Wastewater Facilities Plan Update

City of Bay City
PO Box 3309
Bay City, OR 97107

Prepared for:

City of Bay City

December 2019
611013.151

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Phone: (541) 266-9890 **Email:** info@shn-engr.com **Web:** shn-engr.com
275 Market Avenue, Coos Bay, OR 97420-2228

Reference: 611013.151

December 31, 2019

Mr. Chance Steffey, PE
City of Bay City
PO Box 3309
Bay City, OR 97107

Subject: Wastewater Facilities Plan Update

Dear Mr. Steffey:

Enclosed please find three (3) copies of the Draft Wastewater Facilities Plan Update report for your review and comment. Please submit any comments for incorporation into the final draft. We will review the comments and issue reviews or clarification. We anticipate a final report to be presented to the Council once the Plan is complete. Once the plan is adopted, the City can begin its implementation.
Should you have any questions or comments, feel free to give me a call at 541-266-9890.

Sincerely,

SHN Consulting Engineers & Geologists, Inc.

Ron Stillmaker, PE
Regional Principal

RFS: dkl

Enclosures: Three (3) copies Wastewater Facilities Plan Update

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Reference: 611013.151

Wastewater Facilities Plan Update

Prepared for:

City of Bay City
PO Box 3309
Bay City, Or 97107

REGISTERED PROFESSIONAL ENGINEER
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JULY 17, 1981
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EXPIRES: 06-30-20

Prepared by:

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December 2019

QA/QC:

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Table of Contents

List of Illustrations

Figures **Page**

Tables **Page**

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Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
edu	equivalent dwelling units
gpd	gallons per day
gpad	gallons per acre per day
gpcd	gallons per capita per day
gpm	gallons per minute
in	inches
fsp	feet per second
ft	feet
hp	horsepower
hz	hertz
lf	lineal feet
m	meters
mgd	million gallons per day
mg/L	milligrams per liter
ml	milliliters
rpm	revolutions per minute
su	standard pH units
v	volt
yr	year

AAF	annual average flow
ADF	average daily flow
ADWF	average dry weather flow
AWWF	average wet weather flow
Bay City	City of Bay City
BOD	biochemical oxygen demand
BSF	base sanitary flow
CBOD	Carbonaceous Biochemical Oxygen Demand
CCTV	closed circuit television
CDBG	Community Development Block Grant
CFR	Code of Federal Regulations
CIP	Capital Improvement Plan
CIPP	cured-in-place pipe
CMC	Criteria Maximum Concentration
CWA	Clean Water Act
DEQ	Oregon Department of Environmental Quality
DMR	daily monitoring report
EDA	Economic Development Administration
EDU	equivalent dwelling unit
ENR	Engineering News Record
EPA	Environmental Protection Agency
F/M	food to microbe ratio

Acronyms and Abbreviations, Continued

FELL	focused electron leak locator
FOG	Fats, Oils, and Grease Program
FSL	facultative sludge lagoon
FTE	full time equivalent
GIS	geospatial information system
GO	general obligation bonds
GWI	groundwater infiltration
H_2S	hydrogen sulfide
HDPE	high density polyethylene
HUD	Housing and Urban Development
I/I	infiltration and inflow
ID/SC	influent distribution/sludge collection
IDM	inch diameter miles
IFA	Infrastructure Finance Authority
IPS	influent pump station
IRS	Internal Revenue Service
LF	lineal feet
LID	Local Improvement District
Mgal	million gallons
MGD	million gallons per day
MHHW	mean higher high water
MHI	median household income
MLW	mean low water
MMDWF	maximum month dry weather flow
MMWWF	maximum month wet weather flow
MSL	mean sea level
NAVD88	North American Vertical Datum of 1988
NBOD	nitrogenous biochemical oxygen demand
NCEI	National Centers for Environmental Information
NA	not applicable
ND	not determined
NM	not measured
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NR	not required
O&M	operations and maintenance
OAR	Oregon Administrative Rules
OBDD	Oregon Business Development Department
OCCRI	Oregon Climate Change Research Institute
ORS	Oregon Revised Statute
PIF	peak instantaneous flow
PPD	pounds per day
PS	pump station
PSIG	pounds per square inch gauge

Acronyms and Abbreviations, Continued

PVC	polyvinyl chloride
PWF	peak week flow
RII	rainfall induced infiltration
RUS	USDA Rural Utilities Service
SBR	sequencing batch reactor
SCFM	standard cubic feet per minute
SDC	system development charge
SELP	Small-Scale Energy Loan Program
SDWA	Safe Drinking Water Act
SHN	SHN Consulting Engineers & Geologists, Inc.
SPWF	Special Public Works Fund
SSCS	sanitary sewer collection system
SSES	sanitary sewer evaluation survey
SSO	sanitary sewer overflows
TAG	technical assistance grant
TKN	total kjeldahl nitrogen
TSS	total suspended solids
UBO	ultimate build out
UGB	urban growth boundary
USDA	United States Department of Agriculture
UV	ultraviolet
VFD	variable frequency drives
WAS	waste activated sludge
WWFP	wastewater facilities plan
WWSRF	Wastewater State Revolving Fund
WWTP	wastewater treatment plant

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Executive Summary

Introduction

The City of Bay City owns and operates the wastewater system including the sanitary sewer collection system, wastewater treatment facility, and wastewater discharge outfall. The wastewater system serves customers within the incorporated area of the City limits along with a few customers immediately outside the City limits.

The purpose of this Wastewater Facilities Plan Update is to update the plan that was published in 2010 with more recent population and growth projections, and to update project recommendations and cost estimates for repairing and upgrading the wastewater collection and treatment systems for the remainder of the planning period ending in 2040. Additional sewer inspections have occurred since 2010 that introduce new information for assessing sewer repair project prioritization and cost.

Areas of this plan that have not changed significantly since 2010 refer back to the original plan published in 2010 (HBH, 2010). Areas of the plan that have changed, such as population and cost, have been re-evaluated and updated with more recent estimates.

Existing Collection System

City of Bay City serves an area of approximately 755 acres. Within this area, the City has constructed and maintains approximately 11.6 miles of gravity pipelines, 0.1 miles of force main piping, 223 sanitary manholes, and one lift station. The inventory of the collection system ranges in size from 6-inch to 18-inch diameter pipe for the gravity system and 4-inch pipe for the lift station pressure pipe.

The primary pipe type in the collection system consists of bell and spigot concrete pipe that was installed in the 1970s to replace onsite septic systems. The concrete pipe has rubber gasketed joints and original lateral connections were completed with factory made taps. Newer sewer mains and spot repairs have been constructed with poly vinyl chloride (PVC) materials. The newer construction and repairs are minimal compared with the existing installed length and the PVC component comprises approximately 9 percent of the total system.

Most likely due to the age and materials used in the existing collection system this study has identified the system as experiencing an excessive amount of both Inflow and Infiltration. Five peak flow days were selected for review by this study based on high flow rates, high levels of precipitation, and preceding wet conditions. Each event exceeds the Environmental Protection Agency (EPA) criteria for excessive inflow of 275 gallons per capita per day (gpcd), with the lowest value (1,038 gpcd) being approximately 3.7 times greater than the threshold. The average over all five periods is 1,100 gpcd, four times the EPA threshold for excessive, indicating that Bay City has an excessive inflow problem. Based on estimates for groundwater infiltration, Bay City has excessive infiltration according to the EPA criteria. The average infiltration over all periods observed during this study is 254 gpcd, over twice the EPA criteria for excessive infiltration.

The City of Bay City has one lift station associated with the collection system. The Downtown Lift Station is a relatively small installation serving approximately 19 percent of the installed sewer lines within Basin 1. The tributary area to this lift station is the northwest corner of the basin which is relatively flat and low lying compared with the remainder of the basin. This lift station was originally constructed in 1971 and the pump motors were rebuilt in 2008. Other than routine maintenance, no major modifications have been completed. While the pumps for this station are rated at pumping 100 gallons per minute (gpm), recent "draw down" tests indicate pumping capabilities of 22 gpm and 18 gpm for the pumps. This deficiency may be attributed to build up of corrosive materials restricting the discharge force main.

The sanitary sewer collection system appears to be in adequate structural condition; however, inspections have identified a variety of defects and sources of infiltration and inflow (I/I) that are allowing extraneous water into the system. This extraneous flow contributes to high wet weather flow peaks and results in treatment and pumping inefficiencies and loss of treatment and conveyance capacity. The existing pump station and force main within the collection system is nearly over capacity for existing wet weather flows and should be replaced to improve capacity and safety. Several sewer mainline segments appear to be undersized for the ultimate buildout flow projections; however, rerouting and/or I/I reduction efforts may alleviate these issues. Because of the age of the system, and the quantity of extraneous flows, systematic rehabilitation of problem areas is recommended.

A capacity analysis of the collection system was performed in the previous facility plan. Based on the limited population growth from the time of the previous plan to present, the general analysis is assumed to be still relevant. In the previous analysis, the majority of pipe segments were deemed to have sufficient hydraulic capacity to meet current and future needs; however, 11 pipe segments extending from MH1 to MH12 were identified as being undersized for the ultimate build out flow projections at the peak instantaneous flow.

Based on the inspections completed for this Plan and other annual efforts, the typical defects in the sanitary sewer collection system include:

- Aging and capacity limited Downtown Lift Station
- Capacity limited pipes (MH1 – MH12)
- Cross-connections
- Uncapped cleanouts
- Leaky manhole joints and covers
- Poor lateral taps
- Leaky lateral pipelines
- Leaky pipe joints
- Structural defects
- Root intrusion

Existing Treatment System
The Bay City WWTP currently consists of an influent pump station (IPS), a high flow equalization basin, a grinder, two sequencing batch reactor (SBR) basins, an aerobic digester, a facultative sludge lagoon, an ultraviolet (UV) disinfection system, and an effluent discharge outfall pipe leading into Tillamook Bay. The current NPDES permit requires the facility to recirculate effluent within the WWTP when there is less than 2 feet of Bay water over the outfall (the outfall lies in the intertidal zone where tide waters rise and fall above and below the outfall).

The system, as originally designed, has a stated hydraulic design capacity of 1.40 million gallons per day (MGD; peak instantaneous flow rate), with average biochemical oxygen demand (BOD) and total suspended solids (TSS) design loading capacities of 616 pounds per day (ppd) each. Hydraulic capacity of the system was exceeded on four occasions between the years 2009-2017. During these periods, the equalization basin was used to store peak flows above the hydraulic capacity of the WWTP.

The original wastewater treatment plant (WWTP) was constructed in 1971 and consisted of two ponds, the current equalization pond and facultative sludge lagoon. Beginning in 1995, the system received an upgrade to include the components described above. Since 1995, with the exception of an upgrade of the UV system, no significant renovations have occurred to the existing WWTP.

The general condition of the WWTP is fair to good. The system is approximately 24 years old and much of the equipment is nearing its design life expectancy, thus requiring more frequent maintenance. The projected treatment capacity requirements for the WWTP will meet or exceed the design capacity of the existing system within the planning period.

The following deficiencies with the WWTP have been identified through this study:

- Insufficient pumping capacity in the IPS.
- Grit in system reduces equipment life and increases maintenance frequency.
- Insufficient peak flow treatment capacity in SBRs.
- SBR #1 discharge valve malfunctions.
- Differential treatment capacity in each SBR unit.
- Blowers do not have automated air controls.
- Difficulty meeting solids treatment requirements.
- Rip-rap on Bay side of levees is decaying.

Existing Treated Effluent Outfall

After UV disinfection, treated effluent is discharged to Tillamook Bay through the City's 16-inch gravity outfall. The City may only discharge effluent if the water surface in Tillamook Bay is a minimum of two feet above the City's outfall per NPDES requirements. If the level of water above the outfall is less than 2 feet, recirculation is required through the overflow to the facultative sludge lagoon (FSL).

The existing outfall is located approximately 2,000 feet north of Goose Point on the east side of the Bay. The outfall pipe extends approximately 1,250 feet from the eastern shoreline into the Bay, situated in what was once a shallow channel, serving Doty Creek. The Doty Creek channel, when the outfall was planned and installed, was approximately 2-3 feet deep at Mean Low Water. Storm events within the area have relocated that channel closer to the shoreline and the outfall diffuser is currently inundated with sediment and discharges in a "bubble-up" fashion into adjacent mud-flats. When exposed at lower tides, effluent flows across the mud flats as it makes its way back to the channel.

Recommended Collection System Improvements

To address excessive I/I the City needs to initiate a rehabilitation program for its aging concrete sewer pipes. With advances in trenchless technologies, it is anticipated that the majority of the concrete sewer line renovations can be accomplished through installation of cured-in-place pipe (CIPP) system. This method of rehabilitation results in a sealed system without the need for major "dig and replace" operations. Typically, CIPP projects cost about half as much as direct burial replacement work and results in a water-tight, 50 plus year lifetime system.

For the systematic elimination of I/I, rehabilitation of an entire basin at a time is preferred because projects can be monitored for effectiveness and methods can adjusted as needed. However, prior to performing a CIPP project, a more comprehensive Sewer System Evaluation Survey (SSES) will need to be performed to identify the most cost-effective locations and sequencing for focusing sewer rehabilitation efforts.

Total estimated costs for renovating the City's concrete pipe system are approximately $15.4 million; however, as previously stated, rehabilitation may be performed in phases with one basin targeted at a time and through a more focused approach defined by an SSES. Estimated costs for a comprehensive SSES are approximately $85,000.

The Downtown Lift Station requires improvements and an increase in pumping and wet well capacity. This study recommends the construction of a new pump station adjacent to the existing station. It appears that the force main servicing this station may need to be replaced immediately, which could prolong the life of the existing station. However, due to age and other identified deficiencies, the pump station will have to ultimately be replaced in the near future. The cost for the pump station/force main component of the project is estimated at approximately $828,000. In the design phase of the new station installation project, the existing pump control building with back-up generator may be evaluated for reuse.

Installing a new line intercepting flow from Basins 1 and 2 will eliminate capacity restrictions and sanitary sewer overflow issues in the lower end of the collection system (MH1 – MH12). Costs for constructing the new bypass is estimated at $282,000.

Recommended Treatment System Improvements

The IPS needs to be relocated in order to construct a headworks facility upstream due to limited space availability near the current IPS. Moving the IPS nearer to the SBRs will allow placement of a headworks upstream. Due to the conflict between the rim elevation of MH1 and the high-water overflow to the surge basin, sanitary sewer overflows (SSOs) occur at MH1. Relocating the IPS will alleviate this problem. The existing IPS should be converted into a lift station and the new IPS can be plumbed into the collection system via an underground gravity line running beneath Highway 101 from Basin 2. This will re-route a major portion of the collection system directly to the new IPS and will have the added benefit of alleviating capacity restrictions in the lower end of the gravity collection system. Basins 3 and 4 will then drain to the existing IPS which will be converted to a lift station that will pump to the new IPS, and Basins 1 and 2 will drain to the new IPS directly. A preliminary construction cost estimate for relocating the IPS is $1,398,000.

It is recommended that a new head works structure which contains a mechanical screening and degritting system be installed to replace the influent grinder for primary treatment. This project replaces the grinder with industry standard primary treatment equipment to improve secondary treatment efficiency, reduce maintenance costs, and increase the life of downstream equipment. A preliminary construction cost estimate for installing new head works is $2,142,000.

Upgrading the existing secondary treatment system may be necessary if influent loading (hydraulic and organic) cannot be reduced. Influent loading may be reduced through improvements to the collection system, and more efficient management of peak flows diverted to the surge basin. Diversion of influent to the surge basin during peak flows may be reduced with collection system improvements and IPS upgrades. However, increasing the pumping capacity of the IPS may result in decreased performance of the SBRs. If the influent loads cannot be reduced, it may be necessary to upgrade the SBRs. A preliminary construction cost estimate for upgrading the SBRs is $2,068,000.

Due to the location of the existing outfall site being in the mud flats and buried due to observed channel migration, a new outfall is proposed to be located approximately 4,500 feet northwest of the existing outfall, in the upper reach of the Bay City channel, on the eastern side of mid bay, between Sandstone Point and Goose Point. This location is intended to situate the outfall diffuser in a deeper, more stable channel within the Bay. A preliminary construction cost estimate for relocation of the outfall is $3,907,800.

A summary of all estimated improvement costs is presented in Table 35, Section 8.3.

Funding Recommendations

This Wastewater Facilities Plan outlines a plan for all necessary improvements, which represent a significant investment for the City. Those improvement projects identified as high priority projects and are recommend for City actions total in excess of approximately $9.2 million. Therefore, a strategy and plan for financing the recommended improvements was developed.

While the financing package that the City will ultimately utilize depends on the results of coordination with the various funding agencies, a financial strategy to address financing of the Phase I Improvements within the Capital Improvement Plan is discussed below.

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1.0 Introduction, Purpose, and Need

1.1 Introduction

The City of Bay City (Bay City), an incorporated City in Tillamook County, Oregon, located on the shores of Tillamook Bay, approximately 80 miles west of the Portland (Figure 1). Bay City owns and operates a sanitary sewage collection, treatment, and disposal system providing services to businesses and citizens of Bay City. The Bay City wastewater system was constructed in 1970 to replace on-site septic tanks and drain field systems, and includes a sanitary sewer collection system (SSCS), one pump station and force main, a wastewater treatment plant (WWTP), and an outfall pipe that discharges treated municipal wastewater into Tillamook Bay in accordance with a National Pollutant Discharge Elimination System (NPDES) permit (OR-002257-8) issued by the State of Oregon Department of Environmental Quality (DEQ).

1.2 Study Objective

The primary purpose of this wastewater facilities plan (WWFP) update is to update the wastewater system evaluation completed in 2010 by HBH Consulting Engineers (HBH, 2010). This WWFP update examines how the Bay City wastewater system can support the current and projected needs of the City through the year 2040, and to assess recommended improvements to the system to meet current and future user and regulatory requirements. Additional SSCS investigations including smoke testing, closed circuit television (CCTV), and electro-scan inspections have been conducted and are used to update recommendations for improvements to the SSCS. The SSCS evaluation includes an assessment of infiltration and inflow (I/I) in the collection system and whether or not the collection system infrastructure is capable of supporting expansion areas inside the City urban growth boundary (UGB).

The WWTP evaluation includes an assessment of critical pumping facilities, primary and secondary treatment systems used to meet NPDES discharge requirements, and an evaluation of the outfall pipe used to discharge treated effluent to Tillamook Bay including a mixing zone study required by the DEQ as a provision for NPDES permit renewal.

This study has also been performed to: *"Fulfill the engineering planning document requirement of the Clean Water State Revolving Fund, Oregon Infrastructure Finance Authority, and USDA- Rural Development."*

1.3 Previous Planning Efforts

In October of 2010, HBH Consulting Engineers prepared a Wastewater Facilities Plan for the City. Appendix 4 contains the Table of Contents related to the 2010 plan. This Plan updates the following sections of the previous plan:

2010 Plan	2019 Update
Section 1 Executive Summary	Executive Summary
Section 2 Introduction	1.0 Introduction, Purpose and Need
Section 3 Study Area Characteristics	2.0 Study Area Characteristics
3.1 Study area	Unchanged
3.2 Physical Environment	Unchanged
3.3 Economic Environment	Unchanged
3.4 Land User Regulations	Unchanged

3.5 Population and Growth	2.5 Population and Growth
Section 4 Wastewater Characteristics	3.0 Wastewater Characteristics
4.1 Existing Wastewater Flows	3.1 Wastewater Flows
4.2 Wastewater Composition	3.2 Wastewater Composition
4.3 Projected Wastewater Characteristics	
4.3.1 Projected I/I Related Flows	3.1.3.10.1 Projected I/I Flows
4.3.2 Projected Wastewater Flows	3.1.3.10 Projected Wastewater Flows
4.3.3 Projected Wastewater Composition	3.2.5 Design Loads
Section 5 Existing Wastewater Facilities	4.0 Existing Facilities
Section 6 Basis of Planning	5.0 Design Criteria
6.1 Basis for Design	5.2 Collection System 5.3 Treatment System
6.2 Basis for Cost Estimates	6.0 Basis for cost estimates
6.3 Water Quality Impact	2.4 Receiving Waters
6.4 Design Capacity of Conveyance System and WWTP	5.2 Collection System 5.3 Treatment System
Section 7 Development and Evaluation of Alternatives	7.0 Development and Evaluation of Alternatives
Section 8 Rate Study	
8.1 Estimated O, M & Replacement Costs	8.5 Financing Strategy
8.2 Evaluation of Local Funding Resources	8.4.2 Potential Financing Options
8.3 Evaluation of Federal and State Funding Resources	8.4.2 Potential Financing Options
8.4 Recommended Rate structure & Financing Strat	8.5 Financing Strategy
Section 9 Recommended Plan	8.0 Recommended Plan
Section 10 Preliminary Environmental Review	Unchanged

1.4 Scope of Study

Preparation of this wastewater facilities plan update is based on five general tasks:

Task 1 - Planning and Background: Identify recommendations from the previous wastewater facilities plan (HBH, 2010) that need to be updated to include more recent findings.

Task 2 - Collection System Evaluation:

- Review previous recommendations for SSCS improvements.
- Collect and analyze data pertaining to population and flows and compare with prior recommendations.
- Evaluate the potential impacts of expansion on the existing system.
- Evaluate pump station condition.

City of Bay City
Wastewater Facilities Plan Update
Bay City, Oregon

Site Location

SHN 611013.151

December 2019 | 611013-151-WWFPU-FIGS | Figure 1

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- Evaluate deficiencies with the existing system.
- Evaluate alternatives to improve deficiencies in the existing system.

Task 3 - Treatment System Evaluation:

- Review previous recommendations for WWTP improvements.
- Evaluate capacity of existing systems with respect to current and projected flows and loads and compare with prior recommendations.
- Evaluate deficiencies in the existing system.
- Evaluate alternatives to improve deficiencies in the existing system.

Task 4 - Capital Improvements Plan: Based on preceding work, develop a capital improvement plan.

Task 5 - Prepare a wastewater facilities plan update report.

1.5 Acknowledgements

This facilities plan was funded by the City of Bay City with assistance of a low interest loan received from the Clean Water Revolving Loan Fund through DEQ. Many people provided information, input, feedback, and other contribution to the completion of this *Wastewater Facilities Plan*. While certainly not a complete list, the following people deserve recognition for their contributions and assistance provided in this effort:

- The City of Bay City Mayor and City Council members
- Chance Steffey, City of Bay City Administrator/Public Works Superintendent
- City of Bay City wastewater treatment plant operating staff
- Michael Pinney with Oregon Department of Environmental Quality
- Engineering personnel at SHN
- And many others

1.6 Planning Period

The planning period for this Wastewater Facilities Plan Update is 22 years, beginning in the year 2018 and ending in the year 2040. The period must be short enough for current users to benefit from system improvements, yet long enough to provide reserve capacity for future growth and increased demand. Existing residents should not pay an unfair portion for improvements sized for future growth, yet it is not economical to build improvements that will be undersized in a relatively short time. Infrastructure needs are often projected over 20 years, which is a typical planning period for most municipal master plans. It is important to note that the useful life of the recommended infrastructure and often financing of the infrastructure, may be longer than the 20-year planning period.

1.7 Planning Area

The planning area encompasses the City of Bay City limits and the City urban growth boundary (UGB) which generally defines the planning area (Figure 2). Potential growth areas inside the UGB include large areas to the west and south of the City limits.

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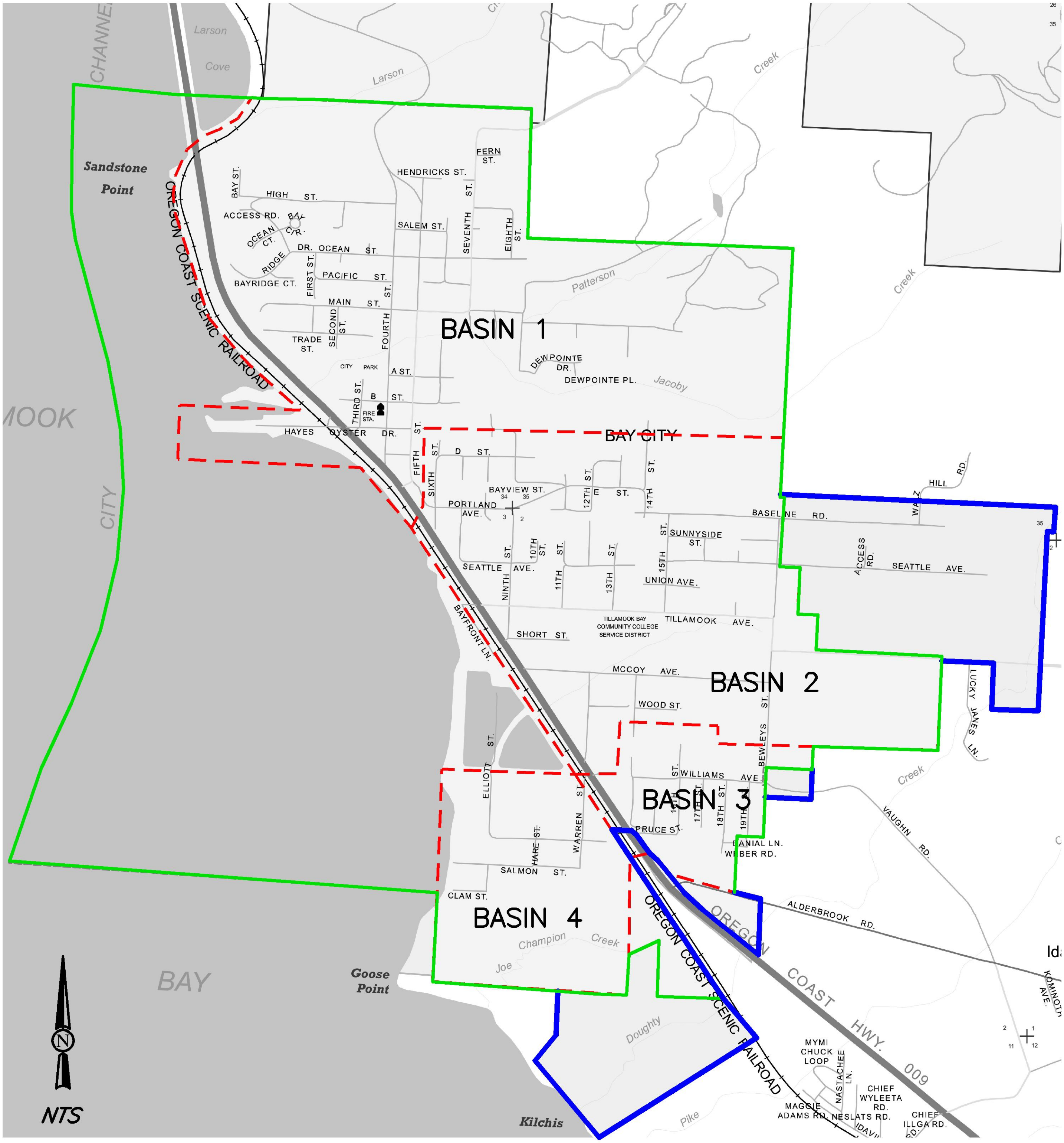

EXPLANATION

- URBAN GROWTH BOUNDARY
- CITY LIMIT
- BASIN BOUNDARY

SOURCES:

THE URBAN GROWTH BOUNDARY (UGB) LINE WORK WAS CREATED BY VARIOUS SOURCES INCLUDING THE OREGON DEPARTMENT OF LAND CONSERVATION AND DEVELOPMENT, THE OREGON DEPARTMENT OF TRANSPORTATION (ODOT), METRO REGIONAL COUNCIL OF GOVERNMENTS, COUNTY AND CITY GIS DEPARTMENTS, AND THE OREGON DEPARTMENT OF ADMINISTRATIVE SERVICES – GEOSPATIAL ENTERPRISE OFFICE. THE UGB LINE WORK IS CURRENT AS OF 2014. THE CITY LIMIT LINE WORK WAS CREATED BY ODOT AND IS CURRENT AS OF 2013. SHAPEFILES FOR THE CITY LIMITS AND UGB WERE DOWNLOADED ON 8/4/15 FROM HTTP://WWW.OREGON.GOV/DAS/CIO/GEO/PAGES/ALPHALIST.ASPX

THE BASIN BOUNDARIES WERE DIGITIZED BY SHN ON 8/4/15 FROM THE CITY OF BAY CITY WASTEWATER COLLECTION SYSTEM MAP.

THE BACKGROUND WAS CREATED IN ARCMAP FROM ESRI, HERE, DELORME, MAPMYINDIA, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY. FOR MORE INFORMATION SEE HTTP://GOTO.ARCGISONLINE.COM/MAPS/WORLD_LIGHT_GRAY_REFERENCE

SHN	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Wastewater Basins SHN 611013.151
December 2019	611013-Collection-Syst	Figure 2

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It is unknown whether additional UGB acreage will be annexed into the City limits during the 20-year planning period, however, a reasonable assessment of expansion areas was required to evaluate how much, if any, of the surrounding areas would be served by the City's existing infrastructure system.

1.8 Authorization

The firm of SHN Consulting Engineers & Geologists, Inc. was retained by the City of Bay City to prepare a wastewater facilities plan.

2.0 Study Area Characteristics

2.1 Location

Bay City is located on the Oregon Coast in Tillamook County. The City Limits have a total area of approximately 1,225 acres, with an additional 106 acres contained within the UGB (Figure 2). US Highway 101 runs along the coast through the City. The City is approximately 80 miles west of Portland with the cities of Tillamook to the south and Garibaldi to the north.

According to The City of Bay City Comprehensive Plan (enacted September 1978 with amendments through June 9, 2015), *…Bay City should retain its quiet residential character, that development should take advantage of the natural environment and that growth should be planned and controlled*.

2.2 Climate

Bay City experiences low and moderate temperatures ranging between 37-52 degrees Fahrenheit (°F) in January, 39-58 °F in April, 50-68 °F in July, and 43-63 °F in October (Table 1).

Table 1 Tillamook Area Climate Data[1]
Wastewater Facilities Plan Update, Bay City, Oregon

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. High Temp. (°F[2])	52	54	56	58	62	65	68	69	69	63	56	51
Avg. Low Temp. (°F)	37	37	38	39	44	48	50	50	46	43	40	36
Avg. Temp. (°F)	45	45	47	49	53	56	59	60	58	53	48	44
Avg. Precip. (inches)	13.5	9.7	9.7	7.1	4.7	3.6	1.4	1.3	3.0	6.9	13.8	13.2

1. NCEI, 2018. *1981-2010 Station Normals of Temperature, Precipitation, and Heating and Cooling Degree Days: Tillamook, OR US USC00358494*. Data accessed: December 17, 2018. Asheville, NC:National Centers for Environmental Information.
2. °F: degrees Fahrenheit

2.3 Land Use Characteristics

Land use characteristics have not changed since the prior assessment in the 2010 WWFP (HBH, 2010).

2.4 Receiving Waters

Tillamook Bay is the receiving water for discharges from the Bay City WWTP. The Bay provides numerous beneficial uses including wildlife habitat, fishing, recreation, and shellfish harvesting (sport and commercial). Approximately 6.2 miles long and 2.1 miles wide, the Bay averages only 6.6 feet depth. At low tide, about 50 percent of the bottom is exposed as intertidal mud flats.

Tillamook Bay is one of the most productive commercial oyster bays on the Oregon Coast, but has been impacted by bacterial contamination from surface waters entering the Bay. Dissolved oxygen, temperature, and sediment are also water quality concerns in the Tillamook Bay watershed according to the Oregon State DEQ. Tillamook Bay is considered water quality limited for temperature and bacteria according to Section 303(d) of the Clean Water Act. For additional information regarding how the 303(d) listings for Tillamook Bay relate to the Bay City wastewater systems see the 2010 WWFP (HBH, 2010). Tillamook Bay is considered an estuary indicating it is significantly influenced by freshwater streams and rivers entering the Bay prior to co-mingling with ocean waters. Estuaries provide critical habitat for wildlife especially the reproductive cycles of anadromous fish species such as salmon. It is important to keep all of these factors in mind when considering treatment and discharge of municipal wastewater to such a sensitive habitat.

Established water quality standards require management of water quality to protect beneficial uses, which fall into the following categories:

- Designated fish uses to be protected in the Bay
- Shellfish harvesting
- Coastal water contact recreation

2.4.1 Fish Habitat

The Bay provides habitat for numerous fish, shellfish, crabs, birds, seals, and sea grasses. Multiple species of fish have been identified in the bay at various times of the year. Five species of anadromous salmon use the bay at some point in their life cycle. The Tillamook Watershed is home to Summer and Winter Steelhead, Coho, Chum, Spring and Fall Chinook, and sea-run Cutthroat Trout. The following fish species resident in the Bay are federally listed as “Threatened” under the Endangered Species Act:

- Coho salmon
- Green sturgeon
- Eulachon (commonly called smelt, candlefish, or hooligan)

None of these species spawn in the Bay but use the Bay for rearing and migration. Water quality is to be managed in order to accommodate salmon and trout rearing and migration within the waters of the Bay. In addition to threatened species, Oregon also lists the Pacific lamprey as a State Species of Concern and Steelhead are listed as a federal Species of Concern.

2.4.2 Shellfish Harvesting

Clam digging and crabbing are important for the economy and lifestyle within the Tillamook watershed. Oysters have been grown commercially in Tillamook Bay since the 1930’s. Tillamook Bay has been one of the leading oyster producing bays in Oregon, with an average annual production of about 21,200 shucked gallons during the 1970s and 1980s. Beginning in 1990, the level of production dropped off sharply and has remained low due to reduced production by several Oyster Companies. 2016 shellfish plat production was 5,926.69 gallons of shucked oysters in Tillamook Bay, (Source: Oregon Department of Agriculture, Natural Resources Program).

2.4.3 Recreation

Water contact recreational use of the estuary is typically limited to activities associated with sport fishing and shellfish harvesting.

2.5 Population and Growth

The population of Bay City was estimated at 1,286 persons based on the 2010 U.S. Census, with an average household size of 2.36 persons. The current, (July 1, 2019) estimated population published by the Portland State University Population Research Center (PSUPRC) is 1,350. Table 2 presents annual population estimates based on the US Census and Portland State University Population Research Center. The projected average annual growth rate between 2020 and 2040 is 1.21 percent.

Table 2 Population and Growth
Wastewater Facilities Plan Update, Bay City, Oregon

Year	1970(1)	1980(1)	1990(1)	2000(1)	2010(1)	2020(2)	2030(2)	2040(2)	UBO(3)
Estimated Population	898	986	1,027	1,149	1,286	1,462	1,636	1,815	2,230(4)
Annual Growth Rate	--	0.98%	0.42%	1.19%	1.19%	1.37%	1.20%	1.09%	--

1. U.S. Census.
2. PRC, 2017. *Forecasts for Total Population: Bay City UGB*. Portland, OR:Population Research Center, Portland State University.
3. UBO: Ultimate Build Out.
4. HBH. 2010. *City of Bay City, Tillamook County, Oregon; Wastewater Facilities Plan*. Sherwood, OR:HBH Consulting Engineers.

2.5.1 Ultimate Build Out

Future growth projections for Bay City include typical population growth rates based on historic trends. However, sewer system design should consider the ultimate build out (UBO) population so that the collection system has the capacity to handle any future growth in the service area. The UBO population of 2,230 people was estimated by HBH (2010) assuming all empty lots with road access are developed and 70 percent of lots without road access are developed within the service area.

The City of Bay City has adopted a Comprehensive Plan (last updated in 2015) to provide guidance for development and growth for the City within the City Limits and within the greater UGB. The primary difference between the City Limits and the UGB is known as Brewley's Addition, which includes approximately 140 acres of partially developed property. This area was included in the 2010 WWFP evaluation of growth and expansion for wastewater facilities.

2.5.2 Equivalent Dwelling Units

The Equivalent Dwelling Unit (EDU) is a term used to equate commercial, industrial, and institutional wastewater flow rates and strengths to the rates and strengths generated by a typical residential household.

Projections for population growth are often utilized to estimate the future demand for public utility services, such as water and sewer. Typically, the future demand is based on an estimated number of residential homes, called average dwelling units, projected for the planning horizon. Residential dwelling units are only a portion of the demand placed on a public utility service. Commercial, industrial, and institutional customers will also demand services. Accounting for these customer types requires comparing the demand for services from the respective customer with the demand from the average dwelling unit. The relationship is defined as the equivalent dwelling unit (EDU) methodology. The typical method for establishing EDU counts for wastewater systems is based on equating nonresidential water usage to residential water usage.

The EDU methodology is also used by the City as the basis for establishing fair and equitable user charges. An example of the EDU methodology follows:

Example:

> *If a typical residential family requires, on the average, 250 gallons of water per day while a restaurant requires 1,000 gallons of water per day, the demand for water from the restaurant is numerically equal to four residential units. In this case, the restaurant is said to be equal to four EDU's.*

The EDU methodology compares non-residential water use to those generated by the City's average residential dwelling unit. Based on average water consumption records for the years 2017-2018 (Table 3 on the following page) the residential (EDU) water use would be defined at 144 gallons per day (gpd) or 4,380 gallons per month. However, current demographics and the presence of vacation homes, which do not have year-around continuous occupancy, places the City's calculated EDU usage at a deceptively low rate. For calculating EDUs associated with non-residential users, the City utilizes a more standard monthly water use of 6,000 gpd per EDU.

The following assumptions were made in the determination of the user equivalence:

- Each residential household, small commercial, and institutional account was designated as one EDU.
- Large commercial EDUs are calculated using the total residential daily water use per EDU (144 gpd/EDU).

Table 3 Summary of EDU[1] Calculations
Wastewater Facilities Plan Update, Bay City, Oregon

Customer Type	No. of Accounts	Annual Water Sales[2] (gallons)	EDU	gpd[3] EDU
Residential	730	38,417,442	730	144[4]
Small Commercial	12	246,706	5	N/A[5,6]
RV Parks	1	415,710	6	200[7]
Restaurants	3	358,255	7	200
Large Commercial	3	26,347,160	212	200
Total	**749**	**65,785,273**	**960**	**-**

1. EDU: Equivalent Dwelling Unit
2. Average annual water sales for the years 2017-2018.
3. gpd: gallons per day
4. Calculated EDU.
5. N/A: not applicable
6. Connections using less that average EDU consumption are assigned 1 EDU.
7. Assumed typical EDU usage.

2.5.3 Equivalent Population

By evaluating the demand for the residential customers, the commercial, industrial, and institutional demand can be converted from connections to EDUs. The combination of EDUs can then be used to evaluate sewer usage based on equivalent population values. Based on the method for determining the number of EDUs and the average household size of 1.94 people per household, the equivalent service population for the Bay City urban growth boundary is estimated at 2,383 people for the year 2040 (Table 4). EDU projections assume that residential, commercial, and industrial average annual growth rates are equal.

Table 4 Equivalent Dwelling Units Summary
Wastewater Facilities Plan Update, Bay City, Oregon

Population Parameter, Average Household	Year		
	2017	2020	2040
Residential EDUs[1]	730	753	935
Small Commercial EDUs	5	5	6
RV Park EDUs	6	6	8
Restaurant EDUs	7	7	9
Large Commercial EDUs	212	219	270
Total EDUs	960	990	1,228
Equivalent Population[2]	**1,863**	**1,921**	**2,383**
Average Annual Growth Rate[3]	--	1.05%	1.05%

1. EDU: Equivalent Dwelling Unit
2. Assumes 1.94 people per household based on the 2017 population and total residential EDU count.
3. PRC, 2017. Forecasts for Total Population: Bay City UGB. Portland, OR:Population Research Center, Portland State University.

3.0 Wastewater Characteristics

3.1 Wastewater Flows

3.1.1 Terminology

Infiltration: *Water other than wastewater that enters a sewer system (including sewer service connections and foundation drains) from the ground through such means as defective pipes, pipe joints, connections, or manholes. Infiltration does not include, and is distinguished from, inflow* (EPA, 1990). Infiltration can be further broken down into two types: groundwater infiltration (GWI) and rainfall induced infiltration (RII). GWI results from increasing groundwater levels and typically exhibit a slower peak flow response in sewer systems. RII is rainfall that enters the sewer system as it is percolating through the ground and typically results in a faster peak flow response in sewer systems. RII is distinguished from inflow as described below.

Inflow: *Water other than wastewater that enters a sewer system (including sewer service connections) from such sources as, but not limited to, roof leaders, cellar drains, yard drains, area drains, drains from springs and swampy areas, manhole covers, cross connections between storm sewers and sanitary sewers, catch* *basins, cooling towers, storm waters, surface runoff, street wash waters, or drainage. Inflow does not include, and is distinguished from, infiltration*. (EPA, 1990)

Inflow and Infiltration (I/I): The total of inflow and infiltration combined.

Wet Season: November 1 through April 30; the 6-month period when monthly rainfall is the greatest.

Dry Season: May 1 through October 31; the 6-month period when monthly rainfall is the least.

3.1.2 Daily Flow Records

Dry and wet weather flows and I/I are important parameters in the design of wastewater collection, treatment, and disposal facilities. Defining the flow characteristics for the two seasons affects the design capacity of the facilities. Recorded inflow data from the Bay City WWTP for the period of January 2009 through June 2018 are compared with recorded daily rainfall rates (Figure 3, on the following page). The strong relationship between daily rainfall and high inflow rates indicates the collection system has an I/I problem. Dry and wet season flow variations are also apparent from daily rainfall and flow records. The firm capacity of the influent pump station (1.4 MGD) is exceeded on six occasions indicating that the overflow surge basin may have been used to store excess flows.

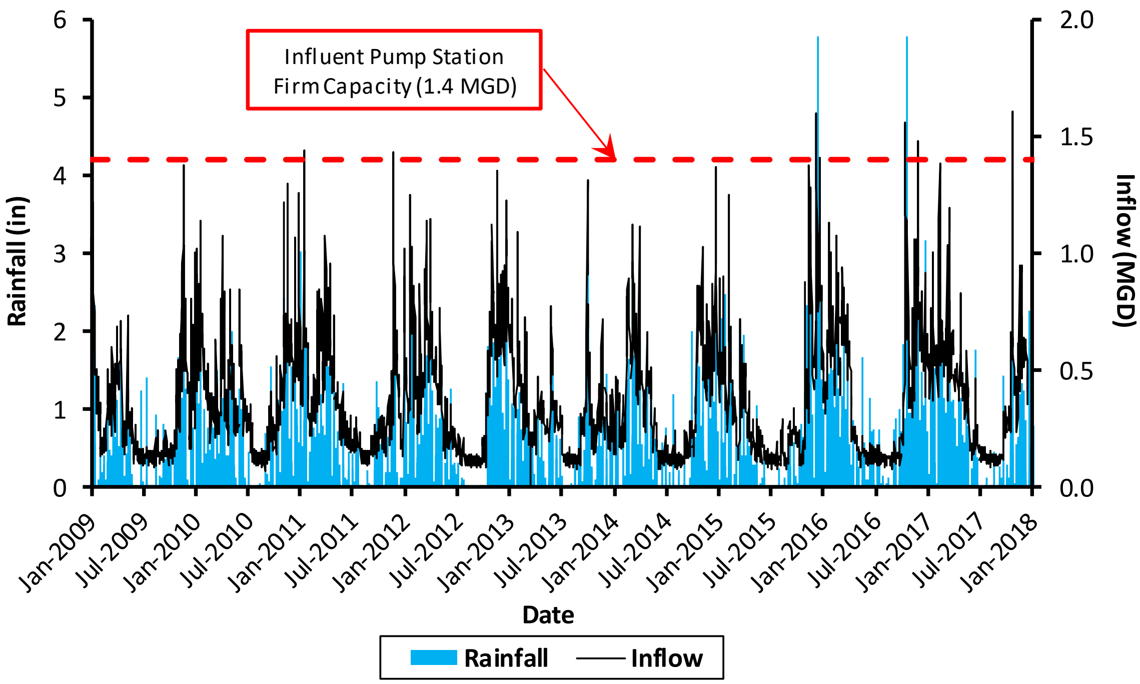


Figure 3. Daily inflow and rainfall (2009-2017).

Seasonal variations in wastewater flows are apparent. Wet season flows increase with the increasing and more frequent rainfall events. This trend exemplifies the typical winter month flow characteristics of western Oregon communities and is a direct result of I/I impacting the wastewater collection system. The yearly reoccurrence of this trend forms the basis of predicting the wastewater flow parameters for these facilities.

Wastewater is collected from a variety of sources within the City, including family residences, RV and hotel connections, industrial connections, and institutional connections. Each of these sources generates wastewater in varying amounts and in varying strengths. To properly plan for growth within the City, it is necessary to first identify wastewater contributions from the various sources relative to the typical residential customer. The accepted practice for estimating the typical contribution is to evaluate each customer account in terms of its equivalence to a typical residential unit. The relationship establishes a customer count and associated population equivalence in terms of EDUs.

3.1.3 Design Flow Rates

The following summarizes the basis of estimating current and projected design flows. In the subsequent discussion, flows are based on an analysis of daily influent flow records for the Bay City WWTP for the period 2009-2017. Statistical analyses for design flow estimations follow the guidelines established by the State of Oregon Department of Environmental Quality (DEQ, 1996).

3.1.3.1 Base Sanitary Flow

0.13 MGD

98 gallons per capita per day (gpcd)

The Base Sanitary Flow (BSF) represents the domestic component of the wastewater in the sewer system resulting from the use of potable water. The BSF is determined from the minimum repeated flow recorded during the driest months of the year occurring in late summer (Figure 4).

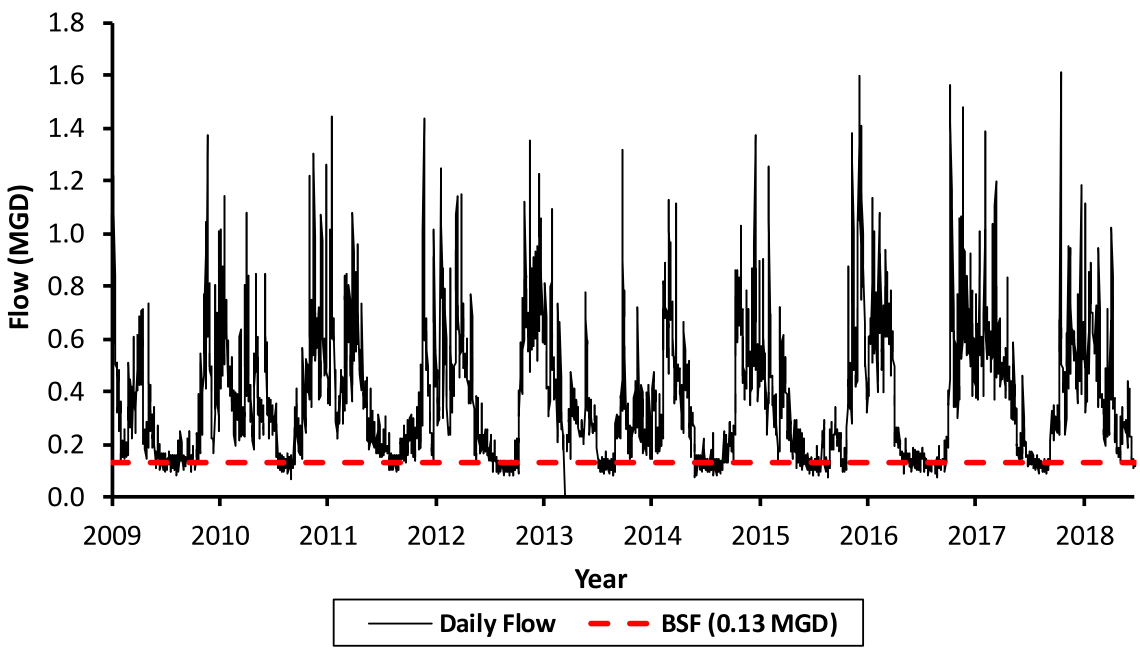


Figure 4. Base Sanitary Flow (BSF), 2009-2018.

3.1.3.2 Base Infiltration
0.10 MGD
69 gpcd

Base Infiltration (BI) is the average amount of infiltration entering the sewer system during the dry season. This parameter is determined by subtracting the Base Sanitary Flow from the Average Dry Weather Flow (ADWF). Base Infiltration is typically not cost-effective to remove and an allowance for this flow is typically included in the estimate of flows for each future connection. In determining projected flows, allowances must be made for unavoidable I/I that is dependent upon such factors as the quality of material, workmanship in the sewers and building connections, maintenance efforts, and the elevation of the groundwater compared with the elevation of the sewer pipes.

3.1.3.3 Average Dry Weather Flow
0.22 MGD
167 gpcd

The ADWF represents the average daily flow during the dry season and is determined from analysis of daily monitoring report (DMR) flow records for the months of May through October, from 2009 through 2017 (Figure 5).

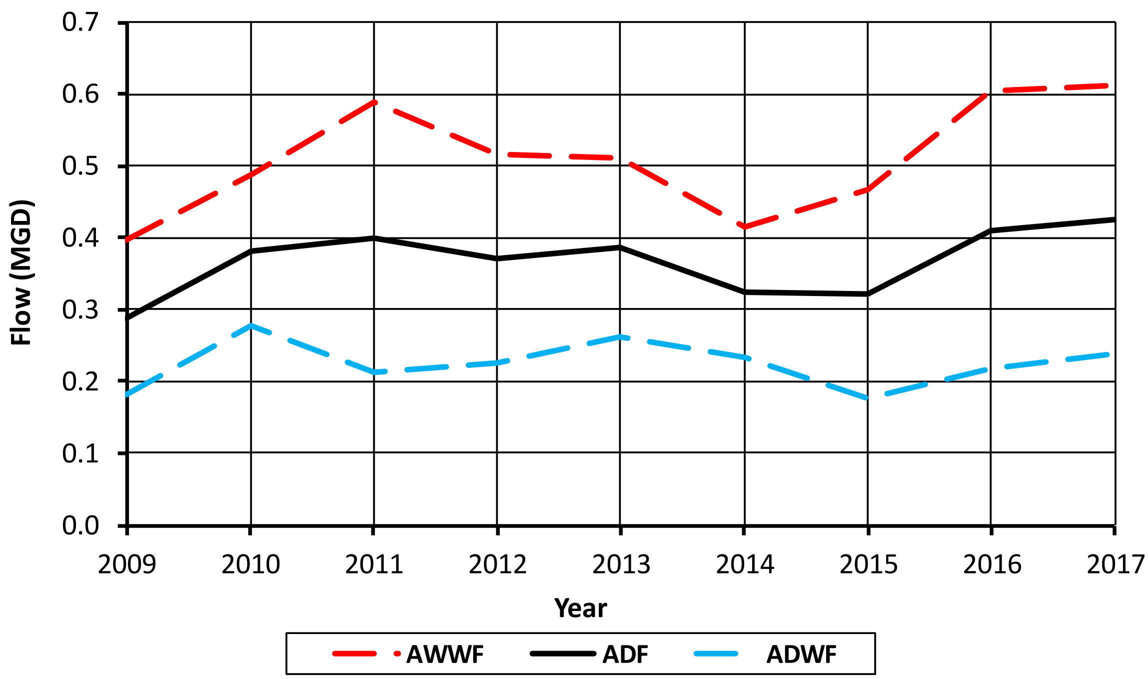


Figure 5. Average Wet and Dry Weather Flows, 2009-2017.

3.1.3.4 Average Wet Weather Flow

0.51 MGD
386 gpcd

The Average Wet Weather Flow (AWWF) represents the average daily flow during the wet season and is determined from analysis of DMR flow records for the months of November through April, from 2009 through 2017 (Figure 5).

3.1.3.5 Average Daily Flow

0.37 MGD
280 gpcd

The Average Daily Flow (ADF) represents the average daily flow rate over a 365-day period and is determined by averaging the ADWF and the AWWF (Figure 5). A 365-day moving average of daily flow rates is shown in Figure 6 between 2009 and 2018 for comparison to the ADF of 0.37 MGD.

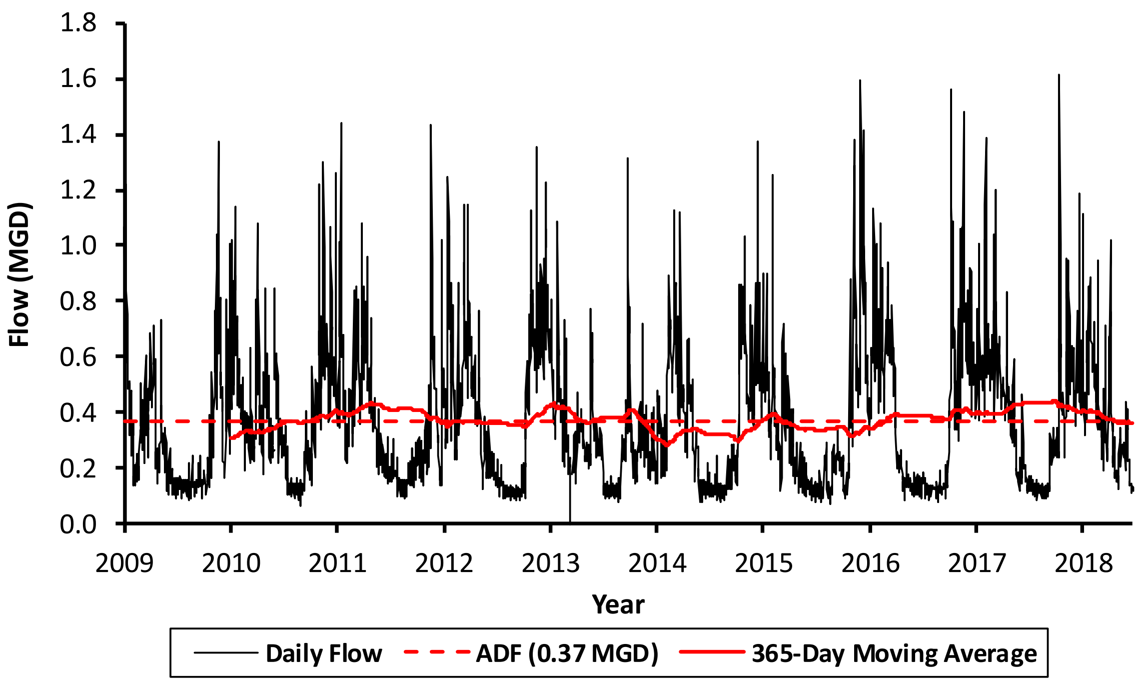


Figure 6. Average Daily Flow (ADF), 2009-2018.

3.1.3.6 Maximum Monthly Flows

MMDWF: 0.35 MGD, 265 gpcd
MMWWF: 0.66 MGD, 500 gpcd

Maximum Month Dry Weather Flow (MMDWF): The highest average monthly flow occurring during the dry season of May through October with a recurrence interval of 10 years (10 percent chance of recurrence in any given year). For western Oregon, the highest monthly average dry weather flow typically occurs in May.

Maximum Month Wet Weather Flow (MMWWF): The highest average monthly flow occurring during the wet season of November through April with a recurrence interval of 5 years (20 percent chance of recurrence in any given year). For western Oregon, typically, the month of January is the highest averaged wet weather flow period.

The calculation of Maximum Month Flows is somewhat more complex than that for other flow parameters. The methodology employed is based on Department of Environmental Quality (DEQ) guidelines that identify the seasonal maximum monthly average flow, which has the probability of recurrence once every 5 years during the winter (January) and once every 10 years during the summer (May). The basis of these recurrence intervals is the EPA policy to accept a failure of a treatment facility overload due to rainfall effects once every 5 years.

Monthly precipitation amounts recorded in Tillamook, Oregon, approximately 5 miles southeast of Bay City, between the years of 1948 and 2018 were analyzed using a Log-Pearson Type III probability distribution for the months of January and May (NCEI, 2018). The results of this analysis are presented for return periods of 2-, 5-, 10-, 25-, 50-, 100-, and 200-years (Figure 7). Based on this analysis, the 5-year return period maximum monthly flow rate for the month of January is 18.6 inches, and the 10-year return period maximum monthly flow rate for the month of May is 7.4 inches.

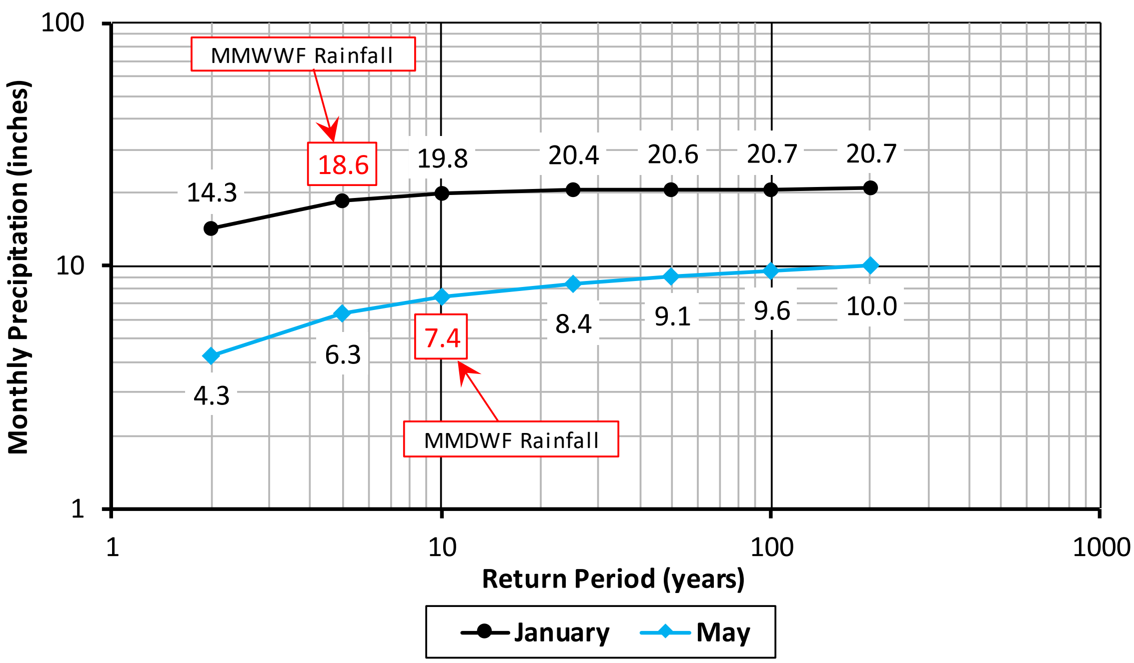


Figure 7. Monthly precipitation probability for the months of January and May, 1948-2018, Tillamook, Oregon (National Center for Environmental Information, Station USC00358494). Log-Pearson Type III probability distribution.

Calculation of the Maximum Month Flow is based on identifying the monthly rainfall and the monthly average wastewater flows during the months when I/I impacts the collection system. Once these flows are identified, they are plotted on a graph to establish a linear relationship between monthly rainfall and wastewater flow (Figure 8, on the following page). The resulting relationship is used to predict the monthly average flow for the 80th percentile and 90th percentile probability rainfall events (once in five year and once in ten-year recurrence, respectively). The method estimates the anticipated flow that will occur if rainfall for the month exceeds the historic probabilistic amounts for the dry and wet seasons. For western Oregon, the historically dry and wet season months with the highest rainfall occur during May and January, respectively.

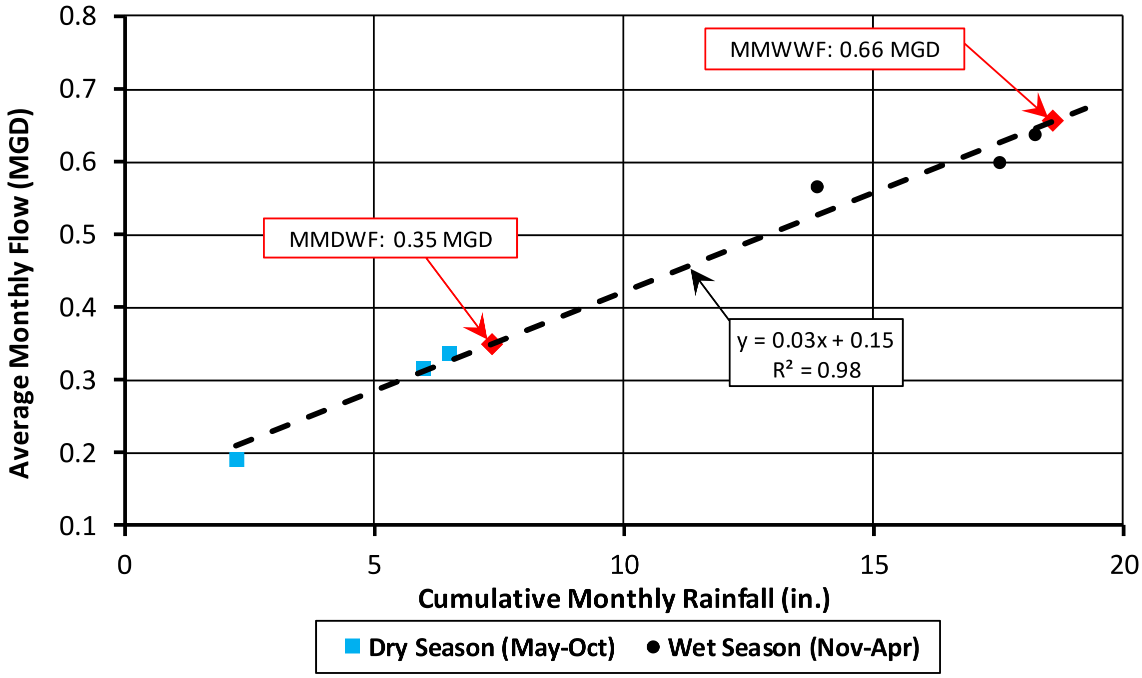


Figure 8. Wet and Dry Season Maximum Monthly Flow and Rainfall.

The MMDWF was ascertained from Figure 8 as developed from the WWTP data from January 2009 through June 2018. Based on historical climatological data the maximum rainfall with the once in ten-year recurrence for the month of May is 7.4 inches as recorded for Tillamook, Oregon (NCEI, 2018). The calculated MMDWF with the same recurrence interval is 0.35 MGD.

The MMWWF was also ascertained from Figure 8. Based on the same climatological data, the maximum monthly rainfall with the one in five-year recurrence interval for January is 18.6 inches. The calculated MMWWF for the 5-year recurrence interval is 0.66 MGD.

3.1.3.7 Peak Day Flow

1.53 MGD

1,159 gpcd

The Peak Day Flow (PDF) is the largest 24-hour average flow. The PDF will probabilistically occur 1 day in 365 days of any given year (0.27 percent probability of recurrence). Projection of the PDF is based on a regression analysis of daily WWTP flows during or immediately following wet season significant rainfall events, (greater than 1 inch in a 24-hour period). The City has an influent storage basin with approximately 3 days of storage capacity; therefore, the PDF will form the basis for the hydraulic design capacity of the influent pumping and conveyance systems.

The PDF event is determined from a plot of the recorded daily flow that occurred during, or 24 hours after, a significant rainfall event. By performing a regression analysis of the data, a linear relationship is established (Figure 9). The PDF is based on the intercept of the regression line with the 5-year, 24-hour precipitation event. For Bay City, the 4.5-inch storm event results in a Peak Day Flow of 1.53 MGD.

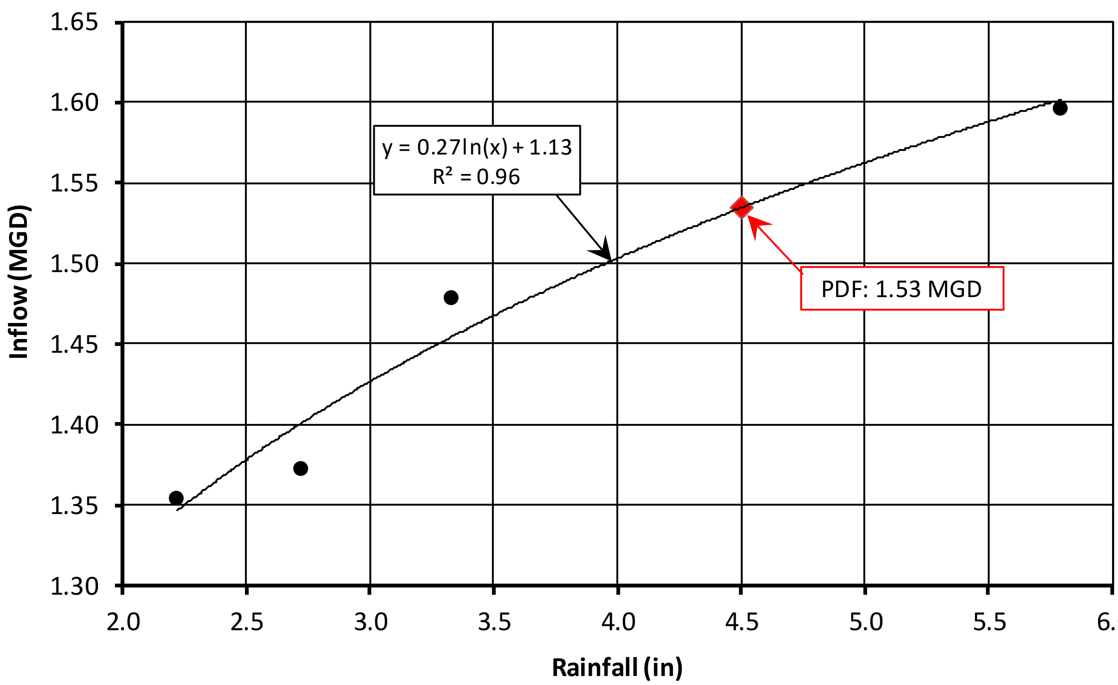


Figure 9. Peak Day Flow estimation; peak wet season rainfall and flow data (2010-2017).

3.1.3.8 Peak Week and Instantaneous Flow
PIF: 2.24 MGD, 1,697 gpcd
PWF: 1.06 MGD, 803 gpcd

Peak Week Flow (PWF): The largest observed flow averaged over a 7-day period. The PWF will probabilistically occur 1 week out of 52 weeks of the year (1.9 percent probability of recurrence). The PWF is based on a probabilistic analysis projected from the PDF, MMWWF, and ADF (Figure 10). The resulting PWF is estimated at 1.06 MGD based on the recurrence probability of 0.019 (1.9 percent).

Peak Instantaneous Flow (PIF): The Peak Instantaneous Flow is the highest sustained hourly flow rate during the wet season. The PIF will probabilistically occur 1 hour in 8,760 hours of the year (0.011 percent probability of recurrence). This flow parameter provides the basis for the hydraulic design of channels and pumps at the treatment facility. The PIF is based on a probabilistic analysis projected from the PDF, MMWWF, and ADF (Figure 10, on the following page).

