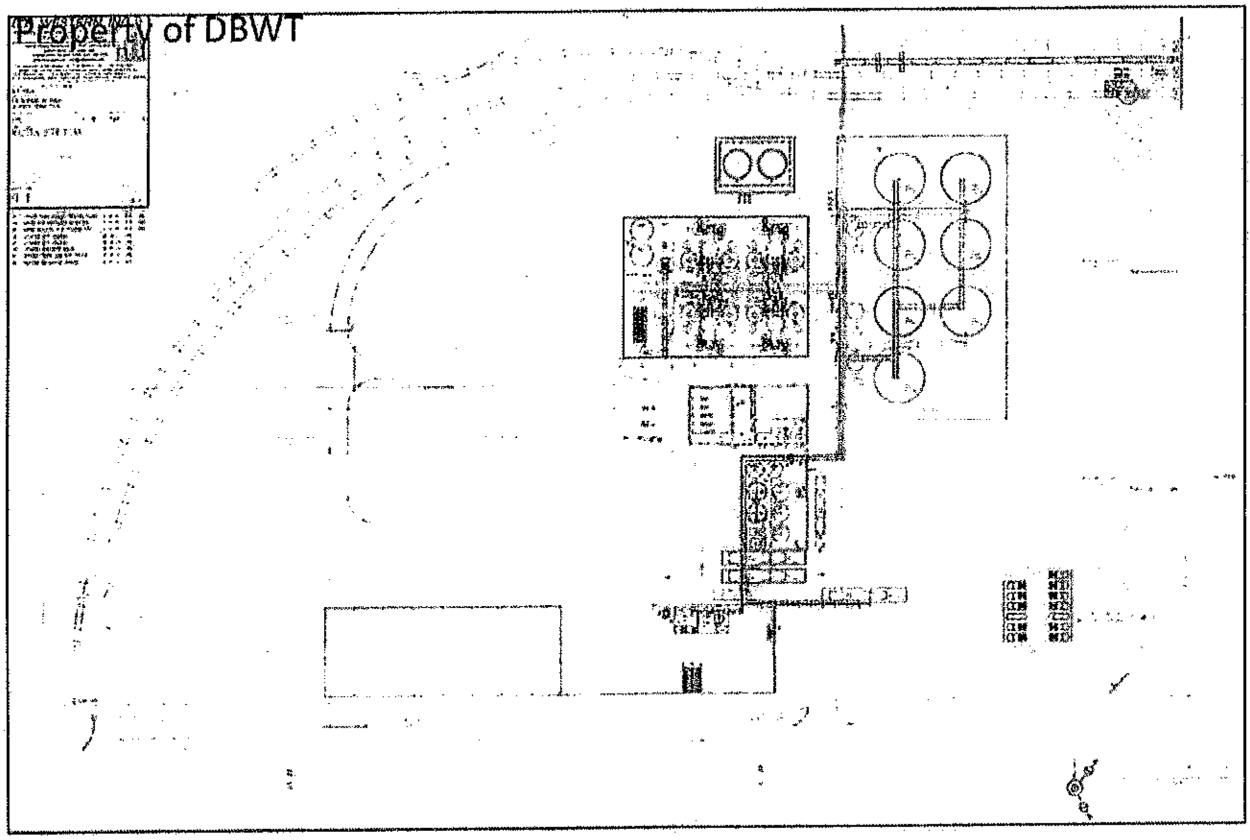
Right: Standing up an Absorber Column in La Porte, TX