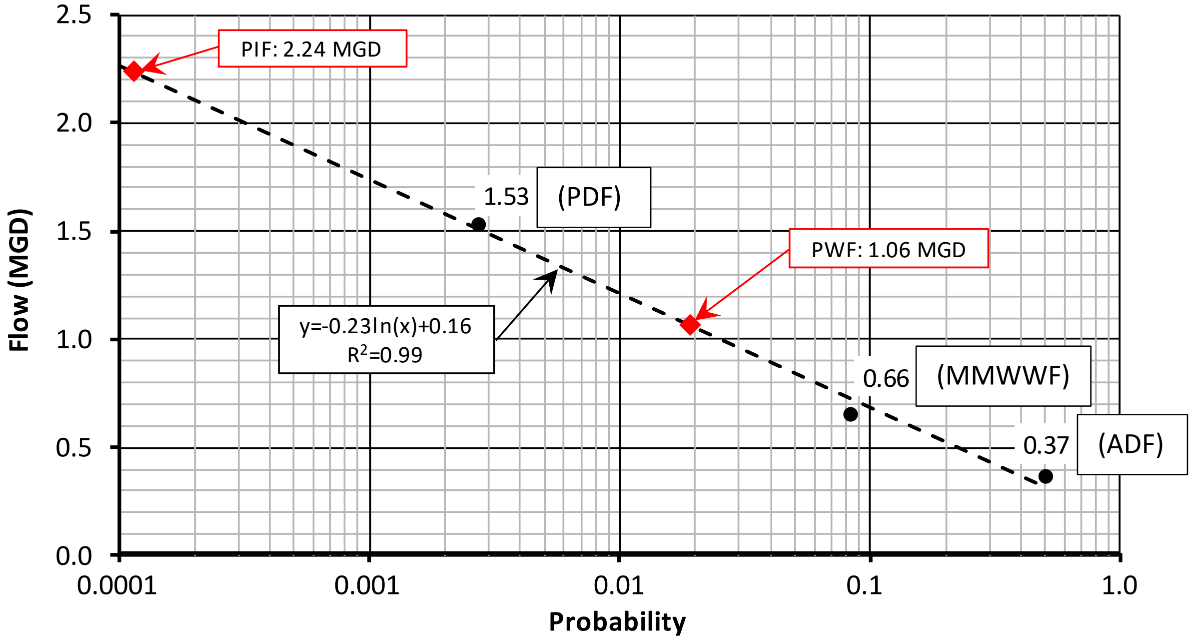


Figure 10. Peak Instantaneous Flow (PIF) and Peak Week Flow (PWF) estimation.

3.1.3.9 Inflow and Infiltration (I/I)

I/I corresponds to the length, diameter, type, and age of pipe in a collection system and not necessarily with the number or type of users as with the sanitary sewage flow rate. Therefore, in forecasting wet weather flows that include I/I, a different approach must be used than population growth. New construction also uses more modern forms of sewer construction that will have lower I/I rates than the older system, so projections should include consideration of a lower rate of I/I than is observed in historic flow records.

I/I will typically increase over time due to aging pipes and joints, expansion of the collection system, and increased use. I/I reduction strategies may mitigate some of this increase; however, the amount of reduction is typically uncertain, and the successful funding and implementation of these projects is also uncertain.

Inflow sources include residential downspouts plumbed illicitly into the sanitary sewer, surface water entering manholes and cleanouts, and rainfall falling into vent pipes. Inflow can typically be identified by the immediate response of peak wet weather flows to precipitation. If peak flows occur on the same day as the storm event, the major contributor may be inflow. Groundwater infiltration must flow through the soil before reaching pipes and joints, or it must increase groundwater levels enough to inundate pipes before a peak flow response is observed, so infiltration derived peak flows may take multiple days to result in increased flow rates at a WWTP. Figure 11 (on the following page) presents daily precipitation and WWTP inflow data collected during the wet season of 2016-2017 (October through March). Peak flow events occur on the same day as storm events indicating that inflow may be a major contributor to I/I in the Bay City collection system.

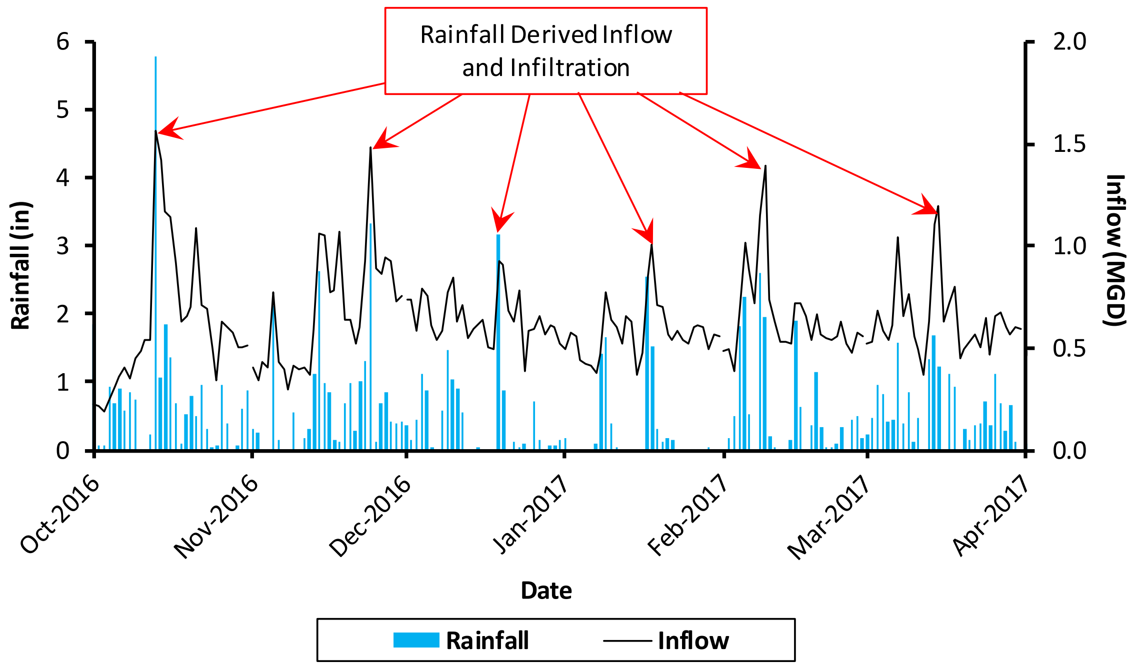


Figure 11. Rainfall derived inflow and infiltration, Winter 2016-2017.

3.1.3.9.1 Non-Excessive Infiltration

The EPA defines non-excessive infiltration as less than 120 gpcd, including the 7-14-day average daily flow measured during periods of seasonal high groundwater excluding major industrial and commercial flows greater than 50,000 gpd each (EPA, 1985). Note that average annual large commercial/industrial water sales in Bay City between 2017-2018 was 26,347,160 gallons, or 72,184 gpd. With three large commercial users, the average large commercial/industrial water use per user is greater than the EPA criteria of 50,000 gpd such that large commercial/industrial wastewater flows have not been excluded from this analysis.

Table 5 (on the following page) presents ten 7-day periods between January 2009 and February 2017, during the latter end of the wet season when groundwater is typically high; the total weekly precipitation was relatively low, and the preceding 7-day period was also relatively dry. Based on these estimates for groundwater infiltration, Bay City has excessive infiltration according to the EPA criteria described previously with the lowest infiltration rate of 134 gpcd. The average infiltration over all periods is 254 gpcd, over twice the EPA criteria for excessive infiltration.

Table 5 Excessive Infiltration Analysis
Wastewater Facilities Plan Update, Bay City, Oregon

Dry Period	Population[1]	7-Day Total Precipitation (inches)	7-Day Average Flow Rate (MGD)[2]	7-Day Average Flow Rate (gpcd)[3]
1/15/2009 - 1/21/2009	1,285	0.00	0.451	351
2/15/2009 - 2/21/2009	1,285	0.17	0.178	139
2/28/2010 - 3/06/2010	1,295	0.12	0.351	271

Table 5 Continued

Dry Period	Population[1]	7-Day Total Precipitation (inches)	7-Day Average Flow Rate	
1/16/2013 - 1/22/2013	1,310	0.04	0.349	266
3/25/2013 - 3/31/2013	1,310	0.10	0.279	213
1/16/2014 - 1/22/2014	1,320	0.06	0.287	218
2/12/2015 - 2/18/2015	1,320	0.03	0.456	345
3/04/2015 - 3/10/2015	1,320	0.04	0.177	134
4/17/2015 - 4/23/2015	1,320	0.15	0.246	187
1/26/2017 - 2/01/2017	1,340	0.08	0.558	416
Average	**1,311**	**0.08**	**0.333**	**254**

1. Population Research Center, Portland State University.
2. MGD: million gallons per day
3. gpcd: gallons per capita per day

3.1.3.9.2 Non-Excessive Inflow

The EPA defines non-excessive inflow as less than 275 gpcd, including the average wet weather flow measured during periods of surface ponding and surface runoff excluding major industrial and commercial flows greater than 50,000 gpd each (EPA, 1985).

Table 6 presents five peak flow days selected based on high flow rates, high levels of precipitation, and preceding wet conditions. Each event exceeds the EPA criteria for excessive inflow of 275 gpcd, with the lowest value (1,038 gpcd) being approximately 3.7 times greater than the threshold. The average over all five periods is 1,100 gpcd, four times the EPA threshold for excessive indicating that Bay City has an excessive inflow problem.

Table 6 Excessive Inflow Analysis
Wastewater Facilities Plan Update, Bay City, Oregon

Date	Population[1]	24-Hour Total Precipitation (inches)	24-Hour Total Flow Rate	
			(MGD)[2]	(gpcd)[3]
11/18/2012	1,305	2.22	1.354	1,038
12/20/2014	1,320	2.72	1.373	1,040
12/08/2015	1,320	5.79	1.597	1,210
11/24/2016	1,330	3.33	1.479	1,112
Average	**1,319**	**3.52**	**1.451**	**1,100**

1. Population Research Center, Portland State University.
2. MGD: million gallons per day
3. gpcd: gallons per capita per day

3.1.3.10 Projected Wastewater Flows

Future wastewater flow projections include consideration of residential population growth, commercial and industrial development, new collection system expansion, existing collection system aging, and sewer rehabilitation projects. Residential population growth will increase the base sanitary flow rate.

Commercial and industrial development may increase the non-sanitary wastewater flow rate. New collection system expansion will increase I/I, but at a much lower rate than existing sewer system components, because new collection system infrastructure is constructed of modern materials using modern construction methods and standards with lower leakage rates. The existing collection system will continue to age, potentially increasing the rate of I/I as more leaks are formed and existing leaks worsen. Sewer rehabilitation projects will reduce I/I in existing areas of the collection system. All of these factors will potentially affect future wastewater flow rates in Bay City.

3.1.3.10.1 Projected I/I Flows

It is difficult to project the rate of commercial and industrial growth in a small community such as Bay City, and even more difficult to project wastewater flows from potential growth due to the different types of facilities that may contribute various amounts of commercial and industrial wastewater to the system. Projected future development in Bay City described by HBH (2010) of 84 acres by 2040 and 171 acres for ultimate build-out (UBO) are used here to estimate additional I/I from new collection system areas that may be added to the system (Table 7). New sewered areas will have far less I/I than the existing older sewered areas; however, the estimated areal rates of I/I presented in Table 7 (on the following page) are within the typical range described by Metcalf & Eddy (2014) of 20-3,000 gallons per acre per day (gpad) and represent a conservative estimate for future development in Bay City.

Table 7 I/I[1] Estimates through 2040
Wastewater Facilities Plan Update, Bay City, Oregon

Area (acres)				755	84[2]	171[2]
Design Flow Rate		Total Flow (MGD)[3]	Existing I/I (gpd)[4]	Existing I/I (gpd/ac)[5]	2040 Additional I/I (gpd)	UBO[6] Additional I/I (gpd)
Base Infiltration	BI	0.10	100,000	132	11,126	22,649
Base Sanitary Flow	BSF	0.13	0	0	0	0
Average Dry Weather Flow	ADWF	0.22	90,000	119	10,013	20,384
Maximum Month Dry Weather Flow	MMDWF	0.35	220,000	291	24,477	49,828
Average Daily Flow	ADF	0.37	240,000	318	26,702	54,358
Average Wet Weather Flow	AWWF	0.51	380,000	503	42,278	86,066
Maximum Month Wet Weather Flow	MMWWF	0.66	530,000	702	58,967	120,040
Peak Week Flow[5]	PWF	1.06	930,000	1,232	103,470	210,636
Peak Day Flow	PDF	1.53	1,400,000	1,854	155,762	317,086
Peak Instantaneous Flow	PIF	2.24	2,110,000	2,795	234,755	477,894

1. I/I: Inflow and Infiltration
2. HBH. 2010. *City of Bay City, Tillamook County, Oregon; Wastewater Facilities Plan*. Sherwood, OR:HBH Consulting Engineers.
3. MGD: million gallons per day.
4. gpd: gallons per day.
5. gpd/ac: gallons per acre per day
6. UBO: ultimate build out.

3.1.3.10.2 Design Flow Summary

Design flow estimates listed in Table 8 (on the following page) are described in more detail in the previous sections.

Table 8 **Design Flow Projections (MGD)**[1]
Wastewater Facilities Plan Update, Bay City, Oregon

Design Flow Rate		Year		
		2018	2040(2)	UBO
Base Infiltration	BI	0.10	0.11	0.12
Base Sanitary Flow	BSF	0.13	0.17	0.20(3)
Average Dry Weather Flow	ADWF	0.22	0.27	0.31
Maximum Month Dry Weather Flow	MMDWF	0.35	0.41	0.47
Average Daily Flow	ADF	0.37	0.43	0.50
Average Wet Weather Flow	AWWF	0.51	0.59	0.67
Maximum Month Wet Weather Flow	MMWWF	0.66	0.75	0.85
Peak Week Flow	PWF	1.06	1.20	1.34
Peak Day Flow	PDF	1.53	1.72	1.92
Peak Instantaneous Flow	PIF	2.24	2.51	2.79

1. MGD: million gallons per day
2. Projected 2040 BSF estimated using the ratio of equivalent populations for 2020 and 2040 of 1,921 and 2,383, respectively.
3. UBO: Ultimate Build Out. Projected UBO BSF estimated using the ratio of equivalent populations for 2040 and UBO of 2,383 and 3,269, respectively.

3.2 Wastewater Composition

3.2.1 Terminology

Biochemical Oxygen Demand (BOD): A measure of wastewater strength in terms of the quantity of oxygen required for biological oxidation of the organic matter. The BOD loading imposed on a treatment plant influences both the type and degree of treatment that must be provided to produce the required effluent quality. BOD loadings are based on actual WWTP data.

Carbonaceous Biochemical Oxygen Demand (CBOD): A measure of the BOD resulting from the oxidation of carbon-containing substances, by inhibiting the nitrogenous biochemical oxygen demand (NBOD) resulting from nitrification (the oxidation of nitrogen). CBOD is typically 2-3 times greater than NBOD. CBOD loadings are based on actual WWTP data.

Total Suspended Solids (TSS): A measure of the quantity of suspended material contained in the wastewater. The quantity of TSS removed during the treatment of wastewater influences the sizing of solids handling and disposal processes, as well as the effectiveness of filtration and disinfection. TSS loadings are based on actual WWTP data.

pH: a logarithmic scale ranging from 0 to 14 indicating the concentration of hydrogen ions; a pH of 7 is neutral, pH above 7 is alkaline (basic), and pH below 7 is acidic.

3.2.2 Analysis of Plant Records

Wastewater entering the treatment plant originates from several types of customer classes within the City's service area: residential, commercial, institutional, and industrial. Each source contributes, in varying degrees, to the wastewater volume and composition requiring treatment. Because each source is not individually metered or monitored, typical values must be determined from the combination of all sources based on the monitoring data at the WWTP.

3.2.2.1 CBOD and TSS Trends

The City samples its influent wastewater for analysis of BOD, CBOD, TSS, pH, and temperature weekly in accordance with the NPDES permit. A detailed analysis of monitoring records from January 2009 through June 2018 was completed to identify trends and extremes in monthly CBOD and TSS loading to the WWTP. Median values were selected for the monthly trend analysis to limit the weighting effects of extreme values in the relatively small dataset (n=12-43).

Median CBOD loading ranged from 150 ppd (July) to 239 ppd (April; Figure 12-1, on the following page) and median TSS loading ranged from 257 ppd (July) to 496 ppd (November; Figure 12-2, on the following page). Peak CBOD loading occurred in February at 839 ppd and peak TSS loading occurred in February and November at 1,982 ppd and 2,043 ppd, respectively. Median monthly CBOD and TSS loading is typically higher than the long-term median loading during the fall, winter, and spring, and below the long-term median loading during the summer (Figure 13, on page 24).

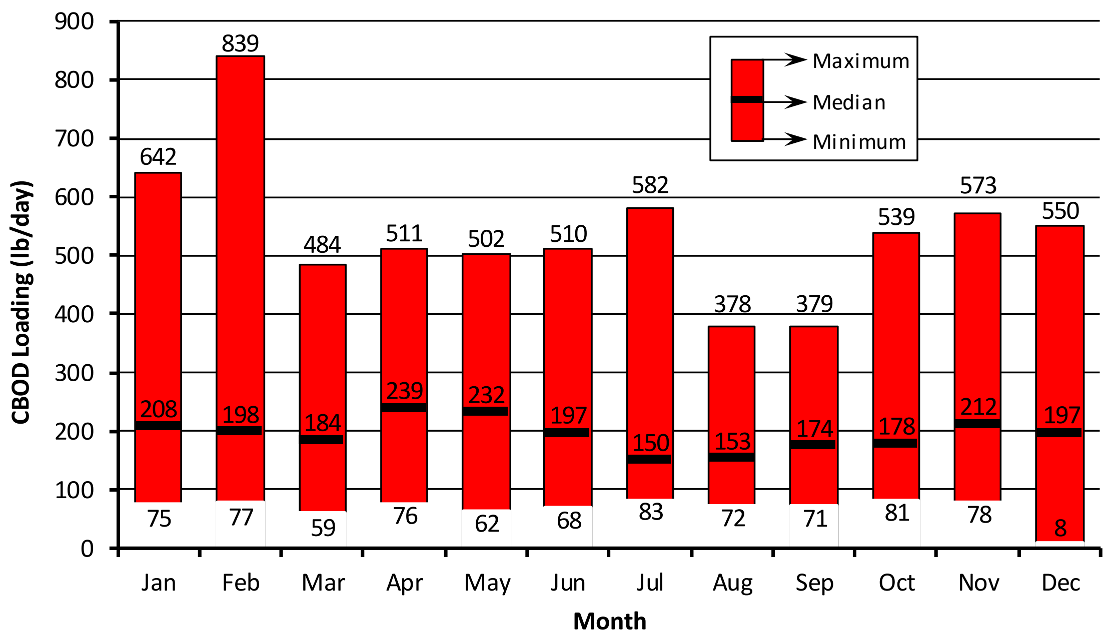


Figure 12-1. Monthly influent CBOD loading statistics (January 2009-June 2018).

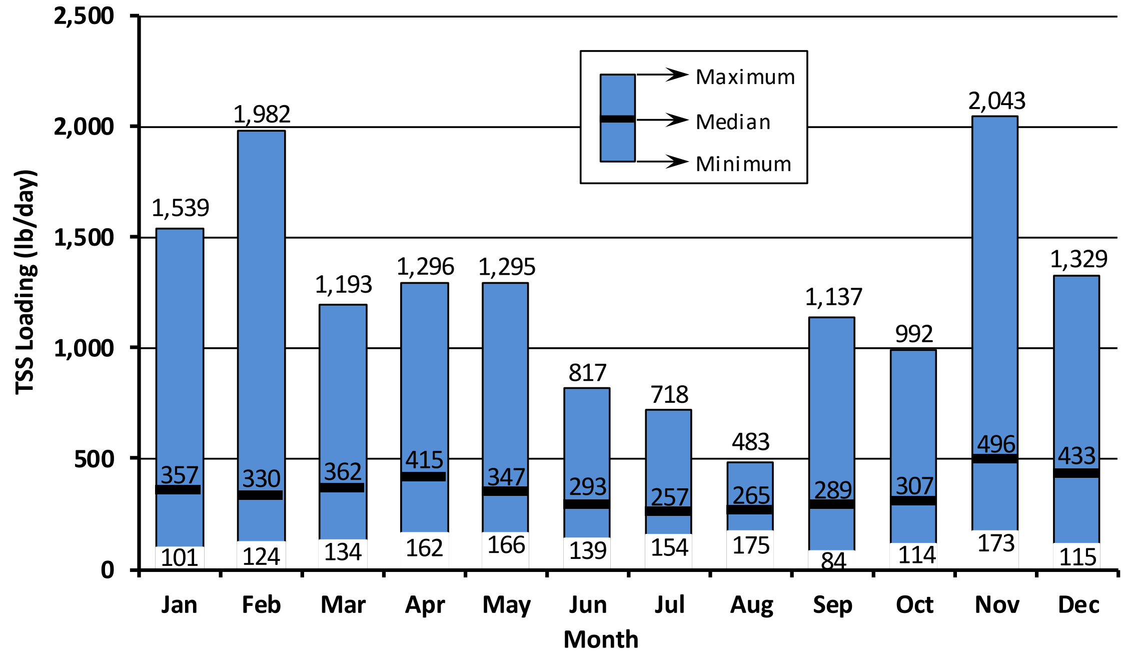


Figure 12-2. Monthly influent TSS loading statistics (January 2009-June 2018).

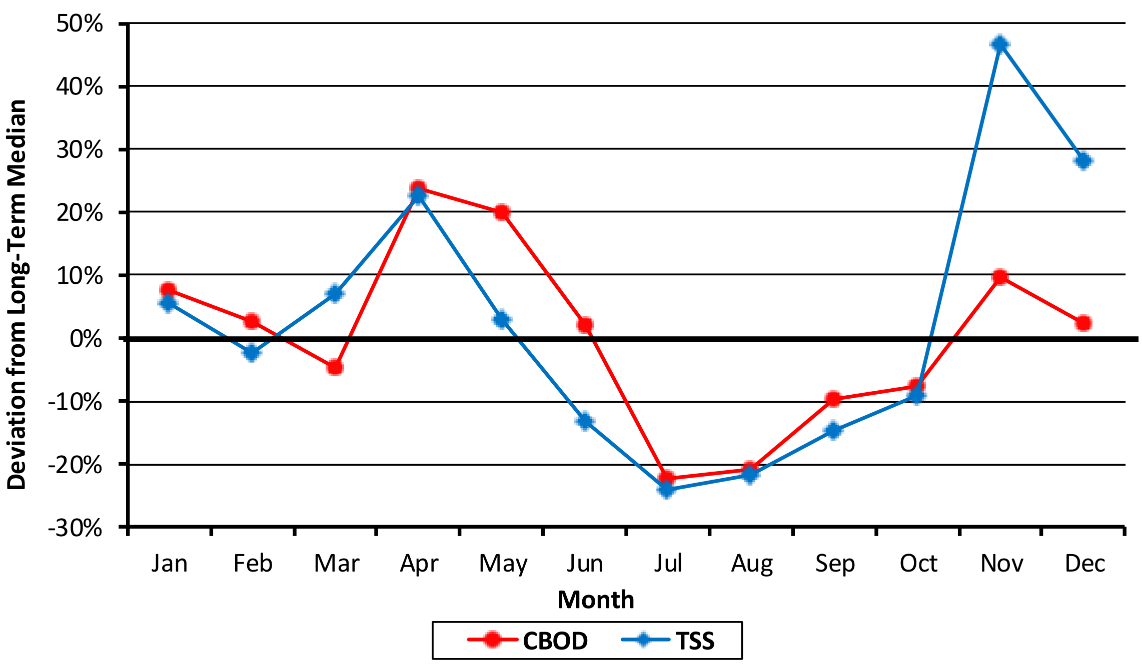


Figure 13. Monthly median CBOD and TSS loading variation from long-term median (January 2009-June 2018).

3.2.2.2 CBOD and TSS Influent Loading

Influent loading of CBOD and TSS are used to design primary and secondary treatment processes. A frequency analysis of plant records from January 2009 to June 2018 was completed, calculating the exceedance probability for CBOD and TSS loads (Figure 14, on the following page). The design loading capacity for the secondary treatment system at the Bay City WWTP is 616 ppd BOD and TSS. Applying the

EPA recommended conversion for BOD to CBOD of 0.83 (CBOD:BOD) results in a design CBOD capacity of 511 ppd. According to the frequency analysis presented in Figure 14 (on the following page), the influent exceeds the design loading capacity of the plant for CBOD and TSS approximately 2 percent and 18 percent of the time, respectively. Table 9 (on the following page) includes a summary of CBOD and TSS loading statistics from the data analysis.

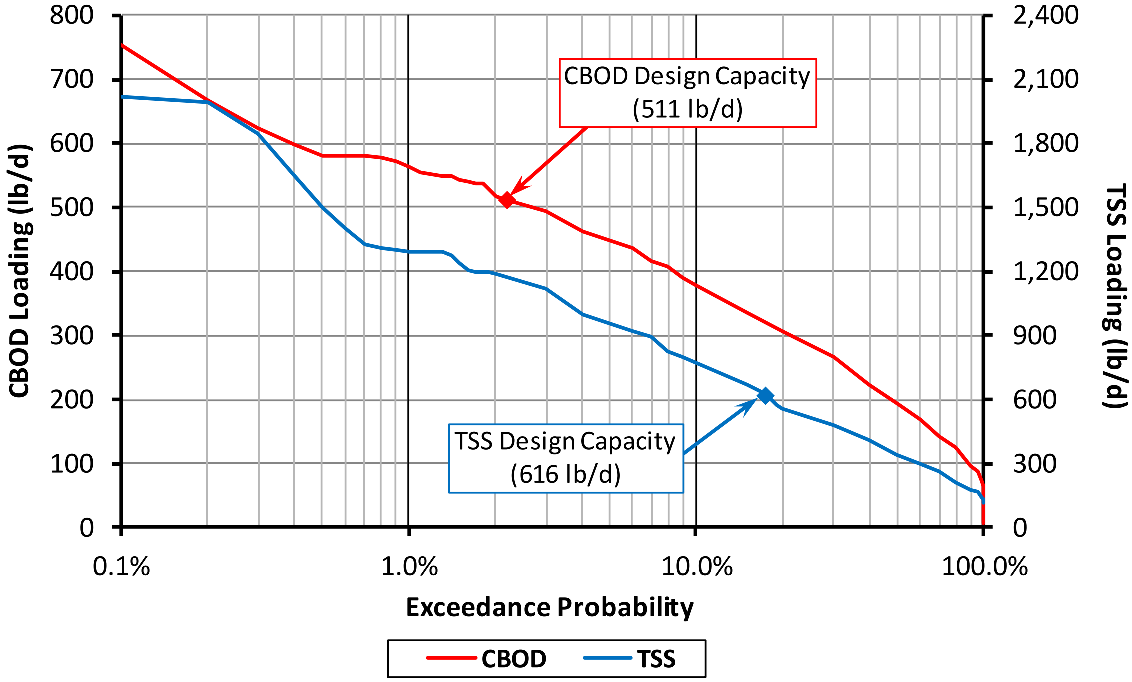


Figure 14. Influent CBOD and TSS loading exceedance probability (2009-2018).

Table 9 Influent BOD and TSS Loading (2009-2018)
Wastewater Facilities Plan Update, Bay City, Oregon

Statistic	BOD[1] (ppd)[2]	CBOD[3,4] (ppd)	TSS[4,5] (ppd)
Design Capacity	**616**	**511[(6)]**	**616**
Minimum Month Average	93[(6)]	77	147
Dry Weather Average	258[(6)]	214	364
Long-Term Average	267[(6)]	221	422
Wet Weather Average	274[(6)]	228	466
Maximum Month Average	578[(6)]	480	1,116
Maximum Day	1,011[(6)]	839	2,043

1. BOD: biochemical oxygen demand
2. ppd: pounds per day
3. CBOD: carbonaceous biochemical oxygen demand.
4. Weekly influent monitoring data collected between January 2009 and June 2018. Loads calculated using total daily flow measured daily at the WWTP influent flow meter on the date that weekly water quality samples were collected.
5. TSS: total suspended solids
6. Based on the EPA recommended conversion factor of 0.83 CBOD:BOD.

3.2.2.3 Temperature and pH

Influent water pH varied insignificantly between the years 2009 and 2018 according to the monitoring data, ranging from 5.9-8.4 with monthly averages ranging from 7.0-7.6 (Table 10, on the following page). Influent water temperature ranged from 9-21 degrees Celsius (°C), with average monthly temperatures decreasing in the winter to approximately 13 °C and increasing in the summer to approximately 17 °C.

Table 10 Influent Temperature and pH (2009-2018)
Wastewater Facilities Plan Update, Bay City, Oregon

Statistic	Temperature (°C)[1]	pH (s.u.)[2]
Long-Term Average	15	7.2
Maximum Day	21	8.4
Minimum Day	9	5.9
Dry Weather Average	17	7.3
Wet Weather Average	13	7.0

1. °C: degrees Celsius
2. s.u.: standard pH units

3.2.3 Wastewater Strength

Wastewater at the Bay City WWTP is considered low to medium strength in comparison with typical domestic wastewater concentrations for BOD and TSS (Table 11).

Table 11 Wastewater Strength
Wastewater Facilities Plan Update, Bay City, Oregon

Pollutant	Concentration (mg/L)[1]		
Typical Domestic Wastewater[2]	**Low Strength**	**Medium Strength**	**High Strength**
Biochemical Oxygen Demand	133	200	400
Total Suspended Solids	130	195	389
Bay City Wastewater[3]	**Wet Weather Average**	**Long-Term Average**	**Dry Weather Average**
Biochemical Oxygen Demand[4]	77	107	141
Total Suspended Solids	126	161	205

1. mg/L: milligrams per liter.
2. Metcalf & Eddy. 2014. *Wastewater Engineering Treatment and Resource Recovery*. New York, NY:McGraw-Hill.
3. Weekly influent monitoring data collected January 2009-June 2018.
4. Based on EPA recommended conversion ratio of 0.83 CBOD/BOD. CBOD data are collected for Bay City WWTP influent compliance monitoring.

3.2.4 Industrial Waste

No change to the industrial wastewater has occurred since the 2010 WWFP was written. For more information regarding industrial wastes affecting the Bay City WWTP, please see the 2010 WWFP (HBH, 2010).

3.2.5 Design Loads

Assuming wastewater strength does not increase over time in Bay City due to significant increases in industrial, commercial, or residential uses, Table 12 presents projected design loading rates for the year 2040. Projected maximum month average and maximum daily loadings exceed current design capacity of the Bay City WWTP.

Table 12 Projected Design Loads for the Year 2040[1]
Wastewater Facilities Plan Update, Bay City, Oregon

Statistic	BOD[2] (ppd)[3]	CBOD[4] (ppd)	TSS[5] (ppd)
Design Capacity	616	511[(6)]	616
Minimum Month Average	118	98	186
Dry Weather Average	329	273	463
Long-Term Average	339	281	536
Wet Weather Average	349	290	593
Maximum Month Average	735	610	1,420
Maximum Day	1,286	1,067	2,599

1. Projected 2040 design loading rates estimated as the 2009-2018 loading rates multiplied by the ratio of the 2040:2020 equivalent population (1.27).
2. BOD: biochemical oxygen demand
3. ppd: pounds per day
4. CBOD: carbonaceous biochemical oxygen demand
5. TSS: total suspended solids
6. Based on the EPA recommended conversion factor of 0.83 CBOD:BOD.

4.0 Existing Facilities

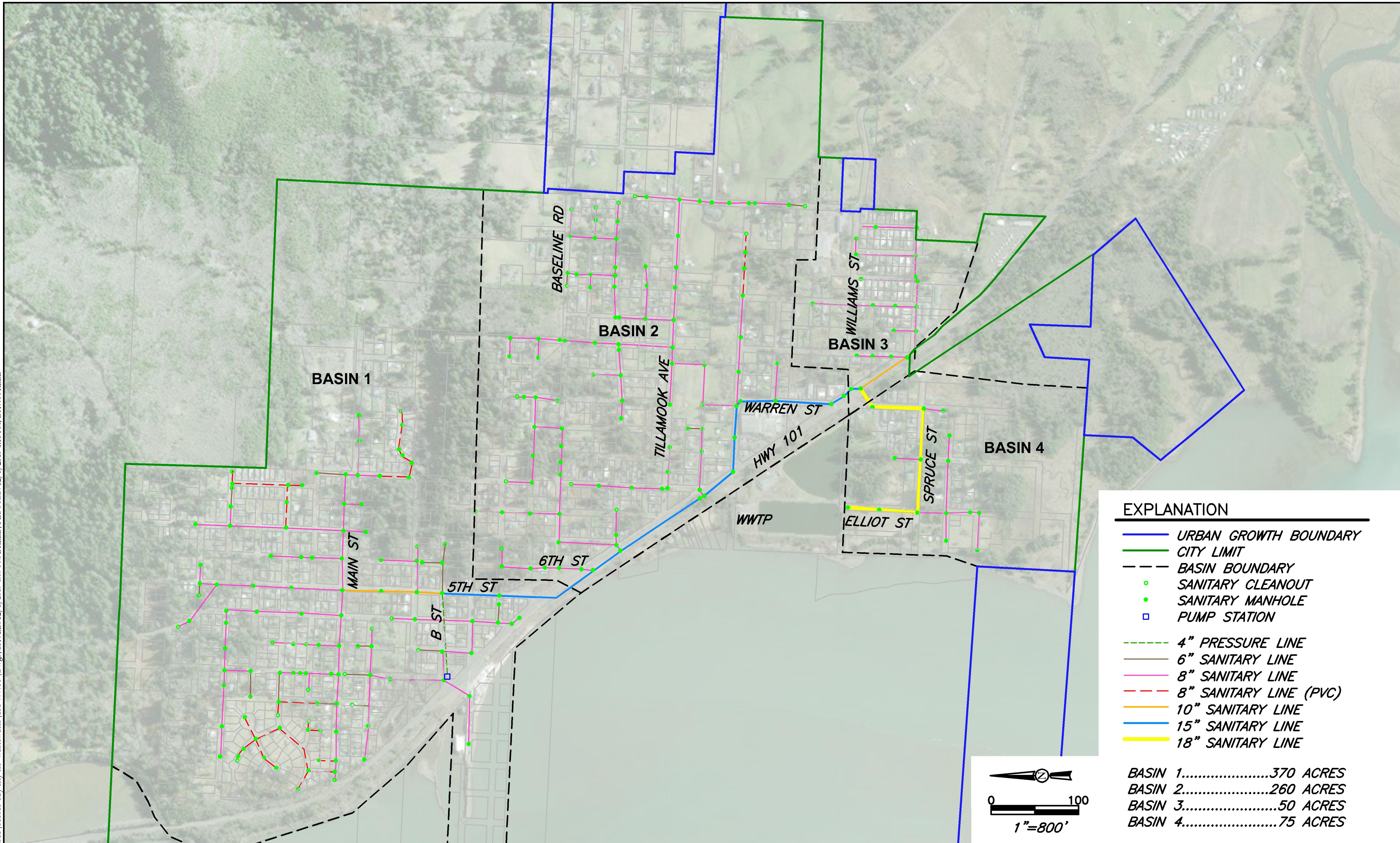
4.1 Collection System

4.1.1 Inventory

As shown in Figure 15, City of Bay City serves an area of approximately 755 acres. Within this area, the City has constructed and maintains approximately 11.6 miles of gravity pipelines, 0.1 miles of force main piping, 223 sanitary manholes, and one lift station. The inventory of the collection system ranges in size from 6-inch to 18-inch diameter pipe for the gravity system and 4-inch pipe for the lift station pressure pipe.

The primary pipe type in the collection system consists of bell and spigot concrete pipe that was installed in the 1970s to replace onsite septic systems. The concrete pipe has rubber gasketed joints and original lateral connections were completed with factory made taps. Newer sewer mains and spot repairs have been constructed with PVC materials. The newer construction and repairs are minimal compared with the existing installed length and the PVC component comprises approximately 9 percent of the total system.

Based on previous planning studies conducted by the City, the service area has been divided into 4 basins, designated 1-4. Within these basins, manholes have a numerical assignment that was initially based on the main sewer alignments; however, additions to the system have been made such that sequentially numbered manholes are not necessarily hydraulically connected. Within the system, manholes are precast



City of Bay City
Wastewater Facilities Plan Update
Bay City, Oregon

Wastewater Collection Systems
Overview
SHN 611013.151

December 2019 | 611013-CLTN-SYST | Figure 15

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concrete type with formed channels. An inventory of piping for each basin is provided in Table 13. A detailed breakdown of the inventory including pipe length and diameter is provided in Table 14. Figure 16 depicts the existing collection system in relation to the local topography presented as an overlay on standard USGS topographic mapping. Figure 17 depicts the existing collection system in relation to the 100- and 500-year flood zones presented as an overlay on the currently adopted Flood Insurance Rate Map.

Table 13 Pipe Type Inventory by Basin (lineal feet)
Wastewater Facilities Plan Update, Bay City, OR

Basin ID	Concrete	PVC	Ductile Iron
1	22,644	5,153	735
2	23,465	550	-
3	5,324	-	-
4	4,359	-	-
TOTAL	**55,792**	**5,703**	**735**

Table 14 Total Pipe Length by Diameter
Wastewater Facilities Plan Update, Bay City, OR

Lineal Feet	Pipe Size	Inch Diameter Miles (IDM)
735	4-inch pipe	0.6
3,256	6-inch pipe	3.7
5,703	8-inch pipe (PVC)	8.6
43,926	8-inch pipe	66.6
1,515	10-inch pipe	2.9
4,832	15-inch pipe	13.7
2,263	18-inch pipe	7.7
62,230	**Total**	**103.8**
Total Miles of Pipe		**11.8**

4.1.2 Basin Descriptions

4.1.2.1 Basin 1

Sewer Basin 1 is the largest basin in the system and is comprised of approximately 370 acres in the north area of the City. The topography in this basin is a mixture of relatively flat low-lying areas in the middle of the basin and hills in the north and south sections of the basin. There are two creeks (Patterson and Jacoby) that run through this basin and combine near 6th Street. Existing land-use in Basin 1 is primarily residential with one industrial connection. The majority of the collection system in this basin flows by gravity through a series of 8-inch and 10-inch concrete sewer mains into a 16-inch gravity main which runs down 5th Street. All flows in this basin are conveyed through the 5th Street main into Basin 2. This basin contains a lift station located at the west end of B street. The lift station drainage consists of approximately 5,400 LF on the western side of the basin. The lift station discharges into the 5th Street main at the intersection of 5th and B Street.

4.1.2.2 Basin 2

Sewer Basin 2 is located in the central portion of the City and is comprised entirely of residential development. This basin has both flat and hilly sections with the natural slope to the south and west. The collection system in this basin flows by gravity through a series of 8-inch concrete sewer mains tributary to the sewer main on Highway 101 which exits the basin through a sewer main at Warren Street. Basin 2 is the second largest basin and encompasses approximately 260 acres.

4.1.2.3 Basin 3

Sewer Basin 3 is comprised of approximately 50 acres in the south portion of the City. Basin 3 is primarily a residential basin with one commercial connection. The primary topography of this basin consists of a hill central to Williams Street. Sewer flow exits this basin through a 10-inch main on Spruce Street and combine with a 15-inch main from Basin 2 at Warren Street. The 10-inch and 15-inch mains exit through an 18-inch interceptor line under Highway 101 to Basin 4.

4.1.2.4 Basin 4

Sewer Basin 4 consists of approximately 75 acres and includes residential developments in the southwestern area of the City. This basin is flat and low lying and is the furthest downstream point of the collection system. Sewer flows generated in and passing through this basin exit down an 18-inch main on Elliot Street to the existing influent pump station at the wastewater treatment plant.

4.1.3 Lift Station

The Downtown Lift Station is a relatively small installation serving approximately 19 percent of the installed sewer lines in Basin 1. The tributary area to this lift station is the northwest corner of the basin which is relatively flat and low lying compared with the remainder of the basin. This lift station was originally constructed in 1971 and the pump motors were rebuilt in 2008. Other than routine maintenance, no major modifications have been completed. Table 15 includes the design data for the lift station.

Table 15 Downtown Lift Station Design Data
Wastewater Facilities Plan Update, Bay City, OR

Parameter	Value/Description
Station Piping:	8-inch
Piping Type:	Ductile Iron
Pump Type (2)	Duplex Self-priming constant speed centrifugal
Make/Model:	Wemco/EVM
Capacity (Each)	100 gpm[1] @ 21 ft[2] total dynamic head
Level Control:	Bubbler system
Overflow:	None
Time to Overflow	4.55 hours @ 10% above firm capacity
Motors:	20 HP[3] – Rebuilt in 2008
Speed:	1,170 rpm[4]
Power Requirements:	230/460V[5], 60 Hz[6], 3-Phase
Drive:	Direct
Auxiliary Power Type:	Propane generator at Pump House Control Room
Wet Well Dimensions:	11 ft x 3.5 ft x 9.5 ft deep
Wet Well Volume:	2,735 gallons

Table 15 Continued

Parameter	Value/Description
Alarm Type:	Red Indicator Light on top of station
EPA Reliability Class I:	No
Force Main	
Length:	735 LF[7]
Diameter:	4-inch
Detention Time	4.8 minutes @ 100 gpm
Material:	Steel
Blow-off Valve	None
Vacuum Release Valves:	None
Sulfide Control System:	None
Discharge	
Location:	Manhole 21 “B” Street and 5th Street
Discharge Manhole Condition:	Good
Firm Capacity:	**100 gpm**

1. gpm: gallons per minute
2. Ft: feet
3. HP: horsepower
4. rpm: rotations per minute
5. V: volts
6. Hz: hertz
7. LF: lineal feet

4.2 Collection System Assessment

4.2.1 Capacity Analysis

A capacity analysis of the collection system was performed in the previous facility plan. Based on the limited population growth from the time of the previous plan to present, the general analysis is assumed to be still relevant. Additionally, the ultimate build out projections are assumed to be unchanged as the land use and urban growth boundary have remained stable since the previous planning effort. In the previous analysis, the majority of pipe segments were deemed to have sufficient hydraulic capacity to meet current and future needs; however, 11 pipe segments extending from MH1 to MH12 were identified as being undersized for the ultimate build out flow projections at the peak instantaneous flow.

In the previous Plan, an alternative was presented for routing the majority of the outflow of Basin 2 directly under Highway 101 to the wastewater treatment plant. If this routing project is completed, it is likely that the lines that were previously deemed to be undersized would be adequate for the ultimate buildout projection because significantly less flow would be carried by them.

However, because the collection system has not been metered, estimates of EDUs and gravity flow capacity calculations were the basis for pipe segment recommendations. As stated in the previous plan, these estimates are limited in value, insufficient for rehabilitation project design, and should be improved with physical data collection. Flow meters should be installed in the basins to measure flow patterns throughout the day and to quantify responses to storm events. Section 5 includes a plan for flow meter efforts to better assess storm response and, with proper installation and data analysis, will serve to inform design and implementation of rehabilitation projects.

4.2.2 I/I Identification and Reduction Efforts

Through annual inspections and repairs, and focused projects, the City has put much effort into identifying and reducing infiltration and inflow into the sanitary sewer collection system. Annual I/I reduction efforts have included CCTV inspections, lateral repairs, manhole sealing, high flow inspections, and inflow shield installation. The focused projects include a rehabilitation project in 1994 and inspection work associated with the 2010 Facility Plan. From these ongoing efforts, sources of I/I have been identified and been used to inform the annual repair tasks.

To build on the information gathered in previous efforts, additional inspections were completed for this Plan update to identify locations of high I/I contribution. These efforts included the following:

1. Smoke Test entire system - August 2015
2. CCTV sewer trunk lines from Manhole 21 to Manhole 1 - November 2015
3. Flow Poke select areas in Basins 1, 2 & 3 – December 2015
4. Electroscan and CCTV problem areas identified in flow poking – March 2016

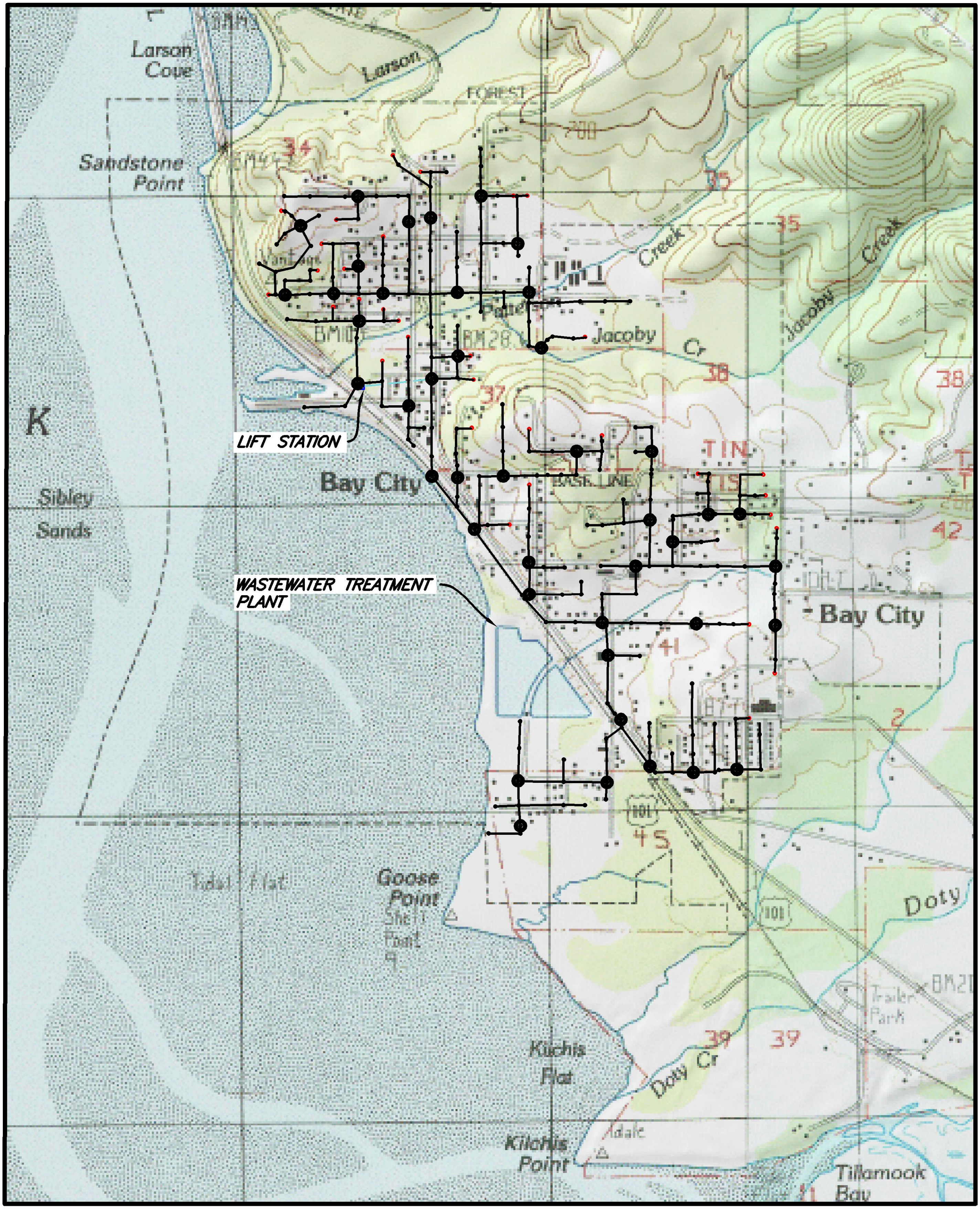
The following sections summarize the assessments completed for this Plan.

4.2.2.1 Smoke Testing Inspection Summary

Smoke testing was completed by SHN staff in August of 2015. The entire system was smoke tested primarily to identify inflow-related point defects. The completed inspection report is included separately in Appendix 1. The report includes description of field work, map of defects identified, recommendations for repairs, and the field data. In general, the types of defects found in the smoke testing efforts were consistent with previous testing efforts. Defects such as uncapped cleanouts, structural damage of pipes and manholes, and broken laterals were identified as well as cross-connections from roof drains and/or the stormwater system to the sewer line. The smoke testing report categorizes repairs into three priority levels with major issues receiving a priority of one. The priority map repair map from smoke testing is included as Figure 16. The City Public Works Department has addressed all identified, significant deficiencies, working with property owners when necessary.

4.2.2.2 Trunk Line CCTV Inspection Summary

CCTV inspection was performed on the trunk line from Manhole 21, which is located at the intersection of B Street and 5th Street, extending to Manhole 1, which is immediately upstream of the influent pump station at the WWTP. This line was selected for visual assessment because it is the main conveyance line in the system. Approximately 6,866 feet were inspected during the period from November 16, 2015 through November 24, 2015. In general, the surface of the concrete pipe did not appear to be substantially degraded or corroded from hydrogen sulfide gas; however, aggregate was exposed to a minor degree at and below the spring line of most of the inspected segments. Manhole troughs, particularly with sharp bends, were also moderately corroded. Throughout all of the inspected segments, substantial accumulations of sediment and gravel were encountered; therefore, it is likely that the corrosion in the pipes and manholes is the result of abrasion from sediment-laden flows. The majority of the debris was removed during the precleaning and inspection process.



SOURCE: BAY CITY, OREGON
USGS TOPO MAP QUAD: GARIBALDI

SHN Consulting Engineers & Geologists, Inc.	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Topo Map SHN 611013.151
	December 2019 / 611013-151-WWFPU-FIGS	Figure 16

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No major structural deficiencies were identified; however, a few minor circumferential cracks were found. The majority of the pipe joints had a buildup of white material which appears to be a remnant from the construction process and not from grease accumulations or infiltration staining. In general, lateral connections from new and original construction appeared to be well made and likely well sealed; however, broken-in and poorly sealed connections are also present in the newer laterals. Additionally, several connections appeared to serve lots with either no visible structure or there appeared to be too many lateral connections for the number of structures on the lot. Dye testing is recommended for suspect connections to determine if the connection is active or capped. During the inspection, active infiltration was only encountered twice; however, soil saturation may not have been sufficient for some leaks to be observed. Additionally, leaks occurring below the flow level would be obscured from the inspection. Infiltration staining was observed at one crack and in the crown of several segments. Several joints were also separated to a moderate degree. It should be noted that, while joint seal integrity could not be determined from the CCTV inspection, age and severity of I/I indicates that joint seals are likely defective and leaky. Figure 17 and 18 are maps of the inspected segments. A table of defects and observations is included in Appendix 2. Overall the inspection segments were in good structural condition and not at risk of immediate failure.

4.2.2.3 Flow Poke Measurement Summary

Manual flow measurements ("Flow Poke") have been taken for previous studies and were also performed for this Facility Plan Update. Flow poking is an instantaneous measurement that is typically performed during a rain event at night (when the domestic sewer flow component is expected to be low). When domestic sewer flows are low, the primary component in the collection system is either extraneous inflow or infiltration. These instantaneous measurements assist in narrowing in on areas contributing proportionally larger amounts of I/I compared with other segments.

Flow poking was completed in Basins 1, 2, and 3 on the night of December 17, 2015. The locations selected for flow measurement for this plan were consistent with previous efforts with the intent to re-measure flows and to evaluate a larger storm response than what was previously measured. In 2010, flow poke data collection was performed during smaller storms which totaled approximately 0.33 inches of rain, while on the day of the data collection event for this Facility Plan Update, a total of 4.06 inches of rain was recorded with the previous 7-day precipitation totaling 5.73 inches. The high levels of rainfall before and during this data collection event provided optimal conditions for observing rainfall response in the collection system. Figures 19-21 include the results of the flow measurements.

The flow poking identified three segments of sewer main that were contributing abnormally high flows. These three areas include Basin 1: 7th Street between Fern and Main; Basin 2: 15th Street and Seattle Street between 15th and Brewley's; Basin 3: Spruce Street. The flows recorded from these areas are substantially higher than those recorded in the previous efforts; however, this is to be expected due to the wetter conditions. Without continuous flow monitoring, the storm response at these locations cannot be further separated into inflow or infiltration components; however, it is clear that these areas contain defects that are allowing significant volumes of extraneous water into the collection system. These three areas were selected for further data collection and physical inspections to determine the condition and to locate defects.

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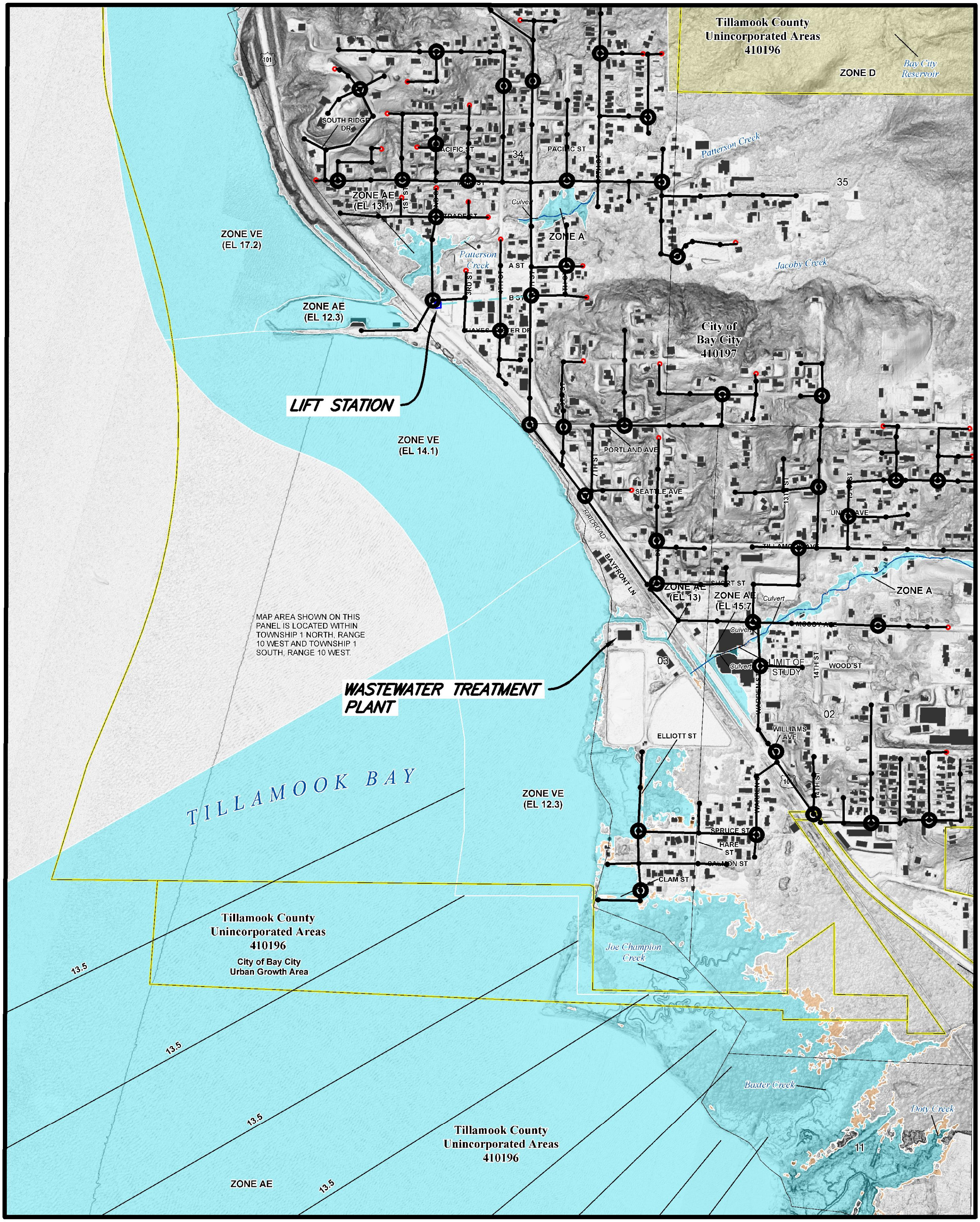

SOURCE: FEMA

SHN Consulting Engineers & Geologists, Inc.	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Flood Map SHN 611013.151
December 2019	611013-151-WWFPU-FIGS	Figure 17

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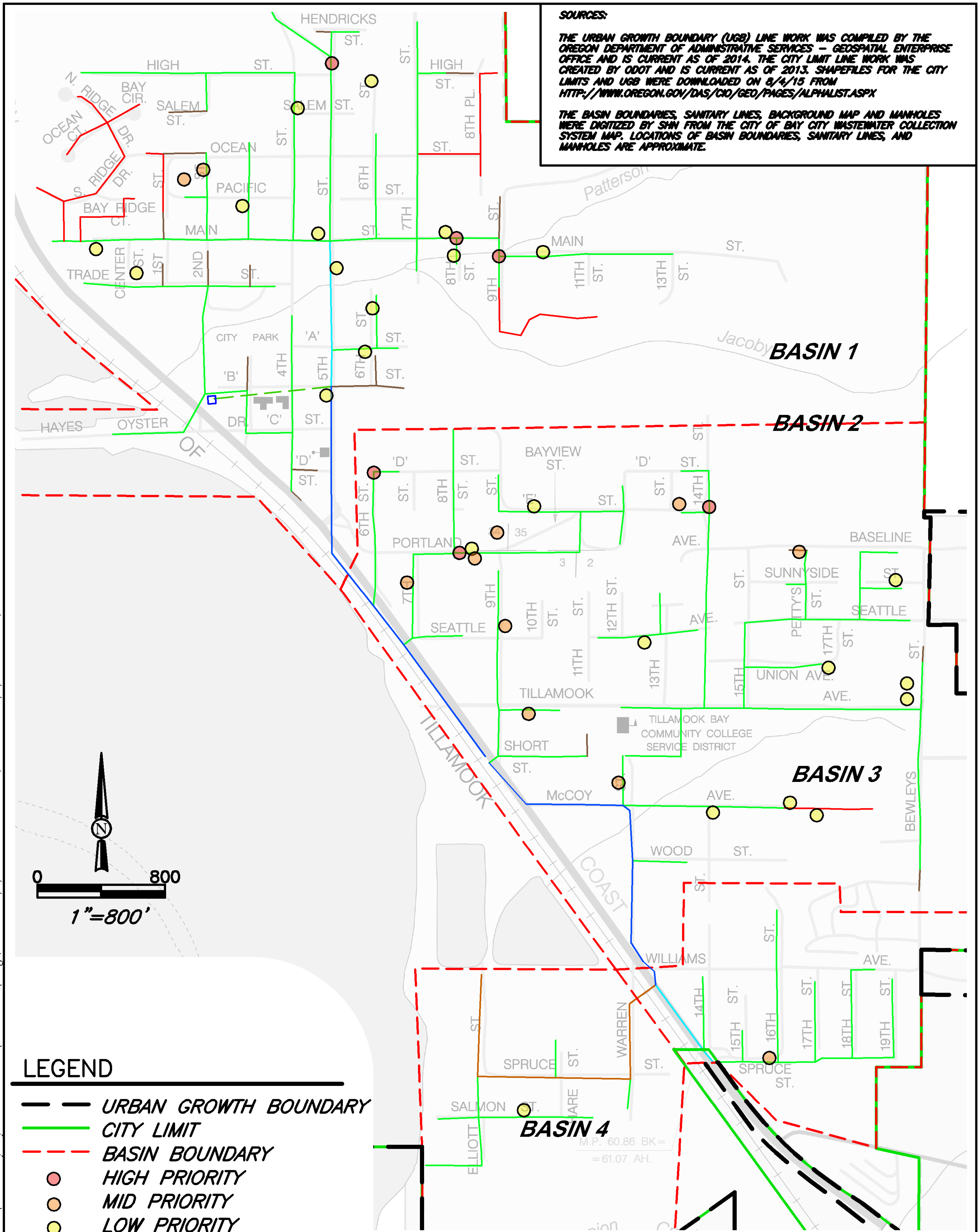

SOURCES:

THE URBAN GROWTH BOUNDARY (UGB) LINE WORK WAS COMPILED BY THE OREGON DEPARTMENT OF ADMINISTRATIVE SERVICES – GEOSPATIAL ENTERPRISE OFFICE AND IS CURRENT AS OF 2014. THE CITY LIMIT LINE WORK WAS CREATED BY ODOT AND IS CURRENT AS OF 2013. SHAPEFILES FOR THE CITY LIMITS AND UGB WERE DOWNLOADED ON 8/4/15 FROM HTTP://WWW.OREGON.GOV/DAS/CIO/GEO/PAGES/ALPHALIST.ASPX

THE BASIN BOUNDARIES, SANITARY LINES, BACKGROUND MAP AND MANHOLES WERE DIGITIZED BY SHN FROM THE CITY OF BAY CITY WASTEWATER COLLECTION SYSTEM MAP. LOCATIONS OF BASIN BOUNDARIES, SANITARY LINES, AND MANHOLES ARE APPROXIMATE.

SHN Consulting Engineers & Geologists, Inc.	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Collection System Evaluation Smoke Testing Results SHN 611013.151
December 2019	611013-TV-Clean	Figure 18

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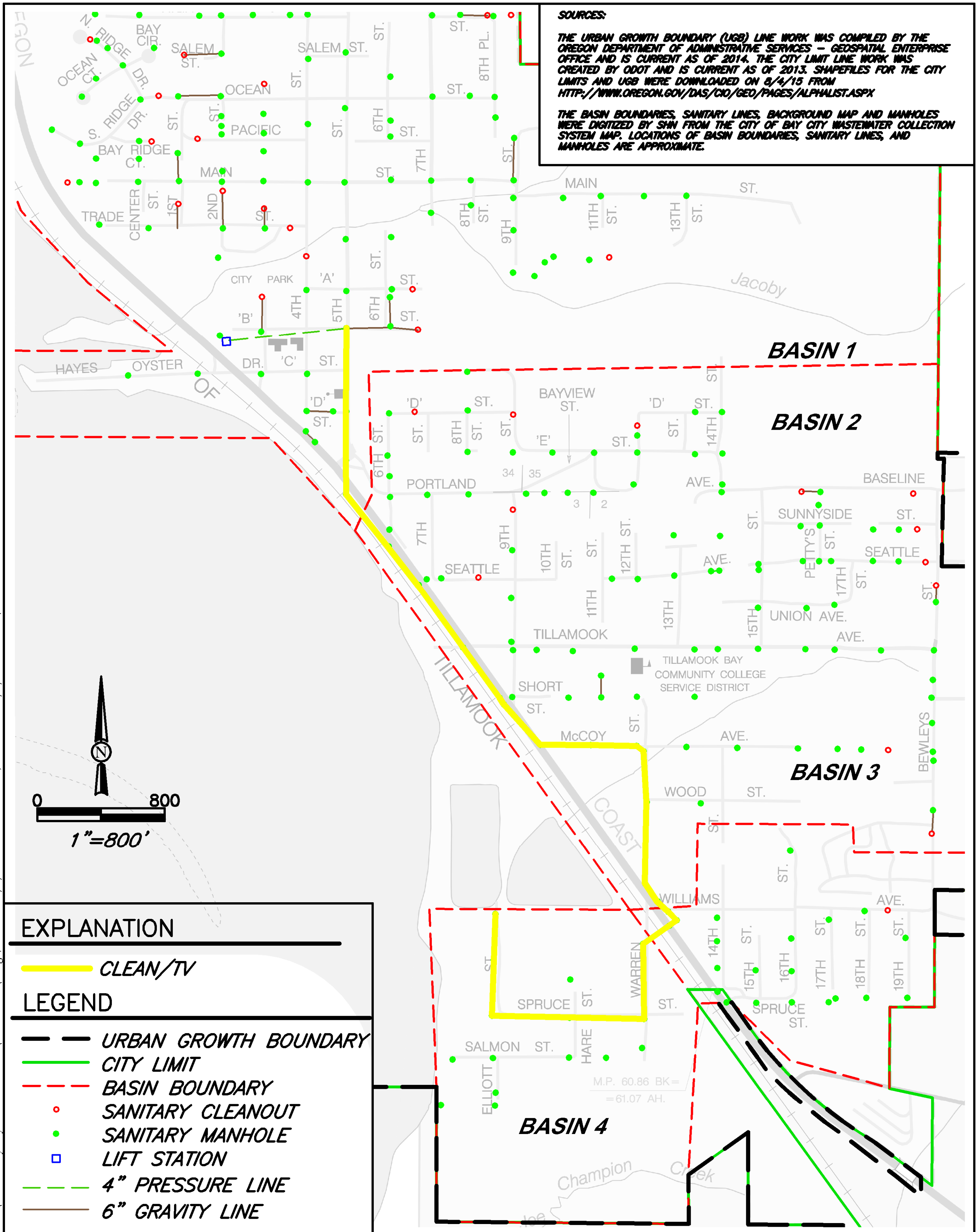

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SHN	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Collection System Evaluation Clean/TV Nov 2015 SHN 611013.151
	December 2019	611013-TV-Clean	Figure 19

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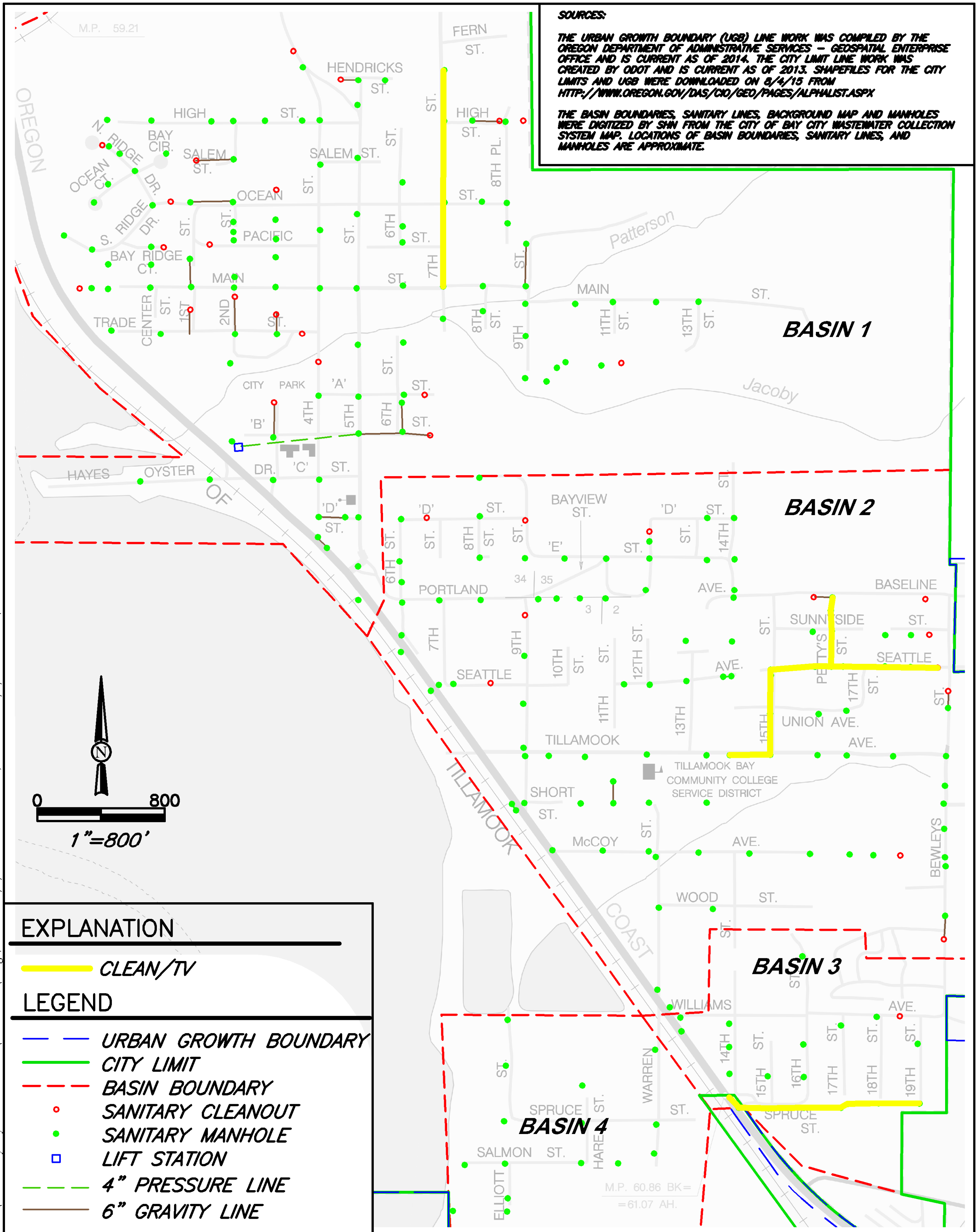

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THE URBAN GROWTH BOUNDARY (UGB) LINE WORK WAS COMPILED BY THE OREGON DEPARTMENT OF ADMINISTRATIVE SERVICES – GEOSPATIAL ENTERPRISE OFFICE AND IS CURRENT AS OF 2014. THE CITY LIMIT LINE WORK WAS CREATED BY ODOT AND IS CURRENT AS OF 2013. SHAPEFILES FOR THE CITY LIMITS AND UGB WERE DOWNLOADED ON 8/4/15 FROM HTTP://WWW.OREGON.GOV/DAS/CIO/GEO/PAGES/ALPHALIST.ASPX

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EXPLANATION

CLEAN/TV

LEGEND

URBAN GROWTH BOUNDARY
CITY LIMIT
BASIN BOUNDARY
SANITARY CLEANOUT
SANITARY MANHOLE
LIFT STATION
4" PRESSURE LINE
6" GRAVITY LINE

SHN	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Collection Systems Evaluation Clean/TV April 2016 SHN 611013.151
December 2019	Clean-TV April 2016	Figure 20

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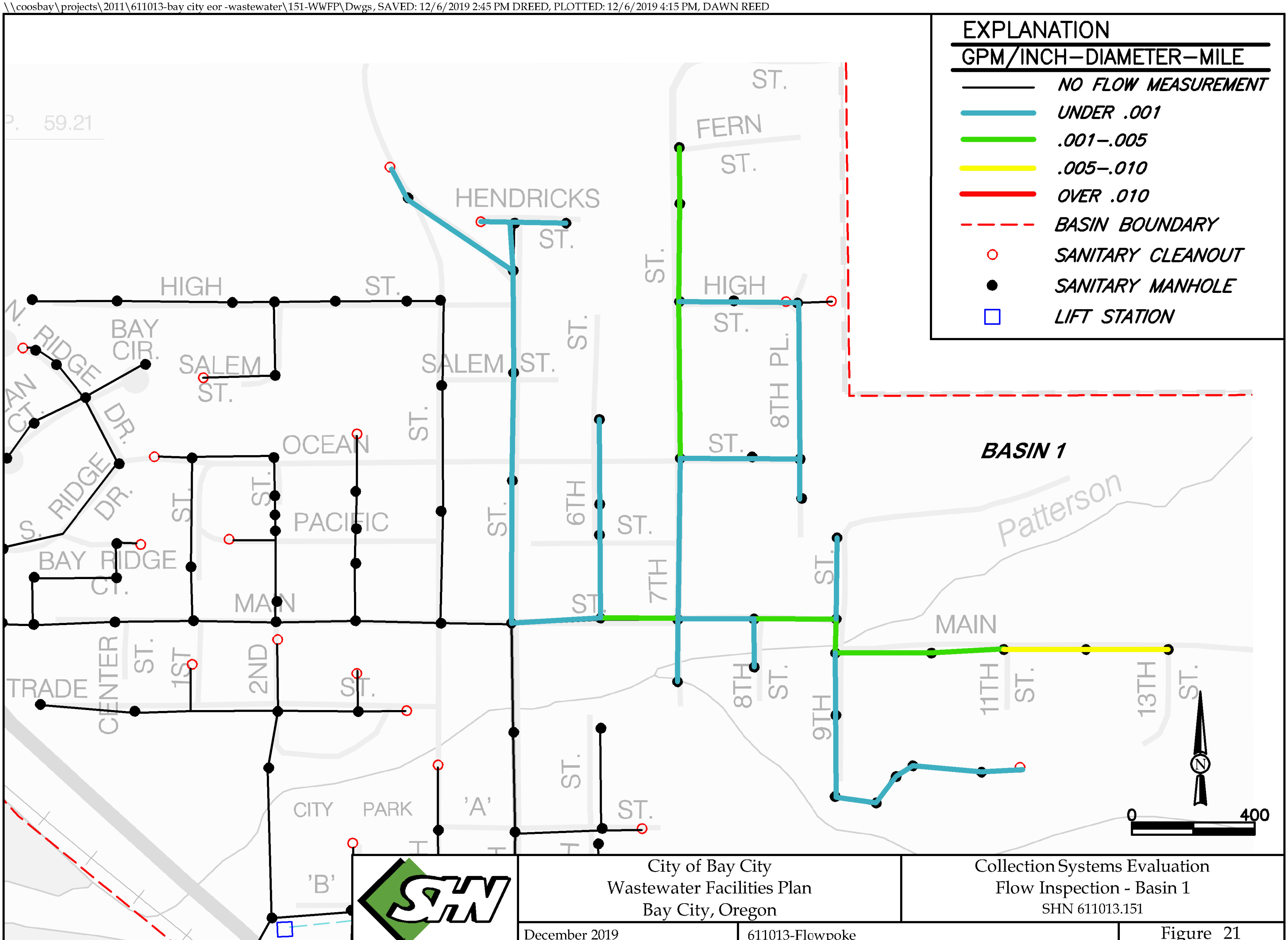

City of Bay City
Wastewater Facilities Plan
Bay City, Oregon

Collection Systems Evaluation
Flow Inspection - Basin 1
SHN 611013.151

December 2019 | 611013-Flowpoke | Figure 21

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4.2.2.4 Priority Areas Closed Circuit Television (CCTV) and Focused Electron Leak Locator (FELL) Inspection Summary

Both CCTV and FELL were completed in the three priority areas identified through the flow poking field work. CCTV was performed on April 13 and April 14, 2016 by Spartan Environmental Services of Salem, OR. FELL was performed by Electro Scan Inc. of Sacramento, CA on April 26, 2016 and April 27, 2016. The CCTV was performed to compare the Electro Scan results with a visual assessment. The three inspected areas are located in Basins 1-3 and are shown in Figure 22.