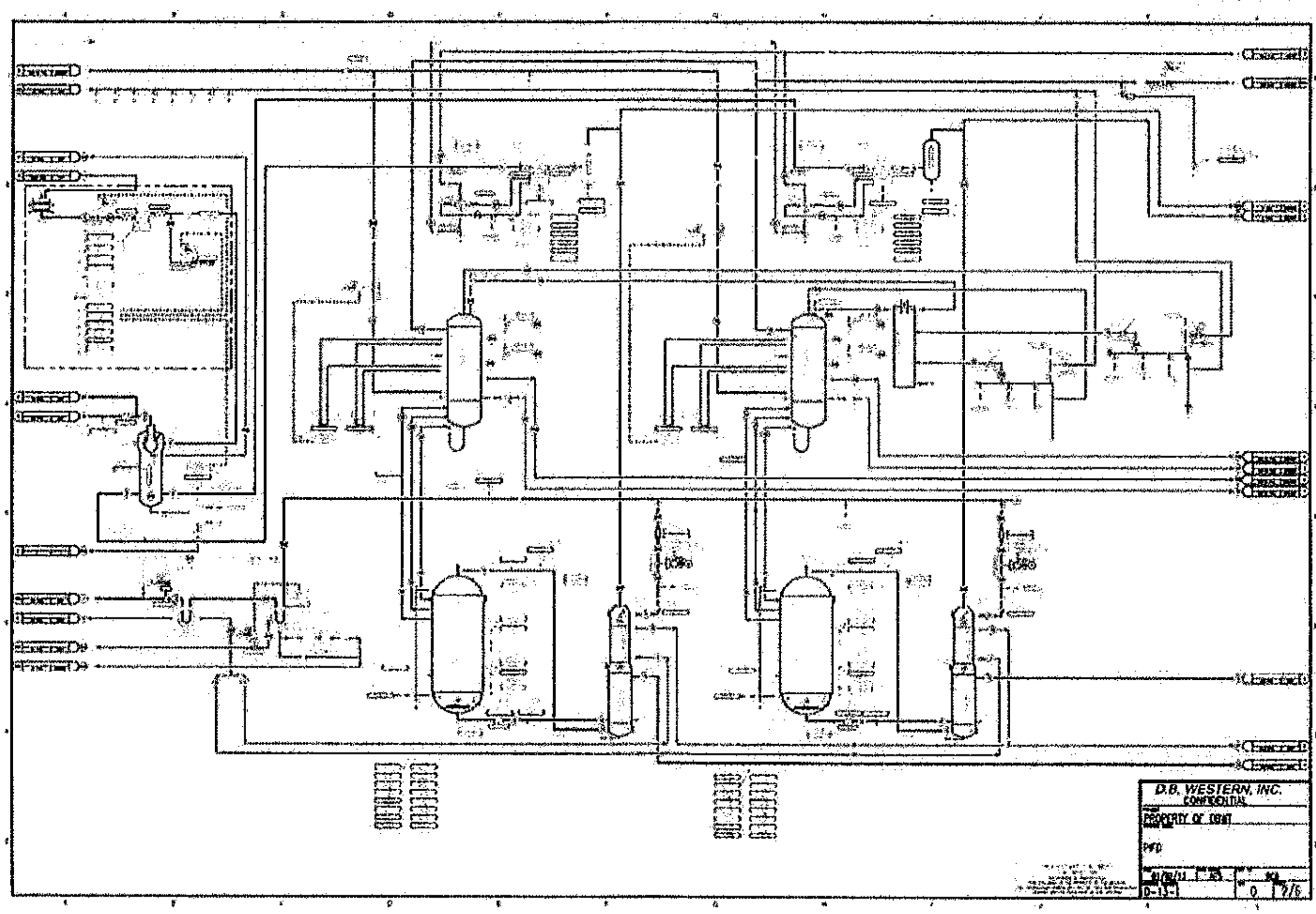
Technology



DBWT - Process, chemical, air quality process diagram for chemical plant operations.



DBWT - $100,000,000 chemical plant in Texas design, engineered, fabricated and installed in 2001. This facility supplies 100% of raw material for Dupont "Spandex" and is owned and operated by DBWT.



DBWT - Developed and patented chemical manufacturing process designs, detailed engineering, and provided turnkey facility installations globally (see list of installations).

DBWT

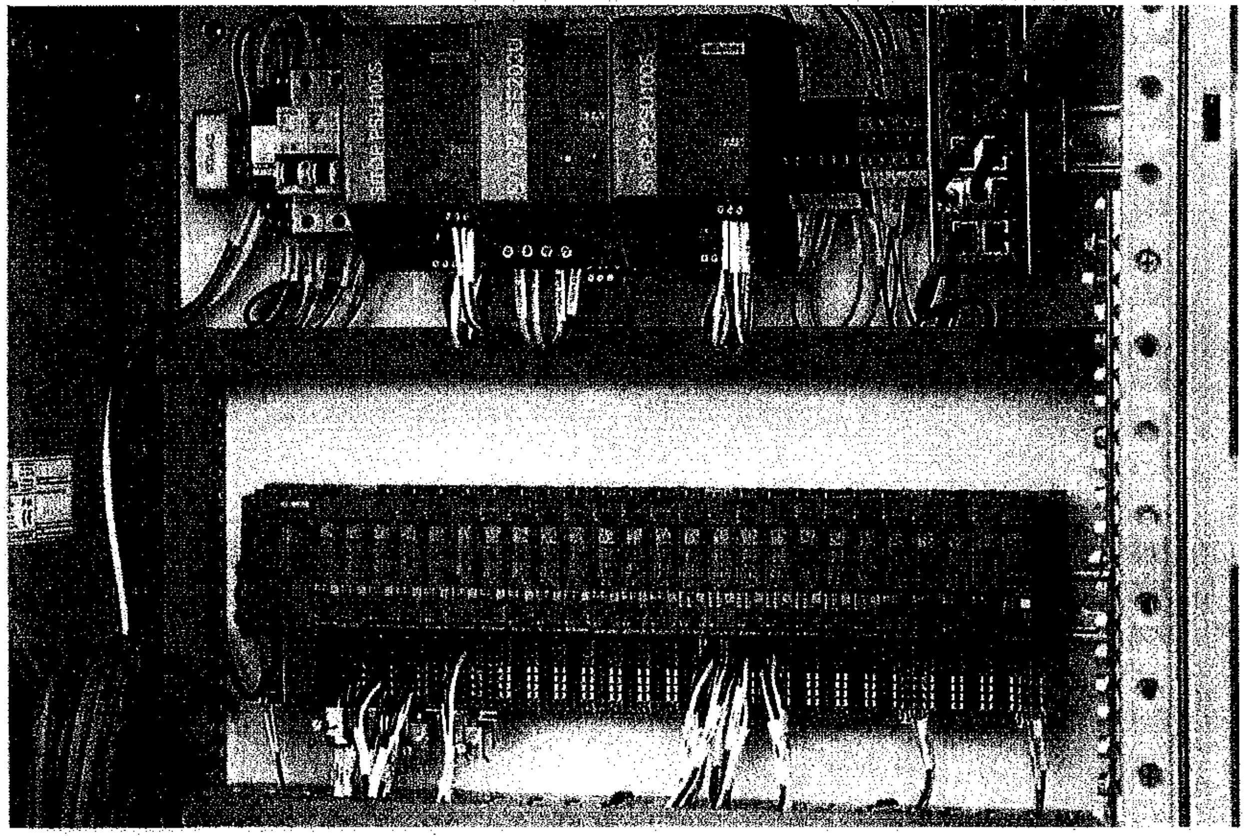
DBWT - Designed the programs, technical formatting, and developed the algorithms for process control. We provide our customers with custom DCS Control Systems including:

Emmerson Delta V

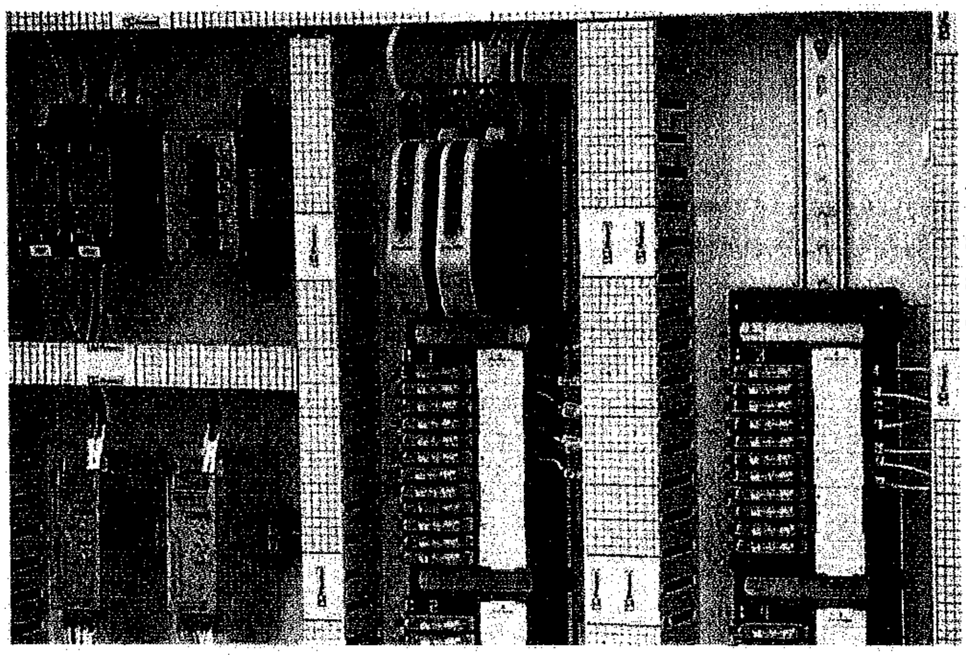
Siemans

Allen Bradley

Honeywell

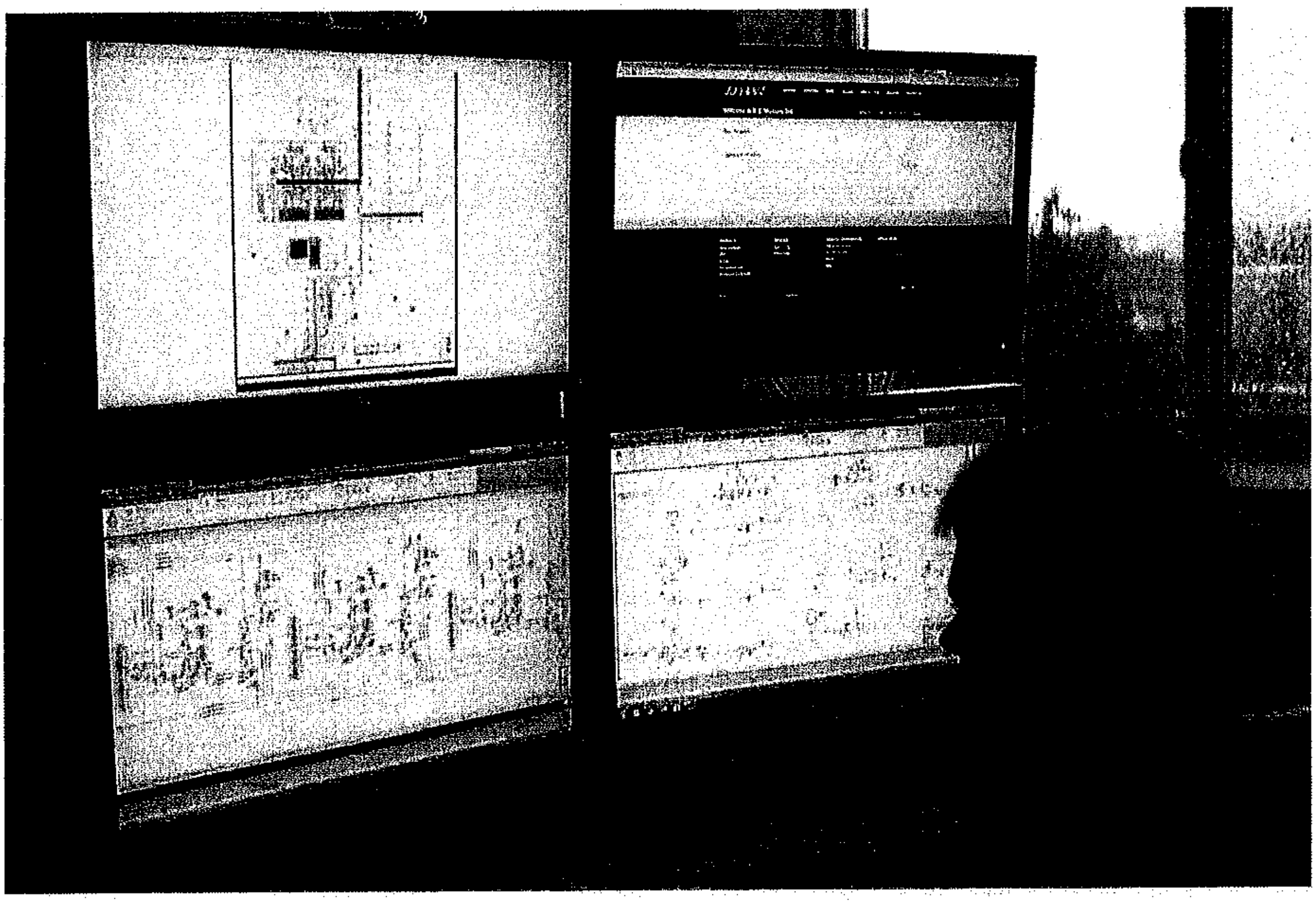


DBWT - Supplies our customers remote I/O in 316 stainless steel panels for distribution throughout the process control systems via either Mod-Bus, Ethernet, or fiber optics.