FELL is a relatively new technology and has not been performed before on Bay City's collection system; therefore, this paragraph provides a brief overview of the inspection methodology. FELL is a defect detection technology that utilizes low voltage electricity to measure changes in electrical current in non-conductive pipes. A probe is sent through the pipe with a "slug" of water surrounding it so that the pipe is completely full around the probe. This water slug allows for full contact between the electrical current emitted from the probe and the pipe wall. A grounding rod is positioned in the inspected area and the current between the probe and rod is recorded and translated into a spatial log as the probe travels down the pipe. Defects that allow passage of water through the pipe wall result in a current being detected with larger defects having higher magnitude current readings. With the magnitude of current and the overall length of defect measured, the severity of a defect is estimated. The report provided by Electro Scan assigns flow in gallons per minute (gpm) to each defect; however, inherent assumptions in the method make the reported values useful for comparative purposes only and not as actual inflow rates. Therefore, visual comparison with CCTV is important to verify results.

Overall, the inspected segments were in good structural condition with only one location of concern for structural failure. Corrosion of piping and manhole channels was minimal; however, debris and sediment were present and required removal in most inspected segments. This debris could be the result of poor manhole sealing, joint failure, or compromised laterals.

In the inspected area, grease accumulations were not significant but occurred to a moderate degree in the invert of the segments between MH55 and MH54 and in the crown of the segments between MH41 and MH33. Because of the grease accumulations, an informational program targeted at residential fats, oils, and grease (FOG) is recommended.

From CCTV review, factory lateral connections appeared to be well-made and in good condition; however, field tap quality varied with some good and others quite poor. Also, several laterals were protruding into the mainline and were poorly sealed. FELL inspection of the connections generally agreed with the visual assessment; however, the scanning indicated that leakage in some field taps was worse than expected. Because the FELL inspection was limited to the mainline, the laterals were not tested upstream of the connection. However, CCTV footage identified active I/I visible from the main and poor lateral sealing where 4-inch laterals were connected to 6-inch stubs. Active I/I was also observed at joints and some cracks.

The FELL inspection results found electrical current leakage through the majority of the pipe joints in the inspected segments. Even though the FELL inspections were completed in a relatively small quantity of the

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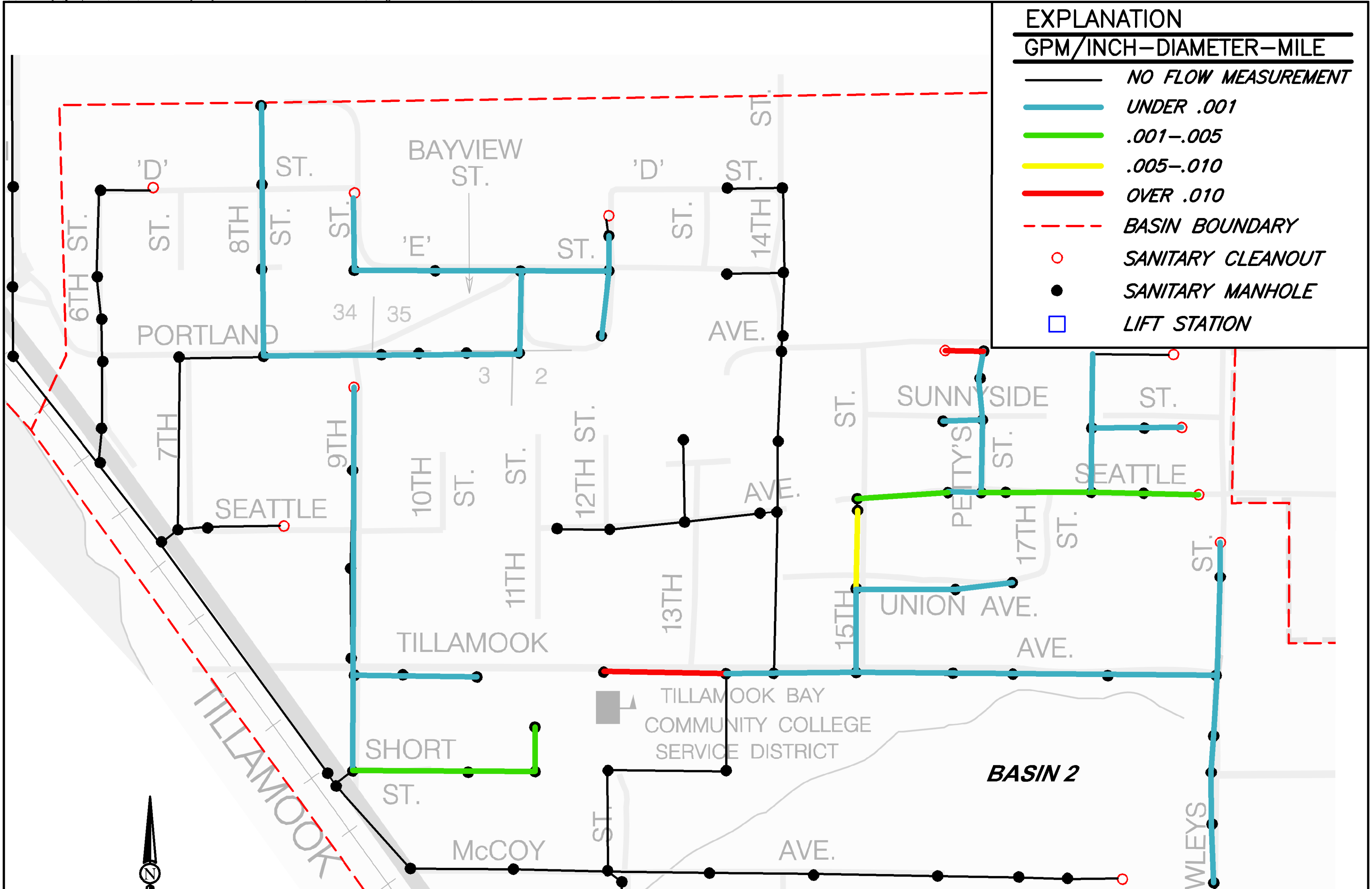

City of Bay City
Wastewater Facilities Plan
Bay City, Oregon

Collection Systems Evaluation
Flow Inspection - Basin 2
SHN 611013.151

December 2019 | 611013-Flowpoke | Figure 22

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collection system, because the majority of SSCS was installed at one time and with the same materials, it is likely that poorly sealed or failed joints are present throughout the entire system. This joint leakage is potentially a significant source of the total I/I at the WWTP. Additional observations at MH 33 and MH145 show that outside drops with failed joints that are allowing infiltration into the system. These defective joints are likely the result of manhole settling. Settlement cracks also occurred immediately upstream of MH57, MH56, and MH55. Point repairs previously completed in the rehabilitation efforts appear to have settled and do not have good seal integrity; additionally, one section was repaired with a larger diameter pipe which caused a low point and potentially a poor seal.

4.2.3 Typical Defects and Deficiencies

Based on the inspections completed for this Plan and other annual efforts, the typical defects in the sanitary sewer collection system include:

- Cross-connections
- Uncapped cleanouts
- Leaky manhole joints and covers
- Poor lateral taps
- Leaky lateral pipelines
- Leaky pipe joints
- Structural defects
- Root intrusion

Similar problems are anticipated to be identified with continued implementation of a sewer system-monitoring program. A summary of the types of problems identified in the field work is included in the following sections.

4.2.3.1 Spot Failures

Spot failures can occur in many forms including circumferential cracks, holes in the pipe walls, areas of minor root intrusion, chipped and broken pipe joints, displaced or separated joints, and joints with excessive deflection. Some areas of spot failure may exhibit signs of active or past I/I, or downstream sections will have observable quantities of sand and gravel.

4.2.3.2 Leaky Service Laterals

Lateral connection quality can vary dramatically in a collection system that has built up over a period of time. Construction methods, backfill compaction, and various other factors impact the long-term sealing ability of the connections. Settlement in the trench can cause laterals to shear off the main or deflect enough to compromise the seal. Offset joints in the lateral or damage from roots is also common and may be much more significant in the shallower portions of the lateral. Some laterals were found to be 4-inch pipe inserted into 6-inch with no reducing coupler, this sharp transition is likely not well sealed. Additionally, when buildings are abandoned or demolished, service laterals are not always sealed-off properly and may allow significant quantities of I/I. Therefore, dye testing in conjunction with CCTV may be necessary for suspect connections.

4.2.3.3 Grease Accumulations

The removal of grease from the sewer system is important to the proper operation of the system because excessive accumulation can lead to clogging, backflow, and flooding problems. In the inspections completed for this Facility Plan Update, no major grease accumulations were identified. However, some deposits were present. Low levels of grease generally indicate effective grease removal mechanisms on commercial establishments, frequent mainline cleaning, or both.

4.2.3.4 Leaky Manholes
Physical observations made during routine inspections have regularly identified manholes that allow I/I into the system. Defects include poorly sealed joints, loose rims and frames, and broken inlet and outlet pipes. Pipe breakage around the manholes are associated with settlement of the structures and were found particularly at manholes with outside drops.

4.2.3.5 Root Intrusion
The United States Environmental Protection Agency stated in 1977 that: "Root intrusion is the single most destructive element facing sewer authorities." Uncontrolled, root intrusions will grow and eventually lead to massive root balls that clog sewers and destroy the pipe. No significant rooting was identified in the field work; however, shallow mains and service laterals are particularly at risk because of their proximity to landscaping.

4.2.3.6 Debris Accumulation
Based on the original design plans for the SSCS within the City, there are considerable lengths of sewer piping that were designed at the minimum grade to achieve minimal scouring velocities (2 feet per second). Due to settlement and construction tolerances, those pipes may have flatter-than-specified slopes; therefore, it is likely that scour velocities are not reached for some of the pipe segments. With low scour velocities, pipes have a tendency to accumulate solids in the bottom of the pipe. Through inspections completed for this Facility Plan Update, significant accumulations of gravel and sand and some larger rock were found. This debris may be entering the system from failed joints, defective laterals, and or poorly sealed manholes. Because no major hole defects were uncovered, sources are most likely either lateral defects or mainline defects that were upstream of the inspected segments.

4.2.4 Collection System Assessment Summary
The SSCS appears to be in adequate structural condition; however, inspections have identified a variety of defects and sources of I/I that are allowing extraneous water into the system. This extraneous flow contributes to high wet weather flow peaks and results in treatment and pumping inefficiencies, and loss of treatment and conveyance capacity. The existing pump station and force main within the collection system is nearly over capacity for existing wet weather flows and should be replaced to improve capacity and safety. Several sewer mainline segments appear to be undersized for the ultimate buildout flow projections; however, rerouting and/or I/I reduction efforts may alleviate these issues. Because of the age of the system, and the quantity of extraneous flows, systematic rehabilitation of problem areas is recommended.

4.3 Treatment System
The Bay City WWTP currently consists of an influent pump station, a high flow equalization basin, a grinder, two sequencing batch reactor (SBR) basins, an aerobic digester, a facultative sludge lagoon, an ultraviolet (UV) disinfection system, and an effluent discharge outfall pipe leading into Tillamook Bay (Figure 23). The current NPDES permit requires the facility to recirculate effluent within the WWTP when there is less than 2 feet of Bay water over the outfall (the outfall lies in the intertidal zone where tide waters rise and fall above and below the outfall).

The system, as originally designed, has a stated hydraulic design capacity of 1.40 million gallons per day (MGD; peak instantaneous flow rate), with average biochemical oxygen demand (BOD) and total suspended

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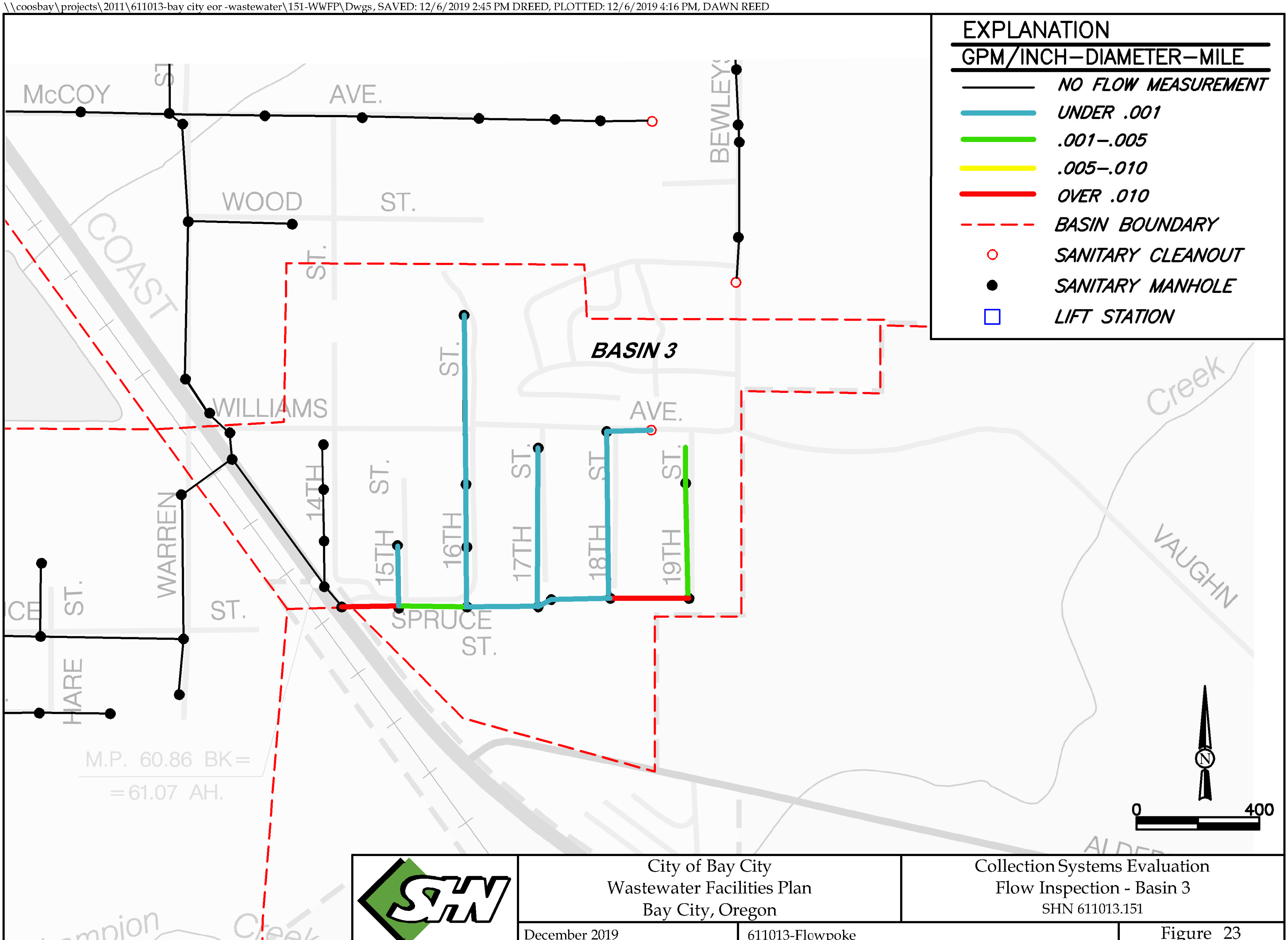

City of Bay City Wastewater Facilities Plan Bay City, Oregon	Collection Systems Evaluation Flow Inspection - Basin 3 SHN 611013.151
December 2019 · 611013-Flowpoke	Figure 23

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solids (TSS) design loading capacities of 616 pounds per day (ppd) each. Hydraulic capacity of the system was exceeded on four occasions between the years 2009-2017 (Figure 3). During these periods, the equalization basin was used to store peak flows above the hydraulic capacity of the WWTP.

The original WWTP was constructed in 1971 and consisted of two ponds, the current equalization pond and facultative sludge lagoon. The UV system was upgraded in 2013. Beginning in 2013, the system received an upgrade to include the components described above. Since 1995, no significant renovations have occurred to the existing WWTP. Table 16 presents design, current, and projected loading conditions for the Bay City WWTP.

Table 16 WWTP[1] Design Capacity, Existing, and Projected Conditions
Wastewater Facilities Plan Update, Bay City, Oregon

Design Characteristic	Design Capacity (1995)	Existing Conditions (2018)	Projected Conditions (2040)
MMDWF[2] (MGD[3])	0.29	0.35	0.41
MMWWF[4] (MGD)	0.86	0.66	0.75
PDF[5] (MGD)	1.02	1.53	1.72
PIF[6] (MGD)	1.40	2.24	2.51
BOD[7] Loading, Max Day[8] (ppd[9])	616	1,011	1,286
TSS[10] Loading, Max Day (ppd)	616	2,043	2,599

1. WWTP: wastewater treatment plant
2. MMDWF: Maximum Month Dry Weather Flow
3. MGD: Million Gallons Per Day
4. MMWWF: Maximum Month Wet Weather Flow
5. PDF: Peak Day Flow
6. PIF: Peak Instantaneous Flow
7. BOD: Biochemical Oxygen Demand
8. Design capacity uses average daily loading, existing and projected conditions represent maximum day loading rates.
9. ppd: pounds per day
10. TSS: Total Suspended Solids

4.3.1 Influent Pump Station

Raw sewage is conveyed to the WWTP influent pump station (IPS) via an 18-inch gravity pipeline (City of Bay City, 2016). The IPS, which is located near the southeast corner of the facultative sludge lagoon, consists of three vertical, non-clog 10 hp Cornell solids handling vertical sump centrifugal pumps that lift the wastewater from the wet well to the secondary treatment system. No more than two pumps operate at a single time, which allows the third pump to act as a backup. The pump station has a firm capacity of 1.4 MGD.

A 12-inch gravity overflow pipe can divert influent to the surge basin when flows exceed the capacity of the IPS pumps. Influent stored in the surge basin is pumped back to the IPS to be treated, once flows subside.

Influent flow is metered upstream of the IPS such that any water returning to the IPS from the facultative sludge lagoon and surge basin, including direct rainfall on the two basins, is not included in influent flow measurements. This volume of water affects the hydraulic loading of the WWTP and the treatment efficiency of all downstream processes.

No changes have been made to the IPS since the 2010 WWFP was written; additional information regarding the IPS may be found in the 2010 WWFP (HBH, 2010).

Deficiencies

Recommendations to alleviate deficiencies in the IPS are discussed in Section 7 Development and Evaluation of Alternatives. The following deficiencies were noted in the 2010 WWFP (HBH, 2010):

- The manhole invert, immediately upstream of the IPS (MH1), is 4.1 feet below the invert elevation of the gravity overflow from the IPS to the surge basin. During high flows, sanitary sewer overflows (SSOs) occur at this manhole in violation of the facility's NPDES permit. SSOs at MH1 may be due to insufficient pumping capacity in the IPS.
- The IPS has a firm capacity rating of 1.4 MGD. Operating in parallel, however, reduces the actual capacity of these pumps. The PIF is currently estimated to be approximately 1.41 MGD such that the IPS likely does not have the capacity to handle current peak flow rates or projected future peak flow rates.
- Cavitation has been reported to occur in the pump station when Pump #2 is running at the same time as either Pump #1 and/or Pump #3 due to the intakes of the pumps being too close together. However, operation of Pump #2 simultaneous with Pump #1 or #3 is not typical.

4.3.2 Flow Equalization (Surge Basin)

During peak flows, influent surges are equalized by gravity flow into the raw sewage surge basin from the IPS. Water from the FSL may also gravity overflow to the surge basin if levels exceed the FSL capacity. As the influent flow rate decreases, water stored in the surge basin can be pumped back to the IPS wet well by a separate recirculation pump station.

The surge basin has a surface area of approximately 5 acres, total volume of approximately 7.3 million gallons (Mgal), and a depth of 4.5 ft. The design freeboard for the basin is 2 ft, such that the design operating depth is 2.5 ft. The operating volume of the surge basin is approximately 4.56 Mgal. The overflow from the FSL is set at a depth of 2.8 ft.

Based on the analysis of daily inflow records from January 2009-June 2018, the influent pump station firm capacity was exceeded on six occasions. Based on these records, the volume of water diverted to the surge basin may have been approximately 0.20 Mgal (influent flow rate was 1.60 MGD on December 8, 2015), the amount of direct rainfall on the surge basin was approximately 0.79 Mgal (5.79 inches of rain), and the amount of rainfall on the FSL was also approximately 0.79 Mgal, for a total storage volume of approximately 1.78 Mgal. This amount represents approximately 44 percent of the operating volume of the surge basin.

HBH (2010) indicated that the surge basin had neared full capacity at times, resulting in backwatering in the influent pipe and SSOs at MH1. Multiple days of heavy rainfall and influent flows may exceed the WWTP's ability to treat stored influent and rainwater in the surge basin. If this occurs, the surge basin may reach capacity. Upsizing of the IPS may allow for quicker drawdown of the surge basin following storage events, however, the treatment capacity of the WWTP unit processes must be considered.

Operation of the surge basin recirculation pump station is complicated by preceding peak flow events, rainfall, and succeeding influent flow rates.

Deficiencies

Recommendations to alleviate deficiencies in the Surge Basin are discussed in Section 7 Development and Evaluation of Alternatives. The following deficiencies were noted in the 2010 WWFP (HBH, 2010):

- The Surge Basin has neared capacity during peak flow events due to the limited capacity of the IPS to pump peak flows into the treatment system, and operators have experienced trouble with recirculating stored influent to the treatment system following peak flow events, fast enough to prepare empty storage volume for future peak flow storage.

4.3.3 Primary Treatment

Primary treatment at the WWTP currently only consists of a grinder with a rated capacity of 1.44 MGD. The IPS pumps raw wastewater through approximately 900 feet of 10-inch force main and through an inline grinder before discharging into the secondary treatment system (City of Bay City, 2016).

Deficiencies

- The grinder is undersized for projected future peak flows.
- The City has no headworks facility to remove debris, grit, and solids.

4.3.4 Secondary Treatment

Secondary treatment is provided by two sequencing batch reactor (SBR) basins. The basins have a decant volume of 37,700 gallons and a maximum water volume of 194,000 gallons (HBH, 2010; NPDES, 2016). Each of the two treatment basins are filled in turn, typically operated in 6-hour cycles; however, during high flows, cycle times can be decreased to as low as 3-hour intervals. The influent distribution/sludge collection (ID/SC) manifold discharges raw sewage into the SBR near the basin floor and is also used to withdraw sludge from multiple points. The ID/SC manifold has a 1,300 gpm (1.87 MGD) allowable capacity. The system is equipped with a floating decanter with a 1,130 gpm (1.63 MGD) capacity, which effectively reduces the capacity of the system below that of the ID/SC manifold. Air is injected into a liquid stream and circulated through the basin for mixing and aeration using a 20-hp positive rotary displacement blower that provides 310 stand cubic feet per minute (SCFM) of air at 7.2 pounds per square in, gauge (psig). Scum is removed from the basins by floating scum skimmers and is discharged to the aerobic digester.

Deficiencies

- The food to microbe (F/M) ratio in the City's SBRs is near the upper end of recommended typical values for this type of treatment system indicating the system is receiving a high organic load.

- Minimum hydraulic retention time in the SBR basins is less than half of typical recommended values indicating the basins are undersized with respect to peak flow rates.

- The system does not have the capacity to handle project peak flows.

- Blowers do not meet current industry standards for energy efficiency.

4.3.5 Aerobic Digester

Waste activated sludge (WAS) from the SBRs is pumped to the aerobic digester at an average rate of approximately 3,806 gpd and a maximum rate of 9,000 gpd. The aerobic digester tank is identical to the SBR basins with a 194,000-gallon capacity. The aerobic digester also has a similar 10-inch ID/SC manifold and 10-inch floating decanter. The maximum capacity of the manifold and decanter are 1,300 gpm and 1,130 gpm, respectively. The basin is also equipped with a jet aeration system at a total rate of 310 SCFM at 7.2 psig. Mixing and wasting of sludge is accomplished with a vertical, non-clog, centrifugal pump, with a flow rate of 1,460 gpm. The digester is cycled between aeration and mixing, which has been found to be effective in maximizing denitrification while maintaining pH control. Digester supernatant is decanted periodically (3-4 times per month) at an average annual rate of 3,471 gpd and is pumped back to the SBRs. Wasted sludge from the aerobic digester is pumped through a 6-inch pipeline to the facultative sludge lagoon at an average rate of 395 gpd (NPDES, 2016).

4.3.6 Facultative Sludge Lagoons

Wasted sludge is pumped from the aerobic digester to the facultative sludge lagoon (FSL) through a 6-inch high density polyethylene (HDPE) pipe. The City also pumps treated effluent which does not meet the requirements of the City's NPDES Permit to the FSL for temporary storage. The FSL has a surface area of approximately 5 acres and a total holding capacity of approximately 7 Mgal equating to an average depth of 4.3 ft (HBH, 2010).

The FSL consists of an anaerobic sludge layer where sludge is further digested and stored, and an aerobic water cap to prevent odors. High strength supernatant from the FSL is pumped back to the influent pump station for re-treatment. The FSL also has a high-level gravity overflow that directs supernatant to the surge basin if the level in the FSL exceeds its capacity.

The City wastes sludge from the aerobic digester at an average rate of 12,245 gallons per month (395 gpd) with a maximum discharge of 20,000 gallons per month (City of Bay City, 2016). To-date, the City has not disposed of any solids from its FSL.

The City has measured the depth of the sludge blanket at the bottom of the lagoon annually since 2009. Based on the average sludge depth in the lagoon from 2009 of 0.71 ft and the average depth of 0.83 ft in 2016, the average sludge accumulation rate is approximately 0.21 inches per year (in/yr).

Sludge that accumulates and digests in an FSL undergoes volume reduction over time as the organic material decomposes, and as the material slowly compacts or settles into a more dense layer. Based on the sludge accumulation estimate of 0.21 in/yr, sludge depth in the FSL will reach approximately 1.19 ft in 2040. This equates to approximately 28 percent of the lagoon volume, and would maintain a water cap of 3.11 ft. At this rate, the FSL will meet the sludge storage needs of the Bay City WWTP for the remainder of the planning period ending in the year 2040 without the need for sludge removal and disposal. However, in 1994 the City identified two possible biosolids disposal sites for future use, should the need arise, in a biosolids management plan prepared by the City under NPDES Permit #101025.

4.3.7 Solids Disposal

The City does not plan to land apply biosolids before 2040 and for this reason has not designated a land application site at this time since the average depth of sludge currently in the FSL is approximately 0.83 ft.

4.3.8 Disinfection

The City utilizes a Trojan 3000 UV system for disinfection consisting of two banks of lamps in concrete channels 10.8 ft in length and 24 inches in width. Each bank contains 96 lamps and has a maximum capacity of 1.4 MGD (2.8 MGD total capacity with both banks in operation). The UV system was completely upgraded in 2013.

4.3.9 Deficiencies Summary

The following deficiencies have been noted by WWTP operators:

- Insufficient pumping capacity in the IPS.
- Grit in system reduces equipment life and increases maintenance frequency.
- Insufficient peak flow treatment capacity in SBRs.
- SBR #1 discharge valve malfunctions.
- Differential treatment capacity in each SBR unit.
- Blowers do not have automated air controls.
- Difficulty meeting solids treatment requirements.
- Riprap on Bay side of levees is decaying.

The general condition of the WWTP is fair to good. The system is approximately 24 years old and much of the equipment is nearing its design life expectancy requiring more frequent maintenance. The projected treatment capacity requirements for the WWTP will meet or exceed the design capacity of the existing system within the planning period.

4.4 Outfall

After UV disinfection, treated effluent is discharged to Tillamook Bay through the City's 16-inch gravity outfall. The City may only discharge effluent if the water surface in Tillamook Bay is a minimum of two feet above the City's outfall per NPDES requirements. If the level of water above the outfall is less than 2 feet, recirculation in required through the overflow to the FSL (HBH, 2010).

The existing outfall is located approximately 2,000 ft north of Goose Point on the east side of the Bay. The outfall pipe extends approximately 1,250 ft from the eastern shoreline into the Bay, situated in what was once a shallow channel, serving Doty Creek. The Doty Creek channel, when the outfall was planned and installed, was approximately 2-3 ft deep at Mean Low Water. Storm events within the area have relocated that channel closer to the shoreline and the outfall diffuser is currently inundated with sediment and discharges in a "bubble-up" fashion into adjacent mudflats. When exposed at lower tides, effluent flows across the mud flats as it makes its way back to the channel.

The City of Bay City is required by NPDES permit 101025 to conduct a periodic review of its outfall and conduct a mixing zone analysis based on current information. During the course of this work, it was determined that the City's existing outfall was failing and becoming inundated by bay sediments. A new outfall and mixing zone was determined necessary. The study was modified to evaluate new outfall locations and to evaluate and optimize an outfall design configuration for Bay City's WWTP effluent disposal system (Outfall Study included as Appendix 3). Based on the study results, an outfall design and mixing zone located lower in the estuary system are recommended to provide the City with a long-term effluent disposal system that is both environmentally and financially acceptable.

Deficiencies

- The existing outfall is located within an identified soft-shell recreational clamming area.
- The outfall has been inundated by bay sediments.
- Does not meet discharge requirements.

5.0 Design Criteria

5.1 Climate Change

Climate change is a serious potential threat to wastewater infrastructure that can impact the health and safety of the general public and the environment. Bay City lies on the shores of Tillamook Bay near sea level, placing it in a potential tsunami hazard zone as well as in a location potentially vulnerable to sea level rise.

5.1.1 Rainfall

Other climate change factors such as changing rainfall patterns may affect flow rates in the Bay City wastewater system; however, the relatively marginal effects on potential wastewater flow rates due to minor increases in rainfall amounts (3-5 percent increase near Tillamook Bay by the year 2100 [OCCRI, 2013])excludes it from further consideration here.

5.1.2 Sea Level Rise

The Bay City WWTP sits at approximately 15.5 ft above mean sea level (MSL; NAVD88). Estimates of sea level rise in Tillamook Bay are approximately 2 ft by the year 2100, with an estimated range of 1.3-4.6 ft (OCCRI, 2013). The current tidal range between mean sea level and mean higher high water (MHHW) in Tillamook Bay is 3.8 ft (NOAA, 2018). The WWTP sits approximately 11.7 ft above current MHHW. Based on sea level rise estimates for the year 2100, the Bay City WWTP will sit approximately 9.7 ft above MHHW, with a range of 7.1-10.4 ft. The current elevation of the Bay City WWTP places it a minimum of 7.1 ft above the projected MHHW elevation for the year 2100.

5.1.3 Tsunami Inundation

Multiple tsunami simulation scenarios have been run using a hydrodynamic model in Tillamook Bay to generate tsunami inundation maps for the Bay City area (DOGAMI, 2012). Based on these simulations, the Bay City WWTP is in the tsunami inundation hazard zone for small to medium sized earthquake events with magnitudes of approximately 8.7 and 8.9, respectively (return periods of 300 years and 425-525 years, respectively). And much of the lower portion of the SSCS lies within the tsunami inundation hazard zone for large to extra-large earthquakes with magnitudes of approximately 9.0 and 9.1, respectively (return periods of 650-800 years and 1,050-1,200 years, respectively).

5.1.4 Ocean Acidification

Additional consideration of ocean acidification may become a relevant factor in determining receiving water conditions and ultimately in setting effluent limitations in the future. However, at this time consideration of the potential impacts of ocean acidification with respect to wastewater dischargers is outside the scope of this project.

5.1.5 Flooding

Bay City does not lie on the banks of any major rivers that may pose a significant flood hazard. However, Patterson Creek and Jacoby Creek do flow through the town and have the potential to create a flood hazard if rainfall events increased significantly in magnitude or frequency. Jacoby Creek flows into Patterson Creek near the lower segment of Patterson Creek before entering Tillamook Bay.

5.2 Collection System

In previous sections of this Master Plan, background information, projections for growth, physical data collection results, and the anticipated wastewater flows were developed. This section builds upon this information by providing guidelines for the proper design and operation of a collection system. These criteria are then used to recommend rehabilitation methods.

5.2.1 Basis for Design

Development of engineering solutions requires identifying the goals for the infrastructure based on standard engineering and wastewater operating principals. The following provides a brief discussion concerning the basis for evaluating and planning the City's improvements.

5.2.1.1 Gravity Sewer

Collection systems should be designed considering natural ground slope, subsurface conditions, capacity requirements, minimum slope considerations, minimum flow velocities required to maintain solids suspension, and potential sulfide and odor generation. Whenever possible, gravity collection systems should be utilized for wastewater service rather than systems that require a pump station.

Collection systems should be designed for the ultimate build-out of a sewer basin, taking into account zoning and UGB limitations. This will ensure that the piping is adequately sized for practically any type and amount of development that may occur within the basin.

The minimum diameter of sewers should be 8-inches. Smaller sewers are difficult to clean or maintain using modern cleaning, CCTV-inspection, and repair equipment. Pipe diameter sizing should be based on anticipated flows and master planning, not minimum slope considerations.

Manholes should be spaced no more than 500 feet apart for sewers up to 24-inches in diameter. Manholes should also be constructed where sewer alignment, slope, or pipe size changes occur. To facilitate self-cleaning, a "drop" or elevation change should occur from the inlet side of the manhole to the outlet and should be required to be incorporated into the manhole base. Flow channels in manholes should include a minimum 0.1-foot drop when the flow is straight through the manhole. If a manhole is constructed with a channel where the flow direction changes by 90-degrees with piping of the same size, the channel should include a base with a drop of 0.2-feet between the inlet and outlet piping runs.
Manholes should have a minimum inside diameter of 48-inches at the bottom and have a standard 23-inch manhole access opening and lid. Manholes located in areas where standing water is common or in the 100-year flood plain should be constructed with a watertight frame and lid to reduce the inflow into the manhole.

Flat top manholes should be utilized for all manhole installations under 6-feet. Otherwise, standard eccentric cone type manholes should be used. New manholes in Bay City should not be provided with integrated ladders in the manhole sections.

Manholes with pipes entering the manhole with inverts two feet or more above the bottom of the manhole should be designed as a drop manhole. An inside drop manhole can be used for all inlets that are 12-inches in diameter or less. Inlets larger than 12-inches will require an outside drop.

Minimum pipe slopes are established to ensure that flow velocities are high enough to provide a self-cleaning action for the gravity piping sections.

Slope is also an important design concern for avoiding hydrogen sulfide problems. Sewers with long, flat pipe runs tend to be prone to hydrogen sulfide generation due to long residence times, poor oxygen transfer, and deposition of solids in the pipe section. Current conventional design practice recommends that a minimum velocity of two feet per second (fps) be achieved regardless of pipe size to maintain a self-cleaning action in sanitary sewers. It is desirable to have a velocity of 3 fps or more whenever topography and existing conditions allow. Minimum pipe slope for service laterals should be 2-percent (¼-inch drop per foot).

Standard methods of determining the slope for self-cleaning velocities are based on pipes flowing at least half-full. Where flows are expected to be less than half-full and adequate grade (topography) exists, a slope should be used that will provide velocities of 3 fps for full or half full pipes. In general, minimum pipe slopes should be established based on the information in Table 17.

Table 17 Recommended Slopes for Gravity Sewers[1] (ft/ft[2])
Wastewater Facilities Plan Update, Bay City, Oregon

Nominal Pipe Diameter (in)	Minimum Slope (2 fps)	Recommended Slope (3 fps)
4	0.0200	0.0200
6	0.0060	0.0110
8	0.0040	0.0075
10	0.0028	0.0056
12	0.0022	0.0044
14	0.0016	0.0035
15	0.0015	0.0033
16	0.0014	0.0030
18	0.0012	0.0026

1. Based on a Manning's 'n' of 0.013.
2. Ft/ft: feet per feet (vertical/horizontal)

While the information in Table 17 provides the theoretical slopes to attain 2 fps or 3 fps for various pipe sizes, it is not usually considered practical to construct a gravity pipeline at a slope less than 0.2 percent. Therefore, while larger diameter pipes (larger than 12-inch) could be placed at a flatter slope, practical application will result in pipes with higher capacities and flow velocities than if they were placed at the minimum slopes presented above.

5.2.1.2 Force Mains

Force mains for public pump stations should have a nominal diameter of at least 4-inches so that they are capable of passing larger solids that are pumped by the solids handling pump stations. In general, velocities of at least 3.5 fps are desirable in force mains to help maintain a self-cleaning or scouring action on the inside of the pipes. Very high velocities in a force main result in high friction losses and inefficient operations requiring larger pump motors and greater energy costs. Velocities above 8 fps are considered excessive. According to Oregon DEQ, Oregon Standards for Design and Construction of Wastewater Pump Stations (May 2001); pump discharge lines including force mains shall have a design velocity of 3.5 to 8 fps. When variable speed drives are used, flows may be reduced to provide a minimum velocity of 2 fps provided the controls are set to increase pump speed to provide a minimum flushing velocity of 3.5 fps for a short time period at the beginning of each pumping cycle.

The standard for pump station piping shall be cement-mortar lined or plastic-lined ductile iron. The standard for force main piping shall be the same as the station piping; however, heavy wall PVC (C900) or HDPE may also be used. When force mains require air injection, piping shall be plastic-lined ductile iron or heavy wall PVC or HDPE. In general, piping should use 45° elbows and wyes rather than 90° bends.
In addition to correct sizing of the force mains based around proper cleansing velocities, the number of high points should be kept to a minimum as these will create a point for air and other gases to be trapped. Trapped gases can reduce a pipes capacity or cause a piping system to become plugged. Typically, a designer should include a means of releasing trapped air at high points through the use of a combination air/vacuum release valve designed for sewer service unless air injection is required. If it is determined that velocities are high enough to keep entrained air moving, air release systems may not be required. Proper force main design should also address transient or pressure surges due to sudden velocity changes, especially in long force mains.

Force mains less than 300 ft in length may be cleaned by conventional methods provided there is access from both the discharge manhole and the station end. Pig launch and retrieval systems shall be provided at all other stations unless waived by the Owner as not being required, particularly at stations equipped with variable speed drives.
Detention times in force mains should also be studied to ensure that sanitary fluids do not reside within the piping too long. If so, high levels of hydrogen sulfide (H_2S) and other gases can form in the sewer causing odor issues, corrosion, and safety concerns. This problem can be reduced by injecting air directly into the force main or backdraining the force main into the wet well. Generally, the force main shall be designed such that the H_2S concentration remains below 0.1 mg/L at 20°C at the point of discharge into the gravity system. When the detention time in the force main averages more than 35 minutes (during low-flow periods in July-September) H_2S control will be required. When the force main is continuously ascending and of moderate length and size, backdrainage should be considered along with an oversized wet well. Alternatively, where backdrainage is not feasible, continuous air injection is needed with a design air delivery of 2 SCFM. When air injection is used, the force main may not contain air release valves and careful pump sizing must be used to accommodate air in the force main.

5.2.1.3 Pump Stations

The correct design of pump (lift) stations is an important and critical element of any sanitary sewer collection system. Pump stations should be designed to handle the peak flows experienced by the system without bypassing or overflowing. The pump stations should also be designed so as not to increase the total sulfide generation potential of the collection system.

Contemporary design practices require some wet well storage of wastewater plus retention in the force main, both of which tend to increase the potential for sulfide generation. In these cases, supplemental aeration or sulfide treatment must be provided to reduce the production of sulfide.

To minimize sulfide generation, wet wells should be sized to be as small as possible while still allowing for future growth. Consideration should be given to detention times, pump cycle times, and storage volumes when sizing the depth and diameter of the wet well. Wet well detention times of 30 minutes or less are recommended to avoid sulfide generation. When detention times in the pump station wet well exceed 25 to 30 minutes, a system for control of sulfide generation and the accompanying odor and corrosion problems is recommended.

Pumps should be sized so that the station can handle the peak hourly flow rates with the largest pump in the station offline. Stations should be configured around duplex, triplex, or larger and consider all flow ranges when sizing the pumps and combinations of pumps in operation at any one time.

Pump stations should have provisions for redundant power generation equipment. This can be accomplished through a standby generation system housed at the station or through the use of trailer-mounted portable generator and manual transfer switch gear. Power outage frequency and duration must be considered in pump station design to ensure that overflows do not occur due to power outages. Proper level controls and alarms capable of autodial should be included in each pump station. Redundant high wet well level sensors or floats should be included as a backup to the regular level sensors.

Designs for pump stations should meet the latest DEQ requirements for pump station design and construction. A summary of the general design criteria from DEQ includes (DEQ, 2001):

- A station with firm capacity to pump the peak hourly and peak instantaneous flows associated with the 5-year, 24-hour storm intensity of its tributary area, without overflows from the station or its collection system.
- A design consistent with EPA Class I reliability standards for mechanical and electrical components and alarms.
- A pumping system consisting of multiple pumps, with one spare pump sized for the largest series of same-capacity pumps to provide for system redundancy.
- Pumps with a minimum of five years' service history for a similar duty and size, unless otherwise approved by the Owner. To ensure a valid warranty, pumps shall either be supplied directly by the manufacturer, or by suppliers who are authorized and licensed by the manufacturer to provide manufacturer's warranty services for the pumps to be furnished.
- Inlet, station, and force main piping with all necessary pressure control and measurement features, surge protection systems, air-vacuum/release valves, isolation valves, couplings, odor control systems, and other appurtenances required for a complete and operable system.
- Mechanical systems for heating and ventilating as required by the selected station equipment, local climatic conditions, and applicable codes.

- Plumbing systems for potable water, wash down, and drainage, unless otherwise approved by the Owner.
- Appropriate sound attenuation for noise created by pumping, mechanical, or electrical systems, including a standby generator.
- Electrical systems for lighting, power, communications, security, control, and instrumentation. A motor control center is to be provided for motor starters, accessories, and devices. The motor control center shall provide an isolated, ultra-filtered power, 120 VAC section designed with separate branch circuits for microprocessor-based instrumentation, controls, etc.
- A secondary source of electrical power. Standby generators shall be of sufficient size to start and run the Firm Pumping Capacity of the station, along with all other associated electrical loads necessary to keep the station operational and functioning. At the Owner's discretion, a secondary power feeder from an independent substation may be required as a redundant power source. With the Owner's approval, the requirement for standby power may be satisfied by providing a trailer-mounted generator and an emergency power connection with manual transfer switch meeting the Owner's specifications.
- A complete system of alarms and alarm telemetry to facilitate operation and maintenance of the station at all hours, including an autodialer or radio telemetry.
- Where required by the Owner, a design to allow remote monitoring of the station through a connection with a Supervisory Control and Data Acquisition (SCADA) system so the Owner can remotely control and monitor station activities. Programmable logic controllers and alarm telemetry must meet the Owner's preferences and standards.
- Structures of adequate size, with interior and exterior clearances to facilitate access for ease of operation and maintenance of all systems. Architectural aspects shall be subject to the Owner's approval.
- Site development including an access road and parking, security, lighting, drainage, signs, and landscaping meeting the Owner's requirements.

5.2.2 Improvements Programs

Repair and rehabilitation of the sewer main lines and lateral connections will maintain or reduce the I/I levels currently present in the system. Previous rehabilitation efforts have been focused on isolated areas; however, based on WWTP influent data, these efforts have not been effective at reducing the overall levels of I/I in the system. Joint failure may be the cause of the lack of significant I/I reduction because the defects are likely systemic. Therefore, major sewer rehabilitation projects are envisioned; however, prioritization and phasing over several years may be required as funding sources are secured and as sewer monitoring and I/I flow mapping is performed. The description of alternatives presented below is based on this approach.

5.2.2.1 Complete Replacement

Pipeline replacement by conventional open cut means is normally required when the existing pipeline is either undersized or deteriorated so badly that other methods of rehabilitation are not feasible.

The obvious advantage of pipe replacement is the service life gained with modern materials and methods, which is generally accepted as more than 50 years. The cost of replacement, though, is generally two times higher than rehabilitation and the associated inconveniences and restoration required can be bothersome to the public. Replacing pipelines also removes any "incidental" I/I (i.e. minor leaks that would not individually be cost effective to remove). Complete replacement also provides the opportunity to correct any misalignments, increase the hydraulic capacity of the line, repair service connections, or eliminate storm water entry points such as catch basins. Complete replacement of a deteriorated pipe segment should therefore significantly reduce I/I especially if service laterals can be replaced to the property line. When rehabilitation of sewers using alternative "trenchless" methodologies is employed, replacement of lateral sewers by conventional construction is typically still required.

5.2.2.2 Cured-In-Place Pipe Rehabilitation

Cured-in-place pipe (CIPP) is best described as "manufacturing a new pipe within an existing pipe". A CIPP installation uses a plastic-lined felt tube that has been impregnated with resins. The impregnated tube is lifted over an existing manhole and inverted (turned inside out) allowing the plastic exterior to be turned inward. The inner space of the bag is then filled with water or air pressure to extend the inverted tube into the existing pipe. The weight of water or air pressure drives the tube's inversion until the entire section of liner has been turned inside out and the end has been retrieved at the downstream manhole. Once the liner is in place, it is filled with hot water or steam to force the resin-impregnated material against the interior surface of the existing sewer pipe. The heated water or steam causes the resins in the tube to cure and harden into a new pipe. For pipes downstream of treatment processes, uv-cured or styrene-free resins may be used to eliminate potential styrene pollution of the receiving waters.

The use of CIPP lining is appropriate for pipelines requiring minor structural repair, sealing of holes, leaky joints, and leaky misalignments, and for correcting corrosion problems. Because this method of rehabilitation does not require excavation, it may also be used under highways, railroads, and buildings. Openings for service lateral connections are typically made with special cutters and sealers from inside the pipe.

For CIPP to be effective at reducing I/I, sealing of lateral connection joints at the main is required. This sealing can be accomplished through lateral CIPP liners, or by open cut lateral replacement. Where lateral connections are free of sharp bends or abrupt or rough size transitions in the lateral pipe, CIPP of the lateral may be accomplished from inside the main. However, open cut replacement of the lateral line and lateral connection may be required if the physical conditions of the lateral are not conducive to lining. Lateral CIPP liners should not be installed prior to or without main sewer lining because proper sealing will not occur.

The entire process typically requires less than 24-hours to complete for each manhole section lined. In larger sewer lines, the 24-hour time frame requires the use of bypass pumping equipment to convey flows around the work area. If properly completed, the service life of a cured-in-place pipe has been claimed by several lining manufacturers to be 50 years. In most cases, CIPP provides an economically preferable alternative to complete pipe replacement, often costing less than half the cost of a new open cut pipeline.

There are approximately 55,700 lineal ft of old (50 years) concrete pipe in the City's sewer system. These segments of the sewer system appear to have systemic joint leakage and, while the inspected segments do not appear to be significantly degraded, sealing of the joints will require manhole-to-manhole rehabilitation. Rehabilitation of these sewers is necessary to prevent escalation of I/I which causes capacity issues at the lift station and the WWTP. Additionally, this work should be completed before the sewer deteriorates to a condition that the pipe can no longer be rehabilitated.

5.2.2.3 Manhole Repairs

The City conducts yearly manhole inspections to identify if any major structural repairs or corrosion prevention are required. A goal of completing up to 48 inspections per year will allow the City to inspect all of the manholes in the system in just under 5 years. In the case of a major structural repair, the City should develop experience with a preferred manhole lining system. In addition to manhole rehabilitation, it is recommended that the City continue to install manhole lid liners to seal manhole lids in potential inflow areas. It is recommended that the City stock lid liners for this purpose.

Chemical grouting of manholes is recommended for the majority of smaller manhole repairs required within the City. Chemical grouts used for rehabilitation of sewers include acrylamide, acrylate, or urethane gels. Typical applications consist of two separate chemicals that are pumped through separate hoses to the joint or manhole being sealed. Once the two chemicals are mixed together, they are pumped through the defect to the exterior of the structure where the mixture forms a gel or foam that expands around the defect and into the surrounding earth. Typical applications include one tank to mix and dispense the grout and another tank to mix and dispense a catalyst. Once mixed, the catalyst initiates a chemical reaction changing both liquids into a gel (grout). Depending upon the amount of catalyst utilized, the time required to form the grout can be adjusted from a few seconds to several minutes.

Chemical grouting does not improve the structural strength of a manhole; therefore, this method of rehabilitation should not be used on structures that are badly broken or deteriorated. If the groundwater table drops below the level of the repair, the chemical grout may become dehydrated and its useful life shortened. Also, many chemical grouts do not have shear strength and will tear or fracture if a load is applied to the surrounding earth. When used appropriately, rehabilitation by chemical grouting should serve a useful life of ten years.

5.3 Treatment System

The original basis for design completed in 1992 for the existing WWTP components projected flows and loads for the year 2011. Design criteria described in the following sections from the original 1992 design were estimated to provide sufficient treatment through the year 2011. The purpose of this evaluation is to project treatment requirements and estimate design flows and loads for the next 20-year period through 2040.

5.3.1 Regulatory Requirements

- CWA via ORS 468B.050 issues NPDES Permit
- OAR 340-041-0007(16): Statewide Narrative Criteria for treatment and control of wastes.
- ORS 468.740: actual operating limits
- OAR 340-041-0230: pH, TDS, BOD in North Coast Basin
- 40 CFR Part 133 and OAR Chapter 340 Division 50 and NPDES permit: Management of sewage sludge
- AOR 340-041-0009 (6) and (7) and OAR 340-041-0007(16)(a): SSO's

5.3.2 Reliability Requirements

The Bay City WWTP meets the EPA criteria for Reliability Class II:
Works which discharge into navigable waters that would not be permanently or unacceptably damaged by short-term effluent quality degradations but could be damaged by continued (on the order of several days) effluent quality degradation. (EPA, 1974).

5.3.2 Effluent Limits

The Bay City WWTP operates under the requirements of an NPDES permit (OR-002257-8). NPDES permits expire every five years and must be renewed through a process of submitting a renewal application and report of waste discharge describing the existing conditions at the facility. The current Bay City WWTP NPDES permit was issued in 2011, and a renewal application was submitted in 2016; however, the permit has not been renewed as of this time and the facility operates under the previous permit from 2011 until a new permit is issued.

Table 18 summarizes seasonal average monthly effluent BOD, CBOD, and TSS discharge limits as originally designed and according to the current 2011 NPDES discharge permit:

Table 18 Seasonal Average Monthly Effluent Discharge Limits (mg/L)[1]
Wastewater Facilities Plan Update, Bay City, Oregon

	Discharge Limits			
	Dry Season (May-October)		Wet Season (November-April)	
Constituent	Design (1992)	Current (2011)	Design (1992)	Current (2011)
CBOD[2]	5	15	15	25
BOD[3]	5	NR[4]	20	NR
TSS[5]	5	20	20	30

1. mg/L: milligrams per liter.
2. CBOD: Carbonaceous Biochemical Oxygen Demand.
3. BOD: Biochemical Oxygen Demand.
4. NR: not required.
5. TSS: Total Suspended Solids.

The Bay City WWTP is also currently required to meet disinfection standards for fecal coliform and *enterococcus* bacteria. Fecal coliform must not exceed a monthly log mean of 42 organisms per 100 milliliters (mL), and not more than 10 percent of the samples may exceed 129 organisms per 100 mL. Enterococcus bacteria limits include a maximum monthly geometric mean of 35 organisms per 100 mL. Effluent must maintain a pH of 6.0-9.0 at all times. And monthly average CBOD and TSS removal must not be less than 85 percent.

The outfall has been granted a 50 ft radius mixing zone such that receiving water quality requirements must be met outside of the mixing zone radius. The mixing zone provides a volume of water immediately surrounding the discharge point where effluent can mix with the receiving water prior to determining potential impacts to the receiving water.

5.3.3 Hydraulic Capacity

Upstream treatment units must have sufficient hydraulic capacity to handle the PIF since there is no flow equalization at this point in the system. This includes the IPS, primary treatment (grinder or headworks), and all flow equalization and conveyance systems. The IPS has a high-level overflow to the surge basin such that downstream processes should be designed for the PDF assuming the surge basin can reliably store peak flows above the PDF. As discussed previously, the surge basin should be capable of equalizing and storing peak flows above the PDF with improvements to the IPS and downstream treatment processes to handle the projected 2040 PDF of 2.51 MGD (Table 19). Treatment unit specific design hydraulic capacity is listed in Table 20, on the following page.

Table 19 Current and Projected Design Flows (MGD)[1]
Wastewater Facilities Plan Update, Bay City, Oregon

Design Flow Rate	Design (1992)	Current (2018)	Projected (2040)
Diurnal Minimum	0.10	0.10	0.11
MMDWF[2]	0.29	0.35	0.41
MMWWF[3]	0.86	0.66	0.75
PWF[4]	0.91	1.06	1.20
PDF[5]	1.02	1.53	1.72
PIF[6]	1.40	2.24	2.51

1. MGD: million gallons per day
2. MMDWF: maximum monthly dry weather flow
3. MMWWF: maximum monthly wet weather flow
4. PWF: peak week flow
5. PDF: peak day flow
6. PIF: peak instantaneous flow

Table 20 Treatment Unit Specific Design Hydraulic Capacity
Wastewater Facilities Plan Update, Bay City, Oregon

Design Flow Rate	Design Flow	Design (1992; MGD[1])	Projected (2040; MGD)
Influent Pump Station	PIF[2]	1.40	2.51
Primary Treatment	PIF	1.40	2.51
Secondary Treatment	PDF[3]	1.02	1.72
Disinfection	PDF	1.02	1.72
Outfall	PDF	1.02	1.72

1. MGD: million gallons per day
2. PIF: peak instantaneous flow
3. PDF: peak day flow

5.3.4 Loading Capacity

Secondary biological treatment processes require consideration of pollutant loading rates in determining treatment unit sizing. Table 21 (on the following page) summarizes design, current, and projected BOD, TSS, and TKN influent loading rates for the Bay City WWTP. Design loading (1192) was based on average daily flows and pollutant concentrations. Current and projected loading is based on weekly monitoring data collected by the City in accordance with the NPDES permit between January 2009 and June 2018. Current and projected loading rates include average daily loading (2009-2018) and maximum month average daily loading. Due to high I/I rates that cause seasonal fluctuations in loading, biological treatment processes should be designed to the maximum month average daily loading rates to reduce the risk of violating discharge requirements.

Table 21 Design, Current, and Projected Influent Loading[1] (ppd)[2]
Wastewater Facilities Plan Update, Bay City, Oregon

Constituent	Design (1992)	Current (2017)		Projected (2040)	
		AD[3]	MM[4]	AD	MM
BOD[5]	616	267	578	339	735
TSS[6]	616	422	1,116	536	1,420
TKN[7]	72	NM[8]	NM	ND[9]	ND

1. Design loading uses average daily loading, current and projected loading presented as average daily loading, and maximum month loading, respectively.
2. AD: average daily
3. MM: maximum monthly
4. ppd: pounds per day
5. BOD: Biochemical Oxygen Demand
6. TSS: Total Suspended Solids
7. TKN: Total Kjeldahl Nitrogen (as N)
8. NM: not measured
9. ND: not determined

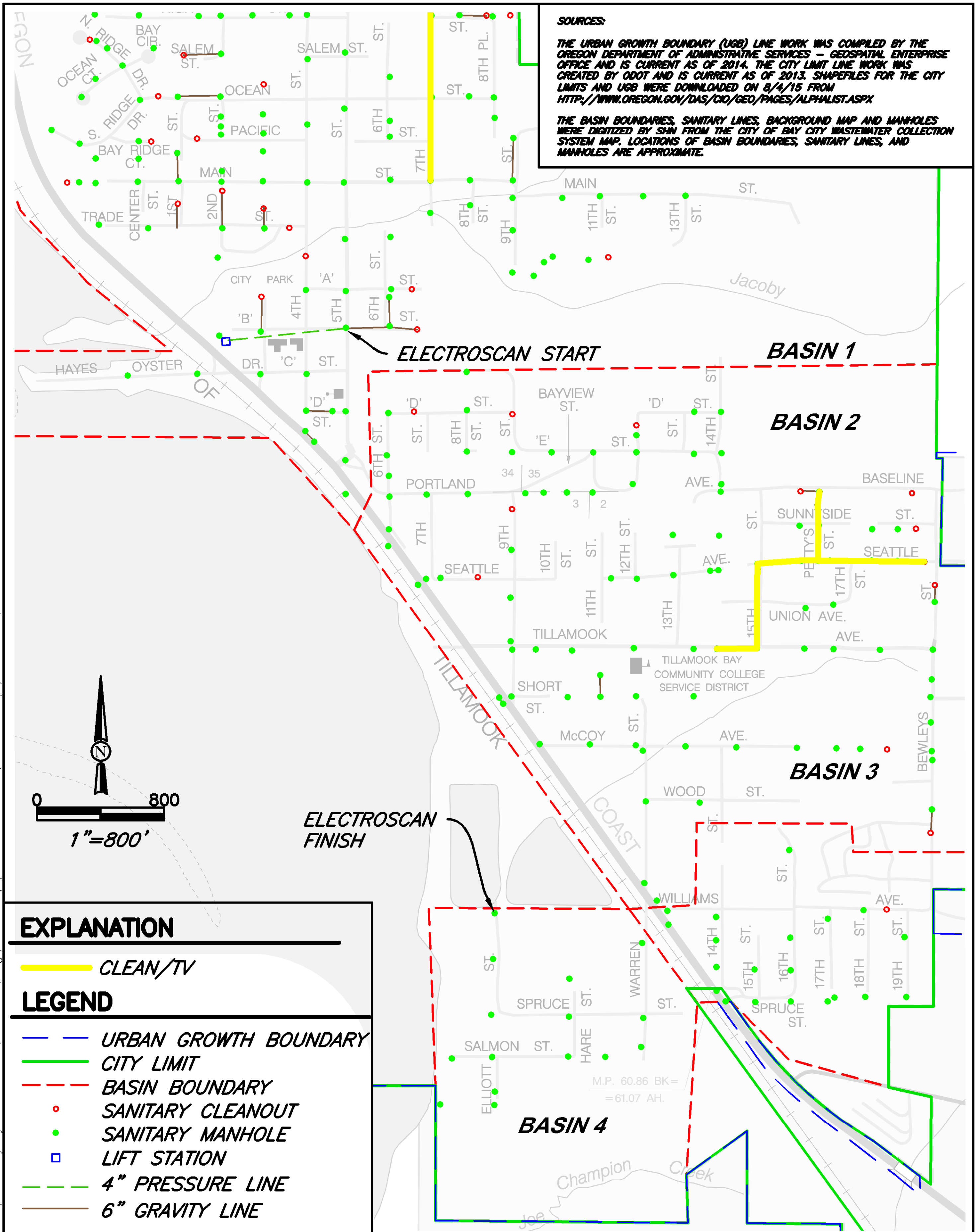
5.4 Outfall

Due to the location of the existing outfall site being in the mud flats and observed channel migration, a new outfall will need to be located in the Tillamook estuary. The proposed outfall site, (Figure 24), is to be located approximately 4,500 feet northwest of the existing outfall, in the upper reach of the Bay City channel, on the eastern side of Mid Bay, between Sandstone Point and Goose Point. This location is intended to situate the outfall diffuser in a deeper, more stable channel within the Bay. Historical NOAA navigation charts indicate this channel has been present at this location and has maintained mean low water depths of seven to nine feet for at least the past 90 years. Selection of the proposed outfall site considered the following:

- Water depth
- Outgoing tidal currents
- Channel stability
- Proximity to existing wastewater facilities
- Distance from designated shellfish reserve areas

Based on these criteria, the outfall site proposed will be located at Latitude N. 45.5237^{o} and Longitude -123.9005^{o}. Plan and profile views of the proposed outfall are presented in Figure 25.

Under all conditions evaluated, modeling predicts that the single-port diffuser will meet acute and chronic toxicity criteria and achieve all water quality objectives for pollutants of concern (see Mixing Zone Study Report, Appendix 3). The mixing zone length of 70 meters (m;30 m upstream and 40 m downstream from



SOURCES:

THE URBAN GROWTH BOUNDARY (UGB) LINE WORK WAS COMPILED BY THE OREGON DEPARTMENT OF ADMINISTRATIVE SERVICES – GEOSPATIAL ENTERPRISE OFFICE AND IS CURRENT AS OF 2014. THE CITY LIMIT LINE WORK WAS CREATED BY ODOT AND IS CURRENT AS OF 2013. SHAPEFILES FOR THE CITY LIMITS AND UGB WERE DOWNLOADED ON 8/4/15 FROM HTTP://WWW.OREGON.GOV/DAS/CIO/GEO/PAGES/ALPHALIST.ASPX

THE BASIN BOUNDARIES, SANITARY LINES, BACKGROUND MAP AND MANHOLES WERE DIGITIZED BY SHN FROM THE CITY OF BAY CITY WASTEWATER COLLECTION SYSTEM MAP. LOCATIONS OF BASIN BOUNDARIES, SANITARY LINES, AND MANHOLES ARE APPROXIMATE.

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SHN

City of Bay City
Wastewater Facilities Plan Update
Bay City, Oregon

Collection System Evaluation
Investigation Pipes
SHN 611013.151

December 2019 | 611013-Electroscan | Figure 24

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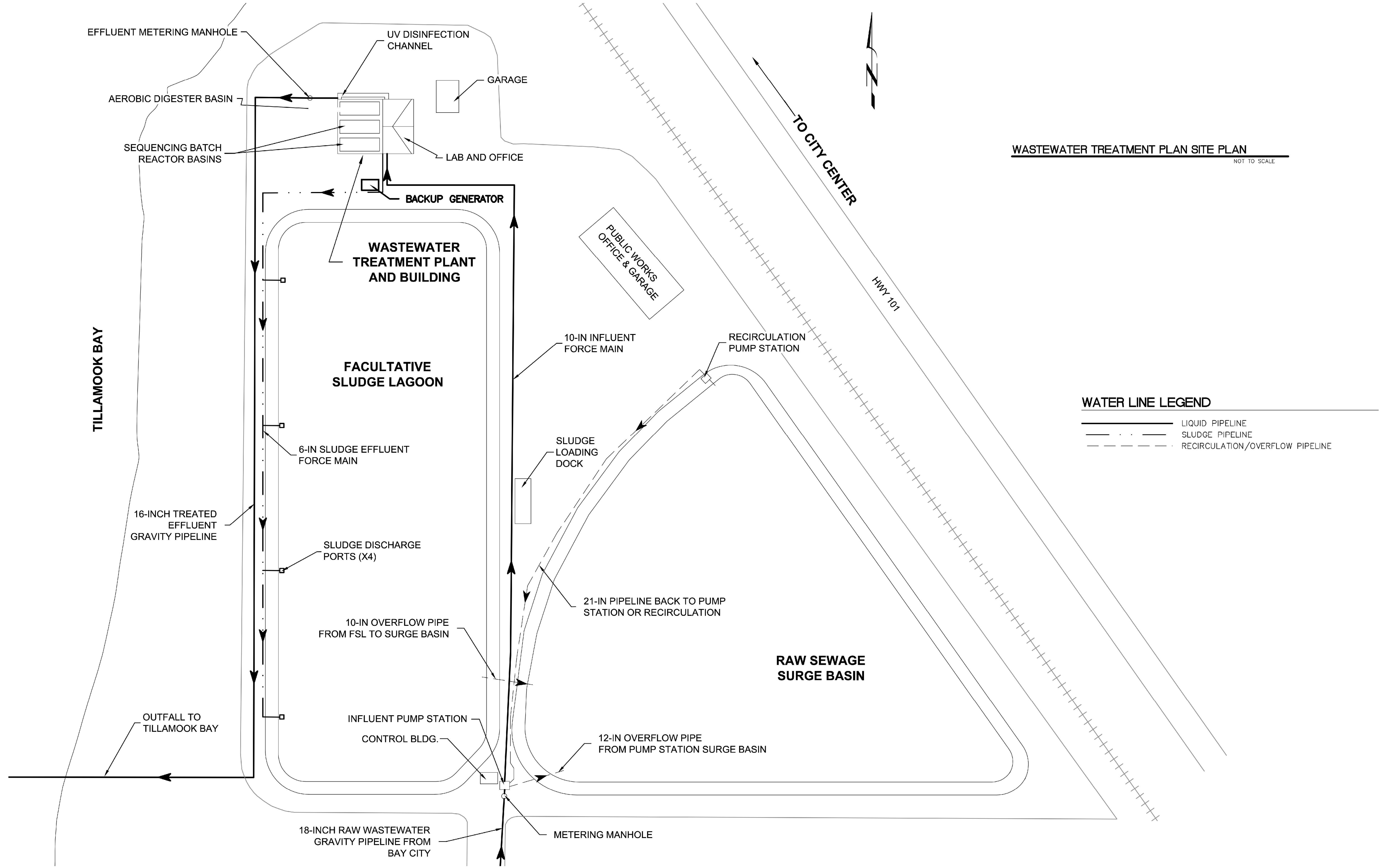

SOURCE:
CITY OF BAY CITY WASTEWATER FACILITIES MASTER PLAN, FEB 2008

SHN	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Wastewater Treatment Plant Existing Conditions SHN 611013.151
December 2019	611013-151-WWFPU-FIGS	Figure 25

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each discharge nozzle) is shown by the model to provide adequate protection for water quality. Based on the limiting criterion of the discharge length scale, a minimum toxic dilution zone of 7 m, each direction, should be permitted to achieve the Criteria Maximum Concentration (CMC) criteria.

6.0 Basis for Cost Estimates

The construction cost estimates presented in this Plan will include a number of basic components, each of which is discussed in the following sections. The estimates presented are preliminary and are based on the level of detail and planning presented in the Master Plan. As projects proceed and as site specific and new information becomes available, the estimates should be reviewed and updated.

6.1 Construction Costs

Construction costs are estimated using a combination of engineering experience with similar past projects, material costs provided by equipment suppliers, material and labor cost estimates, and cost indices. The Engineering News Record (ENR) construction cost index is a common index used for engineering planning and estimating purposes.

The ENR construction cost index is based on a beginning value of 100 established in the year 1913. Cost estimates prepared in this plan are based on January 2019 costs and “linked” directly to an ENR index of 11,205.74. Future ENR indices can be used to calculate the estimated cost of projects for future construction times using the following method:

Updated Cost Estimate = Plan Cost Estimate x (current ENR CCI / 11205.74)

If specific ENR index figures are not available, the average ENR construction cost index increase of 3.2 percent (2000-2019) may be used.

Construction cost estimates developed in the 2010 WWFP (HBH, 2010) reference an ENR construction cost index of 8,141. Based on the 2019 index value of 11,205.74, construction costs from the 2010 WWFP are brought into current 2019 dollars using a multiplier of 1.38.

6.2 Contingencies

Contingencies are typically included in planning cost estimates to account for unforeseen circumstances that may increase costs. For the purposes of this planning document and the preliminary cost estimates provided, a contingency amount between 15 and 25 percent of the estimated construction cost is used depending on the available information, number of unknowns, and other potential unknown factors that could affect the final project costs.

While efforts have been made to provide costs for all facets of the proposed projects, it is appropriate that allowances be made for variations in the final design, bidding market conditions, adverse construction conditions, unanticipated specialized investigation and studies, and other difficulties which cannot be foreseen at this time but may tend to increase the final costs of the proposed projects.

6.3 Engineering

The cost of engineering services for major capital improvement projects typically include surveying, foundation explorations, preparation of contract documents and project drawings, development of construction and material specifications, bidding services, construction management, inspection, construction staking, start-up services, and the preparation of operation and maintenance manuals. Depending on the size and type of the project and the required scope of engineering services, engineering costs may range between 18 to 25 percent.

In some cases, additional engineering or technical services may be required such as flow studies, pre-design reports, and environmental reports or studies. These additional services would typically be in addition to the regular engineering services covering surveying, design, bidding, construction management, and construction inspection.

For the purposes of conservative planning, the cost estimates prepared in this Plan assume that all projects will require a relatively comprehensive and complete scope of engineering services. Therefore, an engineering cost of 25 percent is assumed for all projects. In the future, if it is determined that some projects will not warrant this level of service, the cost for engineering on those projects can be reduced. On the other hand, smaller and less expensive projects may warrant a higher engineering cost percentage.

6.4 Legal and Administrative

Legal and administrative costs include legal counsel review of contracts and contract documents, costs related to obtaining easements and permits, costs for internal budget planning, grant administration, liaison costs, interest on interim loan financing, advertising, and other non-construction costs related to the projects. A cost equal to 5 percent of the estimated construction cost is used for the estimates in this Plan.

6.5 Land Acquisition Costs

On occasion projects require the acquisition of land for placement of new piping, pump stations, or other system components when available property is not available on an existing site or within an existing public right-of-way. In some cases, a property owner will require reimbursement for providing an easement across his/her property. An effort was made in the plan to anticipate and identify which projects would require land or easement acquisition. For these projects, costs have been included for the purchase of additional properties for the improvements.

Property costs can vary depending on location, market volatility, owner's willingness to sell, and many other factors. In some cases, the City may have to condemn property when an owner is unwilling to sell and no alternative site is available. If needed, the condemnation process also has significant costs associated with it.

When a project is undertaken, the City should review the potential need for land acquisition. If it is determined that additional land is required, the costs for the acquisition of that land should be reviewed and updated based on the land cost climate at the time.

6.6 Other Studies and Special Investigations

In some cases, pre-design reports, environmental reports, archeological investigations, special flow studies, and other investigations may be required prior to beginning actual design activities for a project. These studies may be driven by funding or regulatory agencies or by special needs of a specific project. An effort has been made to identify projects where these special studies will most likely be required. However, the need for these investigations and studies will be confirmed on a case by case basis throughout the planning period.

7.0 Development and Evaluation of Alternatives

As the City is not growing, concentration on maintaining the existing plant and collection system should be the focus of money spent. Thus, the emphases should be to ensure the plant operates to the best of its ability, and the collection system collects sanitary sewage and not stormwater.

7.1 Collection System

7.1.1 Pump Station Improvement Alternatives

Bay City maintains one pump station within the collection system at the present; however, to protect the environment and to ensure continued operation it must be robust, well-maintained, and sized properly to convey existing and future wastewater flows.

Basin 1, which contains the Downtown Pump Station, has the potential for considerable future growth. Additionally, the pump station is being considered for replacement as part of a project along Patterson Creek. This project would realign the sewer and water lines crossing the creek to provide passage for spawning fish. The station currently receives flow from approximately 18 percent of the basins size in inch diameter mile (IDM); however, the realignment could increase that value by up to 300 percent.

Therefore, based on the future growth potential and realignment plans, this station is significantly undersized for future needs. Additionally, due to inadequate wet well size and limited pumping capacity, City maintenance staff have had to pump out the wet well during storm events to prevent overflows. Even if no realignment occurs, this lift station is undersized, not up to current DEQ requirements, and is inadequate for future growth. The force main should be adequately sized for current flows; however, age and flow restrictions resulting from corrosion of the steel pipe along with additional growth or realignment will necessitate replacing this line as well.

The Downtown Lift Station requires improvements and an increase in pumping and wet well capacity. In the previous facility plan, alternatives including: “Do Nothing”, converting the dry well compartment into a wet well, and installing a new wet well were examined. The “Do Nothing” option continues to be infeasible due to capacity issues; additionally, the dry well conversion is also infeasible because the resulting wet well will be significantly undersized for the realignment plans. Only one alternative is reasonable for further consideration and includes construction of a new pump station adjacent to the existing station.

The cost for the pump station/force main component of the project is estimated at approximately $827,615, which is higher than the estimate from the previous facility plan due to inflation and upgraded capacity requirements. In the design phase of the new station installation project, the existing pump control building with back-up generator may be evaluated for reuse. Table 22 includes the costs for the pump station replacement.

Table 22 Downtown Pump Station Replacement, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Item Description	Unit	Quantity	Unit Price	Total Price
Mobilization	LS[1]	1	$52,000	$52,000
Demolition/Temporary Facilities	LS	1	$33,000	$33,000
Bypass Pumping	LS	1	$18,000	$18,000
Duplex Pumps	LS	1	$80,000	$80,000
Variable Frequency Drive, Controls, Telemetry	LS	1	$56,000	$56,000
New Wet well, Piping & Fittings	LS	1	$93,000	$93,000
Electrical	LS	1	$69,000	$69,000
New Gravity Line Segment	LF[2]	60	$69	$4,140
New 4-inch Force Main	LF	735	$85	$62,475
Site Work	LS	1	$21,000	$21,000
Valve Vault, Meter, Connect to Existing	LS	1	$42,000	$42,000
			Construction Total	**$530,615**
			Contingency (20%)	$106,000
			Subtotal	**$636,615**
			Engineering and Construction Management (25%)	$159,000
			Legal and Administration (5%)	$32,000
			TOTAL	**$827,615**

1. LS: Lump Sum
2. LF: Lineal Feet

Since flow monitoring has not been performed in the system, flow meters should be installed in the contributing area to the pump station to identify pipeline capacities, flow patterns, and peak storm responses in the system. This flow metering data is essential to the proper sizing of pump station improvements and must be conducted prior to the design work.

Replacing this lift station is the preferred alternative and with this replacement, the risk of overflow will be reduced, the controls and alarms will be modernized and brought up to current standards, and electrical efficiency will be increased.

7.1.2 Wastewater Collection System Piping Projects

7.1.2.1 Leaky, Old, Pipe Replacement/Renovation

Infiltration and Inflow (I/I) represents a significant portion of the total flows that must be handled by the Bay City wastewater collection system. Infiltration exists throughout the system in a majority of the sub basins. Metcalf & Eddy's text "*Wastewater Engineering: Collection and Pumping of Wastewater*", suggests that infiltration rates for whole collection systems (including service connections) that are greater than 1,500 gpd/IDM are considered excessive. This standard, using inch-diameter-miles, considers infiltration with regard to length and diameter of collection system piping. Table 23 (on the following page) presents an inventory of Bay City's pipe in respect to length and diameter and shows the subsequent IDM for each size along with a total IDM for the System.

Table 23 System Lengths by Pipe Size
Wastewater Facilities Plan Update, Bay City, Oregon

Lineal Feet	Pipe Size	IDM[1]
735	4-inch pipe	0.6
3,256	6-inch pipe	3.7
5,703	8-inch pipe (PVC[2])	8.6
43,926	8-inch pipe	66.6
1,515	10-inch pipe	2.9
4,832	15-inch pipe	13.7
2,263	18-inch pipe	7.7
62,129	**TOTAL**	**103.8**
	Total miles of pipe	**11.8**

1. IDM: Inch Diameter Mile
2. PVC: Polyvinyl Chloride

Comparing daily flow and rainfall data obtained from treatment plant operational records, during extended periods without significant rainfall during wet weather/high groundwater periods, an infiltration contribution of approximately 0.21 MGD was determined to occur. Considering the infiltration and IDM of the system, the City experiences an overall infiltration rate of approximately 2,000 gpd/IDM. That figure is approximately 1.3 times the level of the standard threshold for determining excessive I/I. Considering that over 90 percent of the City's collection system is comprised of older concrete pipe, the high infiltration rate is to be expected. Older concrete pipe, compared to PVC or HDPE plastic pipes, has 3-4 times as many joints per equivalent length which are typically not as watertight as the plastic pipes nor as flexible, leading to displaced joints and more avenues for infiltration to be introduced into the system. With exposure to sewer gasses, concrete pipe also has a tendency to deteriorate over time much more extensively than plastic pipes and, being much more rigid, concrete also cracks more easily.

These issues all lead up to the need for the City to initiate a rehabilitation program for its aging concrete sewer pipes. With advances in trenchless technologies, it is anticipated that the majority of the concrete sewer line renovations can be accomplished through installation of cured-in-place pipe (CIPP) system. This method of rehabilitation results in a sealed system without the need for major "dig and replace" operations. Typically, CIPP projects cost about half as much as direct burial replacement work and results in a water-tight, 50-plus year lifetime system. Prior to performing a CIPP project, a detailed video analyses of the area in question will need to be performed to confirm the system under consideration is sound enough for this method.

Upon reviewing comparative proportions of the concrete system and age of each system, all basins initially appear to be suitable for a concrete pipe renovation program. The tables on the following pages represent cost estimates for performing CIPP renovations to concrete pipe in each candidate drainage basin.

Table 24 Basin 1 Rehabilitation Estimate, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Item	Unit	Quantity	Unit Price	Total Cost
Mobilization	LS[1]	1	$420,000	$420,000
Site Prep., Temp. Facilities, and Controls	LS	1	$420,000	$420,000
Pre- and Post-Cleaning & CCTV Insp.	LF[2]	19,900	$20	$398,000
CIPP 8-Inch	LF	18,000	$47	$846,000
CIPP 10-Inch	LF	900	$52	$46,800
CIPP 15-Inch	LF	1,000	$82	$82,000
CIPP 18-Inch	LF	0	$92	-
Internal Lateral Reinstatement	EA[3]	0	$7,300	-
External Lateral Reinstatement	EA	266	$6,200	$1,649,200
Manhole Rehabilitation	EA[4]	10	$2,100	$21,000
Point Repair	EA[5]	10	$5,200	$52,000
Clean Up and Surface Restoration	SF[6]	24,000	$11.00	$264,000
Construction Total				**$4,199,000**
			Contingency (20%)	$840,000
			Subtotal	**$5,039,000**
			Engineering and Construction Management (16%)	$806,000
			Legal and Administration (5%)	$252,000
TOTAL				**$6,097,000**

LS: Lump Sum
LF: Lineal Feet
EA: Each
Assuming 10 percent of the manholes in the basin.
Assuming 1 spot repair per 2,000 lineal feet.
SF: Square Feet

For the systematic elimination of I/I, rehabilitation of an entire basin at a time is preferred because projects can be monitored for effectiveness and methods can adjusted as needed. Spot repairs do not address joint failure which, through the field work performed for this facility plan, appears to be systemic throughout the collection system. Additionally, spot repairs often shift infiltration to surrounding defects intensifying I/I at other locations instead of eliminating it. For these reasons, costs have been developed for rehabilitating the entirety of each basin. As analyzed in the previous facility plan, there are 6-inch sewer lines that are smaller than preferred for new construction; however, the 6-inch segments are short, and growth is not anticipated in the areas contributing to these segments. Therefore, rehabilitation is considered for concrete pipe types that are 8-inches in diameter or larger. Tables 25-27 (Tables 26 – 27 on the following page) include the cost estimates for rehabilitating the mainline, laterals, and manholes in each of the basins.

Table 25 Basin 2 Rehabilitation Estimate, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Item	Unit	Quantity	Unit Price	Total Cost
Mobilization	LS[1]	1	$416,000	$416,000
Site Prep., Temp. Facilities, and Controls	LS	1	$416,000	$416,000
Pre- and Post-Cleaning & CCTV Insp.	LF[2]	22,900	$20	$458,000
CIPP 8-Inch	LF	19,200	$47	$902,400
CIPP 10-Inch	LF	0	$52	-
CIPP 15-Inch	LF	3,700	$82	$303,400
CIPP 18-Inch	LF	0	$92	-
Internal Lateral Reinstatement	EA[3]	0	$7,300	-
External Lateral Reinstatement	EA	219	$6,200	$1,357,800
Manhole Rehabilitation	EA[4]	10	$2,100	$21,000
Point Repair	EA[5]	12	$5,200	$62,400
Clean Up and Surface Restoration	SF[6]	20,000	$11.00	$220,000
			Construction Total	**$4,157,000**
			Contingency (20%)	$831,000
			Subtotal	**$4,988,000**
			Engineering & Construction Management (16%)	$798,000
			Legal and Administration (5%)	$249,000
			TOTAL	**$6,035,000**

1. LS: Lump Sum
2. LF: Lineal Feet
3. EA: Each
4. Assuming 10 percent of the manholes in the basin.
5. Assuming 1 spot repair per 2,000 lineal feet.
6. SF: Square Feet

Table 26 Basin 3 Rehabilitation Estimate, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Item	Unit	Quantity	Unit Price	Total Cost
Mobilization	LS[1]	1	$134,000	$134,000
Site Prep., Temp. Facilities, and Controls	LS	1	$134,000	$134,000
Pre- and Post-Cleaning & CCTV Insp.	LF[2]	5,400	$20	$108,000
CIPP 8-Inch	LF	4,500	$47	$211,500
CIPP 10-Inch	LF	600	$52	$31,200
CIPP 15-Inch	LF	100	$82	$8,200
CIPP 18-Inch	LF	200	$92	$18,400
Internal Lateral Reinstatement	EA[3]	0	$7,300	-
External Lateral Reinstatement	EA	94	$6,200	$582,800
Manhole Rehabilitation	EA[4]	3	$2,100	$6,300
Point Repair	EA[5]	3	$5,200	$15,600

Table 26 Continued

Item	Unit	Quantity	Unit Price	Total Cost
Clean Up and Surface Restoration	SF[6]	8,000	$11.00	$88,000
			Construction Total	**$1,338,000**
			Contingency (20%)	$268,000
			Subtotal	**$1,606,000**
			Engineering & Construction Management (16%)	$257,000
			Legal and Administration (5%)	$80,000
			TOTAL	**$1,943,000**

1. LS: Lump Sum
2. LF: Lineal Feet
3. EA: Each
4. Assuming 10 percent of the manholes in the basin.
5. Assuming 1 spot repair per 2,000 lineal feet.
6. SF: Square Feet

Table 27 Basin 4 Rehabilitation Estimate, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Item	Unit	Quantity	Unit Price	Total Cost
Mobilization	LS[1]	1	$91,000	$91,000
Site Prep., Temp. Facilities, and Controls	LS	1	$91,000	$91,000
Pre- and Post-Cleaning & CCTV Insp.	LF[2]	4,400	$20	$88,000
CIPP 8-Inch	LF	2,300	$47	$108,100
CIPP 10-Inch	LF	0	$52	-
CIPP 15-Inch	LF	0	$82	-
CIPP 18-Inch	LF	2,100	$92	$193,200
Internal Lateral Reinstatement	EA[3]	0	$7,300	-
External Lateral Reinstatement	EA	45	$6,200	$279,000
Manhole Rehabilitation	EA[4]	3	$2,100	$6,300
Point Repair	EA[5]	2	$5,200	$10,400
Clean Up and Surface Restoration	SF[6]	4,000	$11.00	$44,000
			Construction Total	**$911,000**
			Contingency (20%)	$182,000
			Subtotal	**$1,093,000**
			Engineering & Construction Management (16%)	$175,000
			Legal and Administration (5%)	$55,000
			TOTAL	**$1,323,000**

1. LS: Lump Sum
2. LF: Lineal Feet
3. EA: Each
4. Assuming 10 percent of the manholes in the basin.
5. Assuming 1 spot repair per 2,000 lineal feet.
6. SF: Square Feet

Total estimated costs for renovating the City's concrete pipe system are approximately $15.4 million; however, as previously stated, rehabilitation may be performed in a phased approach with one basin targeted at a time. Through the application of continuous flow monitoring, the basins can be analyzed for storm response and the basin contributing the most I/I can be identified and selected for rehabilitation projects. Additionally, if funding cannot be secured in large enough quantity to address a basin in its entirety, further phased break down of a basin may be necessary; however, economies of scale discourage smaller projects.

7.1.2.2 Capacity Improvements

In the previous facility plan, alternatives were considering for segments of the collection system that were deemed to be undersized for the peak flow under ultimate build out conditions. The alternatives analyzed included:

- Option A: "Do Nothing"
- Option B: Upsize approximately 3,450 feet of sewer main along Warren Street and the final interceptor
- Option C: Install a new pipeline crossing under Highway 101 at McCoy Street to the WWTP, in effect bypassing the undersized segments.

Option A is not recommended due to the potential for SSOs at ultimate build out conditions; however, alternatives for increasing influent pump station capacity are discussed in later sections which will alleviate flow restrictions in the lower end of the collection system. Option B is a viable option; however, the costs are fairly high due to the length of pipe requiring upsizing. Option C was deemed to be the most economical option and would be included in the influent pump station improvement project discussed later in this report. Option C eliminates the need for upsizing of the sewer lines; however, CIPP lining is still recommended due to leaky joints. This option remains the preferred alternative and the recommendation for this facility plan.

Installing a new line intercepting flow from Basins 1 and 2 will eliminate capacity restrictions and sanitary sewer overflow issues in the lower end of the collection system. Costs for constructing Option C have been updated from the previous plan and are included in Table 28.

Table 28 New Sewer Line Under Highway 101 to WWTP, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Item Description	Unit	Quantity	Unit Price	Total Price
Mobilization	LS[1]	1	$20,000	$20,000
Boring	LS	1	$83,000	$83,000
New Manholes	EA[2]	2	$10,000	$20,000
18-Inch PVC Piping	LF[3]	400	$145	$58,000
			Construction Total	**$181,000**
			Contingency (20%)	$36,000
			Subtotal	**$217,000**
			Engineering and Construction Management (25%)	$54,000
			Legal and Administration (5%)	$11,000
			TOTAL	**$282,000**

1. LS: Lump Sum
2. EA: Each
3. LF: Lineal Feet

7.1.2.3 Flood Proofing

A portion of the City's collection system has been installed within low-lying areas in Basin 4 and near the creeks in Basins 1 and 2. These areas have portions of the collection system that are within the 100-year flood boundary. In order to reduce the effects of flooding on those parts of the system, the City should consider flood proofing those facilities. In these low-lying areas, the primary introduction of flood waters into the collection system would be through the manholes. It is recommended that the City consider a manhole sealing project which would include sealing the internal portions of the main barrel, cone, and risers along with sealing the lids. Ten (10) manholes have been identified as benefiting from a sealing treatment to prevent flood water intrusion. These manholes may be addressed during rehabilitation projects within each basin. If the City desires to perform a stand-alone project for sealing manholes, the following costs are included in Table 29.

Table 29 Flood Proof Low Lying System, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Item Description	Unit	Quantity	Unit Price	Total Price
Mobilization	LS	1	$2,250	$2,250
Site Prep., Temp. Facilities, and Controls	LS	1	$2,250	$2,250
Manhole Sealing	EA	10	$6,000	$60,000
Clean Up and Surface Restoration	LS	1	$2,500	$2,500
			Construction Total	**$67,000**
			Contingency (20%)	$13,400
			TOTAL	**$80,400**

1. LS: Lump Sum
2. EA: Each

7.1.3 Collection System Monitoring Program

Along with performing the recommended pipe renovation projects to remove infiltration, the City should continue their annual I/I reduction and identification efforts and develop a program to systematically evaluate and remove simple and cost-effective I/I sources as they are discovered. As part of the maintenance program, the City should constantly be on the lookout for leaky manholes, broken piping sections, storm drainage (roof drain, catch basin, manhole lid, etc.) and other sources of I/I that are cost-effective to remove and rehabilitate. The ongoing I/I reduction program should be designed to identify the following:

- Priorities of concern based on the age of the collection system components.
- The impact of high groundwater and rainfall on the collection system.
- Areas in the system with potential for limited hydraulic capacity.
- Areas in the system experiencing blockages or overflow problems.

The ongoing evaluation of the collection system performed by the City operational staff should involve the following inspections and investigative techniques:

1. Expansion of electronic database and record conversion
2. Manhole inspection
3. Smoke testing

4. Line cleaning and closed-circuit television inspection
5. Annual flow mapping studies
6. Flow monitoring data collection and analysis

7.1.3.1 Electronic Database

For future assessments, to prioritize rehabilitation projects, and to track maintenance and operational progress, it is highly recommended that the City translate existing information (electronic or other formats) into a geospatial information systems (GIS) database that allows access to images of historical records, operational records, and data collected during future collection system investigations. Records should be maintained and updated as new information becomes available.

Methods for retaining records of physical inspections, smoke testing, flow mapping, and flow monitoring should be developed. Future engineering services contracts should include a requirement for the contractor to provide the City with electronic copies of any inspections performed on the City's facilities.

7.1.3.2 Manhole Inspections

Records of sewer system inspections involving observing interior and exterior manhole conditions should be recorded in an electronic database. Manhole inspections performed during routine activities should include examining the frame, cover, grade rings, joints between barrel sections, the base, and the pipe penetrations for sources of infiltration, the presence of roots, or deterioration. A standardized checklist form should be developed and carried in the vehicles of the operations staff to document their observations. Over the life of the facility, there should be multiple records of inspection reports for each manhole in the City so that changing condition can be documented throughout time.

7.1.3.3 Smoke Testing

There are several methods available for identifying I/I sources in sewer systems. One method, the smoke test, is a relatively inexpensive and quick method for detecting I/I sources (primarily inflow); through this effort, many inflow sources can be discovered and eliminated. Smoke testing involves the release of nontoxic smoke into a partitioned section of a sewer system. Visible smoke plumes will emanate from direct openings in the sewer. Ideally, smoke signs will only be observed rising from sewer vents on each house. In practice, smoke signs appear from a variety of locations making this test particularly useful in identifying the following inflow sources:

- Combined storm sewer sections
- Point source leaks in drainage paths or ponding areas
- Yard and area drains
- Roof drains
- Abandoned building sewers
- Open clean outs
- Faulty service connections

The City is very familiar with smoke testing and is conscientious of informing customers of these testing activities. A form letter has been prepared and is included in the attached smoke testing report that notifies customers of the testing schedule, reason for testing, and the activities that can be expected to occur around the neighborhood. A similar letter is on file that informs customers of any problems relevant to the respective private property. A review of the City policy in relation to private sewer lateral maintenance and repairs should be performed in order that ground rules can be established which benefit both the City and the user.

Recommended smoke testing activities should be scheduled according to the following:

Table 30 Recommended Smoke Testing Activities Schedule
Wastewater Facilities Plan Update, Bay City, Oregon

Age of System	Annual Interval Between Smoke Testing
Known problem areas	Within 5 years
New Construction	End of 20-year period
New construction older than 20 years	Once every 15 years or less
Old construction (AC[1] and concrete pipe)	Once every 10 years or less
1. AC: Asbestos Cement	

An electronic database and map of the testing areas, year of the test, and the locations of deficiencies in the City system should be prepared and continually updated as new work is completed. Minor repairs to the system should be completed within one year unless a significant defect is encountered. In many cases the inflow sources are on private property and must be corrected at the expense of private property owners. Where major construction is required but an emergency is not warranted, the project should be added to the capital improvement plan and scheduled according to other project priorities.

7.1.3.4 Cleaning and Inspecting

Television inspection and cleaning of sewer mains is an essential collection system-monitoring and maintenance tool. Cleaning provides an effective method for removing excessive grease build-up and line blockages. Digital video files, video logs, and written reports for each pipeline segment should be collected and stored in a database. Based upon an annual rate of 6,200 feet per year, the City would have a complete record of the system within a 10-year period. Any new sewers should be televised as a requirement of acceptance and the video record stored in the City's database. If through regular cleaning and televising activities, a pipe section is found that is in poor condition and shows active infiltration, the City may wish to schedule that section for an isolated rehabilitation project or add it to a ranked list to develop a larger project. Problem areas should be inspected as frequently as required.

7.1.3.5 Flow Mapping

Flow mapping studies have been used by the City to establish which piping sections and which basins have more flow than is reasonable. Such studies can help review the effectiveness of past repair projects, and to track the growth of I/I flows in problem areas. Each wet season the City should continue to implement a flow-mapping study in a few basins to identify the amount of I/I present in various sections of the collection system. Ideally, the flow mapping studies should encompass the entire City within a 5-year time frame.

To maintain consistency in timing of the data, the City could establish a study start date based on groundwater levels near the City's office or after a target amount of rainfall (for example, 1 week after a significant rainfall event after 50-percent of the average rainfall in January has occurred).

Results from the annual flow mapping studies should be recorded on a map of the collection system. Any problem areas should be investigated further using CCTV or evaluated for repair using funds dedicated in a replacement budget category.

7.1.3.6 Flow Monitoring

In addition to the flow mapping, the City should install continuously recording flow meters in the collection system. Monitors should be strategically placed to determine the severity of storm response in each individual basin. With time series data, the storm response can be separated into infiltration and inflow components. Once each basin's response is characterized, further flow monitoring may be conducted on the basin with the most severe I/I to refine repair priorities and methods. With basin characterization complete, rehabilitation projects may be assessed for their effectiveness. The duration of each installation should extend to a minimum of three months during the wet season to capture multiple storm-induced flow periods. Capture of dry season conditions is also necessary to establish baseline flows that are independent of infiltration or inflow components.

7.1.3.7 Staffing Requirements

Carrying out a successful collection system monitoring program will take a commitment by the City to dedicate staffing hours to perform the functions outlined above. The following are estimates of staff hours to perform selected tasks from the monitoring program:

Table 31 Projected Staffing Hours, Collection System Monitoring Program
Wastewater Facilities Plan Update, Bay City, Oregon

Task	Staff Hours
Manhole Inspection	½ hour per manhole for inspection and record keeping (crew of one) 16 manholes per day 223 manholes in system (inspect all on 5-year rotation) 3 person days/year staff time
Smoke Testing	1,200 lineal ft of mainline smoke test/day (3-person crew) 2 week/year smoke testing campaign of identified problem areas 42 person days/year staff time
Clean/TV	1,600 lineal ft of production/day (2-person crew) 6,200 lineal ft per year (inspect all on 10-year rotation) 8 person days/year staff time
Flow Mapping/Monitoring	3 month/year campaign to monitor identified problem areas Flow monitor installation, periodic reading, recording and data analyses 60 person days/year staff time
Estimated Staff Time - Total	**113 person days ≈ 1/2 of one full time equivalent**

Staff hours have been estimated; however, the City may use either in-house forces to undertake this work or consultants and contractors to complete the necessary tasks.

In summary, the City should develop and implement an I/I reduction program including:

1. Systematic smoke testing of basins on a rotating basis.

2. Flow mapping of basins on a rotating basis.

3. Continuous flow monitoring to prioritize repair areas.

4. Identification of deficiencies during televising or manhole inspections.

5. Development of projects to correct deficiencies as part of system maintenance.

7.1.4 Fats, Oils, and Grease Program

Piping sections that have issues with the buildup of fats, oils, and grease (FOG) may be the result of either household or commercial sources. FOG, when dumped into the collection system, enters as a liquid and as it cools it often congeals and collects to form clogs and buildups in the piping sections.

Through the field work associated with this facility plan, FOG was identified in multiple locations, particularly in pipes with flatter slopes and lower velocities. While the CCTV did not extend throughout the whole system, FOG locations are likely to exist in areas that were not inspected. Additionally, the previous facility plan identifies that the commercial sections of the City experience grease problems. The FOG amount encountered in the field work for this plan was not severe; however, accumulation will undoubtedly continue and if unchecked, blockages may eventually occur. FOG results in additional maintenance, collection system problems, and ultimately, increased operational costs for the City. The preferred method to eliminate this problem is for the City to establish a FOG program to eliminate the discharge of FOG into the collection system.

The FOG program should be directed at both residential and commercial sanitary sewer customers. For residential customers, the FOG program should include:

> Public education program to educate the public on what FOG is, what impacts it has on the system, the costs of dealing with FOG, and what residential customers should do to reduce the FOG in their wastewater.

While residential customers can make a major difference in reducing the amount of FOG entering the collection system, commercial FOG contributors typically account for the majority of FOG related problems with the collection system. Restaurants, grocery stores (with delis, chicken cookers, etc.), and other commercial establishments, all contribute a significant amount of FOG to the wastewater collection system.

An effective FOG program should include the following points for commercial accounts:

1. Commercial FOG contributors must install grease traps, interceptors, or other facilities to intercept and remove the FOG before it enters the sanitary sewer.

2. Grease traps and grease interceptors must be emptied and cleaned on a regular basis. The owner must report the cleaning to the City.

3. The City must maintain a database of FOG contributors to ensure that they have grease traps and that the traps are being cleaned on a regular basis. Reports should be generated regularly for inspections of traps that are due for cleaning

4. A member of the City staff must be responsible for inspecting and enforcing the FOG requirements including the cleaning and maintaining of grease interceptor equipment.

5. Emulsifiers, thinners, or other agents intended to break the FOG down cannot be used and discharged to the system.

As FOG programs have been established in many communities, best management practices (BMPs), procedures, and other information is widely available.

7.2 Treatment System

7.2.1 Influent Pump Station

The IPS cannot handle peak flows, resulting in redirection of peak flows to the overflow surge basin. When the water level in the surge basin reaches a maximum, water backs up into the manhole upstream from the IPS (manhole #1; MH1) causing SSOs. Cavitation has also been reported as a problem in the IPS. The IPS should be designed for the projected 2040 PIF of 2.51 MGD.

7.2.1.1 Alternative 1: No-Action

A no-action alternative was considered and discounted due to the potential for continued SSOs at MH1 and the need to eliminate cavitation in the IPS.

7.2.1.2 Alternative 2: Upgrade IPS Capacity

An alternative including upgrading the pumping capacity of the IPS to eliminate SSOs at MH1 and pump cavitation was considered and discounted due to the need for a headworks facility directly upstream of the IPS. The current location of the IPS does not have enough space for construction of a new headworks as it is located at the intersection of two levees used for vehicle travel.

7.2.1.3 Alternative 3: Relocate IPS

The IPS needs to be relocated in order to construct a headworks facility upstream due to limited space availability near the current IPS. Moving the IPS nearer to the SBRs will allow placement of a headworks upstream. Due to the conflict between the rim elevation of MH1 and the high-water overflow to the surge basin that results in SSOs at MH1, relocating the IPS will alleviate this problem. The existing IPS should be converted into a lift station and the new IPS can be plumbed into the collection system via an underground gravity line running beneath Highway 101 from Basin 2. This will re-route a major portion of the collection system directly to the new IPS. Basins 3 and 4 will then drain to the existing IPS which will be converted to a lift station that will pump to the new IPS, and Basins 1 and 2 will drain to the new IPS directly.

7.2.1.4 Recommendation

It is recommended that the IPS be relocated near the existing WWTP as described above in Alternative 3.

7.2.2 Flow Equalization

The surge basin has neared capacity during peak flow events indicating the need for additional capacity or modified recirculation operational procedures. The current storage capacity is estimated to be approximately 4 Mgal, which, when combined with direct rainfall on the surge basin and the FSL (which overflows into the surge basin), may not provide sufficient storage capacity for successive peak flow events.

7.2.2.1 Alternative 1: No-Action

A no-action alternative was considered for addressing surge basin capacity issues. Influent flow records indicate that the surge basin has enough capacity to hold peak flows and direct precipitation for multiple heavy precipitation events allowing operators time to recirculate stored influent through the treatment system. Capacity shortfalls in the surge basin will be reduced by reducing I/I in the collection system and increasing the pumping capacity of the IPS. The complexity of recirculating stored influent from the surge basin to prepare storage volume for successive storm events may be reduced by increasing IPS capacity and secondary treatment capacity as described elsewhere in this report.

7.2.2.2 Alternative 2: Increase Capacity

An alternative to increase the capacity of the surge basin was considered and discounted due to the high cost of increasing the elevation of levees and the depth of the basin, compared with the feasibility and cost of implementing Alternative 1.

7.2.2.3 Alternative 3: Modify Operations

An alternative to modify the operation of the surge basin was considered and discounted due to the limited flexibility with which operators may recirculate stored influent to the treatment system. Operators have little control over the amount of influent that overflows into the surge basin, and no control over the amount of direct precipitation that falls on the surge basin and the FSL (the FSL overflows to the surge basin as well). Operational modifications may entail increasing the recirculation pumping rate from the surge basin back to the IPS, however, this may require increasing the pumping capacity of the IPS and would affect downstream treatment processes.

7.2.2.4 Recommendation

It is recommended that no action be taken to increase the capacity of the surge basin as described in Alternative 1 above.

7.2.3 Primary Treatment

Grit and screenings are not currently removed from the Bay City WWTP influent, reducing the life expectancy and increasing the maintenance frequency of downstream equipment such as pumps and valves. The influent grinder that is currently used reduces screenings to particles small enough to pass through pumps but does not remove recalcitrant material from the waste stream such as plastics or inorganic matter. Inorganic material may accumulate in pipes and basins, degrade pumps and valves, and may ultimately pass through the treatment system and be discharged to the environment.

7.2.3.1 Alternative 1: No-Action

A no-action alternative was considered which would keep the influent grinder in place. This alternative was discounted due to the need for screenings removal and degritting to extend the life of downstream equipment, improve the efficiency of downstream treatment processes, and remove recalcitrant material from the waste stream and prevent it from reaching Tillamook Bay.

7.2.3.2 Alternative 2: Screening

An alternative including adding screening upstream of the influent grinder was considered and discounted due to the need for additional grit removal in the system. Removing debris and recalcitrant material from the influent waste stream leaves inorganic grit and small plastic particles that can cause pumps to fail prematurely, accumulate in SBRs and UV disinfection channels, and increase overall maintenance frequency.

7.2.3.3 Alternative 3: Screening and Degritting

An alternative including mechanical screening and degritting was considered to replace the influent grinder for primary treatment. This alternative replaces the grinder with industry standard primary treatment equipment to improve secondary treatment efficiency, reduce maintenance costs, and increase the life of downstream equipment.

7.2.3.4 Recommendation

It is recommended that an influent screening and degritting headworks be constructed upstream of the IPS and the existing influent grinder be removed as described above in Alternative 3.

7.2.4 Secondary Treatment

The secondary treatment system consists of two SBR basins. The following issues have been noted by operators in the secondary treatment system:

- Insufficient peak flow treatment capacity in SBRs.
- SBR #1 discharge valve malfunctions.
- Differential treatment capacity in each SBR unit.
- Blowers do not have automated air controls.

7.2.4.1 Alternative 1: No-Action

A no-action alternative was considered for addressing issues with the secondary treatment capacity of the SBRs. This alternative was discounted from further evaluation due to the need for additional treatment capacity during peak flows and to meet projected future flow and loading treatment needs.

7.2.4.2 Alternative 2: Upgrade SBR

An alternative was considered to upgrade the existing SBR to meet current and future treatment needs at the Bay City WWTP. Increasing the hydraulic and/or organic loading to the existing SBR's will require adding a third SBR basin, additional aeration, and upgrading the aeration controls, at a minimum. This plan is outlined in the 2010 WWFP (HBH, 2010) and includes converting the existing aerobic digester tank into a third SBR basin, constructing a new aerobic digester adjacent to the existing facility, and upgrading aeration controls.

7.2.4.3 Alternative 3: Replace SBR

An alternative was considered to replace the existing SBRs with a new treatment system with increased treatment capacity, but this alternative was discounted due to the high cost of replacing the whole system compared with the relatively minor cost of upgrading the existing system. Various alternatives for replacing the existing system are included in the 2010 WWFP (HBH, 2010), which clearly describes the benefits of each alternative treatment system.

7.2.4.4 Recommendation

It is recommended that the existing SBR system be upgraded as described above in Alternative 2.

7.2.5 Summary

Table 32 includes a summary of recommended improvements projects for the WWTP.

Table 32 Summary of Recommended Wastewater Treatment Plant Improvements Projects Wastewater Facilities Plan Update, Bay City, Oregon

Project	Description
Influent Pump Station (IPS)	Relocate IPS near sequencing batch reactor (SBR); 3 new IPS pumps with variable frequency drives (VFDs); new influent flow meter; re-route sewer main from Basins 1 and 2 directly to new IPS under Highway 101; new gravity main from existing IPS to new IPS for Basins 3 and 4.
Primary Treatment	New headworks including mechanical belt screen and compactor/washer; new grit removal cell; new grit classifier; new grit pumps.
Secondary Treatment	Upgrade SBR including convert existing aerobic digester to third SBR basin; new aerobic digester.

7.3 Outfall

7.3.1 Alternative 1: No-Action

A no-action alternative was considered for addressing issues with the outfall deficiencies. This alternative was discounted from further evaluation due to the location of the existing outfall site being submerged in the mud flats because of channel migration, a new outfall will need to be located in the Tillamook estuary.

7.3.2 Alternative 2: Relocate Outfall to Deeper Section of Channel

The only viable alternative considered was to relocate the proposed outfall site, (Figure 24), to be located approximately 4,500 feet northwest of the existing outfall, in the upper reach of the Bay City channel, on the eastern side of mid bay, between Sandstone point and Goose Point.

8.0 Recommended Plan

8.1 Introduction

Bay City is faced with a lift station that is 47 years old, has inadequate capacity for current peak flows, is deteriorating, has antiquated equipment, and does not meet current building/electrical codes and DEQ requirements. The collection system is also experiencing excessive I/I problems originating from the older portions of the system that were constructed with concrete piping.

The recommended improvements are comprehensive and meant to last at least 20 years into the future. Ongoing system maintenance and I/I location and repairs should continue in efforts to avoid worsening of the I/I problem over time. Since I/I occurs throughout the system, basin specific targeted I/I reduction projects are proposed to occur as the City can afford them over the projected lifetime of this plan.

8.2 Project Cost Summary

A description of the existing system components and deficiencies is presented in Section 4.0. The basis of planning and cost estimating is presented in Section 6.0. The development and evaluation of alternatives for each project is presented in Section 7.0.

8.2.1 Collection System Improvements

8.2.1.1 Pump Station

Downtown Pump Station Replacement $827,600

8.2.1.2 Collection System Projects

Table 33 Collection System Projects, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Project	Cost
Sewer System Evaluation Survey	$85,000
CIPP Rehabilitation Basin 1	$6,097,000
CIPP Rehabilitation Basin 2	$6,035,000
CIPP Rehabilitation Basin 3	$1,943,000
CIPP Rehabilitation Basin 4	$1,323,000
Capacity Improvements	$282,000
System flood proofing	$80,400
Total Cost All Collection System Projects	**$15,845,400**

The rehabilitation project costs are based on full implementation through a basin by basin approach. Phasing by dividing basins into smaller projects will likely be more feasible; however, because of economies of scale, this approach is less cost effective. As a compromise between full scale and piecemeal projects, the recommended plan for rehabilitation of the basins is to first implement a thorough SSES which includes continuous flow monitoring. This monitoring will collect a seasonal dataset which can be used to determine which basin contributes the highest volume of I/I. With this data in hand, a more detailed and focused rehabilitation project can be established so that the largest amount of I/I can be removed per dollar invested.

8.2.2 Treatment System Improvements

8.2.2.1 Influent Pump Station

Relocation and upgrade of the IPS is recommended to eliminate SSOs at MH1. Construction of a new IPS near the SBRs will provide the space necessary for a new headworks facility upstream of the IPS. It will also allow for design of a new pump station that will eliminate cavitation of pumps. New pumps capable of handling the projected PIF of 2.51 MGD should be included with VFDs to handle lower flows. Relocating the IPS near the SBRs will also allow for diversion of sewage from Basins 1 and 2 directly to the IPS through a gravity main under Highway 101, reducing flows through Basins 3 and 4, and eliminating the need to upsize sewer mains through these basins. A new gravity main will need to be constructed from the existing IPS location to the new IPS to convey sewage from Basins 3 and 4 to the new IPS. A new backup power generator is included as the existing backup power generator for the rest of the treatment system may not be capable of handling the extra load from the new IPS.

A description and preliminary construction cost estimate was developed in the 2010 WWFP (HBH, 2010). Table 34 includes updated costs for items included in the 2010 IPS upgrade according to the ENR construction cost index increase from 2010 to 2019.

Table 34 Influent Pump Station Upgrade and Relocation, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Item Description	Unit	Quantity	Unit Price	Total Cost
Mobilization	LS[1]	1	$97,000	$97,000
Demolition/Temporary Facilities	LS	1	$69,000	$69,000
Cast-in-place wet well	EA[2]	1	$166,000	$166,000
Pumps	EA	3	$38,000	$114,000
Variable Frequency Drives	EA	3	$8,000	$24,000
18-inch Gravity Sewer Main	LF[3]	900	$100	$90,000
Manholes	EA	4	$5,000	$20,000
Instrumentation and Controls	LS	1	$32,000	$32,000
Generator	LS	1	$76,000	$76,000
Hoist	LS	1	$14,000	$14,000
Wet well access covers, safety gates, and appurtenances	LS	1	$21,000	$21,000
Misc. piping, valves, and appurtenances	LS	1	$69,000	$69,000
Electrical	LS	1	$104,000	$104,000
			Construction Total	**$896,000**
			Contingency (20%)	$179,000
			Subtotal	**$1,075,000**
			Engineering and Construction Management (25%)	$269,000
			Legal and Administration (5%)	$54,000
			TOTAL	**$1,398,000**

1. LS: Lump Sum
2. EA: Each
3. LF: Lineal Feet

8.2.2.2 Primary Treatment

Implementation of a headworks facility to handle peak flows provided by the IPS is recommended in a letter dated April 6, 2011 by SHN (SHN, 2011). The headworks design should not inhibit the ability to increase the capacity of the SBR in the future. The headworks facility will divert screened and degritted flows in excess of the SBR capacity to the surge basin. An above-grade installation is recommended for ease of access, lower construction costs, and easier maintenance.

Table 35 (on the following page) includes updated costs for items included in the 2011 headworks recommendation letter (SHN, 2011) according to the ENR construction cost index increase from 2011 to 2019.

Table 35 **Headworks, Engineer's Opinion of Probable Cost**
Wastewater Facilities Plan Update, Bay City, Oregon

Item Description	Unit	Quantity	Unit Price	Total Cost
Mobilization	LS[1]	1	$178,000	$178,000
Vertical Screens and Compactor	EA[2]	1	$98,000	$98,000
Head cell	EA	1	$113,000	$113,000
Grit Classifier	EA	1	$98,000	$98,000
Grit Pumps	LS	2	$26,000	$52,000
Electrical	LS	1	$157,000	$157,000
Instrumental and Controls	LS	1	$26,000	$26,000
Construction	LS	1	$558,000	$558,000
Grating	SF[3]	500	$30	$15,000
Railing	LF[4]	200	$40	$8,000
Yard Piping	LS	1	$26,000	$26,000
Mechanical	LS	1	$44,000	$44,000
			Construction Total	**$1,373,000**
			Contingency (20%)	$275,000
			Subtotal	**$1,648,000**
			Engineering and Construction Management (25%)	$412,000
			Legal and Administration (5%)	$82,000
			TOTAL	**$2,142,000**

1. LS: Lump Sum
2. EA: Each
3. SF: Square Feet
4. LF: Lineal Feet

8.2.2.3 Secondary Treatment

Upgrading the existing secondary treatment system may be necessary if influent loading (hydraulic and organic) cannot be reduced. Influent loading may be reduced through improvements to the collection system, and more efficient management of peak flows diverted to the surge basin. Diversion of influent to the surge basin during peak flows may be reduced with collection system improvements and IPS upgrades. However, increasing the pumping capacity of the IPS may result in decreased performance of the SBRs. If the influent loads cannot be reduced, it may be necessary to upgrade the SBRs.

A description and preliminary construction cost estimate was developed in the 2010 WWFP (HBH, 2010). Table 36 (on the following page) includes updated costs for items included in the 2010 SBR upgrade according to the ENR construction cost index increase from 2010 to 2019.

Table 36 SBR Upgrade, Engineer's Opinion of Probable Cost
Wastewater Facilities Plan Update, Bay City, Oregon

Item Description	Unit	Quantity	Unit Price	Total Cost
Mobilization	LS[1]	1	$138,000	$138,000
SBR[2] Equipment	LS	1	$551,000	$551,000
Digester Equipment	LS	1	$104,000	$104,000
Installation	LS	1	$69,000	$69,000
New Digester Tank	LS	1	$345,000	$345,000
Electrical	LS	1	$69,000	$69,000
Piping, Fittings, and Valves	LS	1	$49,000	$49,000
			Construction Total	**$1,325,000**
			Contingency (20%)	$265,000
			Subtotal	**$1,590,000**
			Engineering and Construction Management (25%)	$398,000
			Legal and Administration (5%)	$80,000
			TOTAL	**$2,068,000**

1. LS: Lump Sum
2. SBR: Sequencing Batch Reactor

8.2.3 Outfall

Due to the location of the existing outfall site being in the mud flats and buried due to observed channel migration, a new outfall will need be located is proposed to be located approximately 4,500 feet northwest of the existing outfall, in the upper reach of the Bay City channel, on the eastern side of mid bay, between Sandstone Point and Goose Point. This location is intended to situate the outfall diffuser in a deeper, more stable channel within the Bay.

A preliminary construction cost estimate was developed and is presented in Table 37.

Table 37 Outfall Relocation, Engineer's Opinion of Probable Cost
Wastewater Facilities Plan update, Bay City, Oregon

Item Description	Unit	Quantity	Unit Price	Total Cost
Mobilization	LS[1]	All	$192,000	$192,000
Temporary Utilities/Facilities	LS	All	$13,000	$13,000
Temporary Protection and Direction of Traffic	LS	All	$3,200	$3,200
Site Preparation	LS	All	$12,800	$12,800
Pavement Saw cutting	LF[2]	100	$5	$500
12" SSFM Direct Bury	LF	320	$65	$20,640
12" SSFM Directional Drill - upland	LF	3,951	$97	$383,260
12" SSFM Directional Drill - Bayside/diffuser	LF	2,872	$450	$1,292,400
Diffuser	EA[3]	1	$200,000	$200,000
CARV[4]	EA	2	$1,500	$3,000
Effluent Pump Station	EA	1	$320,000	$320,000

Table 37 Continued

Item Description	Unit	Quantity	Unit Price	Total Cost
10,000-gallon clear well	EA	1	$42,000	$42,000
Surface Restoration	LS	All	$3,200	$3,200
Surface Restoration - Asphalt Replacement	SF[5]	2,400	$5	$12,000
Cleanup	LS	All	$7,000	$7,000
			Construction Total	**$2,505,000**
			Contingency (20%)	$501,000
			Subtotal	**$3,006,000**
			Engineering and Construction Management (25%)	$751,500
			Legal and Administration (5%)	$150,300
			TOTAL	**$3,907,800**

1. LS: Lump Sum
2. LF: Lineal Feet
3. EA: Each
4. CARV: Combination Air Release Valve
5. SF: Square Feet

8.3 Project Prioritization

8.3.1 Priority Groups

As the projects vary in their criticality, the projects can be divided into three separate and distinct priority groups. The priority groups are further described below:

Priority 1 Projects: Priority 1 projects are the most critical and must be undertaken as soon as possible in order to satisfy the current operational and regulatory requirements. Priority 1 projects should be considered as the most immediate needs of the wastewater system.

Priority 2 Projects: Priority 2 projects are projects that should be undertaken within the first half of the planning period to restore aging facilities to new operating conditions and to increase system capacity. While they do not have to be undertaken immediately, they should be included in the capital improvement plans (CIP) and undertaken as funding is obtained.

Priority 3 Projects: Priority 3 projects are projects that are primarily dependent on development and expansion of the system to provide service to new areas. Priority 3 projects are most likely to be driven by development and the need to expand the system to service new properties and new subdivisions. Funding for Priority 3 projects are likely to be financed through a combination of system funds, developer contributions, and System Development Charge (SDC) funds (if available).

8.3.2 Priorities

In assigning project priorities, the following comments made by Michael L. Pinney PE, Senior Environmental Engineer, Oregon Department of Environmental Quality were considered:

> "*Based on analysis of the results from I/I improvements, the influent pump station relocation, grit removal and downtown pump station renovation can be timed for maximum cost savings.*
>
> *In my opinion, all other projects are priority two. Projects that help protect expensive equipment and improve ease of operation (not waste operator effort doing repetitive and uncomfortable jobs due to poor design) are worthwhile.*"

A comprehensive SSES is recommended as the highest priority project to better focus the feasibility and benefit of system repairs/renovations. Once a SSES has been performed and cost-effective improvements for removing I/I are identified, an accurate evaluation of the quantity of I/I removal can be estimated. If significant amounts of I/I can be cost effectively removed, impacts of flow reduction effects on all of the identified projects would need to be evaluated.

Due to age, deterioration, inability to acquire parts, safe maintenance access and capacity problems, the Downtown Pump Station/Force Main replacement is considered a priority project in the system. A predesign report is being prepared for that facility with possible funding assistance available for replacement through State sponsored programs.

The Influent Pump Station, Primary Treatment, and Capacity Improvement projects are all interrelated and are recommended as the next project(s) for the City to consider in the search for financing.

The existing outfall is functional; however, it is not ideally located and may impact recreational uses of the Bay. Considering the cost of relocation, it is recommended that this project be pursued when financially feasible to perform.

Table 38 represents the identified list of recommended improvement projects for the City to pursue, their associated priority ranking, and estimated costs:

Table 38 Summary of Recommended Improvement Projects, Engineer's Opinion of Probable Cost Wastewater Facilities Plan Update, Bay City, Oregon

Proj. No.	Project Description	Priority	Est. Cost
1	SSES[3]	1	$85,000
2	Downtown Pump Station/Force Main Replacement[1]	1	$827,615
3	Influent Pump Station[2]	1	$1,398,000
4	Primary Treatment[2]	1	$2,142,000
5	Capacity Improvements[2, 5]	2	$282,000
6	Outfall	2	$3,907,800
7	Secondary Treatment[5]	2	$2,068,000
8	CIPP[4] Rehabilitation Basin 1[5]	2	$6,097,000
9	CIPP Rehabilitation Basin 2[5]	2	$6,035,000

Table 38 Continued

Proj. No.	Project Description	Priority	Est. Cost
10	CIPP Rehabilitation Basin 3[5]	2	$1,943,000
11	CIPP Rehabilitation Basin 4	2	$1,323,000
12	System Flood Proofing	2	$80,400

1. Replacement of the force main may extend the useful life of the existing pump station.
2. These three projects are interrelated and need to be performed at the same time.
3. SSES: Sanitary Sewer Evaluation Survey
4. CIPP: Cast-In-Place Pipe
5. SSES report will evaluate and recommend extent of each of these projects

8.4 Plan Implementation

8.4.1 Schedule

A tentative schedule identifying the key activities and approximate implementation dates for the Wastewater Projects over the next five years, is presented in Table 39.

Table 39 Tentative Schedule of Activities
Wastewater Facilities Plan Update, Bay City, Oregon

Key Activity	Project	Implementation Date
Council Review Master Plan	All	July-2019
Submit Plan to DEQ[1]	All	July-2019
Approval of plan by DEQ	All	February 2020
City Council Adoption of Master Plan	All	March 2020
Complete Pump Station Pre-Design Report	1	January 2020
Acquire Funding for Pump Station/Force Main Project	1	March 2020
Perform SSES[2]	1	Winter/Spring 2021
Preparation of Plans, Specifications for Pump Station	2	Spring 2021
Construction of Pump Station project	2	Fall 2021
Acquire Funding for IPS[3]/Headworks/Capacity Project	3, 4, & 5	Winter 2021
Preparation of Plans, Specifications for IPS/Headworks/Capacity Project	3, 4, & 5	Summer/Fall 2021
Advertise for Bids IPS/Headworks/Capacity Project	3, 4, & 5	Spring 2022
Construction of IPS/Headworks/Capacity Project	3, 4, & 5	Summer/Fall/2022
Acquire Funding for Outfall Project	6	2023
Environmental Evaluation and Permitting for Outfall Project	6	2023
Preparation of Plans, Specifications for Outfall Project	6	2024
Advertise for Bids Outfall Project	6	2025
Construction of Outfall Project	6	2025

1. DEQ: Department of Environmental Quality
2. SSES: Sanitary Sewer Evaluation Survey
3. IPS: Influent Pump Station

8.4.2 Potential Financing Options

8.4.2.1 Grant and Loan Programs

Outside funding assistance, in the form of grants or low interest loans, will be necessary to make some of the proposed improvements affordable to the residents of the City of Bay City. The amount and types of outside funding will dictate the amount of local funding the City will have to secure. In evaluating grant and local programs, the major objective is to select a program, or a combination of programs, which are most applicable and available for the intended project.

A brief description of the major federal and state funding programs, which are typically utilized to assist qualifying communities in the financing of major wastewater improvement programs, is given below. Each of the government assistance programs has prerequisites and requirements. With each program's requirements, not all communities or projects may qualify for each of these programs.

Economic Development Administration Public Works Grant Program
The Economic Development Administration (EDA) Public Works Grant Program, administered by the US Department of Commerce, is aimed at projects which directly create permanent jobs or remove impediments to job creation in the project area. Thus, to be eligible for this grant, a community must be able to demonstrate the potential to create jobs from the project. Potential job creations are assessed with a survey of businesses to demonstrate the prospective number of jobs that might be created if the proposed project was completed.

Proposed projects must be located within an EDA-designated Economic Development District. Priority consideration is given to projects that improve opportunities for the establishment or expansion of industry and projects that create or retain private sector jobs in both the short and long term. Communities which can demonstrate the existing system is at capacity (i.e. moratorium on new connections), have a greater chance of being awarded this type of grant. The EDA grants are usually 50 percent or less of the project cost; therefore, some type of local funding is also required. Grants typically do not exceed one million dollars.

US Department of Agriculture Rural Development Wastewater Loans and Grants
US Department of Agriculture Rural Development (USDA-RD) has the authority to make loans to public bodies and non-profit corporations to construct or improve essential community facilities, including wastewater systems. Grants are also available to applicants who meet the MHI requirements. While eligible applicants must have a population less than 10,000, priority is given to public entities in areas with populations less than 5,500 people, for improvements to restore a deteriorating wastewater system, or to improve, enlarge, or modify a facility. Preference is also given to requests that involve the merging of small facilities and those serving low-income communities.

Interim commercial financing will normally be used during construction and USDA-RD funds will be available when the project is completed. If interim financing is not available or if the project cost is less than $50,000, multiple advances of USDA-RD funds may be made as construction progresses.

Funding is provided through a competitive process.

Direct Loan:

- Loan repayment terms may not be longer than the useful life of the facility, state statutes, the applicant's authority, or a maximum of 40 years, whichever is less.
- Interest rates are set by USDA-RD.
- Once the loan is approved, the interest rate is fixed for the entire term of the loan and is determined by the MHI of the service area and population of the community.
- There are no pre-payment penalties.

Grant Approval:

1. Applicant must be eligible for grant assistance, which is provided on a graduated scale with smaller communities with the lowest MHI being eligible for projects with a higher proportion of grant funds. Grant assistance is limited to the following percentages of eligible project costs: Maximum of 75 percent when the proposed project is:
   - Located in a rural community having a population of 5,000 or fewer; and
   - The MHI of the proposed service area is below the higher of the poverty line or 60 percent of the State nonmetropolitan MHI.
2. Maximum of 55 percent when the proposed project is:
   - Located in a rural community having a population of 12,000 or fewer; and
   - The MHI of the proposed service area is below the higher of the poverty line or 70 percent of the State nonmetropolitan MHI.
3. Maximum of 35 percent when the proposed project is:

- Located in a rural community having a population of 20,000 or fewer; and
- The MHI of the proposed service area is below the higher of the poverty line or 80 percent of the State nonmetropolitan MHI.

4. Maximum of 15 percent when the proposed project is:
   - Located in a rural community having a population of 20,000 or fewer; and
   - The MHI of the proposed service area is below the higher of the poverty line or 90 percent of the State nonmetropolitan MHI. The proposed project must meet both percentage criteria. Grants are further limited.
   - Grant funds must be available.

Additional requirements

- Applicants must have legal authority to borrow money, obtain security, repay loans, construct, operate, and maintain the proposed facilities.
- Applicants must be unable to finance the project from their own resources and/or through commercial credit at reasonable rates and terms.
- Facilities must serve rural area where they are/will be located.

- Project must demonstrate substantial community support.
- Environmental review must be completed/acceptable.

The following rates currently apply for the Rural Development program:

Market rate. Those applicants pay the market rate whose MHI of the service area is more than the $52,855 (Oregon non-metropolitan MHI). The market rate is currently 3.375 percent.

Intermediate rate. The intermediate rate is paid by those applicants whose MHI of the service area is less than 80 percent of the Oregon non-metropolitan MHI.

Poverty line rate. Those applicants whose MHI of the service area is below $31,713 (60 percent of the State MHI) pay the lowest rate. Improvements must also be required by a governing agency to correct a regulatory violation or health risk. The current poverty line rate is 2.25 percent.

The grants are calculated on the basis of eligible costs that do not include the costs attributable to reserve capacity or interim financing. In addition, grant funds cannot be used to reduce total user costs below that of comparable communities funded by US Department of Agriculture Rural Utilities Service (USDA-RUS).

The US Census data five-year (2009-2013) average MHI for Bay City is $32,232. The percent of low/moderate income persons in Bay City is unknown without a special income survey. Since Bay City appears to have a low MHI, it may be prudent to look into determination of percent of low/moderate income persons in order to qualify for Community Development Block Grants (CDBG). At this MHI, the City of Bay City may be eligible for a maximum grant of up to 55 percent. If any of the projects were required by a governing agency for the health and safety of the service population, those projects would be at a two percent interest rate, and if the MHI is determined low enough, they could receive a grant of up to 75 percent.

Other restrictions and requirements may be associated with these loans and grants. If the City becomes eligible for grant assistance, the grant will apply only to eligible project costs and is only available after a City has incurred long-term debt resulting in an annual debt service obligation equal to one-half of one percent of the MHI. To receive an RUS Loan, the City must secure bonding authority, usually in the form of general obligation (G.O.) or revenue bonds.

Applications for financial assistance are made at area offices of Rural Development. For additional information on USDA-RD loans and grant programs, call (503) 414-3336 or visit the RUS website at https://www.rd.usda.gov. The USDA-RD website is https://www.rd.usda.gov/or.

Technical Assistance Grants

Available through the USDA-RUS as part of the water and waste disposal programs, technical assistance grants (TAG) are intended to provide technical assistance to associations on a wide range of issues relating to the delivery of water and waste disposal services.

Rural communities with populations of less than 10,000 persons are eligible along with private, nonprofit organizations that have been granted tax-exempt status by the Internal Revenue Service

(IRS). Technical Assistance Grant funds may be used for the following activities:

- Identify and evaluate solutions to water and/or waste related problems for associations in rural areas.
- Assist entities with preparation of applications for water and waste disposal loans and grants.
- Provide training to association personnel in order to improve the management, operation and maintenance of water and/or waste disposal facilities.
- Pay expenses related to providing the technical assistance and/or training.
- Grants may be made for up to 100 percent of the eligible project costs. Applications are filed with any USDA-RD office. For additional information on Rural Development loans and grant programs, visit the RUS website.

Oregon CDBG Program
The CDBG Program section of the Infrastructure Finance Authority (IFA) administers the CDBG Program. Grants and technical assistance are available to develop livable urban communities for persons of low and moderate incomes by expanding economic opportunities and providing housing and suitable living environments.

Non-metropolitan cities and counties in rural Oregon can apply for and receive grants. Oregon Tribes, urban cities (Ashland, Bend, Corvallis, Eugene, Gresham, Hillsboro, Medford, Portland, Salem and Springfield) and counties (Clackamas, Multnomah, and Washington) receive funds directly from Housing and Urban Development (HUD).

All projects must meet one of three national objectives:

- The proposed activities must benefit low- and moderate-income individuals.
- The activities must aid in the prevention or elimination of slums or blight.
- There must be an urgent need that poses a serious and immediate threat to the health or welfare of the community.

Funding amounts are based on:

- The applicant's need;
- the availability of funds; and
- other restrictions defined in the program's guidelines.

The following are the maximum grants possible for any individual project, by category:

- Economic Development: $750,000
- Microenterprise: $100,000
- Public Works
  - Water and Wastewater Improvements: $2,500,000 except preliminary/engineering planning grants: $150,000
  - Downtown Revitalization: $400,000
  - Offsite Infrastructure: $225,000

- Community/Public Facilities: $1,500,000
- Community Capacity/Technical Assistance: no specific per-award-limit but limited overall funds
- Emergency Grants: $500,000
- Regional Housing Rehabilitation: $400,000
- Emergency Projects: $500,000

For additional information on the CDBG programs, call 866-467-3466 or visit the IFA website at http://www.orinfrastructure.org/Infrastructure-Programs/CDBG/.

Oregon Special Public Works Fund
The Special Public Works Fund (SPWF) provides funds for publicly owned facilities that support economic and community development in Oregon**.** The SPWF provides funding for construction and/or improvement of infrastructure needed to support industrial, manufacturing and certain types of commercial development. Funds are available to public entities for:

- Planning;
- designing;
- purchasing;
- improving and constructing publicly owned facilities;
- replacing publicly owned essential community facilities; and
- emergency projects as a result of a disaster.

Public agencies that are eligible to apply for funding are:

- Cities;
- counties;
- county service districts (organized under ORS Chapter 451);
- Tribal councils;
- ports;
- districts as defined in ORS 198.010; and
- airport districts (ORS 838).

Facilities and infrastructure projects that are eligible for funding are:

- Airport facilities;
- buildings and associated equipment;
- restoration of environmental conditions on publicly owned industrial lands;
- port facilities, wharves and docks;
- the purchase of land, rights-of-way and easements necessary for a public facility;
- telecommunications facilities;
- railroads;
- roadways and bridges;
- solid waste disposal sites;
- storm drainage systems;
- water and wastewater systems

Loans
Loans for development (construction) projects range from less than $100,000 to $10 million. The IFA offers very attractive interest rates that reflect tax-exempt market rates for highly qualified borrowers. Currently, the SPWF interest rates for borrowers that do not qualify is 3.54 percent (February 2017). Initial loan terms can be up to 25 years or the useful life of the project, whichever is less.

Grants
Grants are available for construction projects that create or retain trade sector jobs. They are limited to $500,000 or 85 percent of the project cost, whichever is less, and are based on up to $5,000 per eligible job created or retained. As this grant is dependent on job creation, it is not ideal for municipal water infrastructure projects.

Limited grants are available to plan industrial site development for publicly owned sites and for feasibility studies.

For additional information on IFA programs, call 503-801-7155 or visit the IFA website at http://www.orinfrastructure.org.

Water/Wastewater Financing Program
Water/wastewater financing is available for construction and/or improvements of water and wastewater systems to meet state and federal standards. This loan program funds the design and construction of public infrastructure needed to ensure compliance with the Safe Drinking Water Act (SDWA) or the Clean Water Act (CWA).

The public entities that are eligible to apply for the program are:

- Cities;
- counties;
- county service districts (organized under ORS Chapter 451);
- Tribal councils;
- ports; and
- special districts as defined in ORS 198.010.