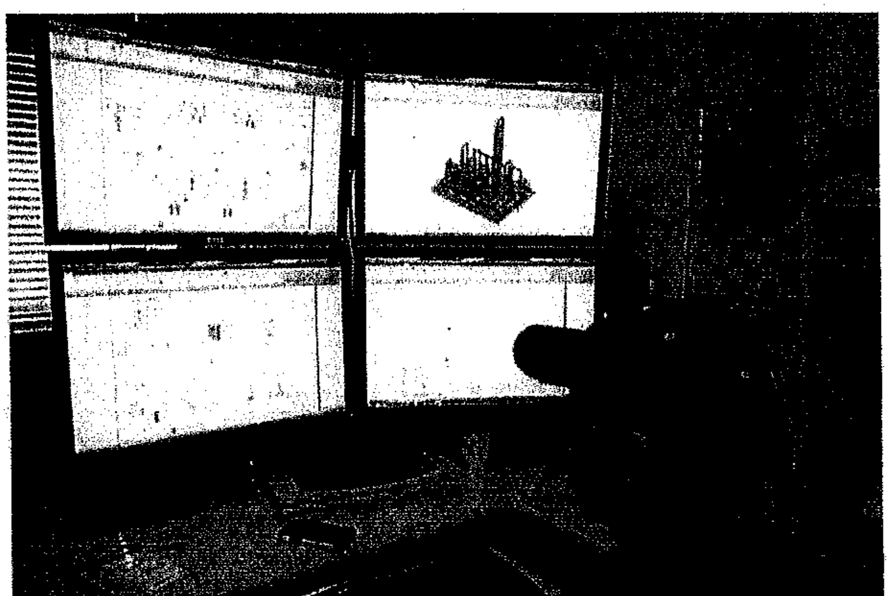
Left - DBWT - Developed several designs for control systems through protective elements and control logic SEL 3.

Design Engineering

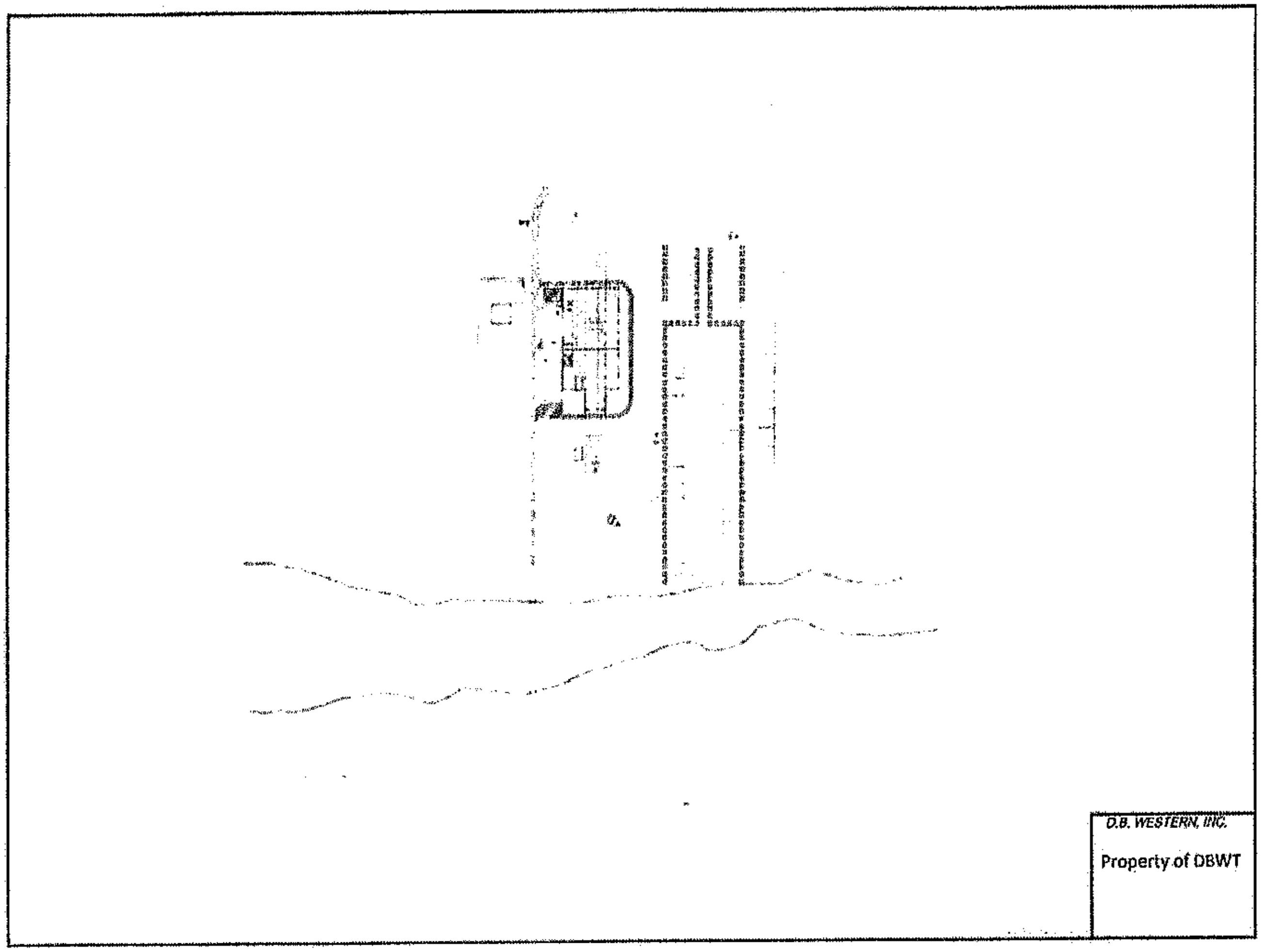


DBWT - Incorporates a broad range of customized computer software programs to enhance its ability in design, engineering & drafting to ensure best value for our clients. Our customized software includes: Auto-Cad 2014, PlantCad 3D, "Compress" for pressure vessels, MasterCam X2 for CNC programming, ChemCad, BJAC/HTRI Heat Exchanger Design, Emmerson Delta V, Honeywell 900, Allen Bradley.

DBWT - Chemical plant constructed in 2000 and retrofitted in 2013 from Honeywell to an Emmerson Delta V system while plant was in operation. New chemical processes were added and implemented in 2011.

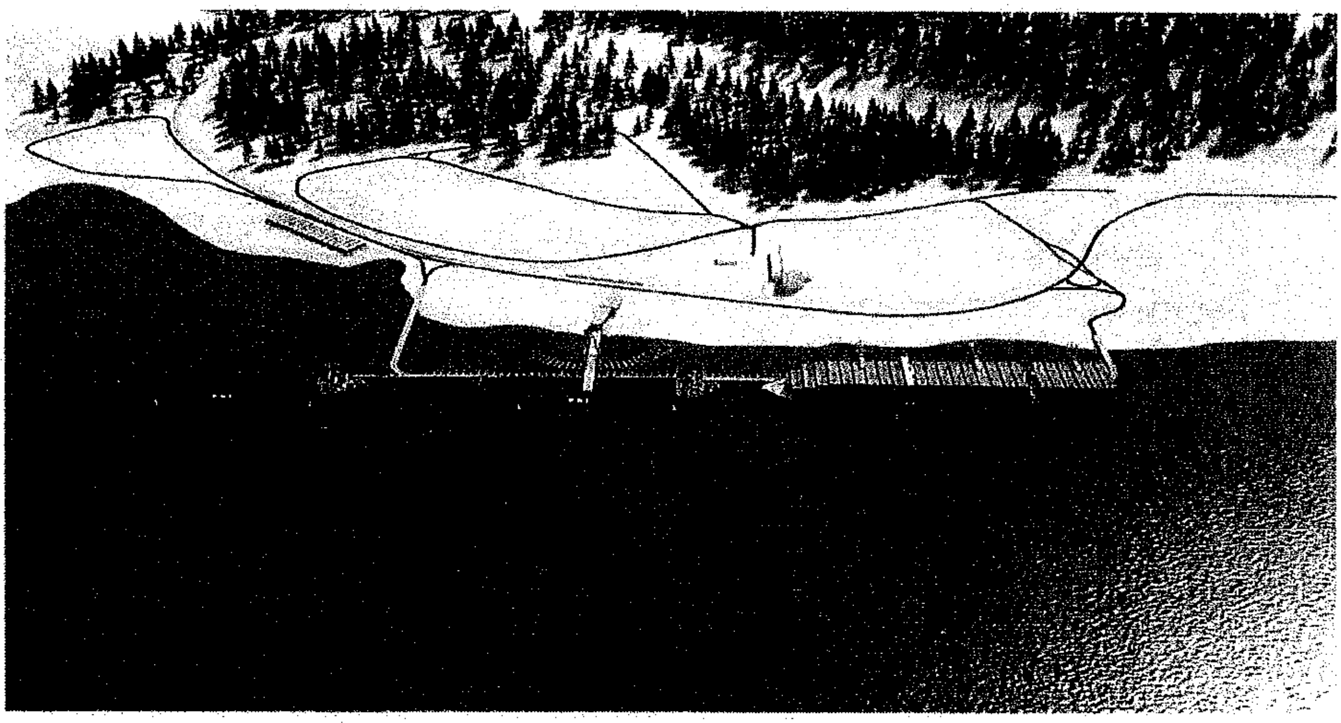


Left - DBWT - Improving process technology from product chemistry through process development, design, fabrication, installation, and start-up.

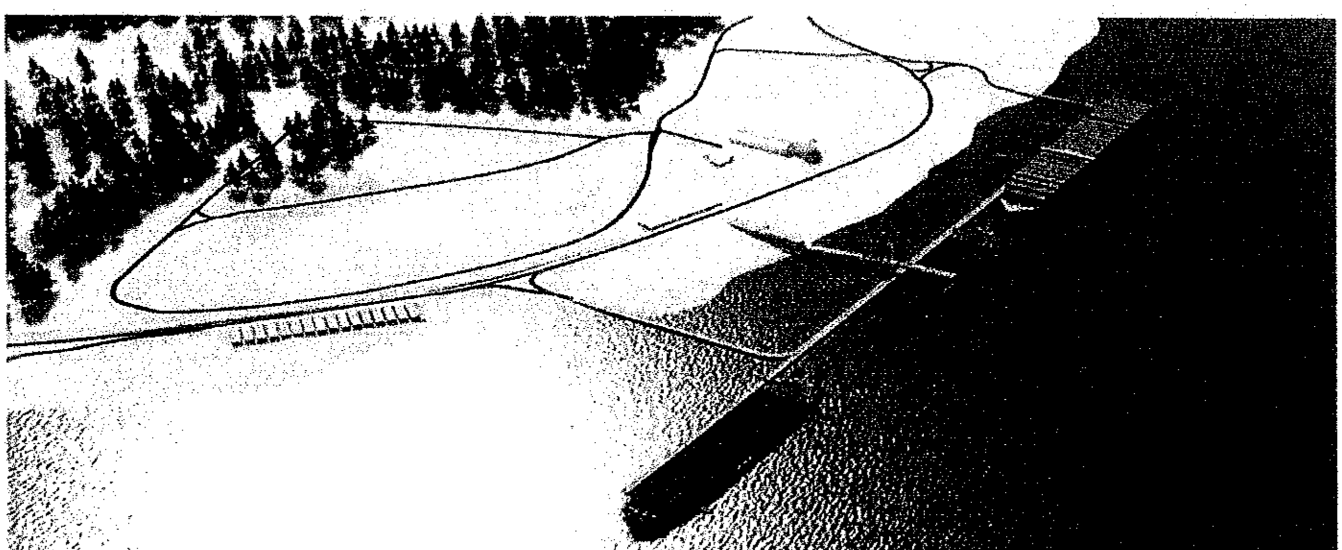


Design for fabrication of 2000T Floating Modules in Graving Dock used for a Wind Energy project.