The proposed project must be owned and operated by a public entity as listed above. Allowable funded project activities may include:

- Reasonable costs for construction improvement or expansion of drinking water system, wastewater system or stormwater system;
- water source, treatment, storage and distribution;
- wastewater collection, treatment and disposal facilities;
- storm water system;
- purchase of rights-of-way and easements necessary for construction;
- design and construction engineering; or
- planning/technical assistance for small communities.

To be eligible for funding:

- A system must have received, or is likely to soon receive, a Notice of Non-Compliance by the appropriate regulatory agency or is for a facility plan or study required by a regulatory agency; and
- A registered Professional Engineer will be responsible for the design and construction of the project.

Funding and Uses
Loan and grant amounts are determined by a financial analysis of the applicant's ability to afford a loan (debt capacity, repayment sources and other factors).

Loans
Program guidelines, project administration, loan terms and interest rates are similar to the SPWF program. The maximum loan term is 25 years, or the useful life of the infrastructure financed, whichever is less. The maximum loan amount is $10 million per project through a combination of direct and/or bond-funded loans. Recently IFA, was offering lower, reduced interest rates for municipalities whose household income is less than the statewide MHI. In February 2017 terms of IFA loans were for 25 years at 3.54 percent interest.

Loans are generally repaid with utility revenues or voter-approved bond issues. A limited tax G.O. pledge also may be required. "Creditworthy" borrowers may be funded through the sale of state revenue bonds.

Grants
Grant awards up to $750,000 may be awarded based on a financial review.

An applicant is not eligible for grant funds if the applicant's annual MHI is equal to or greater than 100 percent of the state average MHI for the same year.

Funding for Technical Assistance
The IFA offers technical assistance with financing for municipalities with populations of less than 15,000. The funds may be used to finance preliminary planning, engineering studies and economic investigations.

Technical assistance projects must be in preparation for a construction project that is eligible and meets the established criteria.

- Grants up to $20,000 may be awarded per project.
- Loans up to $50,000 may be awarded per project.

Interested applicants should contact the Oregon Business Development Department (OBDD) prior to submitting an application. Applications are accepted year-round.

Oregon Department of Energy, Business Energy Tax Credit
The Business Energy Tax Credit was revamped in 2001 to allow public entities to participate. The State of Oregon Department of Energy offers a tax credit of 35 percent of project costs, taken over a five-year period, for qualifying capital improvements that reduce energy use. Requirements for projects are similar to that of the Oregon Department of Energy's Small-Scale Energy Loan Program

(SELP) program. Public entities do not pay taxes and so are not eligible for a direct tax credit but may sell their credit to private businesses at a discounted rate, usually about 28 percent. Lighting retrofits, variable frequency drives (VFD), efficient motors, and controls are typical projects that qualify for funding.

8.4.2.2 Local Funding Sources

The amount and type of local funding obligations for wastewater system improvements will depend, in part, on the amount of grant funding anticipated and the requirements of potential loan funding. Local revenue sources for capital expenditures include *ad valorem* taxes, various types of bonds, water service charges, connection fees, and system development charges. Local revenue sources for operating costs include *ad valorem* taxes, and water service charges. The following sections identify those local funding sources and financing mechanisms that are most common and appropriate for the improvements identified in this study.

General Obligation Bonds

A G.O. bond is backed by the full faith and credit of the issuer. For payment of the principal and interest on the bond, the issuer may levy *ad valorem* general property taxes. Such taxes are not needed if revenue from assessments, user charges or some other sources are sufficient to cover debt service.

Oregon Revised Statutes limit the maximum term to 40 years for cities. Except in the event that Rural Utilities Service will purchase the bonds, the realistic term for which G.O. bonds should be issued is 15 to 20 years. Under the present economic climate, the lower interest rates will be associated with the shorter terms.

Financing of wastewater system improvements by G.O. bonds is usually accomplished by the following procedure:

- Determination of the capital costs required for the improvement.
- An election authorizing the sale of G.O. bonds.
- Following voter approval, the bonds are offered for sale.
- The revenue from the bond sale is used to pay the capital costs associated with the projects.

From a fundraising viewpoint, G.O. bonds are preferable to revenue bonds in matters of simplicity and cost of issuance. Since the bonds are secured by the power to tax, these bonds usually command a lower interest rate than other types of bonds. G.O. bonds lend themselves readily to competitive public sale at a reasonable interest rate because of their high degree of security, tax-exempt status, and general acceptance.

G.O. bonds can be revenue-supported wherein a portion of the user fee is pledged toward payment of the debt service. Using this method, the need to collect additional property taxes to retire the obligated bonds is eliminated. Such revenue supported G.O. bonds have most of the advantages of revenue bonds, but also maintain the lower interest rates and ready marketability of G.O. bonds.

Other advantages of G.O. bonds over other types of bonds are as follows.

- The laws authorizing G.O. bonds are less restrictive than those governing other types of bonds.

- By the levying of taxes, the debt is repaid by all property benefited and not just the system users.
- Taxes paid in the retirement of G.O. bonds are IRS deductible.
- G.O. bonds offer flexibility to retire the bonds by tax levy and/or user charge revenue.

The disadvantage of G.O. bond debt is that it is often added to the debt ratios of the underlying municipality, thereby restricting the flexibility of the municipality to issue debt for other purposes. Furthermore, G.O. bonds are normally associated with the financing of facilities that benefit an entire community, must be approved by a majority vote and often necessitate extensive public information programs. A majority vote often requires waiting for a general election in order to obtain an adequate voter turnout. Waiting for a general election may take years, and too often a project needs to be undertaken in a much shorter amount of time.

Revenue Bonds

Revenue bonds are becoming a frequently used option for long-term debt. These bonds are an acceptable alternative and offer some advantages to G.O. bonds. Revenue bonds are payable solely from charges made for the services provided. These bonds cannot be paid from tax levies or special assessments; their only security is the borrower's promise to operate the system in a way that will provide sufficient net revenue to meet the debt service and other obligations of the bond issue.

Many communities prefer revenue bonding, as opposed to G.O. bonding, because it ensures that no tax will be levied. In addition, debt obligation will be limited to system users since repayment is derived from user fees. Another advantage of revenue bonds is that they do not count against a municipality's direct debt, but instead are considered "overlapping debt." This feature can be a crucial advantage for a municipality near its debt limit or for the rating agencies, which consider very closely the amount of direct debt when assigning credit ratings. Revenue bonds also may be used in financing projects extending beyond normal municipal boundaries. These bonds may be supported by a pledge of revenues received in any legitimate and ongoing area of operation, within or without the geographical boundaries of the issuer.

Successful issuance of revenue bonds depends on the bond market evaluation of the revenue pledged. Revenue bonds are most commonly retired with revenue from user fees. Recent legislation has eliminated the requirement that the revenues pledged to bond payment have a direct relationship to the services financed by revenue bonds. Revenue bonds may be paid with all or any portion of revenues derived by a public body or any other legally available monies. In addition, if additional security to finance revenue bonds was needed, a public body may mortgage grant security and interests in facilities, projects, utilities or systems owned or operated by a public body.

Normally, there are no legal limitations on the amount of revenue bonds to be issued, but excessive issue amounts are generally unattractive to bond buyers because they represent high investment risks. In rating revenue bonds, buyers consider the economic justification for the project, reputation of the borrower, methods and effectiveness for billing and collecting, rate structures, provision for rate increases as needed to meet debt service requirements, and track record in obtaining rate increases historically. In addition, other factors considered include adequacy of reserve funds provided in the bond documents, supporting covenants to protect projected revenues, and the degree to which forecasts of net revenues are considered sound and economical.

Municipalities may elect to issue revenue bonds for revenue producing facilities without a vote of the electorate (ORS 288.805-288.945). In this case, certain notice and posting requirements must be met and a 60-day waiting period is mandatory. A petition signed by five percent of the municipality's registered voters may cause the issue to be referred to an election.

Improvement Bonds
Improvement (Bancroft) bonds can be issued under an Oregon law called the Bancroft Act. These bonds are an intermediate form of financing that is less than full-fledged G.O. or revenue bonds. However, these types of bonds are quite useful especially for smaller issuers or for limited purposes.

An improvement bond is payable only from the receipts of special benefit assessments, not from general tax revenues. Such bonds are issued only where certain properties are recipients of special benefits not accruing to other properties. For a specific improvement, all property within the improvement area is assessed on an equal basis, regardless of whether it is developed or undeveloped. The assessment is designed to apportion the cost of improvements, approximately in proportion to the afforded direct or indirect benefits, among the benefited property owners. This assessment becomes a direct lien against the property, and owners have the option of either paying the assessment in cash or applying for improvement bonds. If the improvement bond option is taken, the City sells Bancroft improvement bonds to finance the construction, and the assessment is paid over 20 years in 40 semi-annual installments with interest. Cities and special districts are limited to improvement bonds not exceeding three percent of true cash value.

With improvement bond financing, an improvement district is formed, the boundaries are established, and the benefited properties and property owners are determined. The Engineer usually determines an approximate assessment, either on a square foot or a front-foot basis. Property owners are then given an opportunity to object to the project assessments. The assessments against the properties are usually not levied until the actual cost of the project is determined. Since this determination is normally not possible until the project is completed, funds are not available from assessments for the purpose of making monthly payments to the Contractor. Therefore, some method of interim financing must be arranged, or a pre-assessment program, based on the estimated total costs, must be adopted. Commonly, warrants are issued to cover debts, with the warrants to be paid when the project is complete.

The primary disadvantage to this source of revenue is that the property to be assessed must have a true cash value at least equal to 50 percent of the total assessments to be levied. As a result, owners of undeveloped property usually require a substantial cash payment. In addition, the development of an assessment district is very cumbersome and expensive when facilities for an entire community are contemplated. In comparison, G.O. bonds can be issued in lieu of improvement bonds, and are usually more favorable.

Capital Construction (Sinking) Fund
Sinking funds are often established by budget for a particular construction purpose. Budgeted amounts from each annual budget are carried in a sinking fund until sufficient revenues are available for the needed project. Such funds can also be developed with revenue derived from system development charges.

A City may wish to develop sinking funds for each sector of the public services. This fund can be used to rehabilitate or maintain existing infrastructure, construct new infrastructure elements, or to obtain grant and loan funding for larger projects.

The disadvantage of a sinking fund is that it is usually too small to undertake any significant projects. Also, setting aside money generated from user fees without a designated and specified need is not generally accepted in municipal or public utility budgeting processes.

Connection Fees
Most cities charge connection fees to cover the cost of connecting new development to wastewater systems. Based on recent legislation, connection fees can no longer be programmed to cover a portion of capital improvement costs.

System Development Charges
A System Development Charge (SDC) is a fee collected as each piece of property is developed and is used to finance the necessary capital improvements and municipal services required by the development. Such a fee can only be used to recover the capital costs of infrastructure. Operating, maintenance, and replacement costs cannot be financed through system development charges.

Two types of charges are permitted under the Oregon Systems Development Charges Act: improvement fees, and reimbursement fees. The SDCs utilized before construction are considered improvement fees and are used to finance capital improvements to be constructed. After construction, SDCs are considered reimbursement fees and are collected to recapture the costs associated with capital improvements already constructed or under construction. A reimbursement fee represents a charge for utilizing excess capacity in an existing facility paid for by others. The revenue generated by this fee is typically used to pay back existing loans for improvements.

Under the Oregon SDC Act, methodologies for deriving improvement and reimbursement fees must be documented and available for review by the public. A Capital Improvement Plan must also be prepared which lists the capital improvements that may be funded with improvement fee revenues and the estimated cost and timing of each improvement. Thus, revenue from the collection of SDCs can only be used to finance specific items listed in a Capital Improvement Plan. In addition, SDCs cannot be assessed on portions of the project paid for with grant funding.

Local Improvement District (LID)
Improvement bonds issued for Local Improvement Districts (LIDs) are used to administer special assessments for financing local improvements in cities, counties, and some special districts. Common improvements financed through an LID include storm and sanitary sewers, street paving, curbs, sidewalls, water mains, recreational facilities, street lighting, and off-street parking. The basic principle of special assessment is that it is a charge imposed upon property owners who receive special benefits from an improvement beyond the general benefits received by all citizens in the community. A public agency should consider three “principles of benefit” when deciding to use special assessment: 1) direct service, 2) obligation to others, and 3) equal sharing/basis. Cities are limited to improvement bonds not exceeding three percent of true cash value.

The Oregon Legislature has provided cities with a procedure for special assessment financing (ORS 223.387-399), which applies when City charter or ordinance provisions do not specify otherwise. To establish an LID, an improvement district is formed, the boundaries are established, and the benefited properties and property owners are determined. An approximate assessment to each property is determined based on the above three principles of benefit and is documented in a written report. Property owners are then given an opportunity to object to the project assessments. The assessments against the properties are usually not levied until the actual cost of the project is determined. Since this determination is normally not possible until the project is completed, funds are not available from assessments for the purpose of making monthly payments to the Contractor. Therefore, some method of interim financing must be arranged based on the estimated total costs.

The primary disadvantage to this source of revenue is that the property to be assessed must have a true cash value at least equal to 50 percent of the total assessments to be levied. As a result, owners of undeveloped property usually require a substantial cash payment. In addition, the development of an assessment district is very cumbersome and expensive.

Ad Valorem Taxes

Ad valorem property taxes are often used as revenue source for utility improvements. Property taxes may be levied on real estate, personal property or both. Historically, *ad valorem* taxes were the traditional means of obtaining revenue to support all local governmental functions.

A marked advantage of these taxes is the simplicity of the system; it requires no monitoring program for developing charges, additional accounting and billing work is minimal, and default on payments is rare. In addition, *ad valorem* taxation provides a means of financing that reaches all property owners that benefit from a wastewater system, whether a property is developed or not. The construction costs for the project are shared proportionally among all property owners based on the assessed value of each property.

Ad valorem taxation, however, is less likely to result in individual users paying their proportionate share of the costs as compared to their benefits. Public hearings and an election with voter approval would be required to implement *ad valorem* taxation.

User Fees

User fees can be used to retire G.O. bonds and are commonly the sole source of revenue to retire revenue bonds and to finance operation and maintenance. User fees represent monthly charges of all residences, businesses, and other users that are connected to the wastewater system. These fees are established by resolution and can be modified, as needed, to account for increased or decreased operating and maintenance costs. The monthly charges are usually based on the class of user (e.g. single-family dwelling, multiple family dwelling, schools, etc.) and the quantity of water through a user's connection.

Assessments

Under special circumstances, the beneficiary of a public works improvement may be assessed for the cost of a project. For example, a City may provide some improvements or services that directly benefit a particular development. A City may choose to assess the industrial or commercial developer to provide up-front capital to pay for the administered improvements.

8.5 Financing Strategy

A financing strategy or plan must provide a mechanism to generate capital funds in sufficient amounts to pay for the proposed improvements over the relatively short duration in design and construction, generally two years. The financing strategy must also identify the manner in which annual revenue will be generated to cover the expense for long-term debt repayment and the on-going operation and maintenance of the system. The objectives of a financial strategy include the following:

- Identify the capital improvement cost for the project and the estimated expense for operation and maintenance.
- Evaluate the potential funding sources and select the most viable program.
- Determine the availability of outside funding sources and identify the local cost share.
- Determine the cost to system users to finance the local share and the annual cost for operation and maintenance.

With any of the proposed funding sources within the financial strategy, the City is advised to confirm specific funding amounts with the appropriate funding agencies prior to making local financing arrangements.

A financial strategy to address financing of the Phase I Improvements (projects 1 – 6, Table 38) within the CIP is discussed below.

Grants and Low Interest Loans

Three types or programs of project financing were identified as viable for funding the City's proposed Improvements: 1) USDA-RD water and waste disposal grants and loans, 2) wastewater State Revolving Fund, and 3) private financing. Based on these funding programs, three alternative funding packages were compiled and evaluated. These alternatives are designated as Alternatives A, B, and C. A summary of the funding alternatives for these improvements is given in Table 40.

Table 40 Funding Alternative for Priority 1 Projects
Wastewater Facilities Plan Update, Bay City, Oregon

Funding Source	Grant Amount, $ [1]	Loan Amount, $ [1]	Loan Term, yrs[2]	Interest Rate, %	Rate Increase, $/EDU[3]/mth [4]
Alternative A – USDA-RD[5]/Water/Wastewater Financing Program Grants & Loans					
RD[6] 55/45 (Grant/Loan)	$4,753,328	$3,889,087	40	2.75	$14.96
Alternative B – Wastewater SRF[7] Loan					
WWSRF[8]	--	$8,642,415	30	2.77	$39.62
Alternative C – Private Loan					
Private Funding	--	$8,642,415	25	4.35	$53.14

1. Amount based on current dollars.
2. Yrs: years
3. EDU: Equivalent Dwelling Unit
4. Based on 1,900 EDUs. EDUs associated with non-profit or City use were not included in the total EDU tabulation.
5. USDA-RD: US Department of Agriculture Rural Development
6. RD: Rural Development
7. SRF: State Revolving Fund
8. WWSRF: Wastewater State Revolving Fund

The projected rate increases anticipated from the funding options range from $14.96 to $53.14 per EDU per month. These rate increases vary widely in magnitude and should be investigated further at a "One-Stop" meeting with the funding agencies and with discussions with private funding sources. For the purposes of this financing plan, further evaluation will be made with the most conservative value, which is an increase of $14.96 per EDU per month (Alternative A).

Local Financing Requirements

The financing plan for the Priority I Improvements is based on the City securing authorization to issue bonds in the amount of $3,889,087. A breakdown of approximate monthly user costs for the improvements, based on present worth costs and including current wastewater O&M budget and debt reserve is given in Table 41.

Table 41 Estimated Overall EDU[1] Costs Associated with Priority 1 Improvements Wastewater Facilities Plan Update, Bay City, Oregon

Item	Annual Cost	Monthly User Cost/EDU[2]
Debt Service on $3,889,087 low interest loan	$161,520	$13.60
Debt Service Reserve at 10%	$16,152	$1.36
O&M[3], Old Debt Service, Transfers (Based on 2018-19 Budget)	$622,432	$41.90
TOTAL	**$2,337,892**	**$56.86**

1. EDU: Equivalent Dwelling Unit
2. Based on 990 EDUs. EDUs associated with non-profit or City use was not included in the total EDU tabulation.
3. O&M: Operations and Maintenance

The estimated total monthly average cost to each EDU is anticipated to be approximately $56.86. A grant for Alternative A improvements is conditional upon the determination of the City's eligibility for USDA-RD funding. The grants funds will not be offered by USDA-RD if the City does not acquire authorization to issue bonds in the minimum amount required by the agency.

System Development Charges

In addition to the proposed financing strategy consisting of grants and low interest loans, the City should revise its System Development Charges (SDC) to assist in financing necessary capital improvements to the wastewater system required by growth and development.

The SDCs may be developed and assessed as reimbursement and/or improvement fees. The reimbursement fee approach is based on the premise that new customers are entitled to wastewater service at the same cost as existing customers. Consequently, the reimbursement SDC is calculated as the average wastewater system investment per customer. Calculation of a reimbursement SDC is beyond the scope of this study as research and documentation is needed to determine the total investment made to the City's wastewater system, contributed capital, and debt service payments.

Affordability

One major consideration in deciding on any proposed capital improvements is the user's ability to support the full cost, including debt repayment, of utility service. Several measures of household affordability or ability-to-pay have been proposed or are currently being utilized.

The majority of affordability indicators are largely a function of income and rates. One of the most common affordability indicators is the ratio of annual user charges to the MHI. The threshold of affordability for this ratio varies from 1.5 to 2.5 percent of MHI. Business Oregon (formerly The Oregon Economic and Community Development Department) utilizes 1.39 percent of the MHI as a threshold for qualifying for grant monies.

Affordability of rates and projected rate increases are also factors when bond rating agencies are determining credit quality. Fitch Ratings generally considers combined wastewater and sewer service rates higher than 2 percent of MHI (or one percent for individual wastewater and wastewater utilities) to be financially taxing (Water and Sewer Revenue Bond Rating Guidelines, Fitch Ratings September 3, 2015).

A summary of affordability measures and thresholds from selected studies is provided in Table 42.

Table 42 Summary of Affordability Measures and Thresholds
Wastewater Facilities Plan Update, Bay City, Oregon

Source	Indicator(s)	Threshold
Future Investment in Drinking Water & Wastewater Infrastructure (2002)	Ratio of annual user charge & MHI[1]	>2.5% of MHI
RUS[2] Water & Waste Disposal Loans & Grants	Debt service portion of annual user charge & MHI	>0.5% & MHI below poverty l line or >1.0% & MHI between 80 & 100% of statewide non-metropolitan MHI
Department of Housing & Urban Development	Ratio of water & sewer bills, & MHI	1.3 to 1.4%
National Consumer Law Center "The Poor and the Elderly – Drowning in the High Cost of Water", circa 1991	Ratio of sum of water & sewer bills & household income	>2.00%
Future Investment in Drinking Water & Wastewater Infrastructure (2002)	Ratio of AUC[3] & MHI	>2.5% of MHI
EPA[4] Economic Guidance for Water Quality Standards Workbook (1995)	Ratio of AUC & MHI	<1.0% - no hardship expected 1.0 – 2.0% - mid-range >2.0% may be unreasonable burden
Affordability Criteria for Small Drinking Water Systems: An EPA Science Advisory Board Report (2002)	Discussion of affordability threshold, expenditure baselines, and differences in cost, income, and benefits	1. >1.0% must provide additional security. 2. >2.5% - system probably cannot issue debt

Table 42 Continued

Source	Indicator(s)	Threshold
National Drinking Water Advisory Council Affordability Recommendations (2003)	EPA national affordability threshold given s size category	grounds for consideration of measures other than median income
State of Idaho Assessment Tools for SRF[5] Loans	Ratio of AUC & MHI	>1.5% MHI

1. MHI: Median Household Income
2. RUS: Rural Utilities Service
3. AUC: Annual User Charge
4. EPA: Environmental Protection Agency
5. SRF: State Revolving Fund

One limitation of using the ratio of annual user charges to the MHI is the determination of a representative MHI for a community. Currently, most funding agencies still utilize the 2010 Census data for making this determination. We have chosen to use the US Census data five-year (2009-2013) average MHI for Bay City is $32,232.

The affordability of existing and future wastewater rates within Bay City is summarized in Table 43.

Table 43 Affordability Tabulations
Wastewater Facilities Plan Update, Bay City, Oregon

AFFORDABILITY TABULATIONS	
Median Household Income (MHI[1])	$32,232
Current Rates	
Estimated Monthly User Charge/EDU[2] ($)	$41.90
AUC[3]/ MHI (%)	1.56%
Projected Rates	
Estimated Monthly User Charge/EDU ($)	$56.86
AUC/ MHI (%)	2.12%

1. MHI: Median Household Income
2. EDU: Equivalent Dwelling Unit
3. AUC: Annual User Charge

8.5.1 Funding Recommendations

This Wastewater Facilities Plan Update outlines a plan for all necessary improvements, which represent a significant investment for the City. Therefore, a strategy and plan for financing the recommended improvements must be developed. While the financing package that the City will ultimately utilize depends on the results of coordination with the various funding agencies, this section will summarize the general direction the City should proceed with and provide some insight into the potential impacts to rate payers. As outlined earlier in this section, improvements projects recommend for the City total in excess of approximately $8.64 million dollars. The City should proceed with the following steps as it moves forward with the financing strategy for the wastewater system improvement projects:

1. As soon as this Wastewater Facilities Plan Update is approved, the City should contact IFA to schedule a one-stop meeting. At this one-stop meeting, all of the potential agencies who may be

able to provide funding will send representatives to discuss the funding needs and develop a funding package for the improvement projects. The agencies will make recommendations and will discuss what each agency can offer. The result will be a funding package made up of grants and loans from a number of agencies to fund the projects.

2. Following the one-stop meeting, the City should immediately process the necessary paperwork to apply for the funding included in the funding package recommended at the one-stop meeting. This will require numerous applications and other administrative efforts to apply for funding. The City should apply to any and all programs or agencies that have the potential to provide grant money to reduce the impact to rate payers.

3. Due to the magnitude of the required improvements, the City will not likely receive grants sufficient to cover all of the costs of the project. In fact, the City will most likely be required to take out loans for a significant portion of the project costs.

4. Once the City receives notification that they have secured the necessary funding to complete the work, they can begin the pre-design and design activities in preparation for bidding and construction of the improvements.

9.0 References

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Smoke Testing 1

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Smoke Testing

Prepared for:

City of Bay City

SHN **Consulting Engineers & Geologists, Inc.**

275 Market Avenue
Coos Bay, OR 97420-2219
541/266-9890

November 2015

611013.151

SHN CONSULTING ENGINEERS & GEOLOGISTS, INC.
275 Market Avenue• Coos Bay, Oregon 97420-2228 • Phone: 541/266-9890 • FAX: 541/266-9496•shninfo@shn-engr.com

Reference: 611013.151

November 16, 2015

Mr. Brian Bettis
City of Bay City
PO Box 3309
Bay City, OR 97107

Subject: Smoke Testing Results, City of Bay City

Dear Brian:

SHN Consulting Engineers & Geologists, Inc. (SHN) performed smoke testing of the collection system for the City of Bay City (City) on August 24th-25th, 2015. Enclosed are the findings and recommendations, including two bound copies for your records and one reproducible copy for distribution to private property owners.

Please feel free to contact me at 541-266-9890 if you have any questions.

Sincerely,

SHN Consulting Engineers & Geologists, Inc.

Steven K. Donovan, PE
Principal Engineer

NJN:SKD:dkl

CONSULTING ENGINEERS & GEOLOGISTS, INC.
275 Market Avenue• Coos Bay, Oregon 97420-2228 • Phone: 541/266-9890 • FAX: 541/266-9496•shninfo@shn-engr.com

Reference: 611013.151

Smoke Testing

Prepared for:

City of Bay City
PO Box 3309
Bay City, OR 97107

Prepared by:

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420-2228
541-266-9890

November 2015

QA/QC: SKD

\\Coosbaysvr1\projects\2011\611013-Bay City EOR -Wastewater\151-WWFP\PUBS\rpts\20151116-SmokeTesting.doc

Table of Contents

List of Illustrations

Acronyms and Abbreviations

City	City of Bay City
EPA	Environmental Protection Agency
SHN	SHN Consulting Engineers & Geologists, Inc.

1.0 Smoke Testing Procedure

Smoke testing is an Environmental Protection Agency (EPA) recommended procedure to identify flaws in a sewage system. To smoke test sewers, a motorized fan is placed over selected manholes forcing air through the pipes. A smoke bomb is placed on the suction side of the fan which allows the fan to inject smoke into the pipes. A properly functioning sewage system would dissipate the smoke out of the venting systems on the roofs of occupant's homes. Smoke that escapes in any other areas are general indications of a potential inflow source or as health hazards for occupants of homes without proper ventilation.

Smoke testing for the City of Bay City (City) was conducted on August 24th-25th of 2015. Conditions were moderate and sunny on both days. A total of 33 smoke bomb locations were tested for proper coverage of the entire town.

2.0 Smoke Testing Results

As shown on Figure 1, a total of 17 major problems and numerous minor problems were encountered during the test event. The test results located six major areas of inflow from structural damage in sewer pipe, manhole, or combined storm/wastewater cross connections. These areas of damage are highlighted with red arrows on the basin maps and should be the City's highest priority repair issues.

The second priority problem areas consist of broken laterals and roof drains connected to the sewer. These areas are highlighted in orange and could be significantly leading to inflow. There are 11 orange arrows located in three main areas. These must be fixed promptly as they can be large area drains and a major source of inflow during rainfall events. Because these problems reside on private property, the corrections may require the City to take enforcement action against the residents.

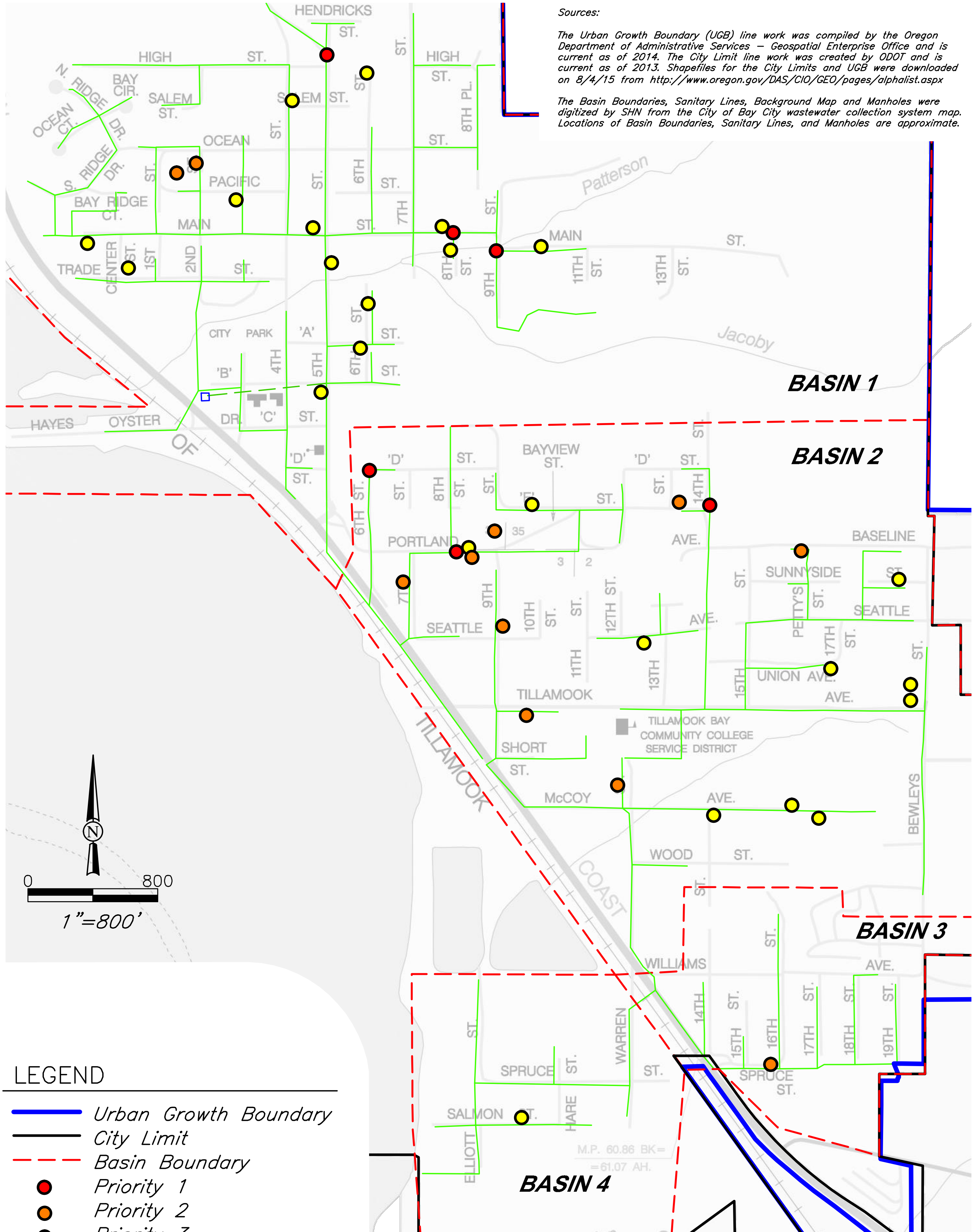
Finally, the yellow arrows mark uncapped cleanouts and venting issues that are not leading to a large portion of inflow but may be a health and safety concern for occupants. Improper venting can lead to sewer gasses within the house where occupants could be exposed.

Reports are attached in Appendix A for each of these areas describing the problem, where it is located, and a recommendation to fix the problem. A map of the North and South basins are also included in the report to show locations that may be experiencing high flows due to the inflow problems indicated.

2.1 List of No-Smoke Houses

These houses did not have smoke exiting their roofs meaning one of three possibilities:

- They do not have their house vented or properly vented
- There is a sag in their lateral causing the smoke to be blocked.
- The sewage is being pumped uphill



SHN Consulting Engineers & Geologists, Inc.

City of Bay City
Wastewater Facilities Plan
Bay City, Oregon

Collection System Evaluation
Smoke Testing Results
SHN 611013

November 2015 | 611013-SMOKE TEST RESULTS | Figure 1

\\coosbaysvr1\Projects\2011\611013-Bay City EOR-Wastewater\151-WWFP\Figs , SAVED: 11/18/2015 3:46 PM NNISSEN, PLOTTED: 11/19/2015 2:58 PM, NATHAN NISSEN

A fourth, less likely issue, could be that the lateral is blocked by roots or broken. If this were the case, the occupants would have a noticeably limited use of the plumbing. Caution must be taken when vactoring next to these properties due to the suction that the vactor creates forcing blowback into the plumbing of the house. This could cause sewage to splash back into the home and residents must be warned to close toilets until the vactor has passed.

Houses With No Sign of Smoke Exiting Roof Vents

- 9975 6th Ave.
- Duplex on 7th St.
- 9955 5th Ave.
- 10135 4th St.
- 10120 4th St.
- 5170 High St.
- 5035 S Ridge Dr.
- 9280 5th St.
- 9275 5th St.
- Pacific Oyster
- 12th St. Brown House
- 7990 18th St.
- 7965 19th St.
- 7850 19th St.
- 8595 Bewleys
- 8390 Bewleys
- 7860 Warren
- 4600 Salmon
- 4715 Salmon
- 5620 A St.
- 9670 Dewpoint
- 8970 15th St.
- 6880 Baseline
- 9435 5th St.
- 9075 12th
- 5195 Seattle
- 9930 3rd St.
- 7865 14th St.
- 7825 14th St.

In summary, there were 17 defects requiring correction to reduce extraneous flow. A document for each defect is attached to this report outlining where the defect is located and possible causes of the defect. A smoke testing result form is also attached that can be sent to property owners notifying them of the problem. Removal of inflow sources is the least expensive corrective measure to lower I/I in a sewer system. Not only is it economical, but removing these identified sources will have an exceptional impact on the reduction of I/I.

A

Smoke Testing Results Forms

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-24-2015

Street Location: 5970 Main St.
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
In front of deck

Probable Cause
No cleanout cap

Recommendations
Replace broken cleanout cap.

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Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 1

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date:

Street Location: 8th Street Manhole

Owner:

Observer: Cody L.

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

No smoke coming out of manhole on 8th Street. Put smoker on manhole at 8th Street and Main.

Probable Cause

Dip or collapse in main

Recommendations

TV line to see what is causing blockage

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Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 2

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-24-2015

Street Location: 9660 8th Street

Owner:

Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
No cap on cleanout

Probable Cause
Missing cleanout cap

Recommendations
Replace missing cap on cleanout.

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275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 3

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-24-2015

Street Location: 5680 Main Street
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Cleanout in demolished house site.

Probable Cause
No cap on cleanout

Recommendations
Repair broken cleanout

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275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 4

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-24-2015

Street Location: Cleanout at end of 6th St.
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Cap is open on cleanout

Probable Cause
Open Cap

Recommendations
Close cap on cleanout.

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 5

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date:
Time:

Street Location: West side of 5th
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Leak north of Ocean Street before Hendricks Street

Probable Cause
Unknown

Recommendations
Check area for cleanout and TV pipe.

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 6

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 2nd Street east of 5365

Owner:

Observer: Cody L.

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Smoke coming out of ground next to power pole guy wire.

Probable Cause

Possible roots from stump.

Recommendations

Inspect pipe

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275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 7

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-24-2015

Street Location: Empty lot on 1st Street
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
To the east side of 1st Street
At 1st and Pacific.

Probable Cause
Too brushy to determine
Location of smoke source.
Possible cleanout

Recommendations
Inspect area for cleanout

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 8

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-24-2015

Street Location: 9590 6th Street

Owner:

Observer: Cody L.

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Black pipe on side of house

Probable Cause

Vent comes out on the side of the house.

Recommendations

Not a problem

Consulting Engineers & Geologists, Inc.

275 Market Avenue

Coos Bay, OR 97420

Phone: 541-266-9890

Photo No: 9

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-24-2015

Street Location: 9360 5th Street

Owner:

Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Smoke through bathroom sink.

Probable Cause

No trap in sink

Recommendations

Install trap

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 10

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-24-2015

Street Location: E St. between 9th & 11th
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Hole in ground.

Probable Cause
Cleanout with no lid.

Recommendations
Replace lid on cleanout.

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 11

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-25-2015

Street Location: Between 8th & 9th
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Manhole with AC patch. Trench patch has smoke Leaking out of cracks. Also, 2" PVC pipe with smoke between houses 6050 8th & 6075 8th.

Probable Cause
Cracks in manhole Casing.

Recommendations
Repair/replace manhole and or sealant

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275 Market Avenue
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Phone: 541-266-9890

Photo No: 12

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Street Location: Empty lot next to 6075 8th Street

Date: 8-25-2015

Owner:

Observer: Cody L.

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Hole with smoke coming out of ground

Probable Cause

Broken lateral

Recommendations

Repair lateral

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Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 13

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: Manhole at 7th & D St

Owner:

Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Smoke leaking out of
Manhole rim on the side.

Probable Cause
Sealant is missing

Recommendations
Seal manhole

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 14

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date:
Time:

Street Location: 8855 9th Street
Owner:
Observer: Cody L.

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Coming up in yard. All of piping up to cleanout is smoking heavily (bricks, concrete, planter box, and retaining wall)

Probable Cause
Lateral is broken in multiple places

Recommendations
Replace lateral

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 15

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 6425 Seattle Street

Owner:

Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Probable Cause

Broken cleanout cap.

Recommendations

Replace cleanout cap.

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 16

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 8870 Bewley Street

Owner:

Observer: Cody L.

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

½ way down Sunny Side 10' off of the road. Leak could be cleanout

Probable Cause

Broken cleanout cap.

Recommendations

Replace cleanout cap.

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275 Market Avenue

Coos Bay, OR 97420

Phone: 541-266-9890

Photo No: 17

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-25-2015

Street Location: 6795 McCoy
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Probable Cause
No cleanout lid.

Recommendations
Cap cleanout.

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 18

Project No. **611013**
Task: **151**

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-25-2015

Street Location: 6780 McCoy
Owner:
Observer: Cody L.

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Probable Cause
No cleanout lid.

Recommendations
Replace cleanout lid.

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Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 19

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date:

Time:

Street Location: 6190 Main Street

Owner:

Observer: Nate Nissen

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Square roof vent on northwest

Side leaking smoke.

Probable Cause

Not properly vented

Recommendations

Vent through roof

SHN

Consulting Engineers & Geologists, Inc.

275 Market Avenue

Coos Bay, OR 97420

Phone: 541-266-9890

Photo No: 27

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-24-2015

Street Location: 9th and Main Street

Owner:

Observer: Nate Nissen

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Water coming into main
from stream culvert that runs
under 9th

Probable Cause

Crack in main

Recommendations

Repair main

SHN

Consulting Engineers & Geologists, Inc.

275 Market Avenue

Coos Bay, OR 97420

Phone: 541-266-9890

Photo No: 28

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 6085 Portland Street

Owner:

Observer: Nate Nissen

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Smoke coming out of gutter.

Probable Cause

Gutter hooked up to sewer

Recommendations

Separate gutter and sewer

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 35

Project No. 611013

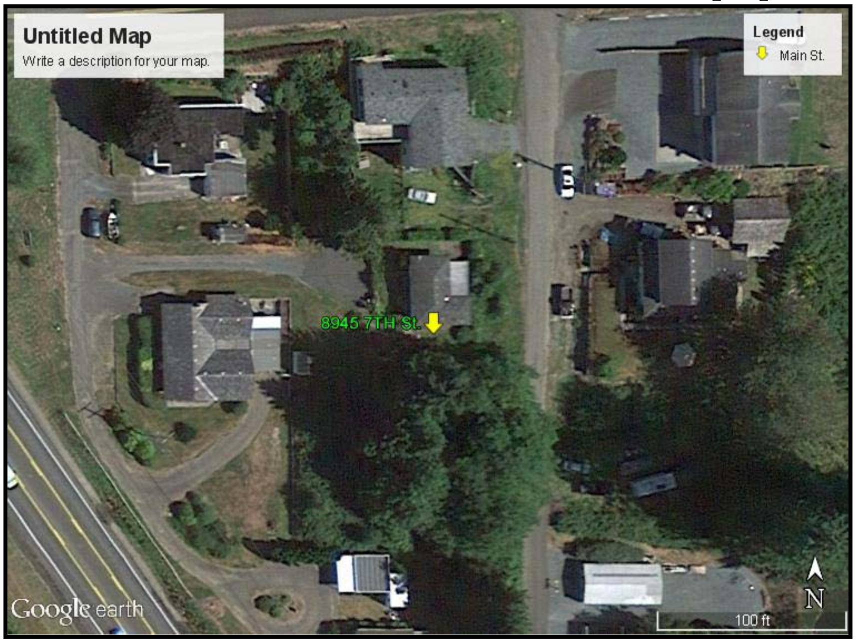
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-25-2015

Street Location: 8945 7th Street
Owner:
Observer: Nate Nissen

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)



Observed Smoke Return
Smoke out of lawn on south side of house.

Probable Cause
Broken lateral

Recommendations
Replace lateral

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275 Market Avenue
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Phone: 541-266-9890

Photo No: 36

Project No. 611013
Task: 151

\\Coosbaysvr1\projects\2011\611013-Bay City EOR -Wastewater\151-WWFP\Rpts\Smoke Testing Forms\36-8945-7thSt.doc

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 6525 E. Street

Owner:

Observer: Nate Nissen

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Ditch is leaking in front of house across from manhole.

Probable Cause

Broken lateral

Recommendations

Repair lateral

SHN

Consulting Engineers & Geologists, Inc.

275 Market Avenue

Coos Bay, OR 97420

Phone: 541-266-9890

Photo No: 37

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 6765 Baseline

Owner:

Observer: Nate Nissen

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Smoke exiting out of water meter box.

Probable Cause

Lateral leaking by water box

Recommendations

Inspect water box and lateral repair if necessary

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 38

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-25-2015

Street Location: 8680 Bewley
Owner:
Observer: Nate Nissen

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Probable Cause
Cleanout not capped.

Recommendations
Replace cap on cleanout.

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275 Market Avenue
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Phone: 541-266-9890

Photo No: 39

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-25-2015

Street Location: 6625 McCoy
Owner:
Observer: Nate Nissen

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Smoke coming out of shop roofline.

Probable Cause
Vent exiting roof or not properly vented

Recommendations
Vent through roof

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275 Market Avenue
Coos Bay, OR 97420
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Photo No: 40

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 6395 Short Street

Owner:

Observer: Nate Nissen

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Smoke exiting vent on south-east side of house. Also exiting gutter line on the south side of the house

Probable Cause

Gutters draining into cleanout

Recommendations

Separate gutter and cleanout

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 41

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-24-2015

Street Location: 9635 5th Street
Owner:
Observer: Walter White

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Vent pipe does not go above eave.

Probable Cause
Vent pipe does not go above eave.

Recommendations
Vent around eave.

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 52

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-24-2015

Street Location: 10035 4th Street

Owner:

Observer: Walter White

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Smoke coming out of crawlspace under house

Probable Cause

Not properly vented/ Possible broken lateral

Recommendations

Inspect lateral and vent

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 53

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-24-2015

Street Location: 5415-5515 Pacific
Owner:
Observer: Walter White

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return
Smoke from 4" PVC
in empty lot

Probable Cause

Recommendations
Cap cleanout

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275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 56

Project No. 611013
Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

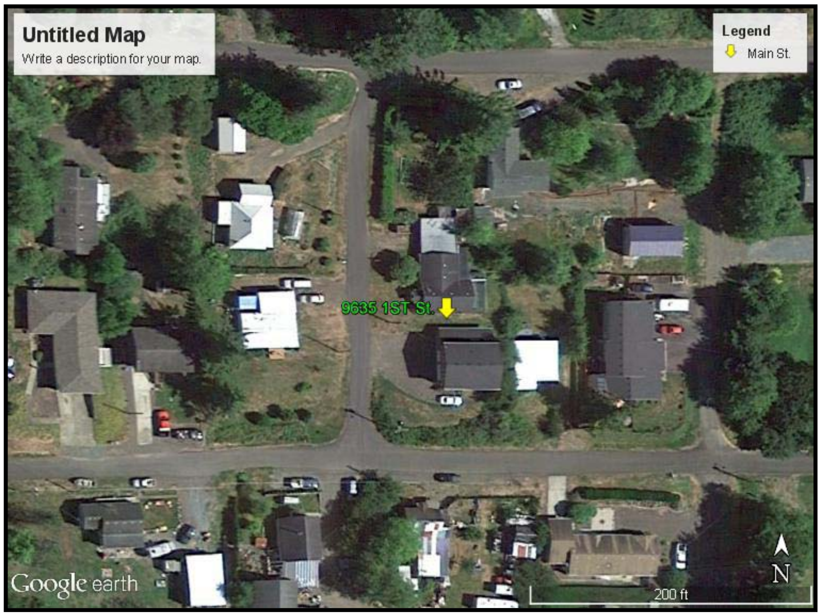
Date: 8-24-2015

Street Location: 9635 Trade

Owner:

Observer: Walter White

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)



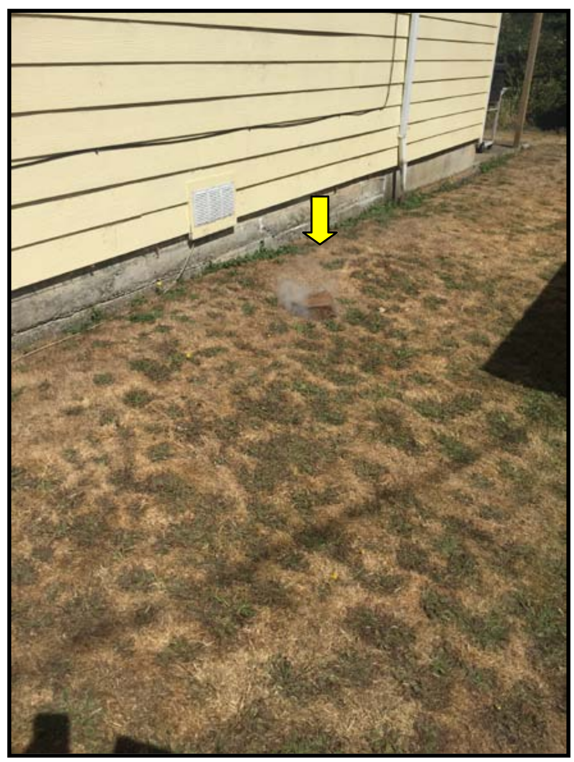
Observed Smoke Return

No cleanout cover south side of house.

Probable Cause

Recommendations

Cap cleanout



Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 57

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 6195 Tillamook

Owner:

Observer: Walter White

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Broken cleanout cover on the West side. Smoke from under House and cracks in sidewalk NE corner of house.

Probable Cause

Broken lateral

Recommendations

Repair lateral

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 61

Project No. 611013

Task: 151

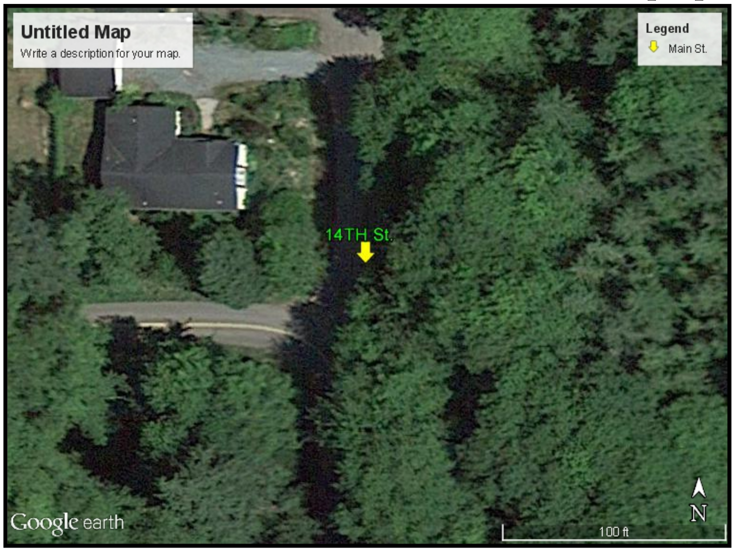
SMOKE TESTING RESULTS

Client: **Bay City**
Date: 8-25-2015

Street Location: SE Corner E & 14th St.
Owner:
Observer: Walter White

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)



Observed Smoke Return

Manhole leaking out of side ring.

Probable Cause

No sealant around ring.

Recommendations

Manhole needs to be sealed.

SHN

Consulting Engineers & Geologists, Inc.

275 Market Avenue

Coos Bay, OR 97420

Phone: 541-266-9890

Photo No: 64

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 6825 Union

Owner:

Observer: Walter White

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

No cleanout cover on the
North side – old home site
East of existing house.

Probable Cause

Recommendations

Cap cleanout

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 65

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 8630 Bewely

Owner:

Observer: Walter White

LOCATION OF RETURN
(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

No cleanout cover on the west side of house.

Probable Cause

Recommendations

Cap cleanout

SHN
Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 66

Project No. 611013

Task: 151

SMOKE TESTING RESULTS

Client: **Bay City**

Date: 8-25-2015

Street Location: 6760 Spruce St.

Owner:

Observer: Brian Bettis

LOCATION OF RETURN

(location of MH, street, house no., areas of smoke escape, photo, etc.)

Observed Smoke Return

Smoke exiting gutter

Probable Cause

Gutter hooked to cleanout

Recommendations

Separate gutter from cleanout

Consulting Engineers & Geologists, Inc.
275 Market Avenue
Coos Bay, OR 97420
Phone: 541-266-9890

Photo No: 67

Project No. 611013

Task: 151

B

Sample Notification Form Letter

City of Bay City
P.O. Box 3309
Bay City, OR 97107
(503)-377-2179

Date________________________

Owner____

Address____

City, State____

Subject Property____

Dear Property Owner:

The Wastewater Treatment Plant experiences extremely high flows during the winter months. This can, in large part, be attributed to "holes" in the sewage collection and piping system including laterals to properties served by the system. In an effort to locate these holes and reduce the high seasonal inflows, the City of Bay City recently undertook a smoke testing project in your neighborhood. The project included pumping smoke into manholes and observing where the smoke escapes from the system. If smoke is observed leaving the sewer system through a "hole," surface and/or groundwater is capable of entering the system through the same "hole." The potential for one of these infiltration "holes" was discovered on your property and requires your attention to correct the problem.

Some of the problems discovered are directly related to the infiltration waters that overload the sewer system during the winter months. Other problems are related to plumbing deficiencies outside the home, which should be corrected.

A side benefit of the smoke testing project was that, in some cases, smoke was observed not venting from homes properly. While this could be a result of a sag or unused element in the household plumbing, it could also represent a potential health risk. If a household sewer system is not functioning properly, harmful sewer gases may find their way into the house. This type of plumbing deficiency should be corrected immediately.

The following sheet includes a checklist of potential problems discovered during the smoke testing project. If a problem is marked with an X, it requires the action described immediately after the marked description.

If, for some reason, you are unable to correct the problem in the time suggested, please contact the City. We are interested in correcting these problems and will help in any way we can to do that.

1._____MAY NOT HAVE A PERMITTED SEWER CONNECTION ON RECORD.
Please contact the City to discuss this matter.

2._____RVS OR ADDITIONAL HOOK-UP INTO SEWER SYSTEM.
Notification is hereby given to remove.

3._____PIPING OR LATERAL PIPE PROBLEMS ON SITE.
Have plumbing inspection by qualified person. Report result to City within four (4) weeks of this notice.

4._____RAIN GUTTERS CONNECTED TO SEWER SYSTEM.
Immediate removal of roof drains from sewer system required. City personnel will be on site within two (2) weeks of the date of this notice to inspect the outfall of the roof drain system to confirm disconnection.

5._____AREA DRAIN OR OTHER SURFACE DRAINAGE SYSTEM TIED INTO SEWER SYSTEM.
Immediate removal of area drains from sewer system required. City personnel will be on site within two (2) weeks of the date of this notice to inspect the area drain to confirm disconnection.

6._____UNCAPPED OR OPEN SEWER LATERAL CLEANOUT.
Immediate cap of lateral cleanout required with watertight cap. City personnel will be on site within four (4) weeks of the date of this notice to inspect the cleanout to confirm capping.

7._____SMOKE INSIDE HOUSE OR BUILDING.
Have inspection and repairs performed by qualified person. Sewer gas passing into the home can pose a serious health risk.

8._____OTHER PROBLEM.
____
____
____

Please note that any of these problems are of a serious nature. Any items marked with an X require your immediate attention and cooperation. Please call the City at 503-377-2179 if you have any questions. By reducing these high seasonal inflows to the sewer system, we can help reduce unnecessary sewer treatment costs, maintain the highest levels of sewer system performance, and keep our sewer rates as low as possible.

Thank you for your help in this matter.

Sincerely,

City of Bay City

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Cleaning – TV Results 2

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City of Bay City
TV/Cleanning Results
November 2015

Manhole #	Feet	Pipe Size	Description	Comments	Total feet Televised
02-01		***15"***	***Reinforced Concrete Pipe***	***Elliot Street***	
@	0.0		Access Point - Manhole	Upstream MH 02	0.0
@	362.5		Access Point - Manhole	Downstream MH 01	362.5
03-02		***15"***	***Reinforced Concrete Pipe***	***Elliot Street***	
@	0.0		Access Point - Manhole	Upstream MH 03	0.0
@	37.4	4"	Tap-Factory Made	Service Left @ 9:00	37.4
@	293.7		Access Point - Manhole	Downstream MH 02	293.7
04-03		***15"***	***Reinforced Concrete Pipe***	***Spruce Street***	
@	0.0		Access Point - Manhole	Upstream MH	0.0
@	54.1	4"	Tap-Factory Made	Service Right @ 2:00	54.1
@	58.1	4"	Tap-Factory Made	Service Left @ 9:00	58.1
@	115.1	4"	Tap-Break-in/Hammer	Service Left @ 10:00	115.5
@	162.8	4"	Tap-Factory Made	Service Left @ 9:00	162.8
@	186.7	4"	Tap-Factory Made	Service Right @ 3:00	186.7
@	238.2	4"	Tap-Factory Made	Service Left @ 9:00	238.2
@	317.8	4"	Tap-Factory Made	Service Left @ 9:00	317.8
@	320.0	4"	Tap-Factory Made	Service Left @ 9:00	320.0
@	464.6		Access Point - Manhole	Downstream MH 03	464.6
05-04		***15"***	***Reinforced Concrete Pipe***	***Spruce Street***	
@	0.0		Access Point - Manhole	Upstream MH	0.0
@	85.5	4"	Tap-Factory Made	Service Right @ 3:00	85.5
@	173.7	4"	Tap-Factory Made	Service Left @ 9:00	173.7
@	192.1	4"	Tap-Factory Made	Service Right @ 3:00	192.1
@	245.9	4"	Tap-Factory Made	Service Right @ 3:00	245.9
@	253.8	4"	Tap-Factory Made	Service Left @ 9:00	253.8
@	291.8	4"	Tap-Factory Made	Service Right @ 3:00	291.8
@	316.1	4"	Tap-Factory Made	Service Right @ 3:00	316.1
@	490.8		Access Point - Manhole	Downstream MH 04	490.8
06-05		***15"***	***Reinforced Concrete Pipe***	***Warren Street***	
@	0.0		Access Point - Manhole	Upstream MH 06	0.0
@	28.3	4"	Tap-Factory Made	Service Right @ 2:00	28.3
@	158.3	4"	Tap-Break-in/Hammer	Service Right @ 1:00	158.3
@	168.4	4"	Tap-Factory Made	Service Left @ 10:00	168.4
@	189.2	4"	Tap-Factory Made	Service Left @ 9:00	189.2
@	211.3	4"	Tap-Factory Made	Service Left @ 9:00	211.3
@	283.8	4"	Tap-Factory Made	Service Right @ 3:00	283.8
@	338.8	4"	Tap-Factory Made	Service Left @ 9:00	338.8
@	503.0		Access Point - Manhole	Downstream MH 05	503.0
07-06		***15"***	***Reinforced Concrete Pipe***	***McCoy Ave***	
@	0.0		Access Point - Manhole	Upstream MH 07	0.0
@	170.3		Access Point - Manhole	Downstream MH 06	170.3

City of Bay City
TV/Cleanning Results
November 2015

Manhole #	Feet	Pipe Size	Description	Comments	Total feet Televised
07A-07		***15"***	***Reinforced Concrete Pipe***	***McCoy Ave***	
@	0.0		Access Point - Manhole	Upstream MH 07A	0.0
@	72.3		Access Point - Manhole	Downstream MH 07	72.3
08-07		***15"***	***Reinforced Concrete Pipe***	***McCoy Ave***	
@	0.0		Access Point - Manhole	Upstream MH 08	0.0
@	31.6		Access Point - Manhole	Downstream MH 07	31.6
08A-08		***15"***	***Reinforced Concrete Pipe***	***McCoy Ave***	
@	0.0		Access Point - Manhole	Upstream MH 08A	0.0
@	34.9		Access Point - Manhole	Downstream MH 08	34.9
09-08A		***15"***	***Reinforced Concrete Pipe***	***McCoy Ave***	
@	0.0		Access Point - Manhole	Upstream MH 09	0.0
@	4.5		Access Point - Manhole	Downstream MH 08A	4.5
10-09		***15"***	***Reinforced Concrete Pipe***	***McCoy Ave***	
@	0.0		Access Point - Manhole	Upstream MH 10	0.0
@	253.2	4"	Tap-Factory Made	Service Left @ 9:00	253.2
@	415.5	4"	Tap-Factory Made	Service Left @ 10:00	415.5
	510.8		Access Point - Manhole	Downstream MH 09	510.8
11-10		***15"***	***Reinforced Concrete Pipe***	***Warren Street***	
@	0.0		Access Point - Manhole	Upstream MH 11	0.0
@	76.1	4"	Tap-Factory Made	Service Right @ 3:00	76.1
@	130.5	4"	Tap-Factory Made	Service Left @ 9:00	130.5
@	331.2		Access Point - Manhole	Downstream MH 10	331.2
12-11		***15"***	***Reinforced Concrete Pipe***	***Warren Street***	
@	46.5		Access Point - Manhole	Downstream MH 12	46.5
@	0.0		Access Point - Manhole	Upstream MH 11	0.0
12A-12		***15"***	***Reinforced Concrete Pipe***	***McCoy Ave***	
@	0.0		Access Point - Manhole	Upstream MH 12A	0.0
@	45.6	4"	Tap-Factory Made	Service Left @ 9:00	45.6
@	160.3	4"	Tap-Factory Made	Service Left @ 9:00	160.3
@	286.1		Access Point - Manhole	Downstream MH 12	286.1
13A-12A		***15"***	***Reinforced Concrete Pipe***	***McCoy Ave***	
@	0.0		Access Point - Manhole	Upstream MH 13A	0.0
@	41.8	4"	Tap-Factory Made	Service Left @ 9:00	41.8
@	102.5	4"	Tap-Factory Made	Service Left @ 9:00	102.5
@	168.6	4"	Tap-Factory Made	Service Right @ 3:00	168.6
@	216.9	4"	Tap-Factory Made	Service Left @ 9:00	216.9
@	223.0	4"	Tap-Factory Made	Service Right @ 3:00	223.0
@	305.4		Access Point - Manhole	Downstream MH 12A	305.4
13A-13		***15"***	***Pre-stressed Concrete Cylinder Pipe***	***US Highway 101***	
@	0.0		Access Point - Manhole	Upstream MH 13A	0.0
@	217.8	4"	Tap-Factory Made	Service Left @ 10:00	217.8
@	289.7		Access Point - Manhole	Downstream MH 13	289.7

City of Bay City
TV/Cleanning Results
November 2015

Manhole #	Feet	Pipe Size	Description	Comments	Total feet Televised
14B-13		***15"***	***Reinforced Concrete Pipe***	***US Highway 101***	
@	0.0		Access Point - Manhole	Upstream MH 14B	0.0
@	345.8		Access Point - Manhole	Downstream MH 13	345.8
14C-13		***15"***	***Reinforced Concrete Pipe***	***US Highway 101***	
@	0.0		Access Point - Manhole	Upstream MH 14C	0.0
@	66.1		Access Point - Manhole	Downstream MH 13	66.1
14-14B		***15"***	***Reinforced Concrete Pipe***	***US Highway 101***	
@	0.0		Access Point - Manhole	Upstream MH 14	0.0
@	95.6		Access Point - Manhole	Downstream MH 14B	95.6
15A-15		***15"***	***Reinforced Concrete Pipe***	***US Highway 101***	
@	0.0		Access Point - Manhole	Upstream MH 15A	0.0
@	438.0	4"	Tap-Factory Made	Service Left @ 10:00	438.0
@	447.6		Access Point - Manhole	Downstream MH 15	447.6
16-15		***15"***	***Reinforced Concrete Pipe***	***US Highway 101***	
@	0.0		Access Point - Manhole	Upstream MH 16	0.0
@	168.3		Infiltration-Runner	at 6:00	168.3
@	231.1	4"	Tap-Factory Made	Left @ 10:00	231.1
@	395.4		Access Point - Manhole	Downstream MH 15	395.4
17-16		***15"***	***Reinforced Concrete Pipe***	***US Highway 101***	
@	0.0		Access Point - Manhole	Upstream MH 17	0.0
@	435.2		Access Point - Manhole	Downstream MH 16	435.2
18-17		***15"***	***Reinforced Concrete Pipe***	***5th Street***	
@	0.0		Access Point - Manhole	Upstream MH 18	0.0
@	72.6		Infiltration-Runner	at 10:00	72.6
@	94.3		Access Point - Manhole	Downstream MH 17	94.3
21-20		***15"***	***Reinforced Concrete Pipe***	***5th Street***	
@	0.0		Access Point - Manhole	Upstream MH 21	0.0
@	99.8		Tap-Factory Made	Service Left @ 9:00	99.8
@	104.2		Tap-Factory Made	Service Right @ 3:00	104.2
@	162.0		Tap-Factory Made	Service Right @ 3:00	162.0
@	191.0		Tap-Factory Made	Service Left @ 9:00	191.0
@	326.7		Tap-Factory Made	Service Right @ 3:00	326.7
@	347.0		Tap-Factory Made	Service Right @ 3:00	347.0
@	360.5		Tap-Factory Made	Service Left @ 9:00	360.5
@	389.0		Tap-Factory Made	Service Left @ 3:00	389.0
@	447.1		Tap-Factory Made	Service Left @ 9:00	447.1
@	488.0			Downstream MH 20	488.0
20-19		***12"***	***Reinforced Concrete Pipe***	***5th Street***	
@	0.0		Access Point - Manhole	Upstream MH 20*	0.0
@	300.0		Access Point - Manhole	Downstream MH 19*	300.0

* Upstream MH 20 = infront of post office. Downstream HM 19 = bottom of 5th Street

City of Bay City
TV/Cleaning Results
April 2016

Manhole #	Feet	Pipe Size	Description	Comments	Total feet Televised
33-32A		***10"***	***Reinforced Concrete Pipe***	***14th Street***	
	0.0		Access Point-Manhole	Upstream MH 33	0.0
@	32.2	4"	Tap-Factory Made-Capped	Service Right @ 2:00	32.2
@	79.5	4"	Tap-Factory Made-Capped	Service Right @2:00	79.5
@	106.7		Access Point-Manhole	Downstream MH 32A	106.7
40-40A		***8"***	***Reinforced Concrete Pipe***	***Spruce Street***	
	0.0		Access Point-Manhole	Upstream MH 40	0.0
@	74.1	6"	Tap-Factory Made	Service Left @ 9:00	74.1
@	109.3	6"	Tap-Factory Made	Service Right @ 3:00	109.3
@	175.3		Infiltration-Stain	From 10:00 to 7:00	175.3
@	204.7		Access Point-Manhole	Downstream MH 40A	204.7
40A-33		***8"***	***Reinforced Concrete Pipe***	***Spruce Street***	
	0.0		Access Point-Manhole	Upstream MH 40A	0.0
@	52.1		Infiltration - Dripper	at 3:00	52.1
@	92.3	4"	Tap-Factory Made	Service Left @ 9:00	92.3
@	151.9	6"	Tap-Factory Made	Service Right @ 3:00	151.9
@	156.6	6"	Tap, Break-in/Hammer	Service Right @ 3:00 Plugged	156.6
@	199.0		Infiltration - Dripper	at 2:00 Deposits Attached: Encrustation 5% @2:00	199.0
@	220.5		Infiltration - Dripper	at 3:00	220.5
@	220.6		Access Point-Manhole	Downstream MH 33 outside Drop	220.6
41-40		***8"***	***Reinforced Concrete Pipe***	***Spruce Street***	
	0.0		Access Point-Manhole	Upstream MH 41	0.0
@	31.8	6"	Tap, Break-in/Hammer	Service Right @ 3:00	31.8
@	34.4	4"	Tap, Break-in/Hammer	Service Left @ 9:00	34.4
@	66.9	6"	Tap, Factory Made	Service Right @ 2:00	66.9
@	95.4	6"	Tap, Break-in/Hammer	Service Right @ 9:00	95.4
@	98.4	6"	Tap-Factory Made	Service Left @ 9:00	98.4
@	119.3	6"	Tap-Factory Made	Service Right @ 3:00	119.3
@	123.9	6"	Tap, Break-in/Hammer	Service Left @ 9:00	123.9
@	151.3	6"	Tap, Break-in/Hammer	Service Left @ 9:00	151.3
@	220.1	6"	Tap-Factory Made	Service Left @ 9:00	220.1
@	229.6		Access Point-Manhole	Downstream MH 40	229.6
41A-41		***8"***	***Reinforced Concrete Pipe***	***17th Street***	
	45.1		Access Point-Manhole	Upstream MH 41A	45.1
@	0.0		Access Point-Manhole	Downstream MH 41	0.0
42-41		***8"***	***Reinforced Concrete Pipe***	***18th Street***	
	0.0		Access Point-Manhole	Upstream MH 42	0.0
@	41.7	4"	Tap, Break-in/Hammer	at 10:00	41.7
@	43.0	4"	Tap-Factory Made	Service Left @ 10:00	43.0
@	73.0	6"	Tap, Break-in/Hammer	Service Right @ 9:00	73.0
@	86.1	4"	Tap-Factory Made	Service Right @ 3:00	86.1
@	158.6	6"	Tap-Factory Made Infiltration- Gusher	Service Right @ 2:00 Infiltration in the Lateral @6:00 Gusher	158.6
@	185.0		Access Point-Manhole	Downstream MH 41	185.0