New Business Development



DBWT - A recognized global leader in the petro chemical industry with a culture of innovation promoting advanced technology, economic sustainability, modeling employee safety, community involvement, education and development. Above is a 3D rendering of a state of the art export Container/Coal Terminal.



DBWT - Top view of 3D rendering of export Container/Coal Terminal.

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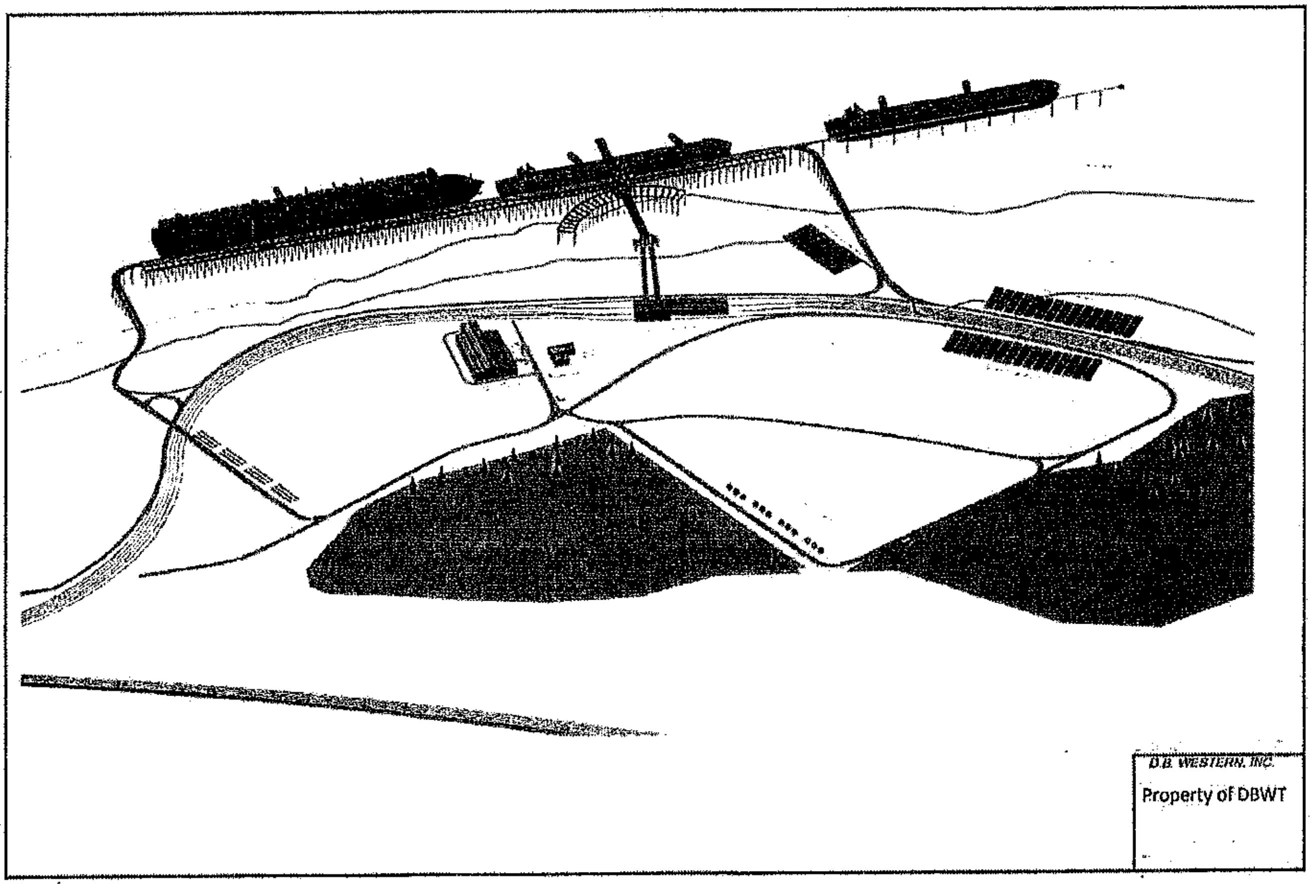
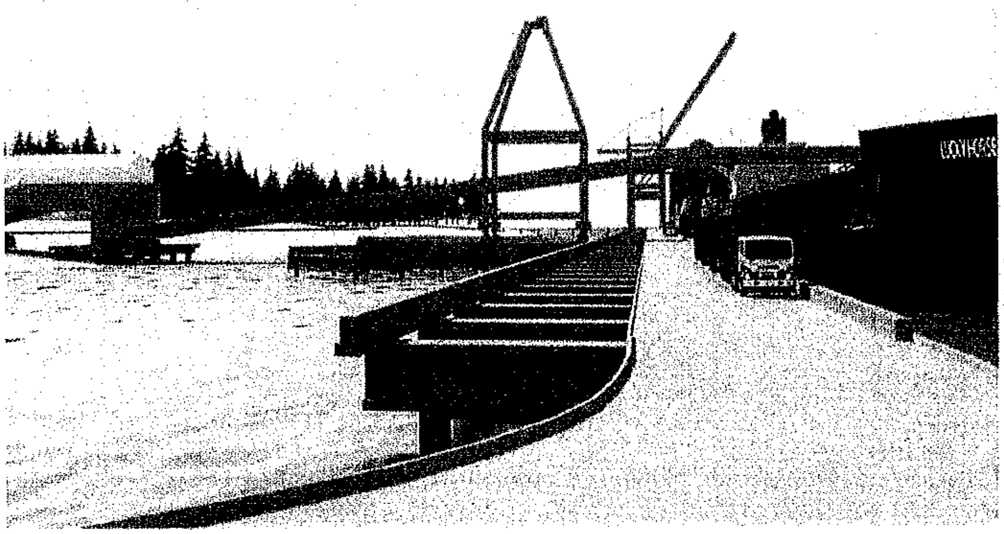
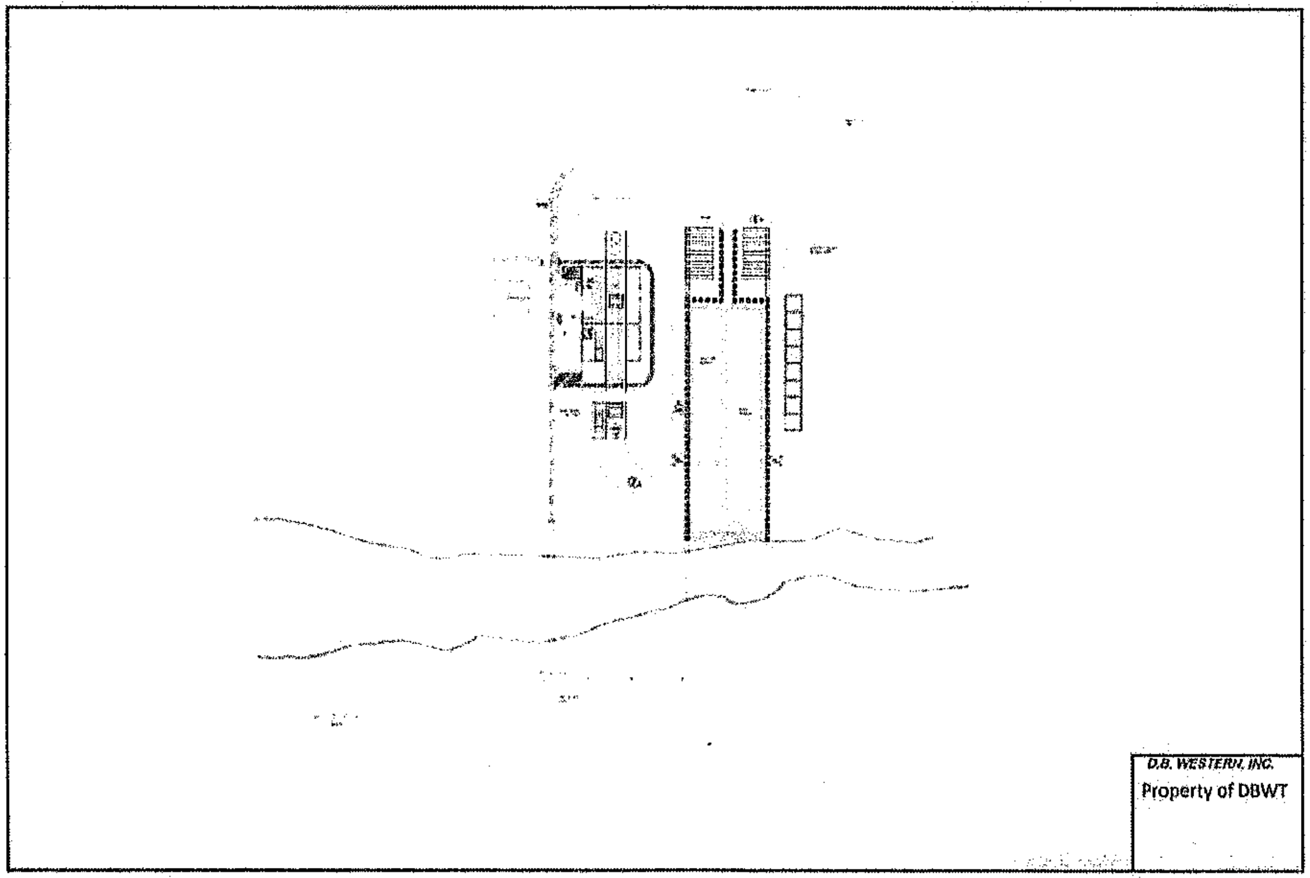


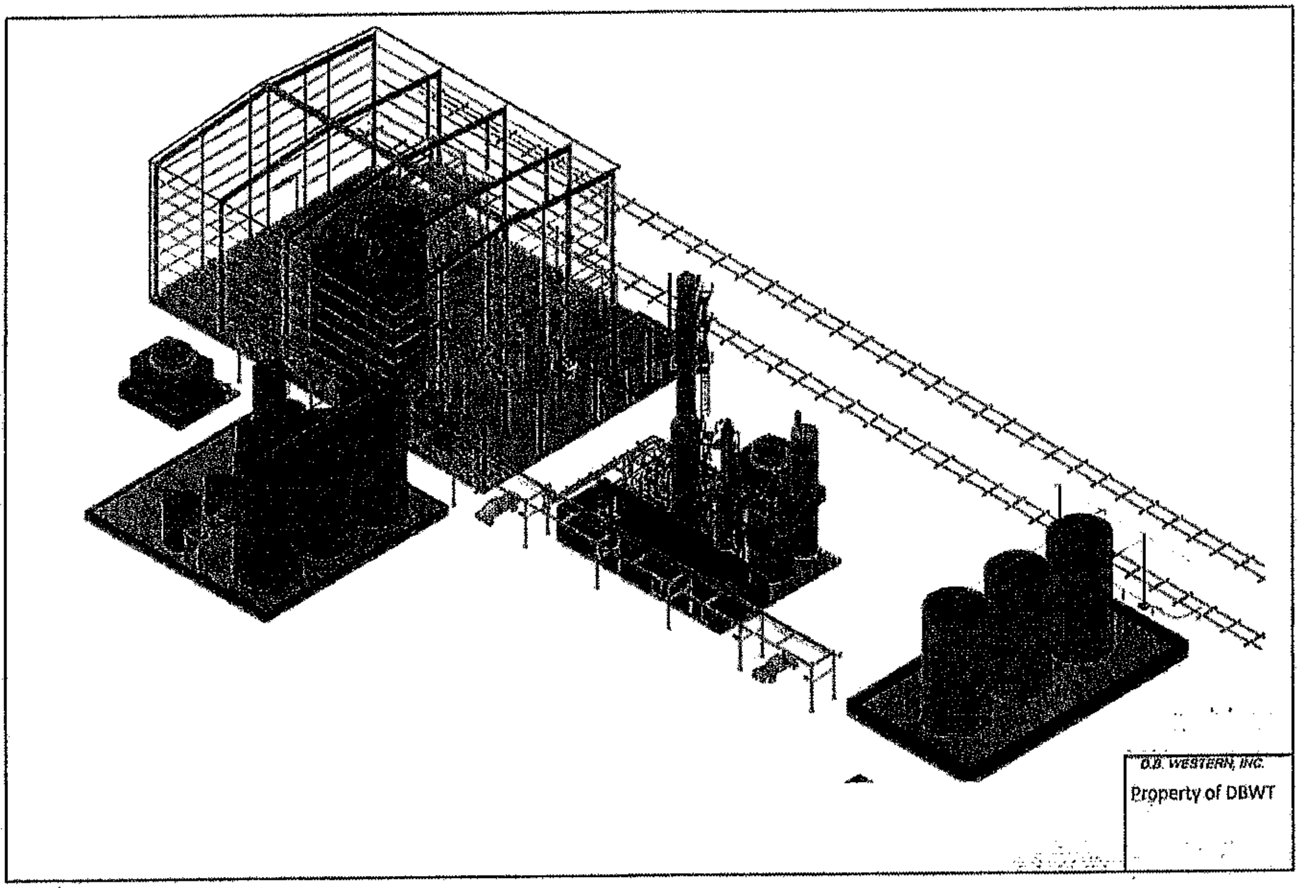
DBWT - Design engineering for a new terminal on the West Coast with 3D rendering in AutoCad. Adjacent container dock with 50,000 mt/yr Powder River Basin coal export.