City of Bay City
TV/Cleaning Results
April 2016

43-42		***8"***	***Reinforced Concrete Pipe***	***19th Street***	
@	261.6		Access Point-Manhole	Upstream MH 43	261.2
@	182.2	4"	Tap, Break-in/Hammer	Service Right @ 2:00	182.2
@	158.0	6"	Tap-Factory Made	Service Left @ 10:00	158.0
@	124.3	4"	Tap, Break-in/Hammer	Service Right @ 2:00 Pipe Broken @ 4:00	124.3
@	99.2	6"	Tap-Factory Made	at 10:00	99.2
@	44.0	4"	Tap, Break-in/Hammer	at 2:00	44.0
@	36.0		Infiltration - Stain	at 2:00	36.0
@	20.9		Infiltration - Stain	at 3:00	20.9
@	19.4		Infiltration - Stain	at 2:00	19.4
@	0.4	2"	Tap, Break-in/Hammer	Service Right @ 2:00 pipe Intruding 2"	0.4
@	0.0		Access Point-Manhole	Downstream MH 42	0.0
52-79		***8"***	***Reinforced Concrete Pipe***	***Tillamook Ave***	
@	0.0		Access Point-Manhole	Upstream MH 52	0.0
@	92.7	6"	Tap-Factory Made	Service Left @ 9:00	92.7
@	225.1		Access Point-Manhole	Downstream MH 79	225.1
53-52		***8"***	***Reinforced Concrete Pipe***	***15th Street***	
	0.0		Access Point-Manhole	Upstream MH 53	0.0
@	82.4	8"	Tap-Factory Made	at 9:00	82.4
@	166.1	8"	Tap-Factory Made	Service Right @ 3:00	166.1
@	284.9		Access Point-Manhole	Downstream MH 52	284.9
54-53		***8"***	***Reinforced Concrete Pipe***	***15th Street***	
	0.0		Access Point-Manhole	Upstream MH54	0.0
@	8.9	6"	Tap-Factory Made	Service Right @ 3:00	8.9
@	38.7	4"	Tap, Break-in/Hammer	Service Right @ 2:00 Capped	38.7
@	134.4	6"	Tap-Factory Made	Service Right @ 3:00 Capped	138.4
@	184.3		Access Point-Manhole	Downstream MH 53	184.3
55A-54		***8"***	***Reinforced Concrete Pipe***	***15th Street***	
	0.0		Access Point-Manhole	Upstream MH 55A	0.0
@	84.7		Access Point-Manhole	Downstream MH 54	84.7
55-54		***8"***	***Reinforced Concrete Pipe***	***Seattle Ave***	
	0.0		Access Point-Manhole	Upstream MH 55	0.0
@	6.1	6"	Tap-Factory Made	Service Left @ 9:00	6.1
@	16.4	6"	Tap-Factory Made	Service Right @ 3:00	16.4
@	58.4	6"	Tap-Factory Made	Service Left @ 9:00	58.4
@	166.5	4"	Tap, Break-in/Hammer	Service Right @ 1:00	166.5
@	290.5		Access Point-Manhole	Downstream MH 54	290.5
56-55		***8"***	***Reinforced Concrete Pipe***	***Seattle Ave***	
	0.0		Access Point-Manhole	Upstream MH 56	0.0
@	3.2		Water Mark 40% (diameter)		3.2
@	15.4		Infiltration - Stain	at 10:00	15.4
@	100.5		Access Point-Manhole	Downstream MH 55	100.5
57-56		***8"***	***Reinforced Concrete Pipe***	***Seattle Ave***	
	0.0		Access Point-Manhole	Upstream MH 57	0.0
@	72.7		Access Point-Manhole	Downstream MH 56	72.7

58-57		***8"***	***Reinforced Concrete Pipe***	***Seattle Ave***	
	0.0		Access Point-Manhole	Upstream MH 58	0.0
@	44.7		Infiltration - Stain	at 2:00	44.7
@	113.5	6"	Tap, Break-in/Hammer	Service Right @ 3:00	113.5
@	236.8	6"	Tap, Break-in/Hammer	Service Right @ 3:00	236.8
@	270.6		Access Point-Manhole	Downstream MH 57	270.6
59-58		***8"***	***Reinforced Concrete Pipe***	***Seattle Ave***	
	0.0		Access Point-Manhole	Upstream MH 59	0.0
@	92.3	6"	Tap-Factory Made	Service Right @ 3:00 Infiltration Stain in Lateral on right side	92.3
@	96.7		Infiltration - Stain	from 6:00 to 11:00	96.7
@	130.8	6"	Tap-Factory Made	Service Left @ 9:00	130.8
@	156.8		Access Point-Manhole	Downstream MH 58	156.8
64-56		***8"***	***Reinforced Concrete Pipe***	***Sunnyside Street***	
	0.0		Access Point-Manhole	Upstream MH 64	0.0
@	67.0	4"	Tap-Factory Made	Service Left @ 10:00	67.0
@	105.4	6"	Tap-Factory Made	Service Right @ 2:00	105.4
@	163.5		Infiltration - Stain	at 9:00	163.5
@	168.1	4"	Tap-Factory Made	Service Right @ 3:00	168.1
@	218.4		Infiltration - Runner	at 10:00	218.4
@	220.1		Access Point-Manhole	Downstream MH 56	220.1
65-64		***8"***	***Reinforced Concrete Pipe***	***Sunnyside Street***	
	127.2		Access Point-Manhole	Upstream MH 65	127.2
@	108.7	4"	Tap-Factory Made	Service Left @ 9:00	108.7
@	0.0		Access Point-Manhole	Downstream MH 64	0.0
66-65		***8"***	***Reinforced Concrete Pipe***	***Portland Ave***	
	0.0		Access Point-Manhole	Upstream MH 66	0.0
@	74.6	6"	Tap, Break-in/Hammer	Service Right @ 2:00	74.6
@	86.0		Access Point-Manhole	Downstream MH 65	86.0
153-145		***8"***	***Reinforced Concrete Pipe***	***7th Street***	
	0.0		Access Point-Manhole	Upstream MH 153	0.0
@	6.2		Deposits Settled: Compactated from 5:00 to 7:00		6.2
@	45.5	6"	Tap-Factory Made	Service Right @ 3:00	45.5
@	49.0	6"	Tap-Factory Made	Service Left @ 9:00	49.0
@	115.5	6"	Tap-Factory Made	Service Left @ 9:00	115.5
@	213.2	6"	Tap-Factory Made	Service Right @ 3:00	213.2
@	221.1		Water Level: Sag	10% (diameter)	221.1
@	312.4		Surface: Aggregate Projecting from 7:00 to 4:00		312.4
@	328.1	4"	Tap, Break-in/Hammer	Service Left @ 10:00 Pipe Intruding 2"	328.1
@	405.4	4"	Tap-Factory Made	Service Left @ 9:00	405.4
@	412.3	6"	Tap-Factory Made	Service Right @ 3:00	412.3
@	478.9		Point Repair - Pipe Replaced	Pipe Replaced	478.9
@	508.7		Infiltration - Runner	at 10:00	508.7
@	510.6		Access Point-Manhole	Downstream MH 145 Outside drop	510.6

City of Bay City
TV/Cleaning Results
April 2016

154-153		***8"***	***Reinforced Concrete Pipe***	***7th Street***	
	0.0		Access Point-Manhole	Upstream MH 154	0.0
@	76.6	6"	Tap-Factory Made	Service Right @ 3:00	76.6
@	85.1		Point Repair - Pipe Replaced	Pipe Replaced Settled to cause offset joint	85.1
@	87.1	4"	Tap-Factory Made	Service Right @ 9:00	87.1
@	118.7	6"	Tap-Factory Made	Service Left @ 9:00-Capped	118.7
@	160.7	8"	Tap-Factory Made	Service Right @ 3:00	160.7
@	185.3	6"	Tap-Factory Made	Service Left @ 9:00-Capped	185.3
@	188.3		Surface: Missing Aggregate at 6:00		188.3
@	201.1		Point Repair - Pipe Replaced	Pipe Replaced Settled to cause offset joint	201.1
@	202.7	4"	Tap-Factory Made	at 9:00	202.7
@	204.5		Infiltration - Dripper	at 2:00	204.5
@	208.8		Hole in pipe: soil visible	at 12:00	208.8
@	220.1	6"	Tap-Factory Made	Service Left @ 9:00-Capped	220.1
@	325.1	6"	Tap-Factory Made	at 9:00	325.1
@	328.5	4"	Tap-Factory Made	at 3:00	328.5
@	330.3		Point Repair - Pipe Replaced	Pipe repair settled	330.3
@	332.0	4"	Tap-Factory Made	Service Left @ 9:00. Heavy infiltration in the Lateral	332.0
@	405.6	6"	Tap-Factory Made	Service Left @ 9:00-Capped	405.6
@	417.8		Point Repair - Pipe Replaced	Pipe Replaced Settled to cause offset joint	417.8
@	419.9	4"	Tap-Factory Made	Service Left @ 10:00	419.9
@	423.4	6"	Tap, Break-in/Hammer	Service Left @ 9:00	423.4
@	447.2	4"	Tap-Factory Made	Service Right @ 3:00	447.2
@	501.4		Point Repair - Localized Lining	Local Lining	501.4
@	505.1		Access Point-Manhole	Downstream MH 153	505.1
155-154		***8"***	***Reinforced Concrete Pipe***	***7th Street***	
	0.0		Access Point-Manhole	Upstream MH 155	0.0
@	80.3	6"	Tap, Break-in/Hammer	Service Right @ 3:00	80.3
@	119.0		Roots, Tap: Barrel Crack Circumferential	at 8:00 from 7-4	119.0
@	119.7	6"	Tap, Break-in/Hammer	Service Right @ 3:00	119.7
@	120.6		Roots, Fine: Barrel	From 8:00-4:00	120.6
@	140.1	4"	Tap, Break-in/Hammer	Service Right @ 10:00	140.1
@	216.7	8"	Tap-Factory Made	Service Right @ 3:00	216.7
@	266.8	6"	Tap, Break-in/Hammer	Service Right @ 10:00	266.8
@	313.3		Crack Circumferential Infiltration - Stain	From 7:00-11:00 From 7:00-11:00	313.3
@	315.1		Access Point-Manhole	Downstream MH 154	315.1

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Mixing Zone Report - Draft

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Mixing Zone Report

City of Bay City
PO Box 3309
Bay City, OR 97107

Prepared for:

City of Bay City

Engineers & Geologists

September 2018

611013.151

Reference: 611013.151

Mixing Zone Report

Prepared for:

City of Bay City

PO Box 3309

Bay City, OR 97107

Prepared by:

SHN

Engineers & Geologists

275 Mark Avenue

Coos Bay, OR 97420

541-266-9890

August 2018

QA/QC:SKD___

Table of Contents

Appendices

List of Illustrations

Figures **Follows Page**

Tables **Page**

Abbreviations and Acronyms

m/s	
mg/L	
pH	
ppt	parts per thousand
ADWF	Average Dry Weather Flow
AOU	Apparent Oxygen Utilization
AWWF	Average Wet Weather Flow
BOD	Biological Oxygen Demand
CCC	Criteria Chronic Concentration
CMC	Criteria Maximum Concentration
DEQ	Oregon Department of Environmental Quality
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
FONSI	Finding of No Significant Impact
NPDES	National Pollutant Discharge Elimination System
SBR	Sequential Batch Reactor
SHN	SHN Engineers & Geologists
TDZ	Toxic Dilution Zone
US EPA	United States Environmental Protection Agency
ZID	Zone of Immediate Dilution

1.0 Introduction

1.1 Purpose

The City of Bay City is required by NPDES permit 101025 to conduct a periodic review of its outfall and conduct a mixing zone analysis based on current information. During the course of this work, it was determined that the City's existing outfall was failing and becoming inundated by bay sediments. A new outfall and mixing zone was determined necessary. The study was modified to evaluate new outfall locations and to evaluate and optimize an outfall design configuration for the City of Bay City's Wastewater Treatment Plant effluent disposal system. Based on the study results, an outfall design and mixing zone located lower in the estuary system are recommended to provide the City with a long-term effluent disposal system that is both environmentally and financially acceptable. The proposed project site, shown in Figure 1 is located the North Coast Basin of Western Oregon west of the City of Bay City in Tillamook Bay.

1.2 Objective

This study applied research on ambient conditions and a computer model to simulate discharge scenarios and predict how much dilution will occur in an area defined as the "mixing zone". The results of the study are intended to demonstrate that, outside of the mixing zone, the recommended outfall design will meet all regulatory criteria under all foreseeable ambient conditions and foreseeable future uses.

Predictions of dilution consider two critical regulatory areas within the mixing zone:

The zone of initial dilution where acute criteria (Criteria Maximum Concentration) must be achieved and

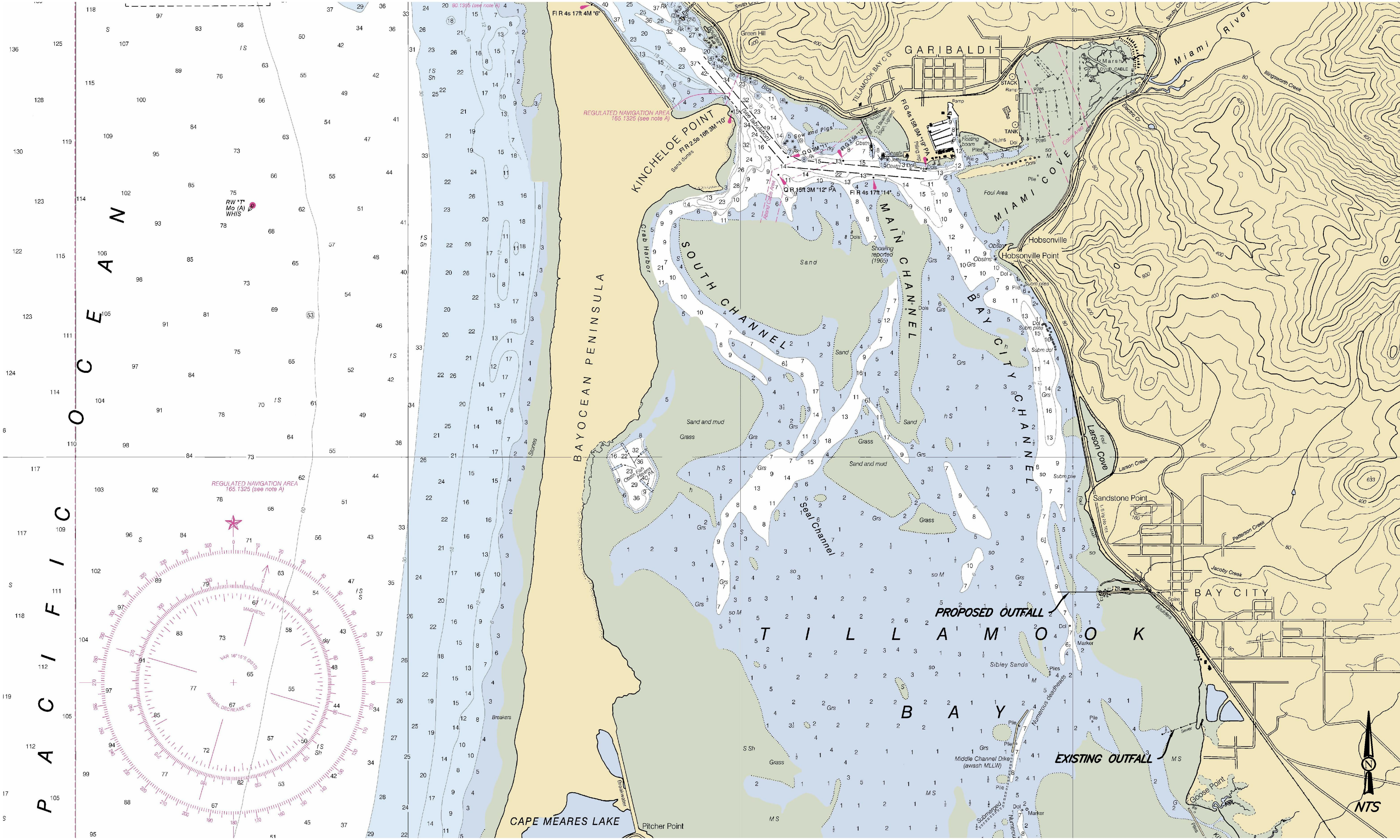
The fringe of the mixing zone where all water quality criteria including chronic criteria (Criteria Continuous Concentration) must be achieved.

Criteria, which define adequate mixing in these two locations and an analysis of the dilution of the parameters of concern for each criterion, are considered in this study.

1.3 Scope of Work

This report includes the following items:

- Field reconnaissance and an evaluation of the existing outfall.
- A summary of past studies and data collected to characterize ambient conditions that affect the discharge and effluent disposal system design.
- Conducting an analysis of outfall designs using the Environmental Protection Agency's (EPA) CORMIX, version GI mixing zone model.
- Modeling different outfall diffuser configurations to optimize the mixing achieved from the disposal system.



SOURCE:
US DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
COAST SURVEY

SHN	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Proposed Wastewater Outfall Site Plan SHN 611013.151
December 2019	611013-OFALL	Figure 1

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- Preparing a mixing zone study report that presents the background data, mixing zone modeling results, and recommendations for the design of a diffuser structure.]

The City's mixing zone study should identify an optimum diffuser design, demonstrate that dilution effect in the ambient water mitigate effluent pollutants, and support a finding of no significant impact (FONSI), concerning continued disposal of the City of Bay City's wastewater effluent to the Tillamook estuary.

2.0 Principal Rules and Regulations

Water Quality Standards for the North Coast basin are set forth in OAR 340-041-0230 and are enforced by the Oregon Department of Environmental Quality (DEQ). Specific water quality standards not to be exceeded for wastewater discharge are determined for marine waters. Primary regulations of concern are provided below:

OAR **340-041-0230**
Basin-Specific Criteria (North Coast): Beneficial Uses to Be Protected in the North Coast Basin
(1) Water quality in the North Coast Basin must be managed to protect the designated beneficial uses shown in Table 230A (November 2003). (see Appendix 1)
(2) Designated fish uses to be protected in the North Coast Basin are shown in Figures 230A and 230B (November 2003). (see Appendix 1)
(3) Coastal water contact recreation use is to be protected in all North Coast Basin marine waters and in coastal waters designated in Figures 230C through 230H (August 2016). (see Appendix 1)
(4) Shellfish harvesting use is to be protected in all North Coast Basin marine waters and in coastal waters as designated in Figures 230Cthrough 230H (August 2016). (see Appendix 1)
[ED. NOTE: To view tables referenced in rule text, click here to view rule.]
Statutory/Other Authority: ORS 468.020, 468B.030, 468B.035 & 468B.048
Statutes/Other Implemented: ORS 468B.030, 468B.035 & 468B.048
History:
DEQ 9-2016, f. & cert. ef. 8-18-16
DEQ 17-2003, f. & cert. ef. 12-9-03

OAR **340-041-0234**
Basin-Specific Criteria (North Coast): Approved TMDLs in the Basin:
The following TMDLs have been approved by EPA, and appear on the Department's web site:
Nestucca Bay Drainage — Temperature, Bacteria and Sediment — May 13, 2002
Tillamook Bay Drainage — Temperature and Bacteria — July 31, 2001
North Coast — Temperature and Bacteria — August 20, 2003
Statutory/Other Authority: ORS 468.020, 468B.030, 468B.035 & 468B.048
Statutes/Other Implemented: ORS 468B.030, 468B.035 & 468B.048
History:
DEQ 17-2003, f. & cert. ef. 12-9-03

OAR **340-041-0235**
Basin-Specific Criteria (North Coast): Water Quality Standards and Policies for this Basin
(1) pH (hydrogen ion concentration). pH values may not fall outside the following ranges:

(a) Marine waters: 7.0–8.5;
(b) Estuarine and fresh waters: 6.5–8.5.
(2) Total Dissolved Solids. Guide concentrations may not be exceeded unless otherwise specifically authorized by DEQ upon such conditions as it may deem necessary to carry out the general intent of this plan and to protect the beneficial uses set forth in OAR 340-04l-0230: All Fresh Water Streams and Tributaries (other than the main stem Columbia River) — 100.0 mg/l.
(3) Minimum Design Criteria for Treatment and control of Sewage Wastes in this Basin:
(a) During periods of low stream flows (approximately April 1 to October 31): Treatment resulting in monthly average effluent concentrations not to exceed 20 mg/l of BOD and 20 mg/l of SS or equivalent control;
(b) During the period of high stream flows (approximately November 1 to April 30): A minimum of secondary treatment or equivalent control and unless otherwise specifically authorized by the Department, operation of all waste treatment and control facilities at maximum practicable efficiency and effectiveness so as to minimize waste discharges to public waters.
Statutory/Other Authority: ORS 468.020, 468B.030, 468B.035 & 468B.048
Statutes/Other Implemented: ORS 468B.030, 468B.035 & 468B.048
History:
DEQ 2-2007, f. & cert. ef. 3-15-07
DEQ 17-2003, f. & cert. ef. 12-9-03

2.1 Application of Regulatory Criteria

North coast basin rules pertaining to the City of Bay City discharge are within the design capabilities of the wastewater treatment plant. Effluent quality requirements can be met provided the City achieves adequate secondary treatment at the facility. Some allowances for toxic pollutants may be necessary to account for a toxic dilution zone for ammonia. Chlorine discharge will not be considered since the City will be utilizes a UV disinfection system.

2.2 Pollutants of Concern

The significant pollutants of concern, reasons for concern, and probable concentration limits are summarized in the Table 1 below. Ammonia represents the toxic substance that must be addressed in a toxic dilution zone.

Table 1 Summary of Significant Pollutants of Concern

Pollutant of Concern	Reason for Concern	Water Quality Criteria
Ammonia at end of toxic dilution zone	Acute Toxicity	Temp & pH dependent
Ammonia at Fringe of Mixing Zone	Chronic Toxicity	Temp & pH dependent
Chlorine at end of toxic dilution zone	Acute Toxicity	0.013 mg/L (not)[1]
Chlorine at Fringe of Mixing Zone	Chronic Toxicity	0.0075 mg/L (not)[1]
Temperature at Fringe of Mixing Zone	Biological Life	+/- 0.2°C
Turbidity at Fringe of Mixing Zone	Aesthetics	< 10% Increase
DO at Fringe of Mixing Zone	Biological Life	+/- 0.1 mg/L
Geometric Mean of Bacteria at End of Pipe	Human exposure	126 E. coli org./100 ml
Geometric Mean of Bacteria at Fringe of Mixing Zone	Human exposure	14 E. coli org./100 ml
1. Not present in effluent discharge.		

Ammonia concentrations for chronic and acute toxicity limits at the anticipated range of temperatures and pH for a salinity of 30 kg/L as defined by EPA's Ambient Water Quality Criteria for Ammonia (Saltwater) - 1989 are summarized in Table 2 below.

Table 2 Water Quality Criteria for Saltwater Aquatic Life Based on Total Ammonia Concentration as N, (mg/L)

Temperature	11.8°C		14.4°C		17.0°C	
	Acute	**Chronic**	**Acute**	**Chronic**	**Acute**	**Chronic**
pH 7.6	25.38	3.81	21.31	3.20	17.65	2.65
pH 8.2	6.52	0.98	5.50	0.83	4.58	0.69
pH 8.9	1.45	0.22	1.25	0.19	1.04	0.16
Data developed from DEQ Ammonia Calculator Based on EPA 440/5-88-004 April 1989						

2.3 Mixing Zones

A mixing zone is an established area where water quality standards may be exceeded as long as acute toxic conditions are prevented and the states designated beneficial uses are protected. Generally, regulatory criteria apply at the fringe of the mixing zone.

2.3.1 Regulatory Mixing Zone

The RMZ at the Bay City outfall must be redefined. Currently the outfall provides no mixing during events.

2.3.2 Zone of Immediate Dilution (ZID)

In accordance with OAR 340-041-0325.4.b, allowances for exceeding acute criteria may be necessary in a zone of immediate dilution (ZID) in order to allow dilution of toxic constituents to below acute criteria(in other words, the CMC). The EPA in Technical Support Document for Water quality-Based Toxics Control provides guidance for setting stringent criteria that can be used to limit the ZID (referenced by EPA as a toxic dilution zone or TDZ) based on probable exposure with no impact from short-term contact with toxic constituents. Three criteria are provided, the more stringent of which should govern the limit of the ZID.

1. The CMC should be met at a distance of 10 percent of the distance from the edge of the outfall structure to the edge of the regulatory mixing zone.
2. The CMC should be met within a distance of 50 times the discharge length scale in any special direction. (The discharge length scale is calculated as the square root of the discharge port area).
3. The CMC should be met within a distance of five times the local water depth in any horizontal direction from any discharge outlet.

Each of these criteria should be considered in defining the mixing zone and ZID for the Bay City outfall.

3.0 Ambient Conditions of Tillamook Bay

Tillamook Bay is a small, shallow estuary about 60 miles west of Portland on the Oregon Coast. Tillamook Bay, along with other Oregon estuaries, is a truly a unique environments. This environment is influenced by numerous and complex estuarine factors that affect the mixing process. Approximately 6.2 miles long and 2.1 miles wide, the Bay averages only 6.6 feet depth. At low tide, about 50% of the bottom is exposed as intertidal mud flats.

In addition to ambient forces, the design of the outfall diffuser will have an initial influence on the transport and spreading of effluent. Design criteria are discussed later in this report and are based on an understanding of how ambient conditions, primary currents, and turbulence control the transport and mixing phenomenon farther from the discharge. This section describes the research, analytical tools, and background data gathered to describe ambient conditions.

3.1 Physical Setting

The proposed outfall site, shown in Figure 1, is to be located approximately 4,500 feet northwest of the existing outfall, in the upper reach of the Bay City channel, on the eastern side of mid bay, between Sandstone point and Goose Point. This area of the bay was selected as a probable outfall location due to the proximity of a main channel (that holds water during low tide), proximity to the WWTP, and the location's distance from environmental receptors.

3.2 Environmental Mapping

"Environmental mapping" has been prepared to identify the areas in and around the proposed outfall area that may be sensitive to the impact of the discharge on beneficial uses within the bay. Habitats, critical resources areas, and other beneficial uses are mapped within the segment of the water body receiving the discharge.

Established water quality standards require management of water quality to protect beneficial uses, which fall into the following categories:

- Designated fish uses to be protected in the Bay
- Shellfish harvesting
- Coastal water contact recreation

3.2.1 Fish Use

The bay provides habitat for numerous fish, shellfish, crabs, birds, seals and sea grasses. Multiple species of fish have been identified in the bay at various times of the year. Five species of anadromous salmon use the bay at some point in their life cycle. The Tillamook Watershed is home to Summer and Winter Steelhead, Coho, Chum, Spring and Fall Chinook and sea-run Cutthroat Trout. The following fish species resident in the bay are federally listed as "Threatened" under the Endangered Species Act:

- Coho salmon
- Green sturgeon

- Eulachon (commonly called smelt, candlefish, or hooligan)

None of these species spawn in the bay, but use the bay for rearing and migration. Water quality is to be managed in order to accommodate salmon and trout rearing and migration within the waters of the Bay. In addition to threatened species, Oregon also lists the Pacific lamprey as a State Species of Concern and Steelhead are listed as a federal Species of Concern. Figure 2 depicts fish use areas in the Bay (http://www.oregonfishinginfo.com/Tillamook%20Bay.html).

3.2.3 Shellfish Harvesting Use

Clam digging and crabbing are important for the economy and lifestyle within the Tillamook watershed. Oysters have been grown commercially in Tillamook Bay since the 1930's. Tillamook Bay has been one of the leading oyster producing bays in Oregon, with an average annual production of about 21,200 shucked gallons during the 1970s and 1980s. Beginning in 1990, the level of production dropped off sharply and has remained low due to reduced production by several Oyster Companies. Figure 3 depicts the oyster growing lease areas in the Bay. 2016 shellfish plat production was 5,926.69 gallons of shucked oysters in Tillamook Bay, (Source: Oregon Department of Agriculture, Natural Resources Program). Figure 4 depicts clamming and crabbing use areas in the Bay.

3.2.2 Recreational Use

Water contact recreational use of the estuary is typically limited to activities associated with sport fishing and shellfish harvesting. Figure 4 generally depicts the location of public boating access points and recreational shellfish harvesting areas within the bay.

3.3 Existing Outfall Site

The existing outfall is located approximately 2,000 feet north of Goose Point on the east side of the Bay. The outfall pipe extends approximately 1,250 feet from the eastern shoreline into the Bay, situated in what was once a shallow channel, serving Doty Creek. The Doty Creek channel, when the outfall was planned and installed, was approximately 2-3 deep at Mean Low Water. Storm events within the area have relocated that channel closer to the shore line and the outfall diffuser is currently inundated with sediment and discharges in a "bubble-up" fashion into adjacent mud-flats. When exposed at lower tides, effluent flows across the mud flats as it makes its way back to the channel.

3.4 Proposed Outfall Site

Due to the location of the existing outfall site being in the mud flats and observed channel migration, a new outfall will need to be located in the Tillamook estuary. The proposed outfall site, (Figure 1), is to be located approximately 4,500 feet northwest of the existing outfall, in the upper reach of the Bay City channel, on the eastern side of mid bay, between Sandstone point and Goose Point. This location is intended to situate the

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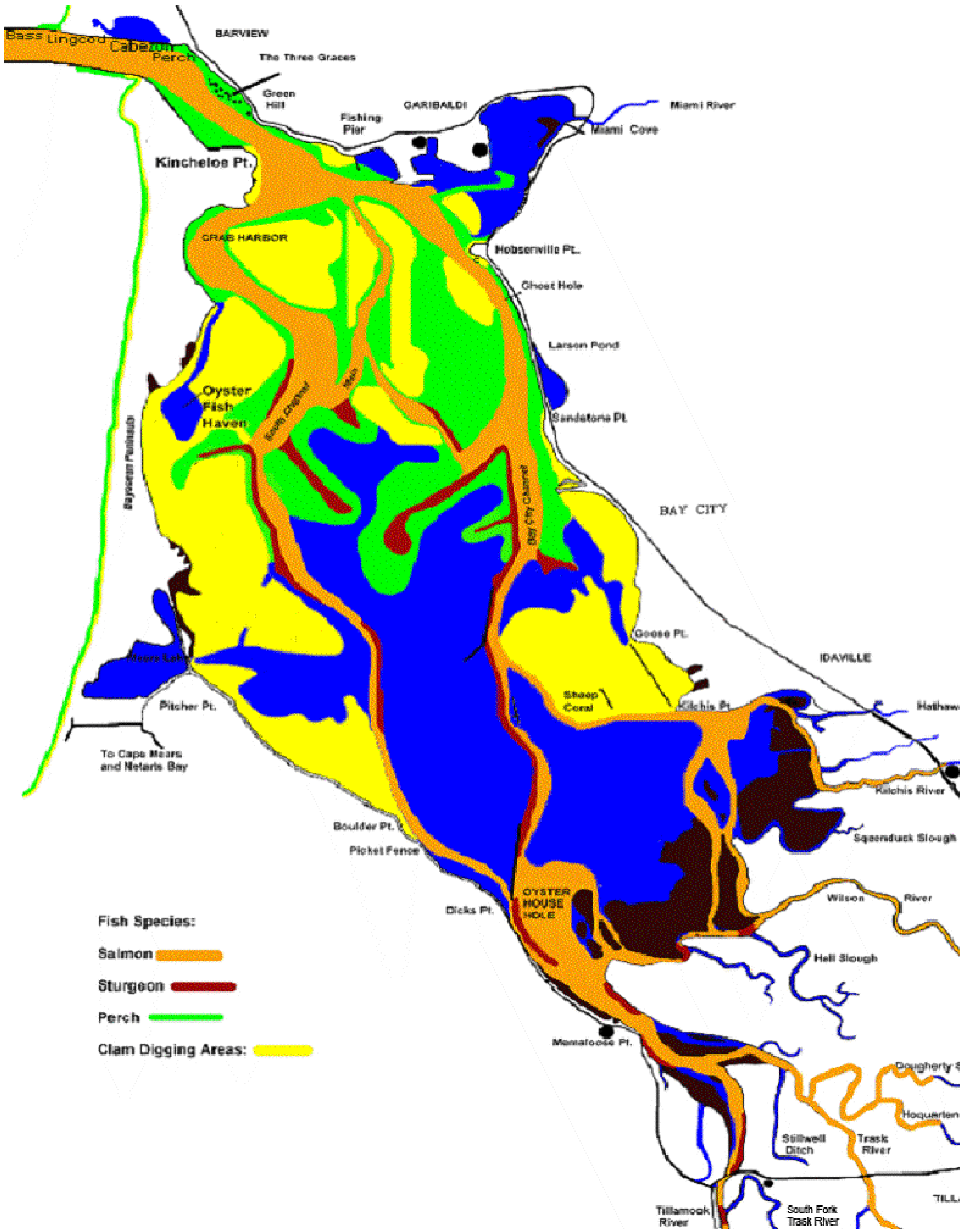

SHN Consulting Engineers & Geologists, Inc.	City of Bay City Wastewater Facilities Plan Bay City, Oregon	ENVIRONMENTAL MAPPING FISH USE AREAS SHN 611013.151
September 2018	611013-OFALL	Figure 2

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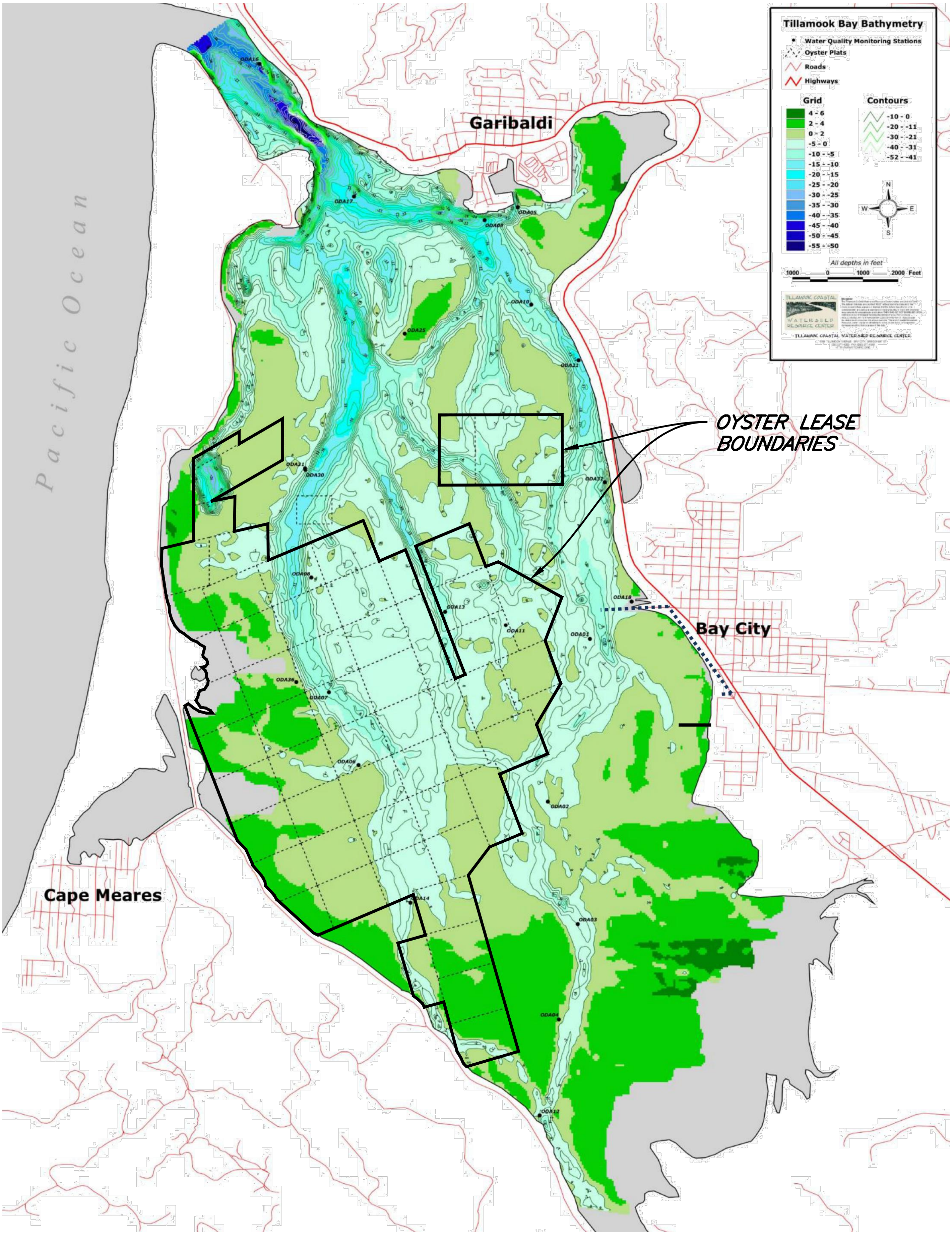

SHN Consulting Engineers & Geologists, Inc.	City of Bay City Wastewater Facilities Plan Bay City, Oregon	ENVIRONMENTAL MAPPING OYSTER LEASE AREAS SHN 611013.151
September 2018	611013-OFALL	Figure 3

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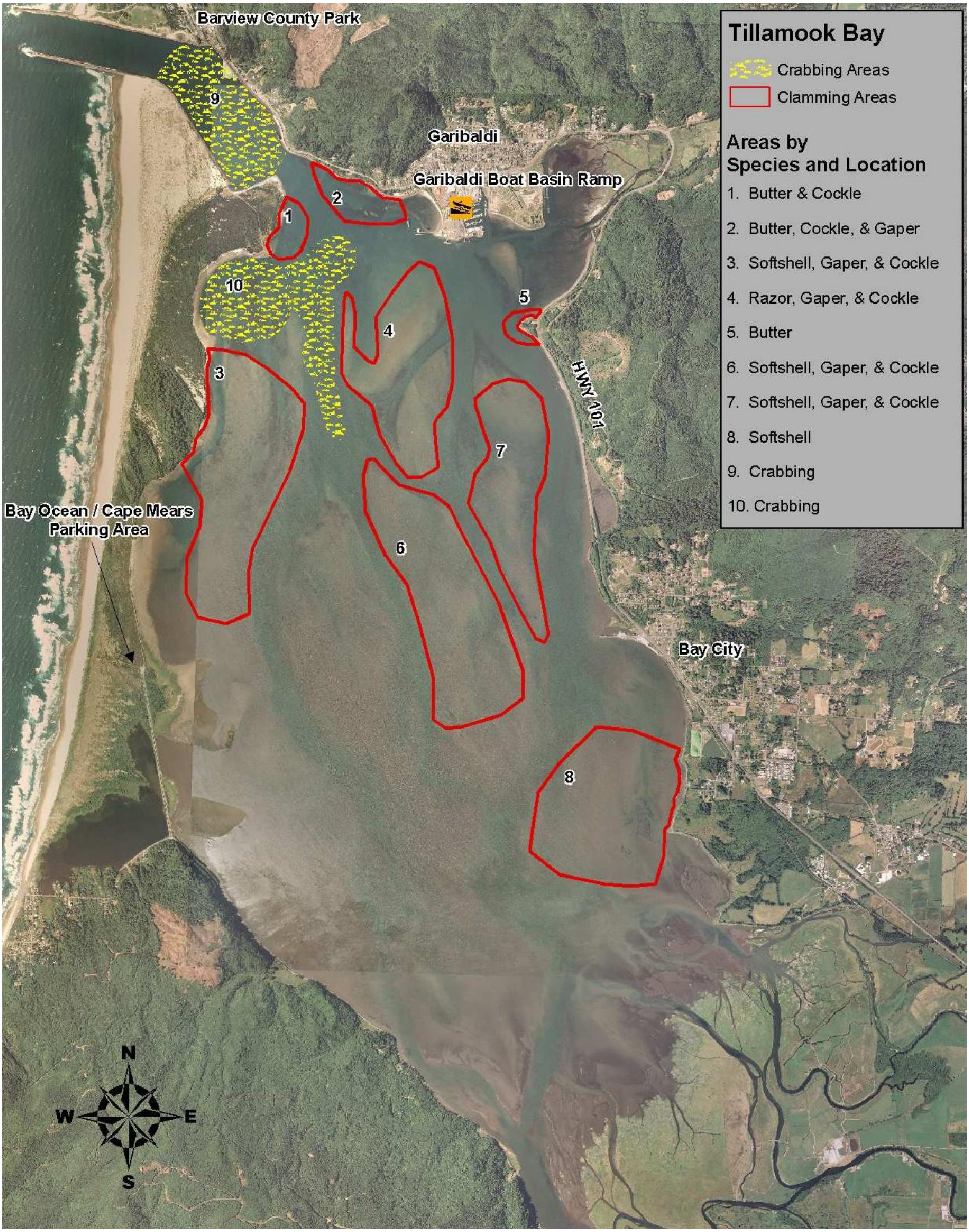

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SHN Consulting Engineers & Geologists, Inc.	City of Bay City Wastewater Facilities Plan Bay City, Oregon		ENVIRONMENTAL MAPPING CLAM/CRAB USE AREAS SHN 611013.151
	September 2018	611013-OFALL	Figure 4

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outfall diffuser in a deeper, more stable channel within the Bay. Historical NOAA navigation charts indicate this channel has been present at this location and has maintained mean low water depths of seven to nine feet for at least the past 90 years (1926 chart attached). Selection of the proposed outfall site considered the following:

- Water Depth
- Outgoing Tidal Currents
- Channel Stability
- Proximity to existing wastewater facilities
- Distance from designated shellfish reserve areas

Based on these criteria, the outfall site proposed will be located at Latitude N. 45.5237^{o} and Longitude -123.9005^{o}.

Plan and profile views of the proposed outfall are presented in Figure 5.

4.0 Background Water Quality Data

Background water quality data for Tillamook Bay and the Bay City wastewater treatment plant effluent are discussed in the following section. The data are utilized to model ambient conditions assuming the worst case (1 in 10 year flow and treatment performance) discharge scenario.

4.1 Ambient Water Quality Data

The majority of information derived for the study of outfall impact on Tillamook Bay was obtained from various published studies and papers, which have been previously performed in association with some aspect of the Bay or its associated water shed.

4.1.1 Salinity and Temperature

Past studies of the Bay have classified the estuary as a two-layered stratified system during the high run-off periods (November through March) and well-mixed, vertically homogeneous during low flow periods (April through October). The studies suggest that due to the large tidal amplitude, shallow depth and moderate freshwater inflow, stratification is not sustained for extended periods of time.

Salinity and temperature conditions were derived from two previous studies associated with Tillamook Bay. Overall, it appears that salinity and temperature conditions were similar between the two studies. In both studies, mean temperatures in the mid-region of the Bay varied over a wider range than in the lower Bay due to shallow depths and the strong influence of air temperature. Mean temperature associated with measurements taken in April through July, in the midregion of the Bay was 14.4^{o} C and ranged from 9 to 17^{o} C, dependent upon the season.

Mean salinity associated with measurements taken in April through July, in the midregion of the Bay was 22.8 ppt and ranged from 18.3 to 31 ppt, dependent upon the season. In comparison, the Pacific Ocean has an average salinity of 35 ppt.

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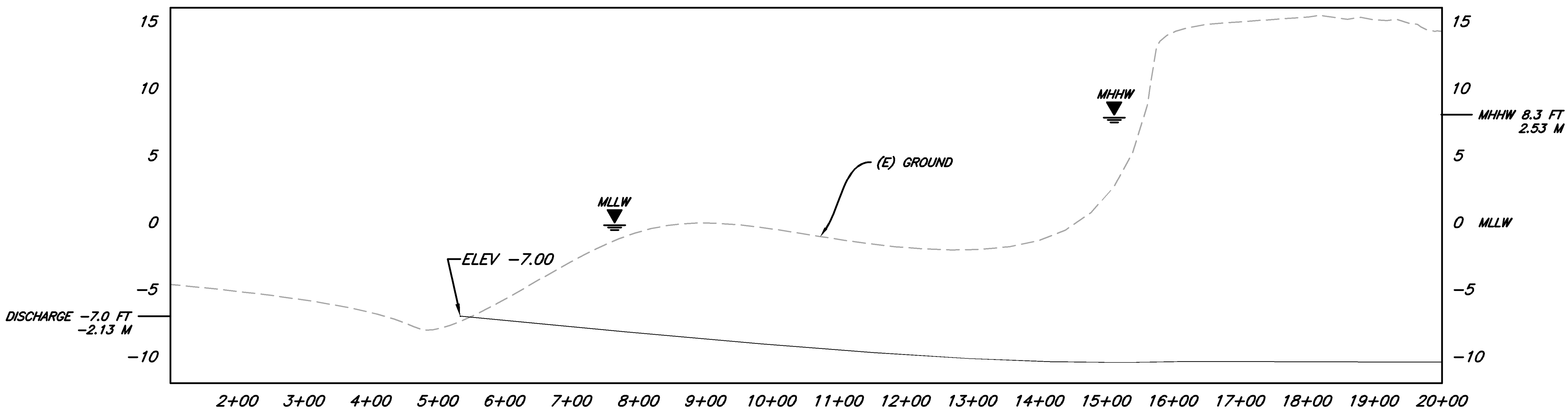
PLAN
1"=150'



PROFILE
SCALE: 1"=150' H
1"=2' V

SOURCE:
CITY OF BAY CITY WASTEWATER FACILITIES MASTER PLAN, FEB 2008

SHN	City of Bay City Wastewater Facilities Plan Update Bay City, Oregon	Proposed Wastewater Outfall Plan & Profile SHN 611013.151
	December 2019	611013-OFALL
		Figure 5

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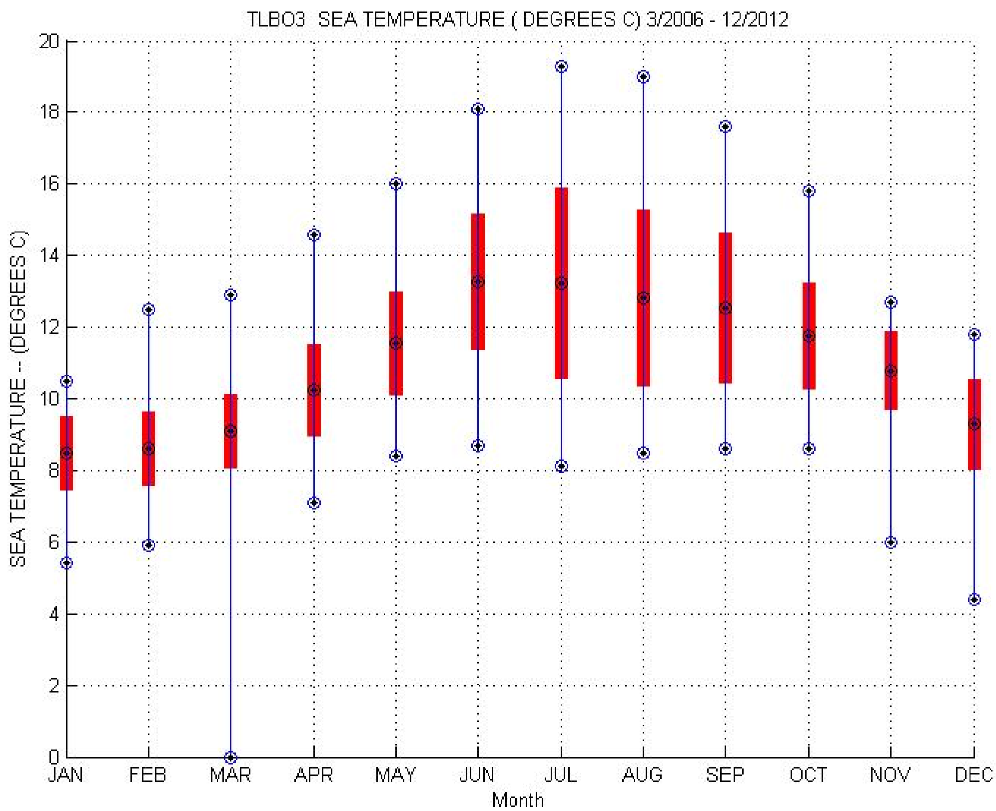
The following graph, downloaded from NOAA, National Buoy Data Center, for readings made at the Garibaldi station (located on the Bay approximately 12,000 ft north of the proposed outfall sit), depicts a recent history of lower bay temperatures:

Figure 6
Station TLBO3 - Climatic Summary Plots for Sea Temperature
Mean and Standard Deviation Plot



4.1.2 Water Depth

Water depth at the proposed outfall location is affected by tidal forces, storm surges and hydrologic inputs from the upstream drainage basins . . For modeling purposes, the average tidal forces will be assumed to control water levels elevations. The National Oceanographic and Atmospheric Ocean Administration collect data on water elevations. The nearest tidal data station closest to the outfall site is the Garibaldi Station (9437540). The elevations for this station are as follows:

Highest Observed Water (12/31/2005)	15.91 feet
Mean Higher High Water	12.3 feet
Mean High Water	11.59 feet
Station Datum (NAVD88)	0.00 feet
Mean Tide Level (MTL)	8.47 feet
Mean Low Water	5.35 feet
Mean Lower Low Water	3.99 feet
Lowest Observed Water (11/26/2007)	-0.52 feet

Under Mean Lower Low Water elevation, the estuary floor at the proposed outfall site will have 9 feet of water above it. In comparison, the existing disposal site will be completely exposed mud flats.

4.1.2 Density

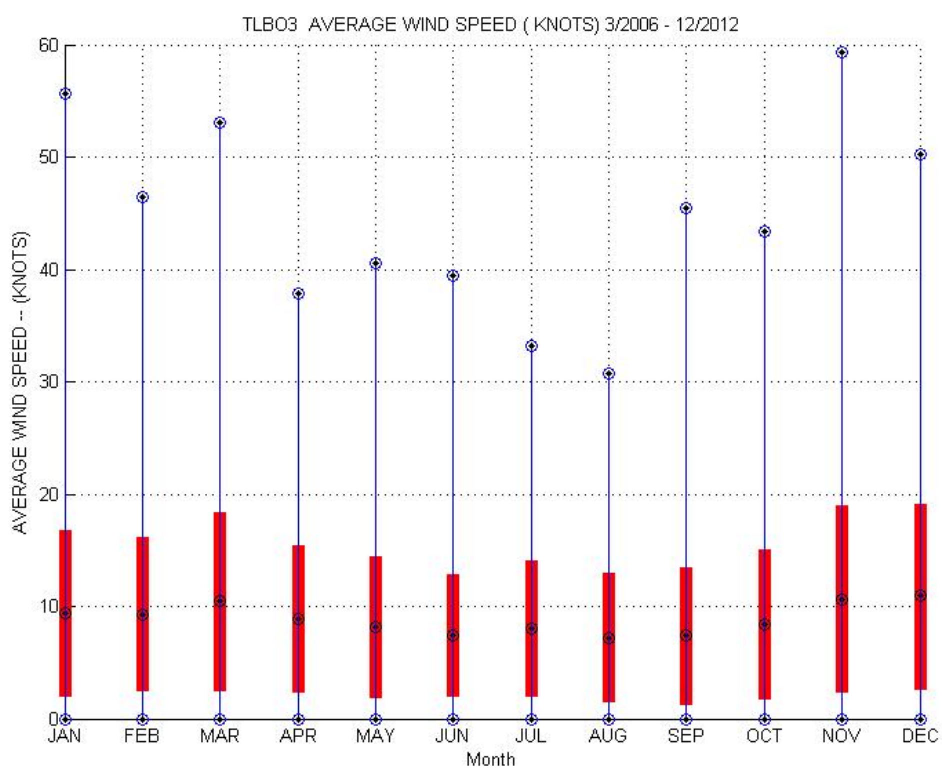
Density profiles for the outfall site were derived by correlating the density of seawater to the associated temperature and salinity. The range in density from 1,013 kg/m^3 to 1252 kg/m^3, depending on salinity and temperature. An average density of 1,136 kg/m^3 will also be used for modeling purposes based on an average temperature of 14.4°C and a salinity of 22.8 ppt.

4.1.3 Winds

Mixing zone modeling will also consider the influence of wind speed on mixing once the discharge floats to the surface. Winds along the Tillamook estuary can be characterized as strong with predominate directions from either the northwest in the winter and southwest or southeast in the summer. Average wind speeds for the Garibaldi weather station, located on the north shores of the Tillamook Bay are shown in Figure 7 below. Based on the data provided from this weather station, wind speeds for modeling purposes will be based on an 11-knot wind (5.7 m/s).

Figure 7
Average Wind Speed at Garibaldi, OR

Station TLBO3 - Climatic Summary Plots for wind speed
Mean and Standard Deviation Plot



The strong winds occurring along the Estuary will generally enhance mixing at the surface layer but may also tend to push the effluent shoreward. Modeling of the diffuser structure should target identifying a design that creates a well-mixed plume at the surface layer to reduce the significance and risk of the strong winds pushing the effluent shoreward

4.1.4 pH

Data for water pH in Tillamook Bay is limited. The water quality data collected with the 1998 fish sampling in the Bay indicates a pH of 9.92 in the vicinity of the proposed outfall site, taken on July 15, 1998. Considering the tidal influence in the mid Bay location of the proposed outfall site, the pH of the ocean will be used for data representing the lower values of the Bay.

The ocean pH is maintained by the net charge balance of positive ions (Na^+, K^+, Mg^{++}, and Ca^{++}) and negative ions (Cl^-, $SO_4^=$, and Br^-). Whenever there is a slight charge imbalance, the ocean buffering capacity neutralizes the additional acid or base. This buffering ability is controlled by the carbonate system that balances the ocean pH in a narrow range between 7.6 and 8.1.

4.1.5 Summary of Ambient Properties

Ambient properties proposed as representative of the Tillamook Bay at the outfall site are provided in Table 3 below.

Table 3 Summary of Tillamook Bay Ambient Properties

Ambient Property	Lowest	Average	Highest
Water Temperature	11.8°C	14.4°C	17°C
Density, kg/m^3	1,013	1,136	1,252
Density Gradient, kg/m^3	none	none	none
pH	7.6	8.2	8.9
Ammonia as N μg/L	0.10	1.0	3.4
Wind speed, knots	0	11	60

4.2 Effluent Quality Characteristics

Effluent characteristics for parameters of concern will be controlled by the efficiency of the wastewater treatment plant. Based on the NPDES permit, the discharge of secondary effluent should meet a 30 mg/L BOD and 30 mg/L TSS criteria. A summary of the NPDES effluent limitations for the WWTP is provided in Table 4 below.

Table 4 NPDES Permit Limits

May 15 – Oct 30		
BOD	30	45
TSS	30	45
Nov 1 – May 14		
BOD	30	45
TSS	30	45

Table 4, Continued NPDES Permit Limits

Year-round	Year-round Limitations
E. coli bacteria:	Shall not exceed 126 organisms per 100 ml monthly geometric mean. No single sample shall exceed 406 organisms per 100 ml.
pH:	Shall be within the range of 6.0 to 9.0
BOD_5 and TSS Removal Efficiency:	Shall not be less than 85% monthly average based on ADWF and AWWF for the facility.
Total Chlorine Residual:	No chlorine or chlorine products shall be allowed.
* Based on average dry weather flow (ADWF) to the facility of 0.132 mgd and average wet weather flow (AWWF) of 0.248 mgd.	

4.2.1 Ammonia

The ammonia concentrations in the discharge is not an NPDES parameter of concern. However, ammonia testing has been performed on plant effluent once a week since 2009. Effluent ammonia ranged from 0.0016 mg/L to 13.93 mg/L, with an average of 1.37 mg/L over the past 8 years.

Variations in effluent ammonia will depend on operational modes of the Sequencing Batch Reactor (SBR) process. During the summer, the treatment plant will be operated to promote nitrification resulting in lower effluent NH_3-N concentrations. Average summer time ammonia concentrations over the past 8 years have been 1.77 mg/L.

During the winter, higher flows may require the plant to operate in a high rate batching process that does not allow nitrification. It is reasonable to expect ammonia removal to be limited by the rapid process time and lower temperatures. Average winter time ammonia concentrations over the past 8 years has been 1.09 mg/L.

The 90^{th} percentile of exceedence (1 in 10 year) ammonia level over the past 8 years is 6.79 mg/L and will be used as the upper limit of ammonia concentration in the discharge for modeling purposes

Ammonia toxicity criteria that determine mixing requirements are defined in Table 2. Worst case scenario for toxicity criteria are encountered with ambient properties of 17 ^{o}C, a pH of 8.9 and salinity of 18.2 ppt. These conditions represent ambient conditions in the highest range of temperature and pH along with the lowest range of salinity found in previous documentation of estuary conditions.

4.2.2 Effluent Temperature

Wastewater temperature is known to vary seasonally and generally parallels climatic temperatures. Data evaluated from the Bay City Wastewater Treatment Plant Discharge Monitoring Report (DMR) for effluent temperature suggests winter temperature ranges between 7 ^{o}C and 21 ^{o}C and during the summer ranging between 11 ^{o}C and 21 ^{o}C. The maximum thermal discharge that could influence the Bay temperature for the winter and summer seasonal average is 21 ^{o}C. Temperature standards for the protection of fish relate to the mid bay region, that is associated with rearing and migration is a maximum of 17.8^{o}C.

4.3 Constituents of Concern

Summaries of effluent properties of concern are provided in Table 5 below.

Table 5 Summary of Effluent Properties and Required Standards

Ambient Property	Lowest	Average	Highest	Standards
Biochemical Oxygen Demand, mg/L	1	2.9	12	30
Total Suspended Solids, mg/L[1]	1	6.3	22	30
E coli bacteria, #/100ml[2]	2	6.7	38	End of Pipe
Summer Temperature, ^{o}C	11	16.5	21	17.5
Winter Temperature, ^{o}C	7	13.1	21	
Density, kg/m[3]	998	998.8	1000	N/A
pH	6.0	6.9	7.3	6-9
Summer Ammonia as N, mg/L	0.004	1.77	13.93	1.04 CMC[4] Acute
Winter Ammonia as N, mg/L[5]	0.0016	1.09	8.80	0.16 CCC[6] Chronic

1. mg/L – milligrams per liter
2. ml - millileter
3. kg/m – kilograms per meter
4. CMC – Criteria Maximum Concentration
5. Wastewater Treatment Plant Design, WPCF MOP 8
6. CCC – Criteria Chronic Concentration

4.4 Hydraulic Loadings

The effluent discharge rate can have a significant impact on the receiving water because the loading of pollutants is based on the discharge rate but also because the comparison to receiving water velocities (estimated flow rate for ambient with assumed boundary conditions) and the effluent momentum affect the mixing phenomenon. Effluent will be discharged from the City's Wastewater Treatment Plant through the proposed installation of a new discharge pumping system. Pump discharge rates are dictated by the process of the existing Sequential Batch Reactor (SBR) treatment system used by the City. The SBRs are typically operated in 6-hour cycles producing a total of eight batches per day. However, during high flows, cycle times can be decreased to as low as 3-hour intervals.

Treated supernatant is withdrawn from the SBR basins utilizing a floating 10-inch diameter decanter mechanism and discharged for disinfection. Effluent from the SBR is disinfected using a single-channel with two UV disinfection systems. The UV system is designed to disinfect a peak decant flow rate of 2.8 MGD, assuming a tranmissivity of 65%.
After UV disinfection, treated effluent will be discharged via effluent pump station to Tillamook Bay through the proposed 12 inch discharge pipeline and 8 inch discharge port outfall. The effluent pump station will be sized to accommodate the SBR decant rate of approximately 1,700 gallons per minute.

4.5 Discharge Velocities

Effluent discharge velocities will be controlled by the design of the diffuser port. According to the CORMIX model design recommendations, effluent discharge velocities should be high, ranging between 3 m/s to 8 m/s. Lower velocities may be allowed, but discharge velocities less than 0.5 m/s are not recommended.

It is important to note that the discharge port size will affect the analysis of the toxic dilution zone (by reducing the discharge length scale) described in the regulatory review section of this report. In general, smaller discharge ports will decrease the length scale, which in turn reduces the ZID. In some cases, it could become necessary to reduce the length of the mixing zone and install more, smaller area, diffusers to achieve toxic dilution criteria.

5.0 Effluent Modeling

A variety of models exist for evaluating effluent dilution. The primary mixing zone models currently in common use include simple dilution equations, DYNTOX, CORMIX, UM, RSB, UDKHDEN, PDS, and PDSM. The structure, applicability, assumptions, and complexity of each model are summarized in Table 6 below.

Table 6 Summary of Available Mixing Zone Model

Model	Discharge Depth	Receiving Water Depth	# Ports	Dimensions	Complexity
Jet-Momentum Eq.	submerged	any	single	one	low
River Initial Mixing Eq.	any	shallow	single	one	low
Ambient Dilution Eq.	any	shallow	any	one	low
CYNTOX	any	shallow	single	one	moderate
CORMIX	any	any	any	three	moderate
UM	submerged	any	any	three	moderate
RSB	submerged	deep	multiple	three	moderate
PDS	surface	deep	single	three	high
PDSM	surface	deep	single	three	high
UDKHDEN	submerged	deep	multiple	three	high

Model selection for this study was based on the objectives of the study, availability and quality of input data, and the specific conditions of the perceived discharge scenario proposed to be modeled. The following selection criteria were applied to select the model used in this study:

- Input data was limited; therefore the model should not require extensive input data
- The results of the model should be reproducible by others, therefore the model should be readily available, well-documented, and relatively easy to use
- Schedule and budgetary limits were critical to the project, therefore model input parameters should be easy to adjust, enabling relatively rapid analysis of various outfall configurations
- The results of the study are subject to DEQ examination; therefore the model should be recognized and accepted by regulators

Based on these criteria, CORMIX was selected for use in this study. CORMIX satisfies the criteria listed above as follows:

- CORMIX is a length scale analytical model. As such, it does not require extensive input data, as might be required for multi-dimensional numerical models.
- CORMIX engine is a public domain model; readily available and well documented.
- The CORMIX interface allows input parameters to be adjusted relatively quickly, permitting sensitivity analyses to be conducted expeditiously
- CORMIX has been accepted and endorsed by the USEPA and Oregon DEQ
- As an expert system, CORMIX provides design recommendations, which can enhance the design process and lead to an improved diffuser system

5.1 Mixing Zone Modeling Parameters

EPA's *Technical Support Document for Water Quality-based Toxics Control* (*TSD)* describes the critical design flows that should be used when performing mixing zone analyses for the various waterbodies. EPA's *TSD* defines estuaries as having a main channel reversing flow and coastal bays as having significant two-dimensional flow in the horizontal directions. For both water bodies, the critical design conditions recommended by EPA are based on a combination of the tides and the river conditions. Because plume dynamics within an estuarine environment are so complex, discharge dilution cannot be calculated simply based on the receiving stream critical low flow and the effluent discharge rate. Effluent mixing within an estuary is complicated by density stratification, tidal variation, wind effects, riverine inputs, and complex circulation patterns.

In addition to evaluation of the above critical design conditions, an off-design condition was evaluated as well. The recommended off-design condition for both stratified and unstratified conditions is that of maximum velocity during a tidal cycle. It was assumed the off-design condition would likely result in greater dilution but it could carry the plume further downstream. An evaluation of this condition was made to assure toxic conditions are not carried downstream into critical resource areas such as shellfish habitat.

For application of acute criteria, the 10th % velocity over one tidal cycle was used for critical slack conditions and 90th % for the off-design condition. For chronic and human health criteria the 50th% velocity was used.

5.1.1 Detailed Tidal Simulations

A high variation in both ambient velocity and tidal elevation occurs during the tidal episode shown in Figure 8. In such highly time-variant ambient conditions, CORMIX recommends predictions are performed at critical tidal conditions throughout a reversal episode. These critical tidal conditions are identified as:

1. Shortly after slack tide: Effects of re-entrainment of discharge from the previous half-cycle are greatest. However, the flow is evolving rapidly in time, causing CORMIX tidal predictions to be limited in spatial extent. Several predictions should be made at hourly or half hourly intervals following the reversal.
2. Maximum flood and ebb currents: These represent extremes of along-shore extent and shoreline interaction. Re-entrainment will be less important at these times.

Per CORMIX guidance, seven simulations were performed at the times indicated on Figure 8 by the letters a-g. In the following section, a detailed simulation is performed corresponding to time b, one hour after slack tide. The results are contrasted for that case to the steady-state assumption simulated in the preceding.

Along with the recommended CORMIX tidal simulations, four simulations were performed to correlate with the prescribed conditions by the EPA's TSD.

Figure 8 represents the ambient water conditions associated with each simulation.

Minimal initial dilution generally will not occur at slack tide, but shortly after slack tide when the plum re-entrains material remaining from the previous tidal cycle In tidal mode, CORMIX considers the reduction in initial dilution due to renentrainment of material remaining from the previous cycle.

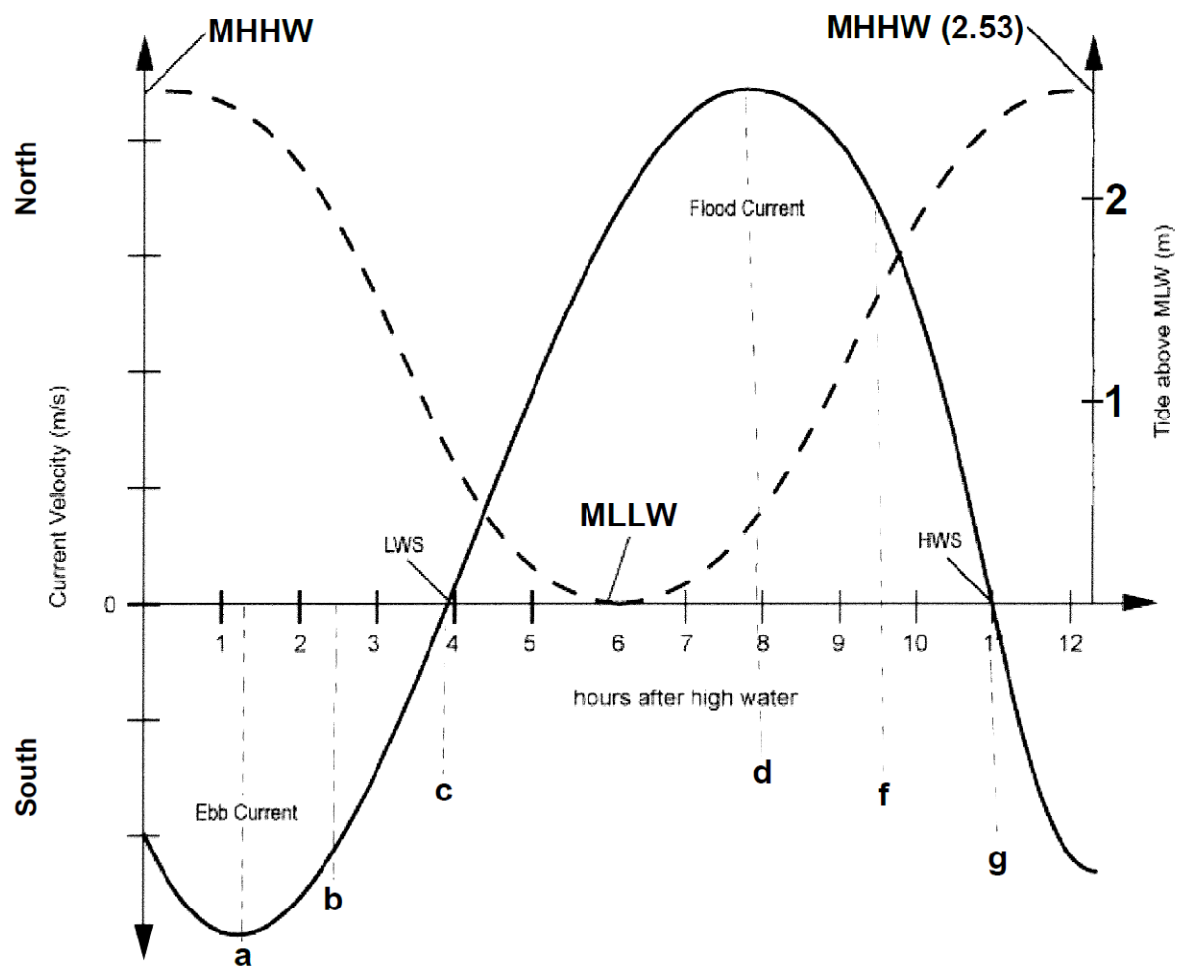


Figure 8.