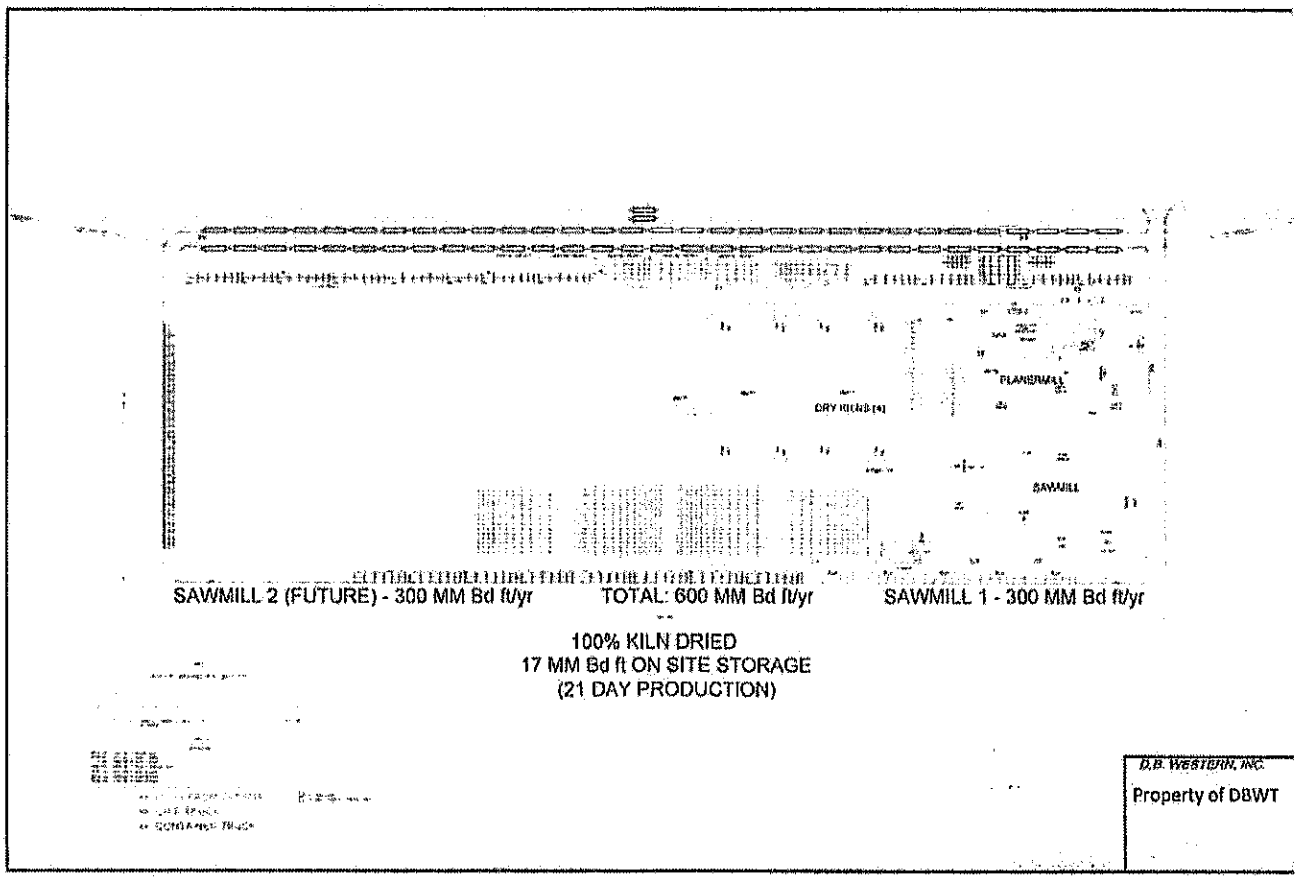
DBWT - Technology design Coal Terminal with rendering.



DBWT - Engineering design of 250ft x 850ft Graving Dock with 24ft draft for barge manufacturing, repair, sandblasting and painting.



DBWT - AutoCad 3D Modeling, design and engineering of a chemical polymer plant in the south east US.



DBWT - Engineered design for a new 600,000,000 bd ft/yr, 100% kiln dried metric lumber for sawmill for China markets utilizing USNR newest advanced technology and engineering.