Table 7 Detailed Tidal Simulations

Flow Scenario		Tidal Elevation (ft)	Tidal Elevation (m)	Average Depth (m) 4.11 Water Depth to Bottom (m)	Average Depth (ft) 13.5 Water Depth to Bottom (ft)	Maximum Velocity (m/s) 1.0 Current Velocity (m/s)	distance to left bank (m)
Ebb Current	a	7.9	2.4	5.14	16.9	0.75	unbounded
	b	4.5	1.37	4.11	13.5	0.5	unbounded
Low Water Slack	c	1.3	0.4	3.14	10.3	0.01	unbounded
Flood Current	d	0.0	0	2.74	9.0	0.8	560
	e	8.3	2.53	5.27	17.3	1	unbounded
	f	5.9	1.8	4.54	14.9	0.75	unbounded
High Water Slack	g	7.4	2.25	4.99	16.4	0.01	unbounded
Acute Criteria	10th % velocity over one tidal cycle	0.7	0.2	2.94	9.7	0.1	unbounded
	90th % for off-design (impacts on shellfish habitat)	0.0	0	2.74	9.0	0.9	560
Chronic and human health criteria	50% velocity (Ebb)	0.7	0.2	2.94	9.7	0.5	unbounded
	50% velocity (Flood)	6.6	2	4.74	15.6	0.5	unbounded

5.2 Mixing Zone Modeling Results

Several simulations were run with various discharge port sizes and at various directional configurations to determine the most effective combination for mixing. For simplicity and cost effectiveness, a mixing zone based upon a single port discharge was evaluated. An eight inch diameter port, discharging perpendicular to the tidal flow directions (Sigma = 90^{o}) with an upward angle (Theta) of 10^{o}, was found to provide adequate mixing for all discharge scenarios under consideration. The eight inch diameter port discharges the effluent at an initial velocity of approximately 3.3 meters/sec. Due to the buoyant nature of the discharge (lower density than ambient receiving stream) the plume will eventually make its way to the surface. However, with the proposed discharge velocities and the modeled scenarios, the Zone of Immediate Dilution is achieved prior to plume surfacing.

A summary of the results from mixing zone analyses in which the distance from the port where the CMC and CCC are met are provided in Table 8 presented below:

Table 8 Mixing Zone Analyses

Flow Scenario		CMC (ZID) Dist. (m)	CCC Dist. (m)
a.	Ebb Current	2.37	25.4
b.		2.85	18.26
c.	Low Water Slack	6.93	
d.	Flood Current	2.35	19.63
e.		2.28	32.75
f.		2.38	25.36
g.	High Water Slack	6.64	
Acute Criteria	10th % velocity over one tidal cycle	5.86	
	90th % for off-design (impacts on shellfish habitat)	2.31	22.88
Chronic and human health criteria	50% velocity (Ebb)	2.81	14.3
	50% velocity (Flood)	2.84	19.05

5.3 Summary of Mixing Zone Modeling Results

Under all conditions, modeling predicts that the single-port diffuser will meet acute and chronic criteria and achieve all water quality objectives for pollutants of concern. The mixing zone length of 70 meters (30 m upstream and 40 m downstream from each of discharge nozzle) is shown by the model to provide adequate protection for water quality. Based on the limiting criterion of the discharge length scale, a minimum toxic dilution zone of 7 meters, each direction, should be permitted to achieve the CMC criteria.

DEQ Basin-Specific Criteria

1

DEQ Basin-Specific Criteria

1

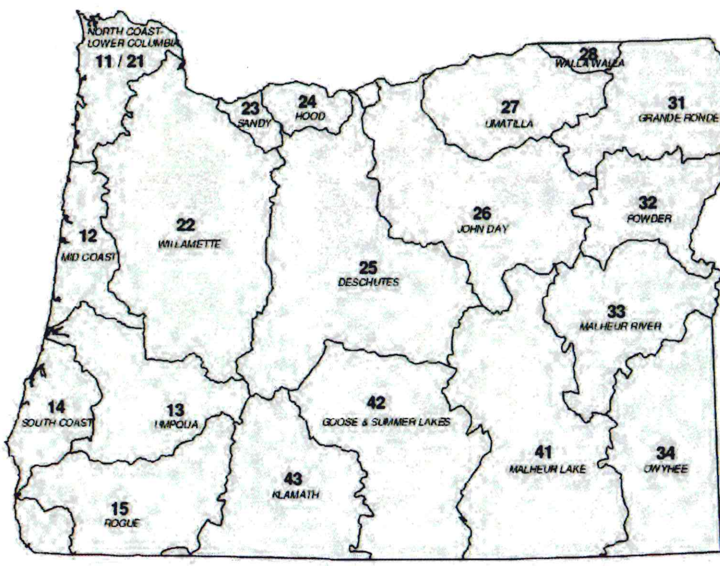
State of Oregon Department of Environmental Quality

Basin-Specific Criteria (North Coast)

340-041-0230

Beneficial Uses to Be Protected in the North Coast Basin

Figure 1: Oregon Basin Index Map



Basin Name	Basin #	OAR #
DESCHUTES	25	340-41-0130
GOOSE & SUMMER LKS	42	340-41-0140
GRANDE RONDE	31	340-41-0151
HOOD	24	340-41-0160
JOHN DAY	26	340-41-0170
KLAMATH	43	340-41-0180
MALHEUR LAKE	41	340-41-0190
MALHEUR RIVER	33	340-41-0201
MID COAST	12	340-41-0220
NORTH CST-LWR COL	11-21	340-41-0230
OWYHEE	34	340-41-0250
POWDER	32	340-41-0260
ROGUE	15	340-41-0271
SANDY	23	340-41-0286
SOUTH COAST	14	340-41-0300
UMATILLA	27	340-41-0310
UMPQUA	13	340-41-0320
WALLA WALLA	28	340-41-0330
WILLAMETTE	22	340-41-0340

Table 230A
Designated Beneficial Uses
North Coast Basin
(OAR 340-041-0230)
(November 2003)

Beneficial Uses	Estuaries & Adjacent Marine Waters	All Streams & Tributaries Thereto
Public Domestic Water Supply[1]		X
Private Domestic Water Supply[1]		X
Industrial Water Supply	X	X
Irrigation		X
Livestock Watering		X
Fish & Aquatic Life[2]	X	X
Wildlife & Hunting	X	X
Fishing[3]	X	X
Boating	X	X
Water Contact Recreation[3]	X	X
Aesthetic Quality	X	X
Hydro Power		
Commercial Navigation & Transportation	X	

[1] With adequate pretreatment (filtration & disinfection) and natural quality to meet drinking water standards.

[2] See also Figures 230A and 230B for fish use designations for this basin.

[3] For coastal water contact recreation and shellfish harvesting uses, see also Figures 230C (Necanicum River Estuary), 230D (Nehalem Bay), 230E (Tillamook Bay), 230F (Netarts Bay), 230G (Sand Lake), and 230H (Nestucca Bay)

*Figure 230A: Fish Use Designations**
North Coast Basin, Oregon

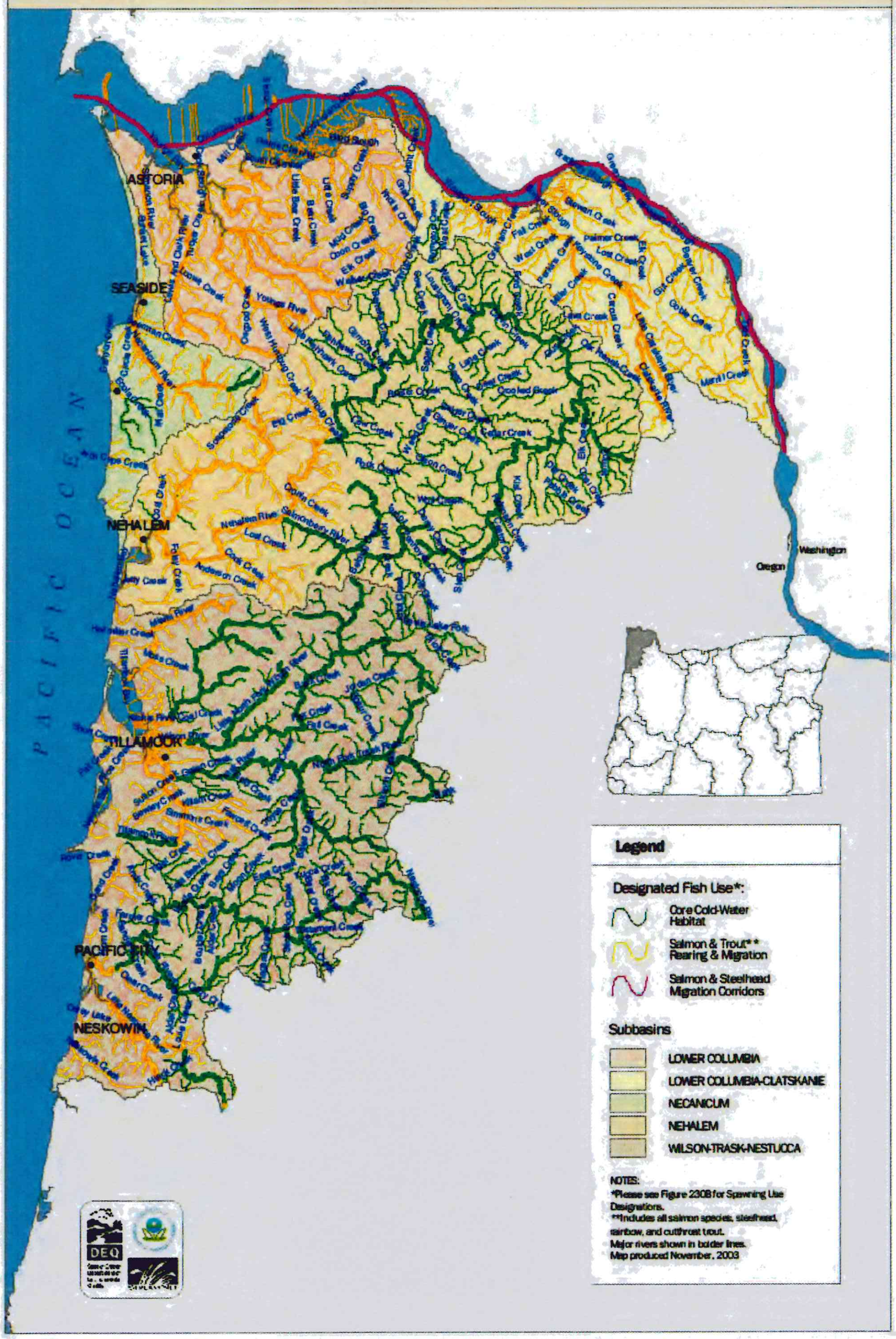


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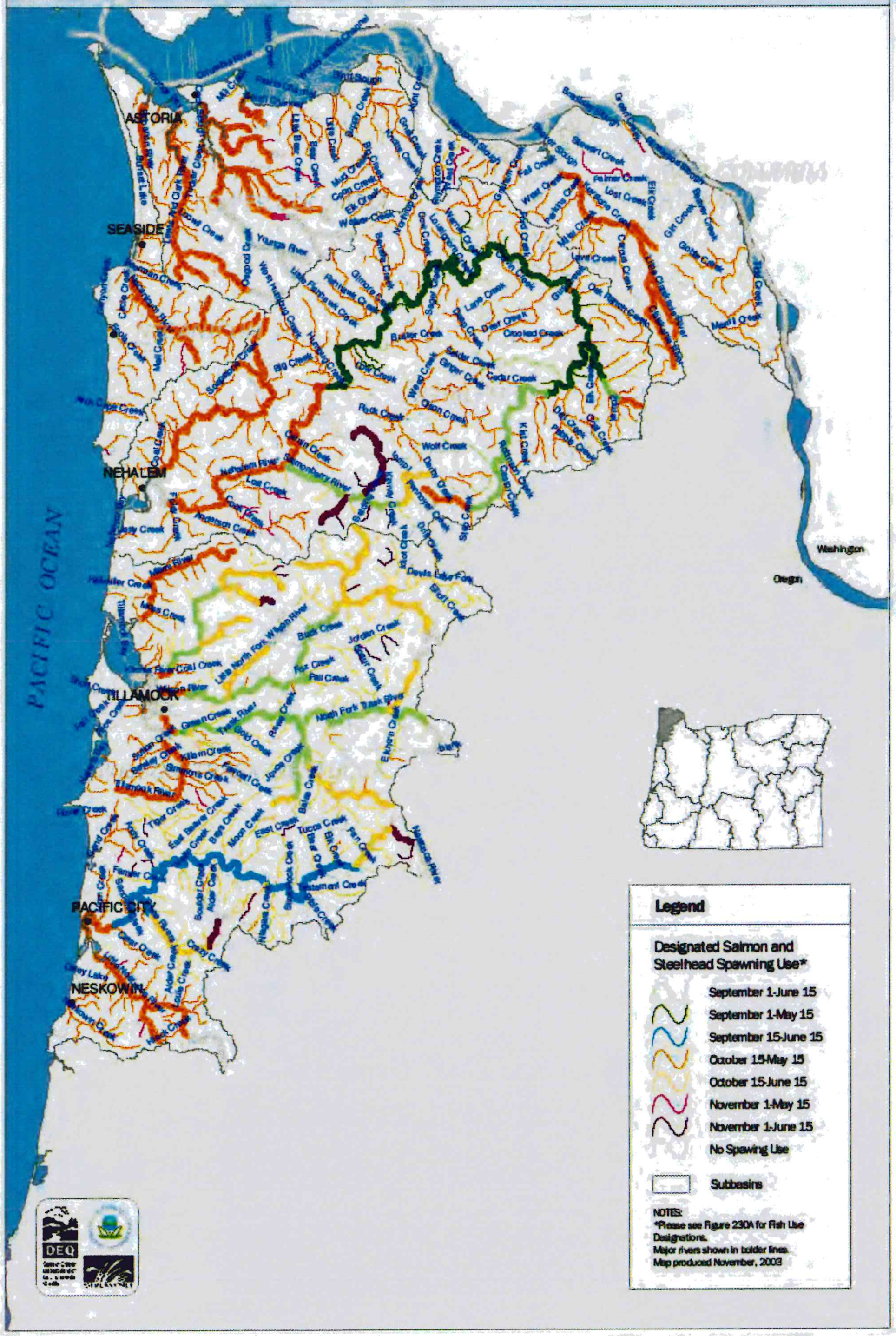
Figure 230B: Salmon and Steelhead Spawning Use Designations*
North Coast Basin, Oregon



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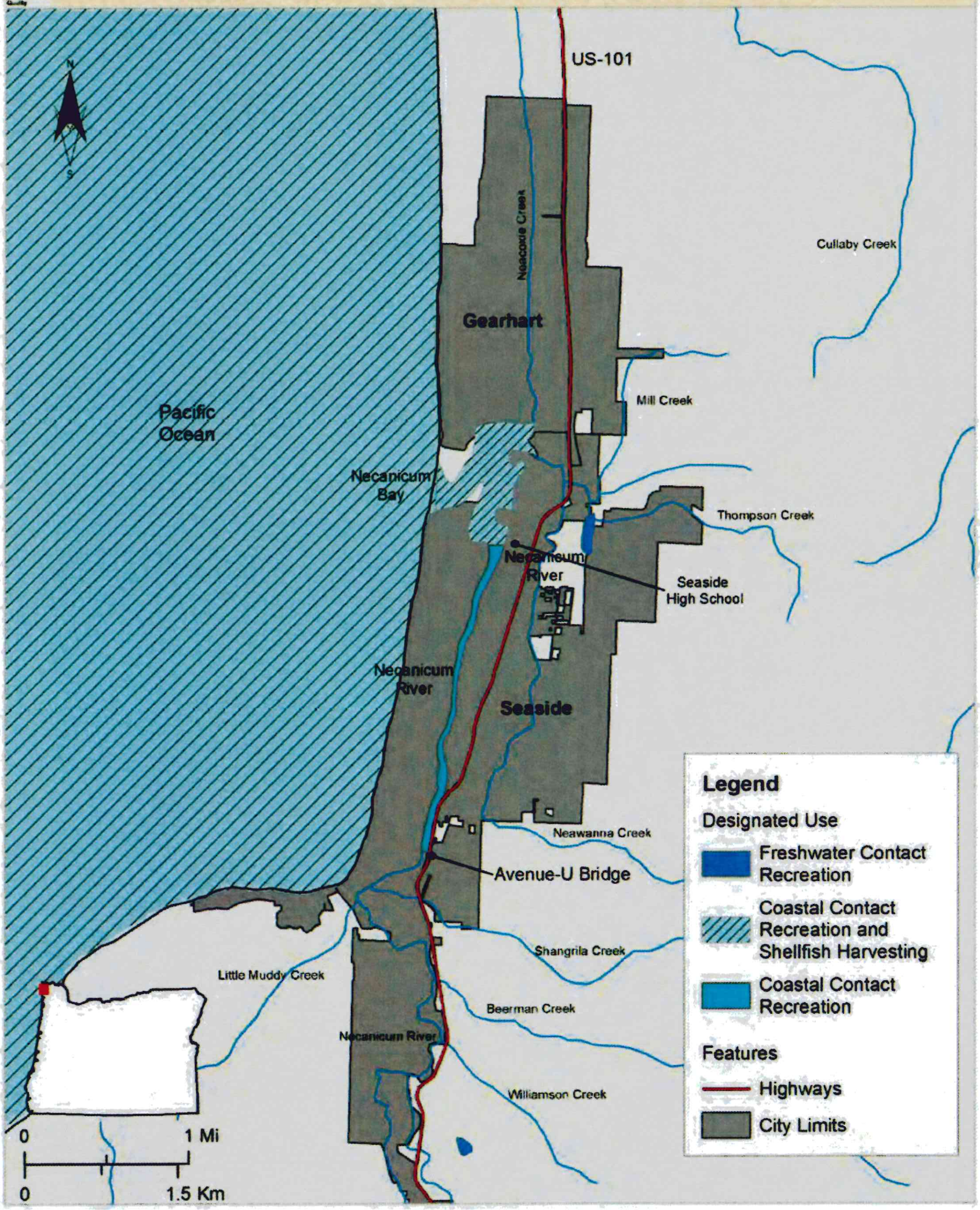
OAR 340-041-0230

Figure 230C: Water Contact Recreation and Shellfish Harvesting Designated Uses Necanicum Bay, North Coast Basin, Oregon (Draft February, 2016)



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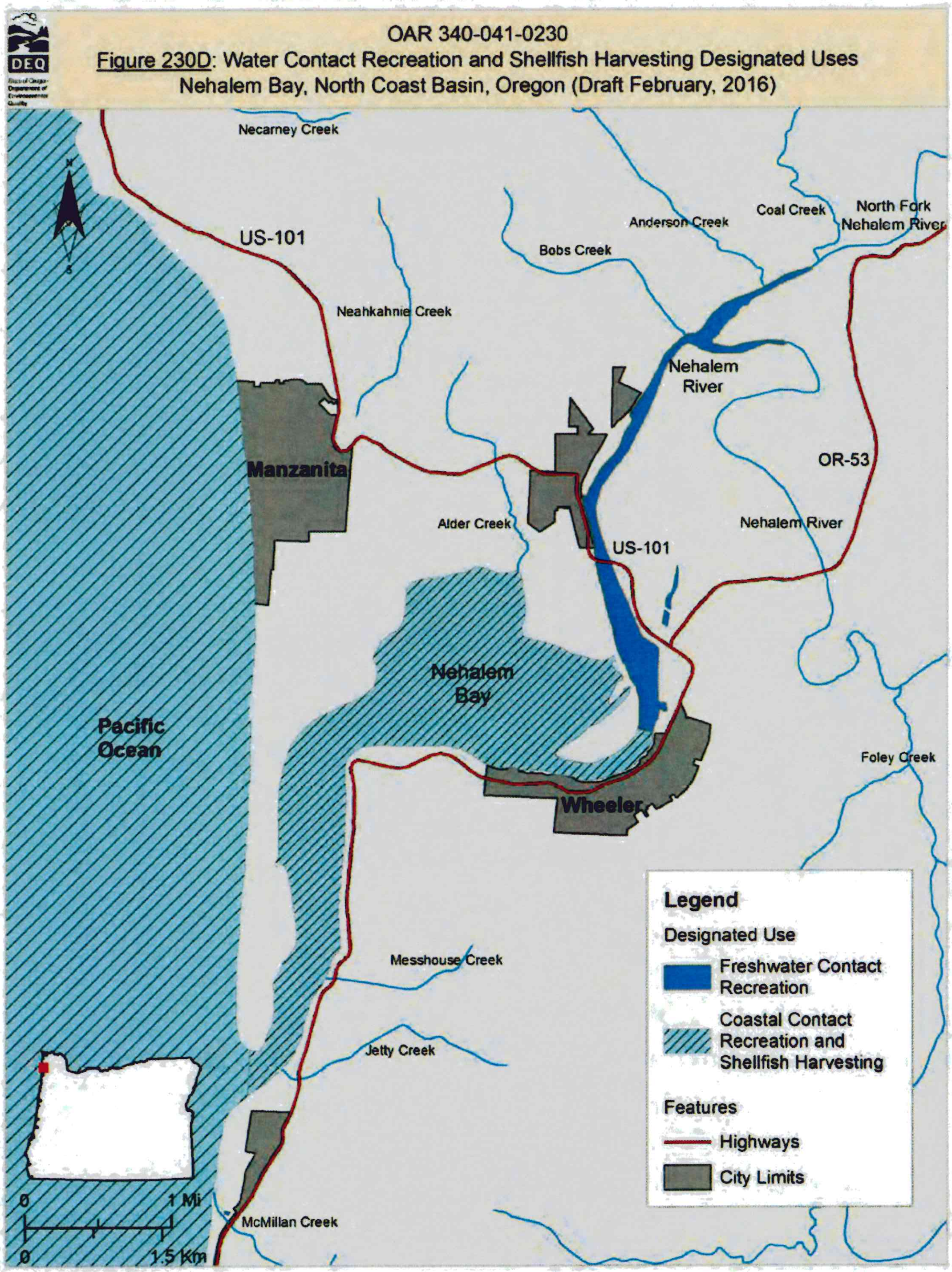
OAR 340-041-0230
Figure 230D: Water Contact Recreation and Shellfish Harvesting Designated Uses
Nehalem Bay, North Coast Basin, Oregon (Draft February, 2016)
DEQ
Necarney Creek
US-101
Anderson Creek
Coal Creek
North Fork Nehalem River
Bobs Creek
Neahkahnie Creek
Nehalem River
Manzanita
OR-53
Alder Creek
US-101
Nehalem River
Nehalem Bay
Pacific Ocean
Foley Creek
Wheeler
Legend
Designated Use
Freshwater Contact Recreation
Coastal Contact Recreation and Shellfish Harvesting
Features
Highways
City Limits
Messhouse Creek
Jetty Creek
McMillan Creek
0
1 Mi
0
1.5 Km

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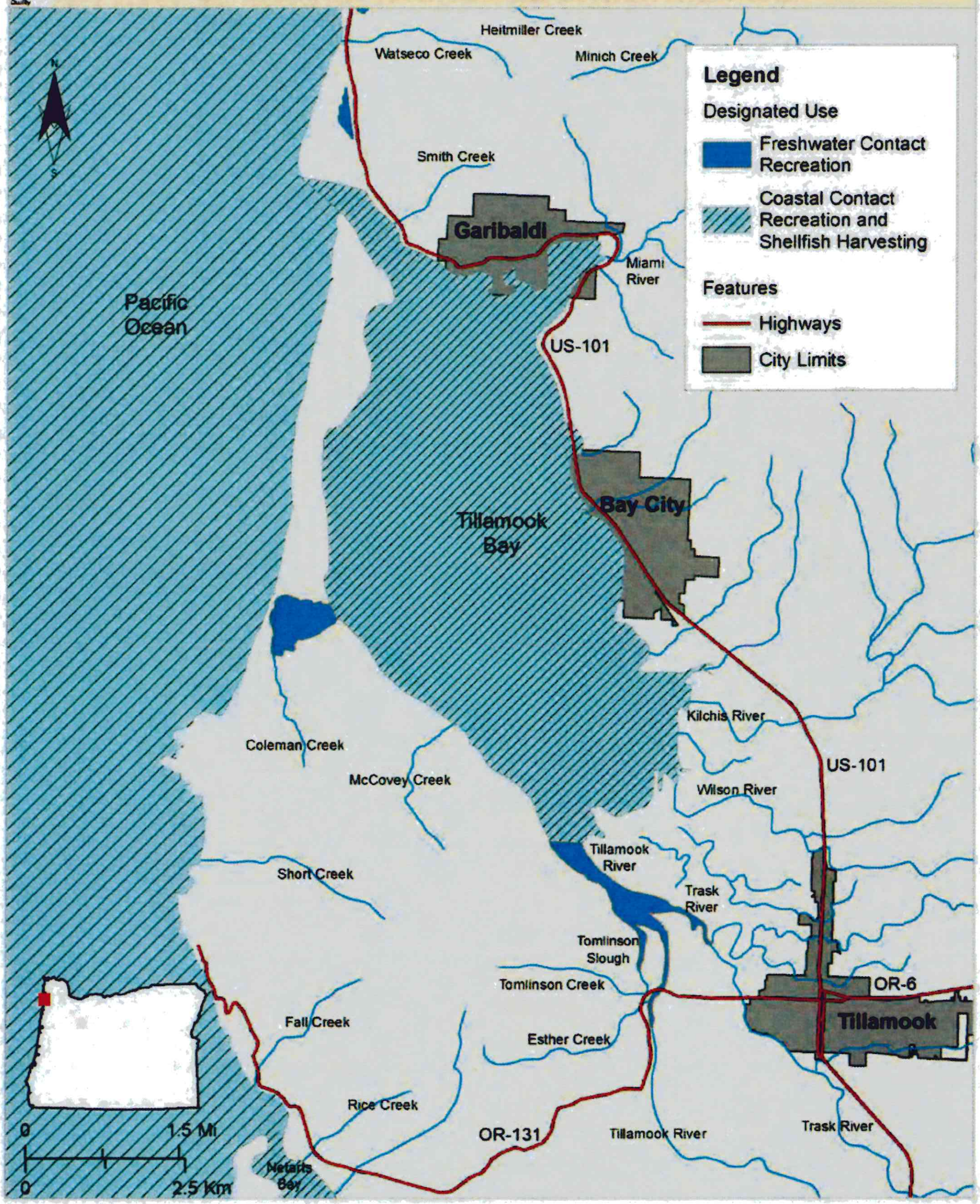
OAR 340-041-0230

Figure 230E: Water Contact Recreation and Shellfish Harvesting Designated Uses

Tillamook Bay, North Coast Basin, Oregon (Draft February, 2016)



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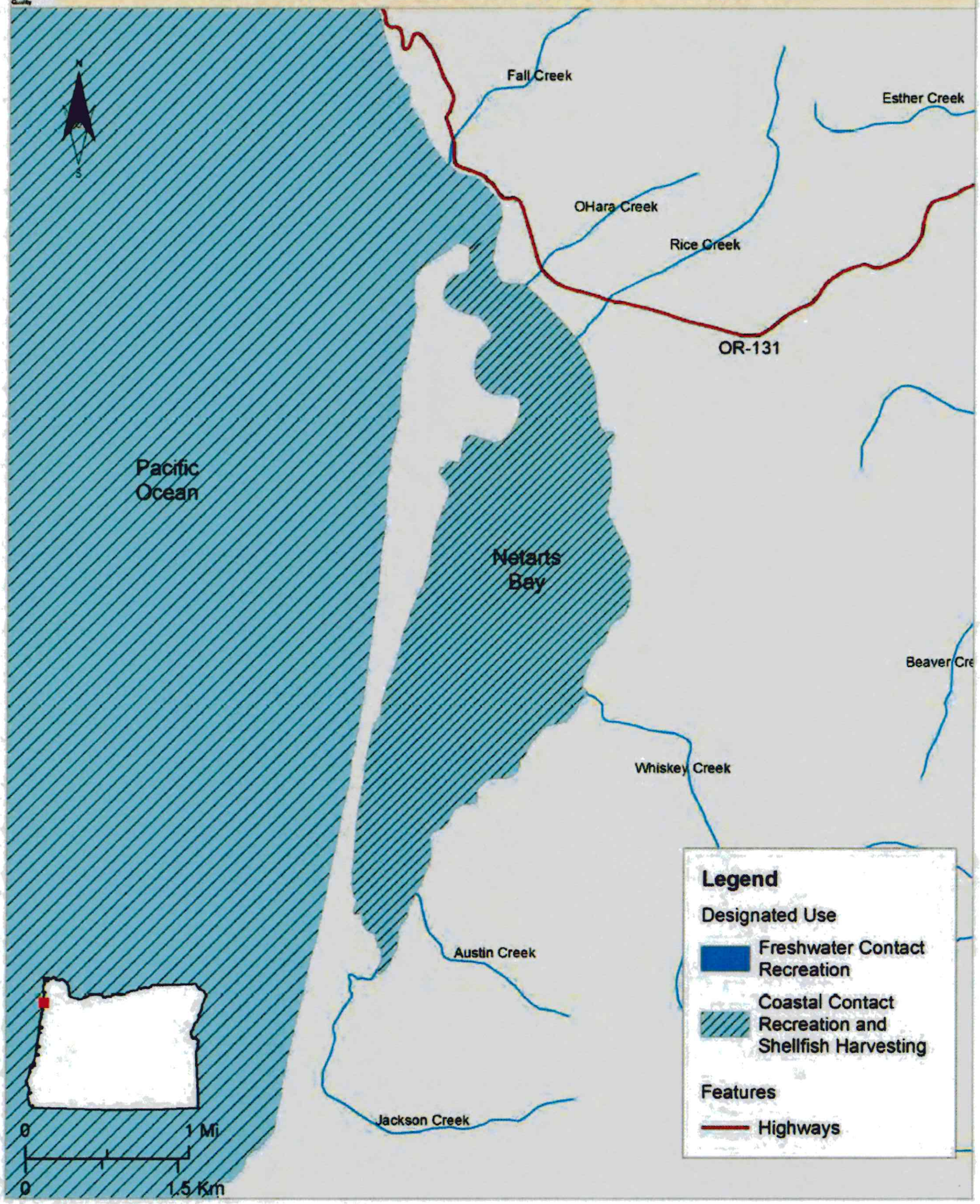
OAR 340-041-0230

Figure 230F: Water Contact Recreation and Shellfish Harvesting Designated Uses

Netarts Bay, North Coast Basin, Oregon (Draft February, 2016)



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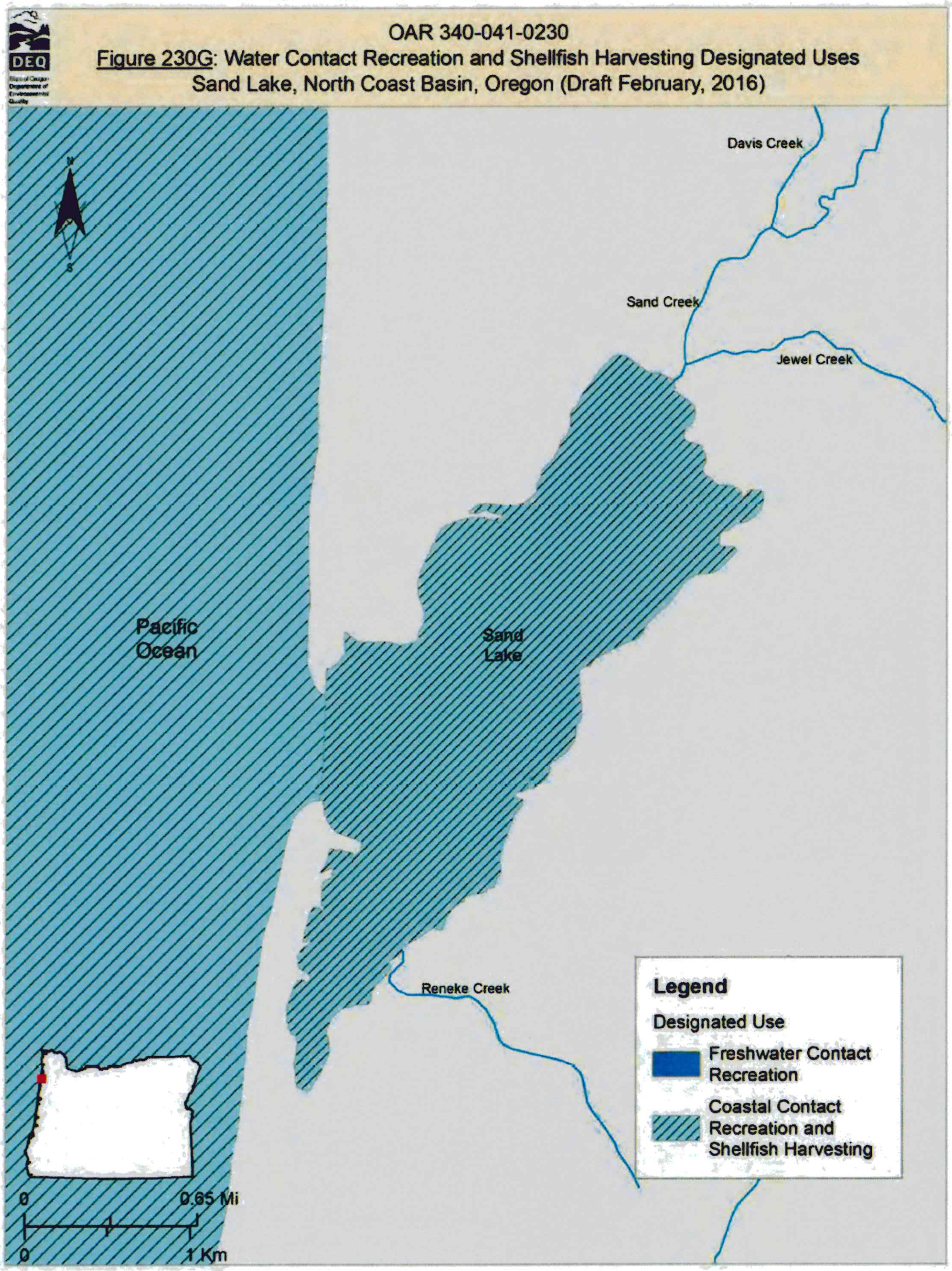
OAR 340-041-0230
Figure 230G: Water Contact Recreation and Shellfish Harvesting Designated Uses
Sand Lake, North Coast Basin, Oregon (Draft February, 2016)
DEQ
Davis Creek
Sand Creek
Jewel Creek
Pacific Ocean
Sand Lake
Reneke Creek
Legend
Designated Use
Freshwater Contact Recreation
Coastal Contact Recreation and Shellfish Harvesting
0
0.65 Mi
0
1 Km

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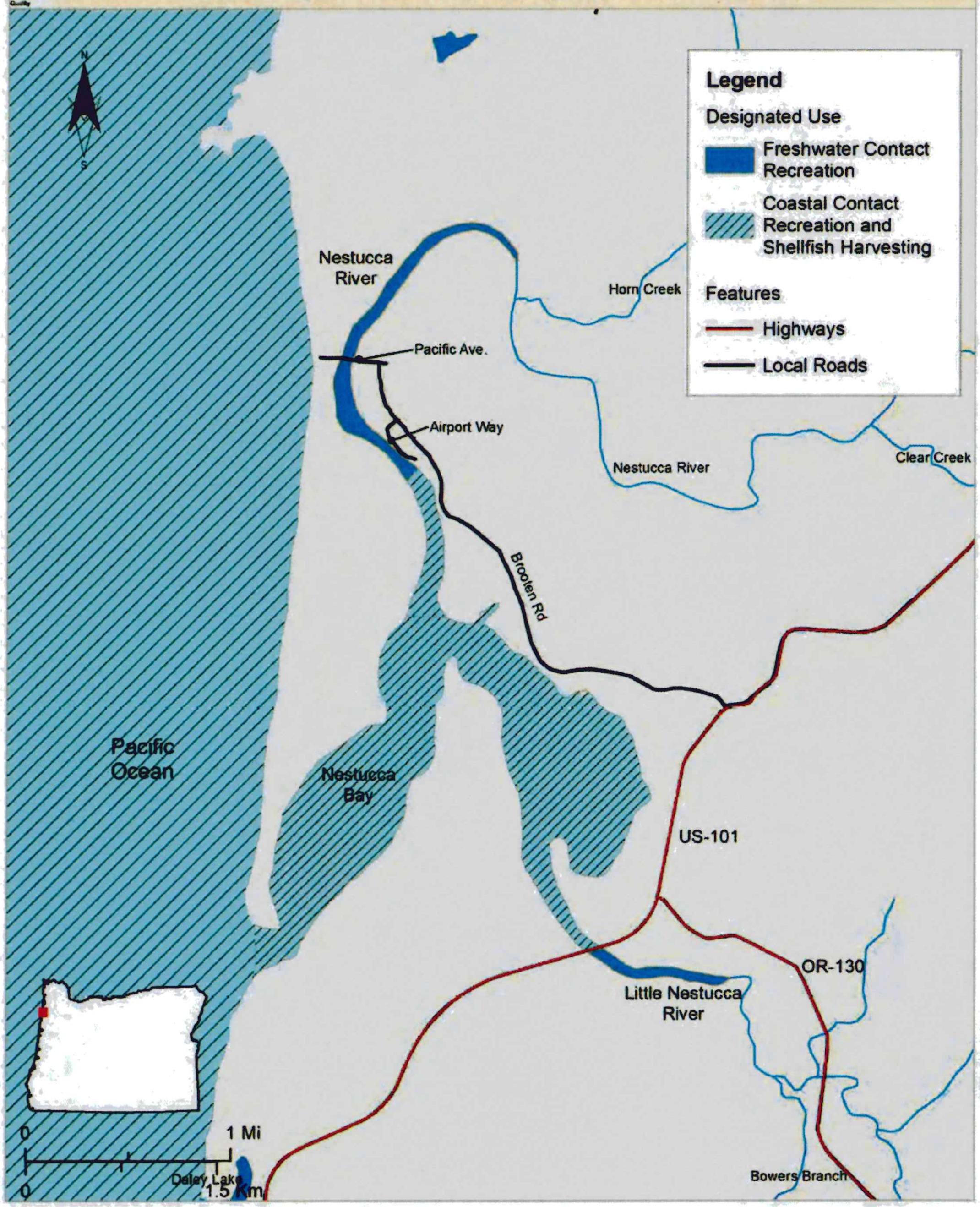
OAR 340-041-0230

Figure 230H: Water Contact Recreation and Shellfish Harvesting Designated Uses
Nestucca Bay, North Coast Basin, Oregon (Draft February, 2016)



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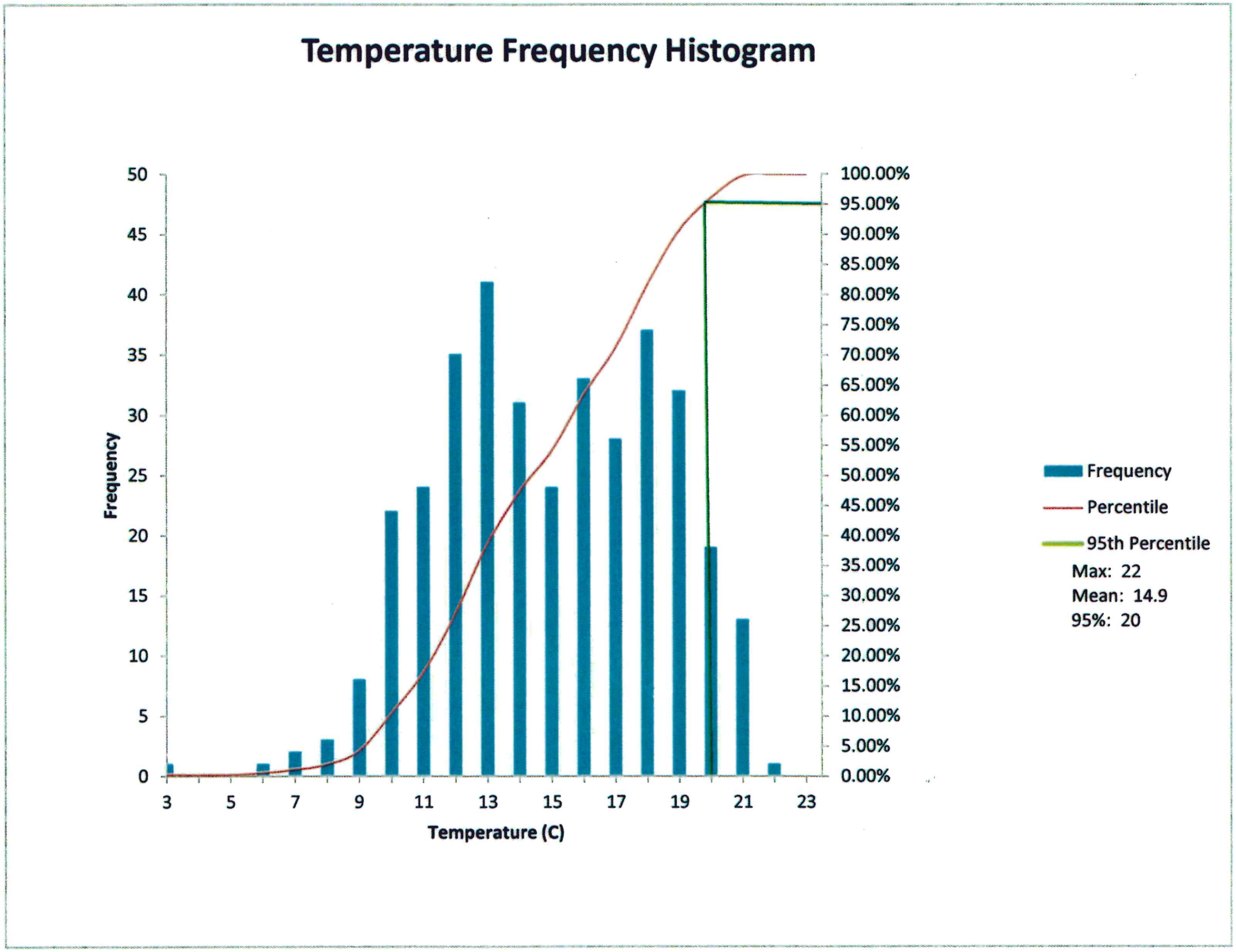
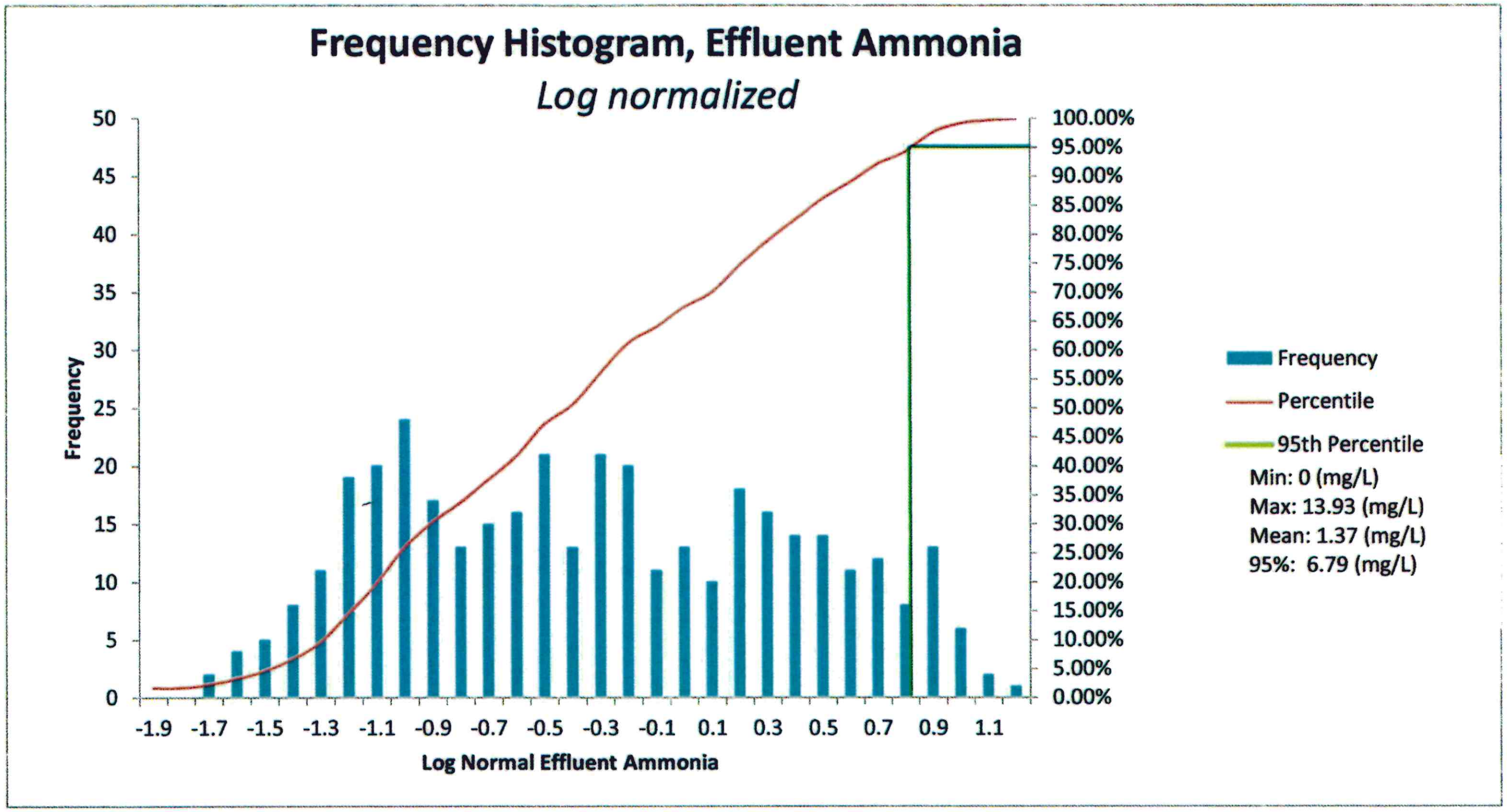
Effluent Characteristics 2

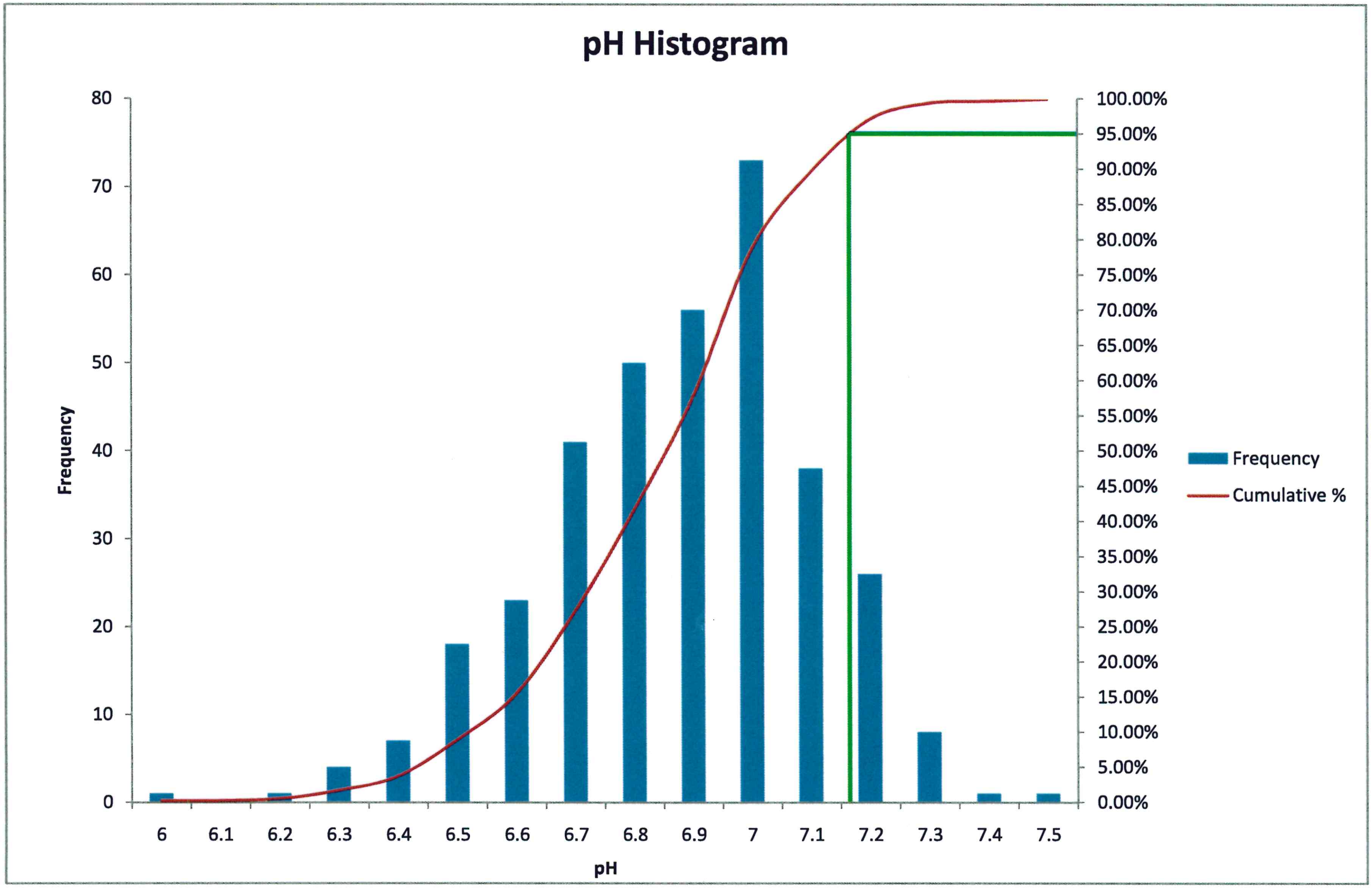
2

Effluent Characteristics

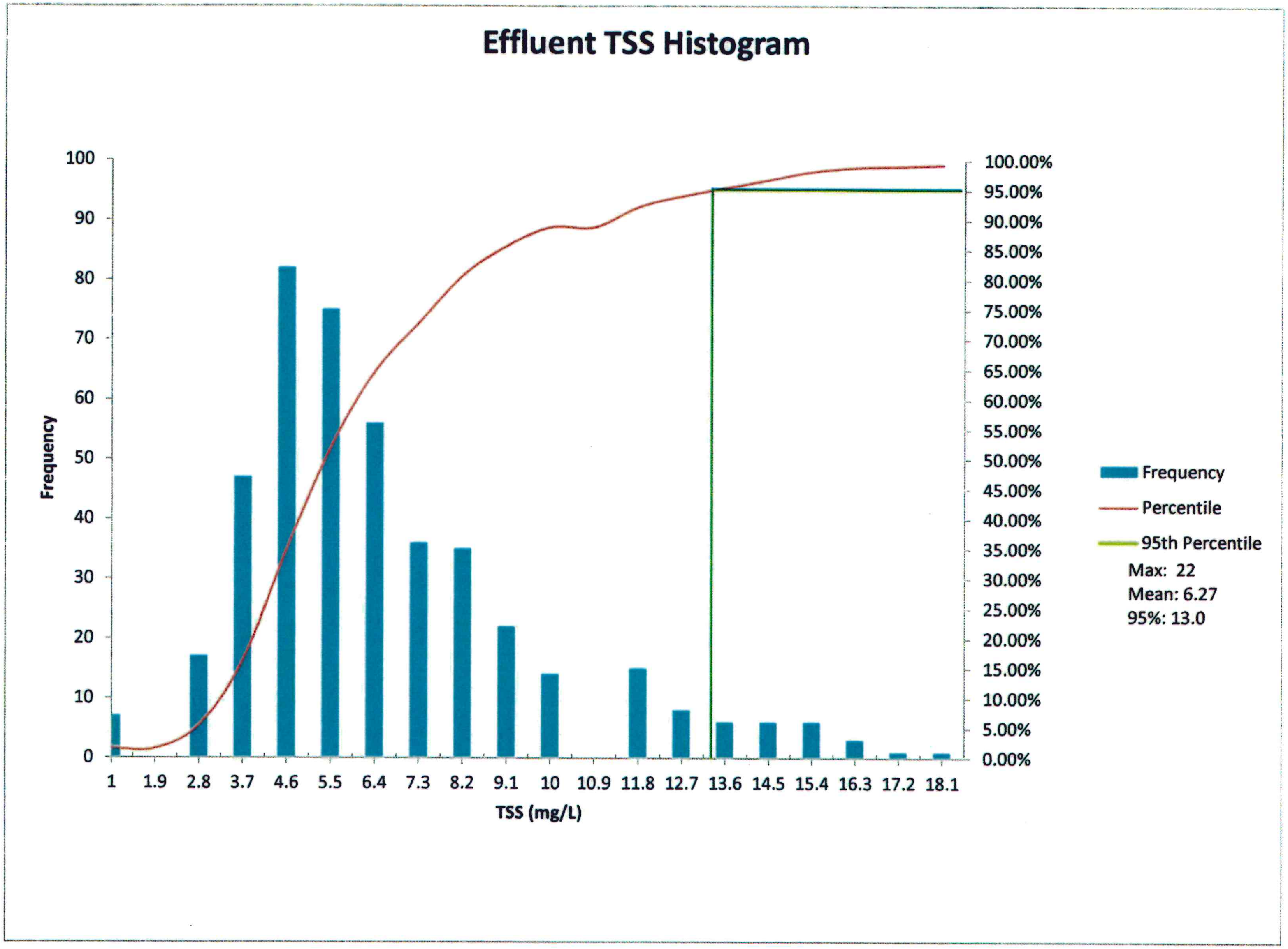


Temperature Frequency Histogram
Frequency
50
45
40
35
30
25
20
15
10
5
0
3
5
7
9
11
13
15
17
19
21
23
Temperature (C)
100.00%
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Frequency
Percentile
95th Percentile
Max: 22
Mean: 14.9
95%: 20

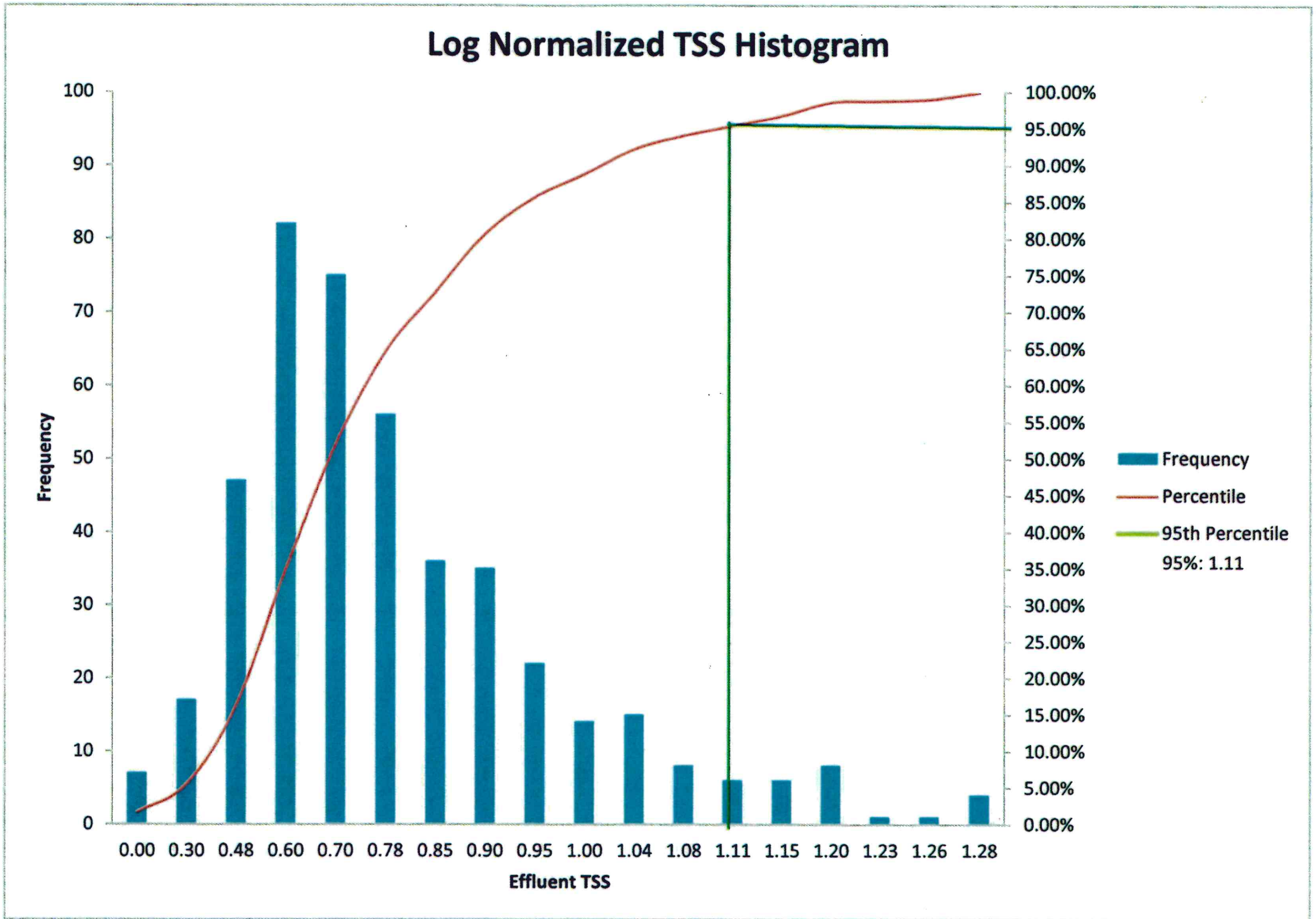

Frequency Histogram, Effluent Ammonia
Log normalized
Frequency
50
45
40
35
30
25
20
15
10
5
0
100.00%
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
-1.9 -1.7 -1.5 -1.3 -1.1 -0.9 -0.7 -0.5 -0.3 -0.1 0.1 0.3 0.5 0.7 0.9 1.1
Log Normal Effluent Ammonia
Frequency
Percentile
95th Percentile
Min: 0 (mg/L)
Max: 13.93 (mg/L)
Mean: 1.37 (mg/L)
95%: 6.79 (mg/L)



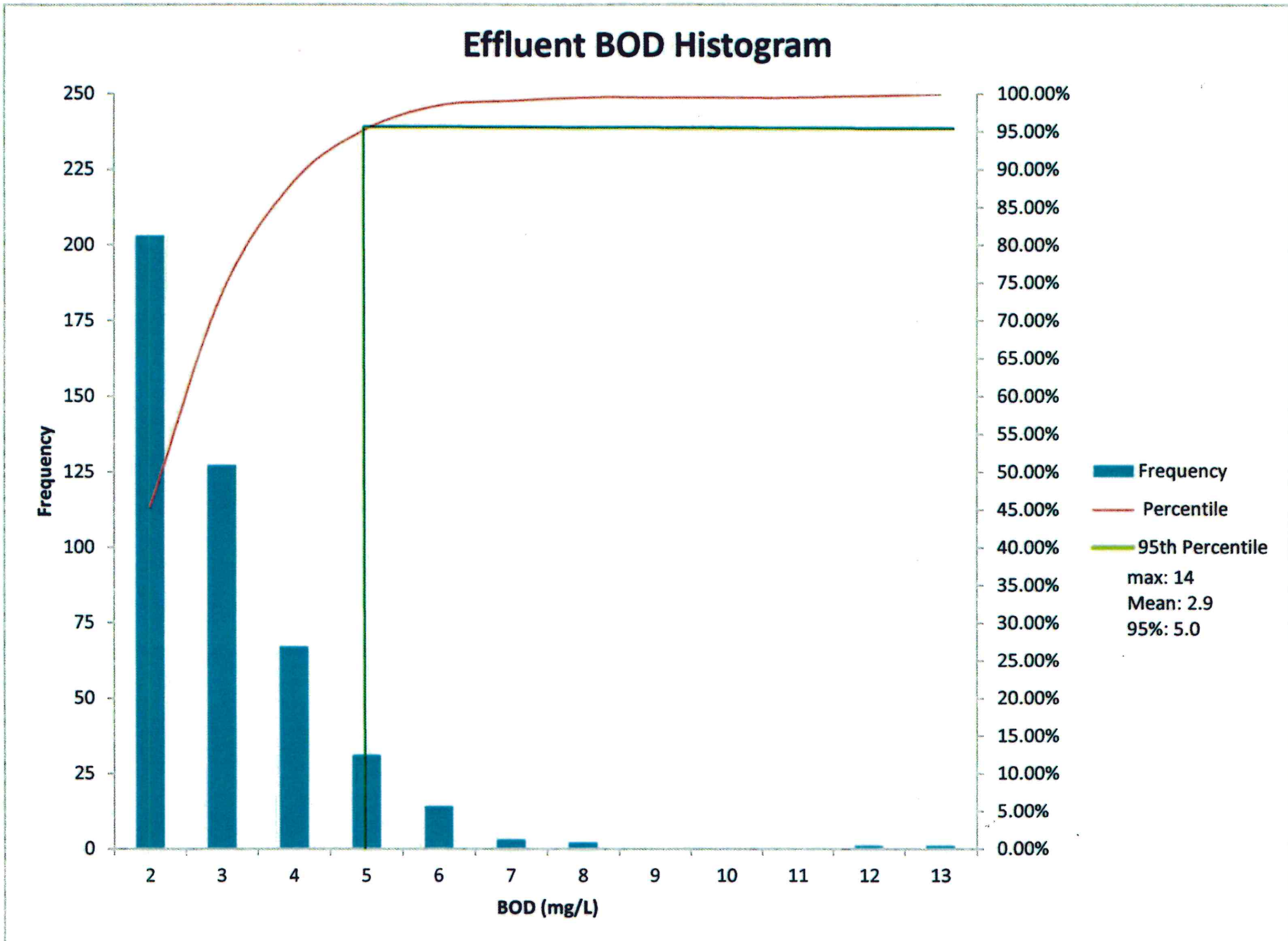
pH Histogram
Frequency
80
70
60
50
40
30
20
10
0
6
6.1
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
7
7.1
7.2
7.3
7.4
7.5
pH
100.00%
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Frequency
Cumulative %

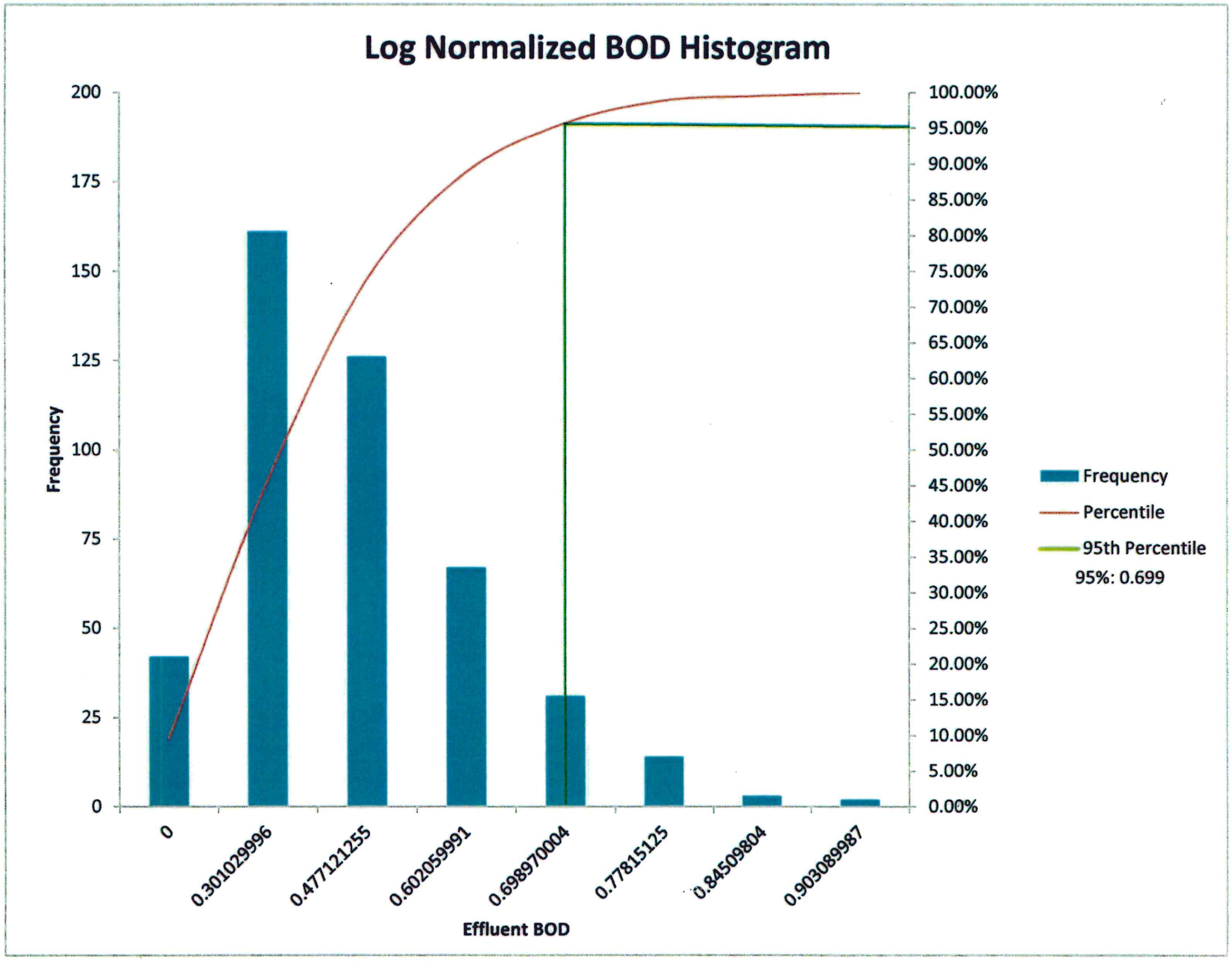


Effluent TSS Histogram
Frequency
100
90
80
70
60
50
40
30
20
10
0
1
1.9
2.8
3.7
4.6
5.5
6.4
7.3
8.2
9.1
10
10.9
11.8
12.7
13.6
14.5
15.4
16.3
17.2
18.1
TSS (mg/L)
100.00%
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Frequency
Percentile
95th Percentile
Max: 22
Mean: 6.27
95%: 13.0



Log Normalized TSS Histogram
Frequency
100
90
80
70
60
50
40
30
20
10
0
0.00 0.30 0.48 0.60 0.70 0.78 0.85 0.90 0.95 1.00 1.04 1.08 1.11 1.15 1.20 1.23 1.26 1.28
Effluent TSS
100.00%
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Frequency
Percentile
95th Percentile
95%: 1.11


Effluent BOD Histogram
Frequency
250
225
200
175
150
125
100
75
50
25
0
2
3
4
5
6
7
8
9
10
11
12
13
BOD (mg/L)
100.00%
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
Frequency
Percentile
95th Percentile
max: 14
Mean: 2.9
95%: 5.0


Log Normalized BOD Histogram
Frequency
200
175
150
125
100
75
50
25
0
100.00%
95.00%
90.00%
85.00%
80.00%
75.00%
70.00%
65.00%
60.00%
55.00%
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
0
0.301029996
0.477121255
0.602059991
0.698970004
0.77815125
0.84509804
0.903089987
Effluent BOD
Frequency
Percentile
95th Percentile
95%: 0.699

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CORMIX Model Results 3

CORMIX Model Results 3

```
CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORMIX MIXING ZONE EXPERT SYSTEM
                 Subsystem CORMIX1: Single Port Discharges
                         CORMIX Version 11.0GTH
                   HYDRO1 Version 11.0.0.0 April 2018
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       a.  Max Ebb Current, MHHW
 FILE NAME:         U:\...ixZn\Output\a MHHW max eb current 8 inch port.prd
 Time stamp:        09/06/2018--16:18:57

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =      4.11  HD    =       5.14
 Tidal Simulation at TIME =     -2.600 h
 PERIOD=     12.40 h UAmax =      1.000 dUa/dt=      0.288 (m/s)/h
 UA    =      0.750 F     =       0.020 USTAR =0.3712E-01
 UW    =      5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U          RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  =  RIGHT     DISTB =       1.00
 D0    =      0.203 A0    =       0.032 H0    =      0.31  SUB0  =      4.84
 THETA =     10.00  SIGMA =      90.00
 U0    =      3.258 Q0    =       0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02  GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS=  mg/l
 IPOLL =  1         KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00  M0    =0.3441E+00  J0    =0.1508E-01  SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =       3.66  Lm    =       0.78  Lb    =      0.04
                                        Lmp   =   99999.00  Lbp   =  99999.00
 Tidal:             Tu    =   0.1251 h  Lu    =     16.254  Lmin  =      0.180
 Tidal Cutoffs (m): lmax  =   2941.769  xmax  =   8370.000  ymax  =   219.432

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.13  R     =       4.34

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)        =   H2    1
 1  Applicable layer depth HS =    5.14   1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS=  mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   =  CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   2000.00  XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X         Y        Z         S       C         B        Uc        TT
      0.00      0.00     0.31      1.0 0.679E+01   0.10     3.258    .00000E+00

END OF MOD101: DISCHARGE MODULE
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:            THETAE=       9.95  SIGMAE=      84.47
  LE    =      0.26  XE    =       0.01  YE    =       0.26  ZE    =      0.35

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X         Y        Z         S       C         B        Uc        TT
      0.00      0.00     0.31      1.0 0.679E+01   0.10     3.258    .00000E+00
      0.01      0.26     0.35      1.0 0.679E+01   0.11     3.258    .12117E-01
** CMC HAS BEEN FOUND **
```

```
 The pollutant concentration in the plume falls below CMC value of 0.104E+01
   in the current prediction interval.
 This is the extent of the TOXIC DILUTION ZONE.
      3.49      1.95    0.78     10.0 0.678E+00   0.54    0.134   .37366E+01
      7.67      2.39    1.09     16.4 0.414E+00   0.70    0.078   .87385E+01
     11.87      2.63    1.41     22.3 0.304E+00   0.82    0.060   .13915E+02
     16.07      2.80    1.74     28.4 0.239E+00   0.93    0.049   .19177E+02
     20.21      2.92    2.07     34.6 0.196E+00   1.03    0.043   .24427E+02
     24.42      3.01    2.40     41.3 0.164E+00   1.13    0.038   .29779E+02
**WATER QUALITY STANDARD OR CCC HAS BEEN FOUND**
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.160E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     28.62      3.09    2.73     48.2 0.141E+00   1.22    0.034   .35161E+02
     32.82      3.14    3.04     55.4 0.123E+00   1.31    0.031   .40566E+02
     37.02      3.19    3.36     62.8 0.108E+00   1.40    0.028   .45990E+02
     41.17      3.23    3.66     70.3 0.965E-01   1.48    0.026   .51353E+02
 Cumulative travel time =          51.3532 sec  (     0.01 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

  Control volume inflow:
       X         Y       Z        S        C       B         TT
     41.17      3.23    3.66     69.4 0.978E-01   1.48 .51353E+02

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X         Y       Z        S        C       BV        BH       ZU       ZL       TT
     39.69      3.22    5.14     70.4 0.965E-01   0.00     0.00     5.14     5.14 .51353E+02
     40.14      3.22    5.14     70.4 0.965E-01   1.84     0.92     5.14     3.30 .51353E+02
     40.58      3.23    5.14     70.4 0.965E-01   2.18     1.31     5.14     2.96 .51353E+02
     41.03      3.23    5.14     70.3 0.965E-01   2.40     1.60     5.14     2.74 .51353E+02
     41.47      3.23    5.14     72.3 0.940E-01   2.56     1.85     5.14     2.58 .51748E+02
     41.92      3.23    5.14     81.2 0.836E-01   2.68     2.07     5.14     2.46 .52341E+02
     42.36      3.23    5.14     93.6 0.726E-01   2.77     2.26     5.14     2.37 .52933E+02
     42.80      3.24    5.14    104.8 0.648E-01   2.84     2.44     5.14     2.30 .53525E+02
     43.25      3.24    5.14    112.6 0.603E-01   2.88     2.61     5.14     2.26 .54118E+02
     43.69      3.24    5.14    116.8 0.582E-01   2.91     2.77     5.14     2.23 .54710E+02
     44.14      3.24    5.14    119.5 0.568E-01   2.92     2.92     5.14     2.22 .55302E+02
 Cumulative travel time =          55.3025 sec  (     0.02 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
-----------------------------------------------------------------------------------------------
BEGIN MOD141: BUOYANT AMBIENT SPREADING

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 1 (not bank attached):
       X         Y       Z        S        C       BV        BH       ZU       ZL       TT
     44.14      3.24    5.14    119.5 0.568E-01   2.92     2.92     5.14     2.22 .55302E+02
     46.78      3.24    5.14    121.4 0.559E-01   2.83     3.07     5.14     2.31 .58831E+02
     49.43      3.24    5.14    123.2 0.551E-01   2.75     3.21     5.14     2.39 .62360E+02
     52.08      3.24    5.14    125.0 0.543E-01   2.68     3.34     5.14     2.46 .65888E+02
     54.72      3.24    5.14    126.9 0.535E-01   2.61     3.48     5.14     2.53 .69417E+02
     57.37      3.24    5.14    128.7 0.528E-01   2.55     3.61     5.14     2.59 .72945E+02
     60.02      3.24    5.14    130.5 0.520E-01   2.50     3.74     5.14     2.64 .76474E+02
     62.66      3.24    5.14    132.4 0.513E-01   2.46     3.87     5.14     2.68 .80003E+02
     65.31      3.24    5.14    134.2 0.506E-01   2.41     4.00     5.14     2.73 .83531E+02
     67.95      3.24    5.14    136.1 0.499E-01   2.38     4.12     5.14     2.76 .87060E+02
     70.60      3.24    5.14    138.0 0.492E-01   2.34     4.24     5.14     2.80 .90588E+02
 Cumulative travel time =          90.5885 sec  (     0.03 hrs)

-----------------------------------------------------------------------------------------------
 Plume is ATTACHED to RIGHT bank/shore.
   Plume width is now determined from RIGHT bank/shore.

 Plume Stage 2 (bank attached):
       X         Y       Z        S        C       BV        BH       ZU       ZL       TT
     70.60     -1.00    5.14    138.0 0.492E-01   2.34     8.49     5.14     2.80 .90588E+02
     87.88     -1.00    5.14    147.9 0.459E-01   2.31     9.26     5.14     2.83 .11362E+03
```

```
   105.15    -1.00     5.14    158.8 0.428E-01   2.31     10.01     5.14     2.83 .13666E+03
   122.43    -1.00     5.14    170.9 0.397E-01   2.33     10.72     5.14     2.81 .15970E+03
   139.71    -1.00     5.14    184.2 0.369E-01   2.37     11.41     5.14     2.77 .18273E+03
   156.99    -1.00     5.14    198.9 0.341E-01   2.42     12.09     5.14     2.72 .20577E+03
   174.26    -1.00     5.14    214.9 0.316E-01   2.50     12.74     5.14     2.64 .22880E+03
   191.54    -1.00     5.14    232.3 0.292E-01   2.58     13.38     5.14     2.56 .25184E+03
   208.82    -1.00     5.14    251.1 0.270E-01   2.68     14.00     5.14     2.46 .27487E+03
   226.09    -1.00     5.14    271.5 0.250E-01   2.78     14.61     5.14     2.36 .29791E+03
   243.37    -1.00     5.14    293.3 0.232E-01   2.90     15.21     5.14     2.24 .32095E+03
 Cumulative travel time =         320.9453 sec  (     0.09 hrs)

END OF MOD141: BUOYANT AMBIENT SPREADING
-----------------------------------------------------------------------------------------------
 Bottom coordinate for FAR-FIELD is determined by average depth, ZFB =  1.03m
-----------------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)    = 0.383E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.565E-01 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X          Y        Z         S        C         BV        BH        ZU       ZL        TT
   243.37    -1.00     5.14    293.3 0.232E-01   2.90     15.21     5.14     2.24 .32095E+03
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
   419.03    -1.00     5.14    437.9 0.155E-01   4.11     16.60     5.14     1.03 .55516E+03
   594.70    -1.00     5.14    462.9 0.147E-01   4.11     18.02     5.14     1.03 .78938E+03
   770.36    -1.00     5.14    490.3 0.138E-01   4.11     19.49     5.14     1.03 .10236E+04
   946.02    -1.00     5.14    520.1 0.131E-01   4.11     20.99     5.14     1.03 .12578E+04
  1121.68    -1.00     5.14    552.2 0.123E-01   4.11     22.54     5.14     1.03 .14920E+04
  1297.35    -1.00     5.14    586.3 0.116E-01   4.11     24.11     5.14     1.03 .17262E+04
  1473.01    -1.00     5.14    622.6 0.109E-01   4.11     25.72     5.14     1.03 .19605E+04
  1648.67    -1.00     5.14    660.9 0.103E-01   4.11     27.37     5.14     1.03 .21947E+04
  1824.34    -1.00     5.14    701.2 0.968E-02   4.11     29.05     5.14     1.03 .24289E+04
  2000.00    -1.00     5.14    743.5 0.913E-02   4.11     30.76     5.14     1.03 .26631E+04
 Cumulative travel time =       2663.1201 sec  (     0.74 hrs)

 Simulation limit based on maximum specified distance =    2000.00 m.
   This is the REGION OF INTEREST limitation.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
```

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  a.  Max Ebb Current, MHHW
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\a MHHW max eb current 8 inch port.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:18:57
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                            = unbounded
  Average depth                 HA         = 4.11 m
  Depth at discharge            HD         = 5.14 m
  Darcy-Weisbach friction factor F         = 0.0196
    Calculated from Manning's n            = 0.02
  Wind velocity                 UW         = 5.7 m/s
TIDAL SIMULATION at time        Tsim       = -2.6 hours
  Instantaneous ambient velocity UA        = 0.75 m/s
  Maximum tidal velocity        UaMAX      = 1 m/s
Rate of tidal reversal         dUA/dt = 0.2885 (m/s)/hour
  Period of reversal            T          = 12.4 hours
  Stratification Type           STRCND = U
  Surface density               RHOAS      = 1012.74 kg/m^3
  Bottom density                RHOAB      = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:           Single Port Discharge
  Nearest bank                             = right
  Distance to bank              DISTB      = 1 m
  Port diameter                 D0         = 0.2032 m
  Port cross-sectional area     A0         = 0.0324 m^2
  Discharge velocity            U0         = 3.26 m/s
  Discharge flowrate            Q0         = 0.10564 m^3/s
  Discharge port height         H0         = 0.31 m
  Vertical discharge angle      THETA      = 10 deg
  Horizontal discharge angle    SIGMA      = 90 deg
  Discharge density             RHO0       = 998 kg/m^3
  Density difference            DRHO       = 14.7400 kg/m^3
  Buoyant acceleration          GP0        = 0.1427 m/s^2
  Discharge concentration       C0         = 6.79 mg/l
  Surface heat exchange coeff.  KS         = 0 m/s
  Coefficient of decay          KD         = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m          Lm  = 0.78 m          Lb  = 0.04 m
  LM  = 3.66 m          Lm' = 99999 m         Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.1251 hours     Lu  = 16.25 m         Lmin= 0.18 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0      = 19.13
  Velocity ratio                  R        = 4.34
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                          = yes
  CMC concentration             CMC        = 1.04 mg/l
  CCC concentration             CCC        = 0.16 mg/l
  Water quality standard specified         = given by CCC value
  Regulatory mixing zone                   = no
  Region of interest                       = 2000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS    = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 5.14 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0568 mg/l
  Dilution at edge of NFR              s = 119.5
  NFR Location:                        x = 44.14 m
    (centerline coordinates)           y = 3.24 m
                                       z = 5.14 m
```

```
  NFR plume dimensions:  half-width (bh) = 2.92 m
                          thickness (bv) = 2.92 m
Cumulative travel time:      55.3024 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 419.03 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 70.60 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
  Within the region of interest (ROI), the location and trajectory of flow
  are well represented using steady-state analysis and are not limited by
  any tidal restrictions.
  For this condition BEFORE TIDAL REVERSAL, extensive re-entrainment
  of previously discharged is unlikely.
  To determine the minimum dilution, perform additional simulations
  after slack tide.
*********************** TOXIC DILUTION ZONE SUMMARY ***********************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                      x = 1.71 m
    (centerline coordinates)           y = 1.61 m
                                       z = 0.64 m
  Plume dimension:       half-width (bh) = 0.06 m
                          thickness (bv) = 0.06 m

 Computed distance from port opening to CMC location = 2.37 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
            Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.35 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
            HD = 5.14 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                    = 0.16  mg/l
Corresponding dilution                   = 42.4
  Plume location:                      x = 25.13 m
    (centerline coordinates)           y = 3.03 m
                                       z = 2.46 m
 Computed horizontal distance from port opening to CCC location = 25.40
  Plume dimension:       half-width (bh) = 1.14 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                       CORMIX MIXING ZONE EXPERT SYSTEM
                   Subsystem CORMIX1: Single Port Discharges
                             CORMIX Version 11.0GTH
                     HYDRO1 Version 11.0.0.0 April 2018
----------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       b. mid High and Low Slack
 FILE NAME:         U:\...mid High and Low Slack single diff 8inch port.prd
 Time stamp:        09/06/2018--16:21:12

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =    116.00 AS    =    476.76 QA    =    238.38 ICHREG= 1
 HA    =      4.11 HD    =      4.11
 Tidal Simulation at TIME =    -1.100 h
 PERIOD=    12.40 h UAmax =     1.000 dUa/dt=     0.455 (m/s)/h
 UA    =     0.500 F     =     0.020 USTAR =0.2475E-01
 UW    =     5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U         RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  = RIGHT     DISTB =      1.00
 D0    =     0.203 A0    =     0.032 H0    =      0.30 SUB0  =      3.81
 THETA =     10.00 SIGMA =     90.00
 U0    =     3.257 Q0    =     0.106       =0.1056E+00
 RHO0  =  998.0000 DRHO0 =0.1474E+02 GP0   =0.1427E+00
 C0    =0.6790E+01 CUNITS= mg/l
 IPOLL = 1         KS    =0.0000E+00 KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00 M0    =0.3440E+00 J0    =0.1507E-01 SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18 LM    =      3.66 Lm    =      1.17 Lb    =      0.12
                                     Lmp   =  99999.00 Lbp   =  99999.00
 Tidal:            Tu    =  0.0924 h Lu    =    13.966 Lmin  =     0.180
 Tidal Cutoffs (m): lmax =   869.798 xmax  =  5580.000 ymax  =**********

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12 R     =      6.51

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    H2     1
 1  Applicable layer depth HS =    4.11   1
 1  Limiting Dilution S =QA/Q0= 2258.11   1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01 CUNITS= mg/l
 NTOX  = 1         CMC   =0.1040E+01 CCC   = CSTD
 NSTD  = 1         CSTD  =0.1600E+00
 REGMZ = 0
 XINT  =   2000.00 XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
----------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y       Z        S       C        B        Uc        TT
     0.00     0.00    0.30     1.0 0.679E+01   0.10     3.257   .00000E+00

END OF MOD101: DISCHARGE MODULE
----------------------------------------------------------------------------------------------
----------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:            THETAE=      9.98 SIGMAE=     86.31
  LE    =      0.51 XE    =      0.02 YE    =      0.51 ZE    =      0.39

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X        Y       Z        S       C        B        Uc        TT
     0.00     0.00    0.30     1.0 0.679E+01   0.10     3.257   .00000E+00
```

```
      0.02      0.51     0.39      1.0 0.679E+01   0.11     3.257   .94232E-02
      0.86      2.00     0.71      4.4 0.154E+01   0.40     0.599   .10613E+01
** CMC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below CMC value of 0.104E+01
   in the current prediction interval.
 This is the extent of the TOXIC DILUTION ZONE.
      2.50      2.70     0.95      9.2 0.739E+00   0.62     0.217   .33516E+01
      4.29      3.09     1.17     13.3 0.512E+00   0.75     0.140   .61743E+01
      6.07      3.35     1.39     16.9 0.402E+00   0.86     0.110   .91208E+01
      7.89      3.55     1.62     20.5 0.331E+00   0.95     0.092   .12239E+02
      9.68      3.71     1.85     24.0 0.282E+00   1.03     0.081   .15355E+02
     11.51      3.84     2.08     27.7 0.245E+00   1.11     0.073   .18591E+02
     13.30      3.94     2.31     31.4 0.216E+00   1.19     0.067   .21794E+02
     15.13      4.03     2.55     35.3 0.193E+00   1.26     0.062   .25100E+02
     16.93      4.11     2.78     39.1 0.174E+00   1.33     0.057   .28346E+02
 Cumulative travel time =          28.3460 sec  (     0.01 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

  Control volume inflow:
       X         Y        Z         S         C         B         TT
     16.93      4.11     2.78     39.0 0.174E+00   1.33 .28346E+02

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X         Y        Z         S         C        BV        BH       ZU       ZL         TT
     15.60      4.08     4.11     39.1 0.174E+00   0.00      0.00     4.11     4.11 .28346E+02
     16.00      4.09     4.11     39.1 0.174E+00   1.67      0.84     4.11     2.44 .28346E+02
     16.39      4.10     4.11     39.1 0.174E+00   1.98      1.19     4.11     2.13 .28346E+02
     16.79      4.10     4.11     39.1 0.174E+00   2.18      1.45     4.11     1.93 .28346E+02
     17.19      4.11     4.11     40.2 0.169E+00   2.32      1.68     4.11     1.79 .28879E+02
**WATER QUALITY STANDARD OR CCC HAS BEEN FOUND**
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.160E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     17.59      4.12     4.11     45.2 0.150E+00   2.43      1.88     4.11     1.68 .29676E+02
     17.99      4.13     4.11     52.1 0.130E+00   2.52      2.06     4.11     1.59 .30473E+02
     18.39      4.13     4.11     58.3 0.116E+00   2.58      2.22     4.11     1.53 .31269E+02
     18.79      4.14     4.11     62.6 0.108E+00   2.62      2.37     4.11     1.49 .32066E+02
     19.18      4.15     4.11     65.0 0.105E+00   2.65      2.52     4.11     1.46 .32863E+02
     19.58      4.16     4.11     66.5 0.102E+00   2.65      2.65     4.11     1.46 .33660E+02
 Cumulative travel time =          33.6603 sec  (     0.01 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
-----------------------------------------------------------------------------------------------
BEGIN MOD141: BUOYANT AMBIENT SPREADING

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 1 (not bank attached):
       X         Y        Z         S         C        BV        BH       ZU       ZL         TT
     19.58      4.16     4.11     66.5 0.102E+00   2.65      2.65     4.11     1.46 .33660E+02
     22.43      4.16     4.11     68.3 0.994E-01   2.46      2.95     4.11     1.65 .39344E+02
     25.27      4.16     4.11     70.0 0.970E-01   2.30      3.23     4.11     1.81 .45028E+02
     28.11      4.16     4.11     71.5 0.950E-01   2.17      3.50     4.11     1.94 .50712E+02
     30.96      4.16     4.11     72.9 0.931E-01   2.06      3.76     4.11     2.05 .56396E+02
     33.80      4.16     4.11     74.3 0.914E-01   1.97      4.01     4.11     2.14 .62079E+02
     36.64      4.16     4.11     75.5 0.899E-01   1.89      4.25     4.11     2.22 .67763E+02
     39.48      4.16     4.11     76.8 0.884E-01   1.82      4.49     4.11     2.29 .73447E+02
     42.33      4.16     4.11     78.0 0.871E-01   1.76      4.72     4.11     2.35 .79131E+02
     45.17      4.16     4.11     79.1 0.858E-01   1.71      4.94     4.11     2.40 .84815E+02
     48.01      4.16     4.11     80.3 0.846E-01   1.66      5.16     4.11     2.45 .90498E+02
 Cumulative travel time =          90.4984 sec  (     0.03 hrs)

-----------------------------------------------------------------------------------------------
 Plume is ATTACHED to RIGHT bank/shore.
   Plume width is now determined from RIGHT bank/shore.

 Plume Stage 2 (bank attached):
       X         Y        Z         S         C        BV        BH       ZU       ZL         TT
```

```
   48.01    -1.00    4.11    80.3 0.846E-01  1.66    10.32    4.11    2.45 .90498E+02
  115.45    -1.00    4.11    99.7 0.681E-01  1.44    14.97    4.11    2.67 .22531E+03
  182.89    -1.00    4.11   126.7 0.536E-01  1.45    18.97    4.11    2.66 .36013E+03
  250.33    -1.00    4.11   163.4 0.416E-01  1.59    22.59    4.11    2.52 .49494E+03
  317.76    -1.00    4.11   211.1 0.322E-01  1.80    25.93    4.11    2.31 .62976E+03
  385.20    -1.00    4.11   270.9 0.251E-01  2.07    29.08    4.11    2.04 .76457E+03
  452.64    -1.00    4.11   343.4 0.198E-01  2.40    32.06    4.11    1.71 .89939E+03
  520.08    -1.00    4.11   429.3 0.158E-01  2.77    34.90    4.11    1.34 .10342E+04
  587.51    -1.00    4.11   529.4 0.128E-01  3.18    37.64    4.11    0.93 .11690E+04
  654.95    -1.00    4.11   644.1 0.105E-01  3.63    40.28    4.11    0.48 .13038E+04
  722.39    -1.00    4.11   774.0 0.877E-02  4.11    42.84    4.11    0.00 .14387E+04
 Cumulative travel time =        1438.6505 sec  (    0.40 hrs)

END OF MOD141: BUOYANT AMBIENT SPREADING
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.205E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.256E-01 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X         Y       Z        S       C        BV       BH      ZU      ZL       TT
  722.39    -1.00    4.11   774.0 0.877E-02  4.11    42.84    4.11    0.00 .14387E+04
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
  850.15    -1.00    4.11   774.8 0.876E-02  4.11    43.08    4.11    0.00 .16941E+04
  869.79    -1.00    4.11   775.1 0.876E-02  4.11    43.12    4.11    0.00 .17333E+04
 Cumulative travel time =        1733.3184 sec  (    0.48 hrs)

 CORMIX simulation has been TERMINATED at last prediction interval.
   Limiting distance (lmax) due to TIDAL REVERSAL has been reached.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
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```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                     CORMIX MIXING ZONE EXPERT SYSTEM
                         CORMIX Version 11.0GTH
                      HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  b. mid High and Low Slack
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\b mid High and Low Slack single diff 8inch port.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:21:12
****************************************************************************
SUMMARY OF INPUT DATA:
----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = bounded
  Width                          BS      = 116 m
  Channel regularity             ICHREG  = 1
  Ambient flowrate               QA      = 238.38 m^3/s
  Average depth                  HA      = 4.11 m
  Depth at discharge             HD      = 4.11 m
  Darcy-Weisbach friction factor F       = 0.0196
    Calculated from Manning's n          = 0.02
  Wind velocity                  UW      = 5.7 m/s
TIDAL SIMULATION at time         Tsim    = -1.1 hours
  Instantaneous ambient velocity UA      = 0.5 m/s
  Maximum tidal velocity         UaMAX   = 1 m/s
Rate of tidal reversal         dUA/dt = 0.4545 (m/s)/hour
  Period of reversal             T       = 12.4 hours
  Stratification Type            STRCND  = U
  Surface density                RHOAS   = 1012.74 kg/m^3
  Bottom density                 RHOAB   = 1012.74 kg/m^3
----------------------------------------------------------------------------
DISCHARGE PARAMETERS:            Single Port Discharge
  Nearest bank                           = right
  Distance to bank               DISTB   = 1 m
  Port diameter                  D0      = 0.2032 m
  Port cross-sectional area      A0      = 0.0324 m^2
  Discharge velocity             U0      = 3.26 m/s
  Discharge flowrate             Q0      = 0.105613 m^3/s
  Discharge port height          H0      = 0.30 m
  Vertical discharge angle       THETA   = 10 deg
  Horizontal discharge angle     SIGMA   = 90 deg
  Discharge density              RHO0    = 998 kg/m^3
  Density difference             DRHO    = 14.7400 kg/m^3
  Buoyant acceleration           GP0     = 0.1427 m/s^2
  Discharge concentration        C0      = 6.79 mg/l
  Surface heat exchange coeff.   KS      = 0 m/s
  Coefficient of decay           KD      = 0 /s
----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m        Lm  = 1.17 m          Lb  = 0.12 m
  LM  = 3.66 m        Lm' = 99999 m          Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.0924 hours     Lu  = 13.97 m          Lmin= 0.18 m
----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0    = 19.12
  Velocity ratio                  R      = 6.51
----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = yes
  CMC concentration              CMC     = 1.04 mg/l
  CCC concentration              CCC     = 0.16 mg/l
  Water quality standard specified       = given by CCC value
  Regulatory mixing zone                 = no
  Region of interest                     = 2000 m downstream
****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS    = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 4.11 m

  Limiting Dilution S = (QA/Q0)+ 1.0 = 2258.1

****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
```

```
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.1021 mg/l
  Dilution at edge of NFR              s = 66.5
  NFR Location:                        x = 19.58 m
    (centerline coordinates)           y = 4.16 m
                                       z = 4.11 m
  NFR plume dimensions:  half-width (bh) = 2.65 m
                         thickness (bv) = 2.65 m
Cumulative travel time:       33.6603 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 850.15 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section contacts one bank only at 48.01 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                       x = 869.79 m
                                       y = -1 m
                                       z = 4.11 m.
  For this condition BEFORE TIDAL REVERSAL, extensive re-entrainment
  of previously discharged is unlikely.
  To determine the minimum dilution, perform additional simulations
  after slack tide.
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                      x = 1.51 m
    (centerline coordinates)           y = 2.36 m
                                       z = 0.82 m
  Plume dimension:       half-width (bh) = 0.04 m
                         thickness (bv) = 0.04 m

 Computed distance from port opening to CMC location = 2.85 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.80 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 4.11 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                    = 0.16  mg/l
Corresponding dilution                   = 42.6
  Plume location:                      x = 17.38 m
    (centerline coordinates)           y = 4.12 m
                                       z = 4.11 m
 Computed horizontal distance from port opening to CCC location = 18.26
  Plume dimensions:      half-width (bh) = 1.77 m
                         thickness (bv) = 2.38 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                       CORMIX MIXING ZONE EXPERT SYSTEM
                   Subsystem CORMIX1: Single Port Discharges
                             CORMIX Version 11.0GTH
                     HYDRO1 Version 11.0.0.0 April 2018
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       c. Low Slack
 FILE NAME:         U:\...Zn\Output\c Low Slack single diff 8 inch port.prd
 Time stamp:        09/06/2018--16:25:41

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =      4.11  HD    =      3.14
 UA    =     0.000  F     =     0.020 USTAR =0.0000E+00
 UW    =     5.700  UWSTAR=0.6815E-02
 Uniform density environment
 STRCND=  U         RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  =  RIGHT     DISTB =      1.00
 D0    =     0.203  A0    =     0.032 H0    =      0.60  SUB0  =      2.54
 THETA =     10.00  SIGMA =     90.00
 U0    =     3.257  Q0    =     0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02  GP0  =0.1427E+00
 C0    =0.6790E+01  CUNITS=  mg/l
 IPOLL =  1         KS    =0.0000E+00  KD   =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00  M0    =0.3440E+00  J0    =0.1507E-01  SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =      3.66  Lm    =  99999.00  Lb    =  99999.00
                                       Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12  R     =  99999.00

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)       =    H4-90  1
 1  Applicable layer depth HS =     3.14   1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS=  mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   =  CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   2000.00  XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z         S       C        B        Uc        TT
      0.00     0.00     0.60      1.0 0.679E+01   0.10     3.257   .00000E+00

END OF MOD101: DISCHARGE MODULE
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in weak crossflow.

 Zone of flow establishment:             THETAE=     10.00  SIGMAE=     90.00
  LE    =      1.02  XE    =      0.00  YE    =      1.00  ZE    =      0.78

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X        Y        Z         S       C        B        Uc        TT
      0.00     0.00     0.60      1.0 0.679E+01   0.10     3.257   .00000E+00
      0.00     1.00     0.78      1.0 0.679E+01   0.10     3.257   .58365E-02
      0.00     1.49     0.87      1.3 0.519E+01   0.16     2.946   .14714E+00
      0.00     2.00     0.97      1.8 0.380E+01   0.22     2.169   .35806E+00
      0.00     2.51     1.09      2.3 0.300E+01   0.27     1.720   .63221E+00
      0.00     3.04     1.22      2.8 0.245E+01   0.33     1.417   .98723E+00
      0.00     3.54     1.38      3.3 0.208E+01   0.39     1.217   .13881E+01
```

```
     0.00      4.04     1.55      3.8 0.180E+01   0.45     1.071   .18486E+01
     0.00      4.50     1.73      4.3 0.159E+01   0.50     0.965   .23394E+01
     0.00      4.97     1.95      4.8 0.141E+01   0.56     0.877   .29099E+01
     0.00      5.44     2.19      5.4 0.127E+01   0.61     0.808   .35327E+01
     0.00      5.89     2.46      5.9 0.114E+01   0.67     0.753   .42047E+01
 Cumulative travel time =          4.2047 sec  (     0.00 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

  Control volume inflow:
      X         Y        Z         S        C         B         TT
     0.00      5.89     2.46      5.9 0.114E+01   0.67 .42047E+01

 Profile definitions:
   BV = Gaussian 1/e (37%) vertical thickness
   BH = Gaussian 1/e (37%) horizontal half-width, normal to trajectory
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

      X         Y        Z         S        C        BV        BH       ZU       ZL        TT
    -0.01      5.89     3.14      5.9 0.114E+01   0.00      0.00     3.14     3.14 .42047E+01
    -0.01      6.02     3.14      6.0 0.113E+01   0.60      0.30     3.14     2.54 .45056E+01
    -0.01      6.16     3.14      6.1 0.111E+01   0.71      0.42     3.14     2.43 .48074E+01
    -0.01      6.29     3.14      6.3 0.108E+01   0.78      0.52     3.14     2.36 .51092E+01
    -0.01      6.42     3.14      6.5 0.105E+01   0.83      0.60     3.14     2.31 .54110E+01
** CMC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below CMC value of 0.104E+01
   in the current prediction interval.
 This is the extent of the TOXIC DILUTION ZONE.
    -0.00      6.56     3.14      6.7 0.102E+01   0.87      0.67     3.14     2.27 .57128E+01
    -0.00      6.69     3.14      6.8 0.993E+00   0.90      0.73     3.14     2.24 .60146E+01
    -0.00      6.83     3.14      6.9 0.977E+00   0.92      0.79     3.14     2.22 .63164E+01
    -0.00      6.96     3.14      7.0 0.967E+00   0.94      0.85     3.14     2.20 .66182E+01
    -0.00      7.09     3.14      7.1 0.961E+00   0.95      0.90     3.14     2.19 .69199E+01
     0.00      7.23     3.14      7.1 0.954E+00   0.95      0.95     3.14     2.19 .72217E+01
 Cumulative travel time =          7.2217 sec  (     0.00 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
 Discharge into STAGNANT AMBIENT environment:
   STEADY-STATE MIXING CONDITION IS NOT POSSIBLE in this zone, even though
   some ADDITIONAL DILUTION MAY OCCUR!
   Also, all far-field processes will be UNSTEADY.
 SIMULATION STOPS because of stagnant ambient conditions.
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                     CORMIX MIXING ZONE EXPERT SYSTEM
                         CORMIX Version 11.0GTH
                      HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:            Bay City Outfall
  DESIGN CASE:              c. Low Slack
  FILE NAME:                U:\rstillmaker\2018\BayCityMixZn\Output\c Low Slack single diff 8 inch port.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:         09/06/2018--16:25:41
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                           = unbounded
  Average depth                   HA      = 4.11 m
  Depth at discharge              HD      = 3.14 m
  Ambient velocity                UA      = 0 m/s
  Darcy-Weisbach friction factor  F       = 0.0196
    Calculated from Manning's n           = 0.02
  Wind velocity                   UW      = 5.7 m/s
  Stratification Type             STRCND = U
  Surface density                 RHOAS  = 1012.74 kg/m^3
  Bottom density                  RHOAB  = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Single Port Discharge
  Nearest bank                            = right
  Distance to bank                DISTB  = 1 m
  Port diameter                   D0      = 0.2032 m
  Port cross-sectional area       A0      = 0.0324 m^2
  Discharge velocity              U0      = 3.26 m/s
  Discharge flowrate              Q0      = 0.105613 m^3/s
  Discharge port height           H0      = 0.6 m
  Vertical discharge angle        THETA  = 10 deg
  Horizontal discharge angle      SIGMA  = 90 deg
  Discharge density               RHO0   = 998 kg/m^3
  Density difference              DRHO   = 14.7400 kg/m^3
  Buoyant acceleration            GP0    = 0.1427 m/s^2
  Discharge concentration         C0     = 6.79 mg/l
  Surface heat exchange coeff.    KS     = 0 m/s
  Coefficient of decay            KD     = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m        Lm  = 99999 m        Lb  = 99999 m
  LM  = 3.66 m        Lm' = 99999 m        Lb' = 99999 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0    = 19.12
  Velocity ratio                  R      = 99999
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = yes
  CMC concentration               CMC    = 1.04 mg/l
  CCC concentration               CCC    = 0.16 mg/l
  Water quality standard specified       = given by CCC value
  Regulatory mixing zone                 = no
  Region of interest                     = 2000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H4-90 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 3.14 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.9543 mg/l
  Dilution at edge of NFR              s = 7.1
  NFR Location:                        x = 0 m
    (centerline coordinates)           y = 7.23 m
                                       z = 3.14 m
  NFR plume dimensions:  half-width (bh) = 0.95 m
                         thickness (bv) = 0.95 m
Cumulative travel time:       7.2217 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
```

```
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Because of the specified STAGNANT ambient conditions, there exists
  no steady-state far-field for this discharge.
  Unsteady circulations and pollutant buid-up may result in the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section does not contact bank in this simulation.
************************ TOXIC DILUTION ZONE SUMMARY ***********************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                       x = -0.01 m
    (centerline coordinates)            y = 6.45 m
                                        z = 3.14 m
  Plume dimension:        half-width (bh) = 0.61 m
                           thickness (bv) = 0.84 m

 Computed distance from port opening to CMC location = 6.93 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 6.45 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 3.14 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
The CCC for the toxic pollutant was not encountered within the predicted
  plume region.
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                     CORMIX MIXING ZONE EXPERT SYSTEM
                  Subsystem CORMIX1: Single Port Discharges
                        CORMIX Version 11.0GTH
                   HYDRO1 Version 11.0.0.0 April 2018
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       d. MLLW
 FILE NAME:         U:\...r\2018\BayCityMixZn\Output\d MLLW 8 inch port.prd
 Time stamp:        09/06/2018--16:29:52

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =     3.60  HD    =       2.74
 Tidal Simulation at TIME =      2.000 h
 PERIOD=    12.40 h UAmax =      1.000 dUa/dt=      0.400 (m/s)/h
 UA    =     0.800 F     =       0.020 USTAR =0.4048E-01
 UW    =     5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U         RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  = RIGHT     DISTB =       1.00
 D0    =     0.203 A0    =       0.032 H0    =       0.31  SUB0  =       2.43
 THETA =    10.00  SIGMA =      90.00
 U0    =     3.257 Q0    =       0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02 GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS= mg/l
 IPOLL = 1         KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00  M0    =0.3440E+00  J0    =0.1507E-01  SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =     0.18  LM    =       3.66  Lm    =       0.73  Lb    =       0.03
                                       Lmp   =   99999.00  Lbp   =   99999.00
 Tidal:            Tu    =   0.1006 h  Lu    =     14.574  Lmin  =      0.180
 Tidal Cutoffs (m): lmax  =  2246.170  xmax  =    916.732  ymax  =    196.744

NON-DIMENSIONAL PARAMETERS
 FR0   =    19.12  R     =       4.07

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    H2    1
 1  Applicable layer depth HS =    2.74  1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS= mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   = CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   2000.00  XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y       Z        S       C        B        Uc        TT
     0.00     0.00    0.31     1.0 0.679E+01  0.10    3.257   .00000E+00

END OF MOD101: DISCHARGE MODULE
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:            THETAE=      9.95  SIGMAE=     84.10
  LE    =      0.21  XE    =       0.01  YE    =       0.21  ZE    =       0.34

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X        Y       Z        S       C        B        Uc        TT
     0.00     0.00    0.31     1.0 0.679E+01  0.10    3.257   .00000E+00
     0.01     0.21    0.34     1.0 0.679E+01  0.11    3.257   .62826E-02
     1.33     1.37    0.58     5.5 0.124E+01  0.38    0.288   .12392E+01
```

```
** CMC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below CMC value of 0.104E+01
   in the current prediction interval.
 This is the extent of the TOXIC DILUTION ZONE.
      3.20      1.76    0.72      9.2 0.737E+00   0.51    0.137   .32194E+01
      5.07      2.00    0.85     12.1 0.559E+00   0.58    0.098   .53055E+01
      6.98      2.17    0.98     14.8 0.459E+00   0.65    0.080   .74779E+01
      8.89      2.30    1.11     17.3 0.392E+00   0.70    0.068   .96832E+01
     10.77      2.40    1.25     19.8 0.343E+00   0.75    0.061   .11879E+02
     12.68      2.49    1.38     22.3 0.304E+00   0.80    0.055   .14123E+02
     14.59      2.57    1.52     24.9 0.273E+00   0.85    0.050   .16380E+02
     16.47      2.63    1.66     27.4 0.248E+00   0.89    0.047   .18615E+02
     18.39      2.69    1.80     30.0 0.226E+00   0.93    0.043   .20869E+02
 Cumulative travel time =          20.8685 sec  (    0.01 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

  Control volume inflow:
       X         Y        Z         S         C        B       TT
     18.39      2.69    1.80     29.5 0.230E+00   0.93 .20869E+02

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X         Y        Z         S         C       BV        BH       ZU       ZL        TT
     17.45      2.67    2.74     30.0 0.226E+00   0.00      0.00     2.74     2.74 .20869E+02
     17.73      2.68    2.74     30.0 0.226E+00   1.16      0.59     2.74     1.58 .20869E+02
     18.01      2.68    2.74     30.0 0.226E+00   1.38      0.83     2.74     1.36 .20869E+02
     18.29      2.68    2.74     30.0 0.226E+00   1.52      1.01     2.74     1.22 .20869E+02
     18.57      2.69    2.74     30.8 0.220E+00   1.62      1.17     2.74     1.12 .21103E+02
     18.85      2.69    2.74     34.6 0.196E+00   1.70      1.31     2.74     1.04 .21453E+02
     19.13      2.70    2.74     39.9 0.170E+00   1.76      1.43     2.74     0.98 .21804E+02
**WATER QUALITY STANDARD OR CCC HAS BEEN FOUND**
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.160E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     19.42      2.70    2.74     44.7 0.152E+00   1.80      1.55     2.74     0.94 .22154E+02
     19.70      2.70    2.74     48.0 0.142E+00   1.83      1.66     2.74     0.91 .22505E+02
     19.98      2.71    2.74     49.8 0.136E+00   1.85      1.76     2.74     0.89 .22855E+02
     20.26      2.71    2.74     50.9 0.133E+00   1.85      1.85     2.74     0.89 .23206E+02
 Cumulative travel time =          23.2059 sec  (    0.01 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH
-----------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
-----------------------------------------------------------------------------------------
BEGIN MOD141: BUOYANT AMBIENT SPREADING

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 1 (not bank attached):
       X         Y        Z         S         C       BV        BH       ZU       ZL        TT
     20.26      2.71    2.74     50.9 0.133E+00   1.85      1.85     2.74     0.89 .23206E+02
     23.86      2.71    2.74     52.6 0.129E+00   1.71      2.07     2.74     1.03 .27709E+02
     27.46      2.71    2.74     54.2 0.125E+00   1.61      2.28     2.74     1.13 .32212E+02
     31.06      2.71    2.74     55.8 0.122E+00   1.53      2.48     2.74     1.21 .36716E+02
     34.67      2.71    2.74     57.4 0.118E+00   1.46      2.67     2.74     1.28 .41219E+02
     38.27      2.71    2.74     59.0 0.115E+00   1.41      2.86     2.74     1.33 .45722E+02
     41.87      2.71    2.74     60.7 0.112E+00   1.37      3.04     2.74     1.37 .50225E+02
     45.47      2.71    2.74     62.4 0.109E+00   1.34      3.21     2.74     1.40 .54729E+02
     49.08      2.71    2.74     64.2 0.106E+00   1.31      3.38     2.74     1.43 .59232E+02
     52.68      2.71    2.74     66.1 0.103E+00   1.29      3.55     2.74     1.45 .63735E+02
     56.28      2.71    2.74     68.0 0.999E-01   1.27      3.71     2.74     1.47 .68238E+02
 Cumulative travel time =          68.2382 sec  (    0.02 hrs)

-----------------------------------------------------------------------------------------
 Plume is ATTACHED to RIGHT bank/shore.
   Plume width is now determined from RIGHT bank/shore.

 Plume Stage 2 (bank attached):
       X         Y        Z         S         C       BV        BH       ZU       ZL        TT
     56.28     -1.00    2.74     68.0 0.999E-01   1.27      7.42     2.74     1.47 .68238E+02
     67.12     -1.00    2.74     73.1 0.929E-01   1.30      7.90     2.74     1.44 .81789E+02
```

```
     77.96     -1.00     2.74      78.7 0.863E-01   1.33      8.36     2.74      1.41 .95340E+02
     88.80     -1.00     2.74      84.8 0.801E-01   1.37      8.81     2.74      1.37 .10889E+03
     99.65     -1.00     2.74      91.4 0.743E-01   1.42      9.24     2.74      1.32 .12244E+03
    110.49     -1.00     2.74      98.5 0.689E-01   1.48      9.67     2.74      1.26 .13599E+03
    121.33     -1.00     2.74     106.2 0.639E-01   1.54     10.09     2.74      1.20 .14954E+03
    132.17     -1.00     2.74     114.4 0.594E-01   1.61     10.50     2.74      1.13 .16309E+03
    143.01     -1.00     2.74     123.1 0.551E-01   1.68     10.90     2.74      1.06 .17664E+03
    153.85     -1.00     2.74     132.5 0.513E-01   1.75     11.29     2.74      0.99 .19020E+03
    164.69     -1.00     2.74     142.3 0.477E-01   1.84     11.68     2.74      0.90 .20375E+03
 Cumulative travel time =          203.7466 sec  (     0.06 hrs)

END OF MOD141: BUOYANT AMBIENT SPREADING
-----------------------------------------------------------------------------------------------
 Bottom coordinate for FAR-FIELD is determined by average depth, ZFB = -0.86m
-----------------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.222E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.397E-01 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X         Y        Z         S        C        BV       BH        ZU        ZL        TT
    164.69     -1.00     2.74     142.3 0.477E-01   1.84     11.68     2.74      0.90 .20375E+03
    348.22     -1.00     2.74     220.9 0.307E-01   2.85     12.93     2.74     -0.11 .43316E+03
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
    531.75     -1.00     2.74     287.0 0.237E-01   3.60     14.22     2.74     -0.86 .66257E+03
    715.28     -1.00     2.74     299.8 0.226E-01   3.60     15.55     2.74     -0.86 .89199E+03
    898.81     -1.00     2.74     316.7 0.214E-01   3.60     16.91     2.74     -0.86 .11214E+04
    916.73     -1.00     2.74     318.7 0.213E-01   3.60     17.05     2.74     -0.86 .11438E+04
 Cumulative travel time =         1143.8005 sec  (     0.32 hrs)

 CORMIX simulation has been TERMINATED at last prediction interval.
   Limiting time due to TIDAL REVERSAL as per (xmax) has been reached.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges                 End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
```

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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                  Bay City Outfall
  DESIGN CASE:                    d. MLLW
  FILE NAME:                      U:\rstillmaker\2018\BayCityMixZn\Output\d MLLW 8 inch port.prd
  Using subsystem CORMIX1:       Single Port Discharges
  Start of session:               09/06/2018--16:29:52
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                                = unbounded
  Average depth                     HA         = 3.6 m
  Depth at discharge                HD         = 2.74 m
  Darcy-Weisbach friction factor    F          = 0.0205
    Calculated from Manning's n                = 0.02
  Wind velocity                     UW         = 5.7 m/s
TIDAL SIMULATION at time            Tsim       = 2 hours
  Instantaneous ambient velocity    UA         = 0.8 m/s
  Maximum tidal velocity            UaMAX      = 1 m/s
Rate of tidal reversal              dUA/dt = 0.4 (m/s)/hour
  Period of reversal                T          = 12.4 hours
  Stratification Type               STRCND = U
  Surface density                   RHOAS      = 1012.74 kg/m^3
  Bottom density                    RHOAB      = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:               Single Port Discharge
  Nearest bank                                 = right
  Distance to bank                  DISTB      = 1 m
  Port diameter                     D0         = 0.2032 m
  Port cross-sectional area         A0         = 0.0324 m^2
  Discharge velocity                U0         = 3.26 m/s
  Discharge flowrate                Q0         = 0.105613 m^3/s
  Discharge port height             H0         = 0.31 m
  Vertical discharge angle          THETA      = 10 deg
  Horizontal discharge angle        SIGMA      = 90 deg
  Discharge density                 RHO0       = 998 kg/m^3
  Density difference                DRHO       = 14.7400 kg/m^3
  Buoyant acceleration              GP0        = 0.1427 m/s^2
  Discharge concentration           C0         = 6.79 mg/l
  Surface heat exchange coeff.      KS         = 0 m/s
  Coefficient of decay              KD         = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m          Lm  = 0.73 m          Lb  = 0.03 m
  LM  = 3.66 m          Lm' = 99999 m          Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.1006 hours      Lu  = 14.57 m          Lmin= 0.18 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number    FR0        = 19.12
  Velocity ratio                    R          = 4.07
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                              = yes
  CMC concentration                 CMC        = 1.04 mg/l
  CCC concentration                 CCC        = 0.16 mg/l
  Water quality standard specified             = given by CCC value
  Regulatory mixing zone                       = no
  Region of interest                           = 2000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 2.74 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.1334 mg/l
  Dilution at edge of NFR              s = 50.9
  NFR Location:                        x = 20.26 m
    (centerline coordinates)           y = 2.71 m
                                       z = 2.74 m
```

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  NFR plume dimensions:  half-width (bh) = 1.85 m
                         thickness (bv) = 1.85 m
Cumulative travel time:       23.2059 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 531.75 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 56.28 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                    x = 916.73 m
                                    y = -1 m
                                    z = 2.74 m.
  For this condition AFTER TIDAL REVERSAL, mixed water from the previous
  half-cycle becomes re-entrained into the near field of the discharge,
  increasing pollutant concentrations compared to steady-state predictions.
  A pool of mixed water formed at slack tide will be advected downstream
  in this phase.
************************ TOXIC DILUTION ZONE SUMMARY ***********************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                       x = 1.79 m
    (centerline coordinates)            y = 1.50 m
                                        z = 0.62 m
  Plume dimension:       half-width (bh) = 0.05 m
                          thickness (bv) = 0.05 m

 Computed distance from port opening to CMC location = 2.35 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.33 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 2.74 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                    = 0.16  mg/l
Corresponding dilution                   = 42.6
  Plume location:                      x = 19.29 m
    (centerline coordinates)           y = 2.70 m
                                       z = 2.74 m
 Computed horizontal distance from port opening to CCC location = 19.63
  Plume dimensions:      half-width (bh) = 1.50 m
                          thickness (bv) = 1.78 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                   CORMIX MIXING ZONE EXPERT SYSTEM
                  Subsystem CORMIX1: Single Port Discharges
                        CORMIX Version 11.0GTH
                    HYDRO1 Version 11.0.0.0 April 2018
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       e. MHHW max flood current 8 inch port
 FILE NAME:         U:\...n\Output\e MHHW max flood current 8 inch port.prd
 Time stamp:        09/06/2018--16:32:02

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =      4.11 HD    =       5.27
 Tidal Simulation at TIME =      3.000 h
 PERIOD=    12.40 h UAmax =      1.000 dUa/dt=      0.333 (m/s)/h
 UA    =      1.000 F     =      0.020 USTAR =0.4950E-01
 UW    =      5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U         RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  = RIGHT     DISTB =       1.00
 D0    =      0.203 A0    =      0.032 H0    =      0.30  SUB0  =      4.97
 THETA =     10.00 SIGMA =      90.00
 U0    =      3.257 Q0    =      0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02 GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS= mg/l
 IPOLL = 1         KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00 M0    =0.3440E+00 J0    =0.1507E-01 SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18 LM    =       3.66 Lm    =      0.59 Lb    =      0.02
                                      Lmp   =  99999.00 Lbp   =  99999.00
 Tidal:            Tu    =   0.1136 h Lu    =     15.487 Lmin  =      0.180
 Tidal Cutoffs (m): lmax  =  4228.169 xmax  =  1718.873 ymax  =   209.072

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12 R     =       3.26

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)       =    H2     1
 1  Applicable layer depth HS =    5.27   1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS= mg/l
 NTOX  = 1         CMC   =0.1040E+01  CCC   = CSTD
 NSTD  = 1         CSTD  =0.1600E+00
 REGMZ = 0
 XINT  =   2000.00  XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z         S        C         B        Uc         TT
      0.00     0.00     0.30      1.0 0.679E+01   0.10     3.257    .00000E+00

END OF MOD101: DISCHARGE MODULE
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:              THETAE=      9.92  SIGMAE=     82.64
  LE    =      0.01 XE    =      0.00 YE    =      0.01  ZE    =      0.31

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X        Y        Z         S        C         B        Uc         TT
      0.00     0.00     0.30      1.0 0.679E+01   0.10     3.257    .00000E+00
      0.00     0.01     0.31      1.0 0.679E+01   0.11     3.257    .12761E-01
** CMC HAS BEEN FOUND **
```

The pollutant concentration in the plume falls below CMC value of 0.104E+01
in the current prediction interval.
This is the extent of the TOXIC DILUTION ZONE.

5.91	1.54	0.74	11.9	0.568E+00	0.52	0.069	.53491E+01
12.27	1.88	1.09	18.9	0.359E+00	0.66	0.045	.11414E+02
18.63	2.07	1.45	25.8	0.263E+00	0.78	0.035	.17563E+02
25.05	2.19	1.82	33.2	0.204E+00	0.89	0.029	.23807E+02
31.42	2.28	2.18	40.9	0.166E+00	0.99	0.025	.30029E+02

WATER QUALITY STANDARD OR CCC HAS BEEN FOUND
The pollutant concentration in the plume falls below water quality standard
or CCC value of 0.160E+00 in the current prediction interval.
This is the spatial extent of concentrations exceeding the water quality
standard or CCC value.

37.78	2.35	2.53	49.0	0.138E+00	1.08	0.022	.36271E+02
44.20	2.40	2.87	57.5	0.118E+00	1.18	0.019	.42580E+02
50.57	2.43	3.20	66.2	0.103E+00	1.26	0.018	.48850E+02
56.94	2.47	3.52	75.1	0.904E-01	1.35	0.016	.55129E+02
63.36	2.49	3.83	84.2	0.806E-01	1.43	0.015	.61431E+02

Cumulative travel time = 61.4312 sec (0.02 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B	TT
63.36	2.49	3.83	80.1	0.848E-01	1.43	.61431E+02

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
61.93	2.49	5.27	84.3	0.805E-01	0.00	0.00	5.27	5.27	.61431E+02
62.36	2.49	5.27	84.3	0.805E-01	1.77	0.89	5.27	3.50	.61431E+02
62.79	2.49	5.27	84.3	0.806E-01	2.10	1.26	5.27	3.17	.61431E+02
63.22	2.49	5.27	84.2	0.806E-01	2.31	1.54	5.27	2.96	.61431E+02
63.65	2.49	5.27	86.5	0.785E-01	2.47	1.78	5.27	2.80	.61718E+02
64.08	2.49	5.27	97.2	0.698E-01	2.59	1.99	5.27	2.68	.62148E+02
64.51	2.49	5.27	112.0	0.606E-01	2.67	2.18	5.27	2.60	.62579E+02
64.94	2.49	5.27	125.5	0.541E-01	2.74	2.36	5.27	2.53	.63009E+02
65.37	2.50	5.27	134.7	0.504E-01	2.78	2.52	5.27	2.49	.63440E+02
65.80	2.50	5.27	139.7	0.486E-01	2.81	2.68	5.27	2.46	.63870E+02
66.23	2.50	5.27	142.9	0.475E-01	2.82	2.82	5.27	2.45	.64300E+02

Cumulative travel time = 64.3004 sec (0.02 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
66.23	2.50	5.27	142.9	0.475E-01	2.82	2.82	5.27	2.45	.64300E+02
68.19	2.50	5.27	144.7	0.469E-01	2.79	2.89	5.27	2.48	.66261E+02
70.15	2.50	5.27	146.4	0.464E-01	2.76	2.96	5.27	2.51	.68222E+02
72.11	2.50	5.27	148.3	0.458E-01	2.73	3.03	5.27	2.54	.70182E+02
74.07	2.50	5.27	150.1	0.452E-01	2.71	3.10	5.27	2.56	.72143E+02
76.03	2.50	5.27	152.0	0.447E-01	2.69	3.17	5.27	2.58	.74103E+02
77.99	2.50	5.27	153.9	0.441E-01	2.67	3.24	5.27	2.60	.76064E+02
79.95	2.50	5.27	155.9	0.436E-01	2.65	3.30	5.27	2.62	.78025E+02
81.91	2.50	5.27	157.8	0.430E-01	2.64	3.37	5.27	2.63	.79985E+02
83.88	2.50	5.27	159.9	0.425E-01	2.63	3.43	5.27	2.64	.81946E+02
85.84	2.50	5.27	162.0	0.419E-01	2.61	3.50	5.27	2.66	.83907E+02

Cumulative travel time = 83.9066 sec (0.02 hrs)

Plume is ATTACHED to RIGHT bank/shore.
Plume width is now determined from RIGHT bank/shore.

Discharge is non-buoyant or weakly buoyant.
Therefore BUOYANT SPREADING REGIME is ABSENT.

END OF MOD141: BUOYANT AMBIENT SPREADING

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-----------------------------------------------------------------------------------------------
 Bottom coordinate for FAR-FIELD is determined by average depth, ZFB =  1.16m
-----------------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.522E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.201E-01 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X        Y        Z        S       C         BV       BH       ZU       ZL        TT
     85.84    -1.00     5.27   162.0 0.419E-01   2.61     6.99     5.27     2.66 .83907E+02
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
    277.25    -1.00     5.27   255.9 0.265E-01   4.11     7.87     5.27     1.16 .27532E+03
    468.67    -1.00     5.27   263.9 0.257E-01   4.11     8.79     5.27     1.16 .46674E+03
    660.09    -1.00     5.27   276.6 0.245E-01   4.11     9.74     5.27     1.16 .65816E+03
    851.50    -1.00     5.27   293.0 0.232E-01   4.11    10.71     5.27     1.16 .84957E+03
   1042.92    -1.00     5.27   312.5 0.217E-01   4.11    11.72     5.27     1.16 .10410E+04
   1234.33    -1.00     5.27   334.9 0.203E-01   4.11    12.76     5.27     1.16 .12324E+04
   1425.75    -1.00     5.27   360.1 0.189E-01   4.11    13.83     5.27     1.16 .14238E+04
   1617.17    -1.00     5.27   387.8 0.175E-01   4.11    14.93     5.27     1.16 .16152E+04
   1718.87    -1.00     5.27   403.9 0.168E-01   4.11    15.53     5.27     1.16 .17169E+04
 Cumulative travel time =        1716.9437 sec  (    0.48 hrs)

 CORMIX simulation has been TERMINATED at last prediction interval.
   Limiting time due to TIDAL REVERSAL as per (xmax) has been reached.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
```

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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  e. MHHW max flood current 8 inch port
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\e MHHW max flood current 8 inch port.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:32:02
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = unbounded
  Average depth                 HA       = 4.11 m
  Depth at discharge            HD       = 5.27 m
  Darcy-Weisbach friction factor F       = 0.0196
    Calculated from Manning's n          = 0.02
  Wind velocity                 UW       = 5.7 m/s
TIDAL SIMULATION at time        Tsim     = 3 hours
  Instantaneous ambient velocity UA      = 1 m/s
  Maximum tidal velocity        UaMAX    = 1 m/s
Rate of tidal reversal         dUA/dt = 0.3333 (m/s)/hour
  Period of reversal            T        = 12.4 hours
  Stratification Type           STRCND = U
  Surface density               RHOAS  = 1012.74 kg/m^3
  Bottom density                RHOAB  = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:           Single Port Discharge
  Nearest bank                           = right
  Distance to bank              DISTB  = 1 m
  Port diameter                 D0       = 0.2032 m
  Port cross-sectional area     A0       = 0.0324 m^2
  Discharge velocity            U0       = 3.26 m/s
  Discharge flowrate            Q0       = 0.105613 m^3/s
  Discharge port height         H0       = 0.30 m
  Vertical discharge angle      THETA  = 10 deg
  Horizontal discharge angle    SIGMA  = 90 deg
  Discharge density             RHO0.  = 998 kg/m^3
  Density difference            DRHO   = 14.7400 kg/m^3
  Buoyant acceleration          GP0      = 0.1427 m/s^2
  Discharge concentration       C0       = 6.79 mg/l
  Surface heat exchange coeff.  KS       = 0 m/s
  Coefficient of decay          KD       = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m         Lm  = 0.59 m         Lb  = 0.02 m
  LM  = 3.66 m         Lm' = 99999 m        Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.1136 hours     Lu  = 15.49 m        Lmin= 0.18 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0    = 19.12
  Velocity ratio                R        = 3.26
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = yes
  CMC concentration             CMC      = 1.04 mg/l
  CCC concentration             CCC      = 0.16 mg/l
  Water quality standard specified       = given by CCC value
  Regulatory mixing zone                 = no
  Region of interest                     = 2000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 5.27 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0475 mg/l
  Dilution at edge of NFR              s = 142.9
  NFR Location:                        x = 66.23 m
    (centerline coordinates)           y = 2.50 m
                                       z = 5.27 m
```

```
  NFR plume dimensions:  half-width (bh) = 2.82 m
                          thickness (bv) = 2.82 m
Cumulative travel time:       64.3004 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 277.25 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 85.84 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                      x = 1718.87 m
                                      y = -1 m
                                      z = 5.27 m.
  For this condition AFTER TIDAL REVERSAL, mixed water from the previous
  half-cycle becomes re-entrained into the near field of the discharge,
  increasing pollutant concentrations compared to steady-state predictions.
  A pool of mixed water formed at slack tide will be advected downstream
  in this phase.
************************ TOXIC DILUTION ZONE SUMMARY ***********************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                     x = 1.98 m
    (centerline coordinates)          y = 1.09 m
                                      z = 0.54 m
  Plume dimension:       half-width (bh) = 0.09 m
                          thickness (bv) = 0.09 m

 Computed distance from port opening to CMC location = 2.28 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.27 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 5.27 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                  = 0.16  mg/l
Corresponding dilution                 = 42.4
  Plume location:                     x = 32.62 m
    (centerline coordinates)          y = 2.29 m
                                      z = 2.24 m
 Computed horizontal distance from port opening to CCC location = 32.75
  Plume dimension:       half-width (bh) = 1.00 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                      CORMIX MIXING ZONE EXPERT SYSTEM
                  Subsystem CORMIX1: Single Port Discharges
                           CORMIX Version 11.0GTH
                    HYDRO1 Version 11.0.0.0 April 2018
------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       f. Mid MLLW flood to MHHW
 FILE NAME:         U:\...tyMixZn\Output\f midMLLWfloodtoMHHW8inch port.prd
 Time stamp:        09/06/2018--16:34:06

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =     4.11  HD     =      4.54
 Tidal Simulation at TIME =     -1.200 h
 PERIOD=    12.40 h UAmax =      1.000 dUa/dt=      0.625 (m/s)/h
 UA    =     0.750 F      =      0.020 USTAR =0.3712E-01
 UW    =     5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND=  U        RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  =  RIGHT    DISTB =       1.00
 D0    =     0.203 A0     =      0.032 H0     =      0.30  SUB0  =       4.24
 THETA =     10.00  SIGMA =     90.00
 U0    =     3.257 Q0     =      0.106        =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02  GP0    =0.1427E+00
 C0    =0.6790E+01  CUNITS=  mg/l
 IPOLL =  1        KS     =0.0000E+00  KD     =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00  M0    =0.3440E+00  J0     =0.1507E-01  SIGNJ0=       1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =      3.66  Lm     =       0.78  Lb    =       0.04
                                       Lmp    =  99999.00  Lbp    =  99999.00
 Tidal:            Tu     =    0.0747 h Lu    =     12.559 Lmin   =      0.180
 Tidal Cutoffs (m): lmax  =  1381.603  xmax   =  8370.000  ymax   =    169.549

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12  R     =      4.34

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)       =    H2    1
 1  Applicable layer depth HS =    4.54   1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS=  mg/l
 NTOX  =  1        CMC    =0.1040E+01  CCC    =  CSTD
 NSTD  =  1        CSTD   =0.1600E+00
 REGMZ =  0
 XINT  =   2000.00  XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S       C         B        Uc        TT
     0.00     0.00     0.30     1.0 0.679E+01   0.10     3.257   .00000E+00

END OF MOD101: DISCHARGE MODULE
------------------------------------------------------------------------------------------
------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:            THETAE=      9.95  SIGMAE=      84.47
  LE    =      0.26  XE     =      0.01  YE     =      0.26  ZE     =      0.35

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X        Y        Z        S       C         B        Uc        TT
     0.00     0.00     0.30     1.0 0.679E+01   0.10     3.257   .00000E+00
     0.01     0.26     0.35     1.0 0.679E+01   0.11     3.257   .10622E-01
** CMC HAS BEEN FOUND **
```

The pollutant concentration in the plume falls below CMC value of 0.104E+01
in the current prediction interval.
This is the extent of the TOXIC DILUTION ZONE.

2.88	1.86	0.73	8.9	0.762E+00	0.51	0.155	.30218E+01
6.38	2.28	0.99	14.5	0.467E+00	0.66	0.088	.71645E+01
9.95	2.53	1.26	19.6	0.346E+00	0.77	0.067	.11529E+02
13.48	2.71	1.54	24.6	0.276E+00	0.87	0.055	.15917E+02
17.01	2.83	1.82	29.8	0.228E+00	0.95	0.048	.20353E+02
20.58	2.93	2.10	35.2	0.193E+00	1.04	0.042	.24881E+02
24.11	3.01	2.38	40.8	0.166E+00	1.12	0.038	.29379E+02

WATER QUALITY STANDARD OR CCC HAS BEEN FOUND

The pollutant concentration in the plume falls below water quality standard
or CCC value of 0.160E+00 in the current prediction interval.
This is the spatial extent of concentrations exceeding the water quality
standard or CCC value.

27.64	3.07	2.65	46.7	0.146E+00	1.20	0.034	.33898E+02
31.22	3.12	2.92	52.7	0.129E+00	1.28	0.032	.38492E+02
34.75	3.17	3.19	58.9	0.115E+00	1.35	0.029	.43019E+02

Cumulative travel time = 43.0189 sec (0.01 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B	TT
34.75	3.17	3.19	58.4	0.116E+00	1.35	.43019E+02

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
33.40	3.16	4.54	58.9	0.115E+00	0.00	0.00	4.54	4.54	.43019E+02
33.80	3.16	4.54	58.9	0.115E+00	1.68	0.84	4.54	2.86	.43019E+02
34.21	3.16	4.54	58.9	0.115E+00	1.99	1.19	4.54	2.55	.43019E+02
34.61	3.16	4.54	58.9	0.115E+00	2.19	1.46	4.54	2.35	.43019E+02
35.02	3.17	4.54	60.5	0.112E+00	2.33	1.69	4.54	2.21	.43379E+02
35.42	3.17	4.54	68.0	0.999E-01	2.44	1.88	4.54	2.10	.43919E+02
35.83	3.17	4.54	78.3	0.867E-01	2.53	2.06	4.54	2.01	.44459E+02
36.23	3.17	4.54	87.7	0.774E-01	2.59	2.23	4.54	1.95	.45000E+02
36.64	3.18	4.54	94.2	0.721E-01	2.63	2.38	4.54	1.91	.45540E+02
37.04	3.18	4.54	97.7	0.695E-01	2.66	2.53	4.54	1.88	.46080E+02
37.45	3.18	4.54	100.0	0.679E-01	2.67	2.67	4.54	1.87	.46620E+02

Cumulative travel time = 46.6203 sec (0.01 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
37.45	3.18	4.54	100.0	0.679E-01	2.67	2.67	4.54	1.87	.46620E+02
40.41	3.18	4.54	102.0	0.666E-01	2.56	2.83	4.54	1.98	.50574E+02
43.38	3.18	4.54	103.9	0.653E-01	2.47	3.00	4.54	2.07	.54527E+02
46.34	3.18	4.54	105.8	0.642E-01	2.39	3.16	4.54	2.15	.58480E+02
49.31	3.18	4.54	107.7	0.630E-01	2.32	3.31	4.54	2.22	.62434E+02
52.27	3.18	4.54	109.6	0.619E-01	2.26	3.47	4.54	2.28	.66387E+02
55.24	3.18	4.54	111.5	0.609E-01	2.20	3.62	4.54	2.34	.70340E+02
58.20	3.18	4.54	113.5	0.598E-01	2.15	3.76	4.54	2.39	.74294E+02
61.17	3.18	4.54	115.4	0.588E-01	2.11	3.90	4.54	2.43	.78247E+02
64.13	3.18	4.54	117.4	0.578E-01	2.08	4.04	4.54	2.46	.82200E+02
67.10	3.18	4.54	119.4	0.569E-01	2.04	4.18	4.54	2.50	.86154E+02

Cumulative travel time = 86.1535 sec (0.02 hrs)

Plume is ATTACHED to RIGHT bank/shore.
Plume width is now determined from RIGHT bank/shore.

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
67.10	-1.00	4.54	119.4	0.569E-01	2.04	8.37	4.54	2.50	.86154E+02
83.19	-1.00	4.54	128.3	0.529E-01	2.03	9.09	4.54	2.51	.10761E+03

```
     99.29    -1.00    4.54   138.2 0.491E-01   2.03      9.79     4.54      2.51 .12907E+03
    115.38    -1.00    4.54   149.1 0.455E-01   2.06     10.47     4.54      2.48 .15053E+03
    131.48    -1.00    4.54   161.2 0.421E-01   2.10     11.12     4.54      2.44 .17199E+03
    147.57    -1.00    4.54   174.4 0.389E-01   2.16     11.75     4.54      2.38 .19345E+03
    163.67    -1.00    4.54   188.9 0.360E-01   2.23     12.37     4.54      2.31 .21491E+03
    179.76    -1.00    4.54   204.6 0.332E-01   2.31     12.98     4.54      2.23 .23637E+03
    195.86    -1.00    4.54   221.6 0.306E-01   2.40     13.57     4.54      2.14 .25783E+03
    211.95    -1.00    4.54   240.0 0.283E-01   2.49     14.14     4.54      2.05 .27929E+03
    228.05    -1.00    4.54   259.7 0.261E-01   2.60     14.71     4.54      1.94 .30075E+03
 Cumulative travel time =         300.7504 sec  (     0.08 hrs)

END OF MOD141: BUOYANT AMBIENT SPREADING
-----------------------------------------------------------------------------------------
 Bottom coordinate for FAR-FIELD is determined by average depth, ZFB =  0.43m
-----------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.338E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.541E-01 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
      X         Y        Z        S        C        BV        BH        ZU        ZL        TT
    228.05    -1.00    4.54   259.7 0.261E-01   2.60     14.71     4.54      1.94 .30075E+03
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
    405.24    -1.00    4.54   439.1 0.155E-01   4.11     16.09     4.54      0.43 .53701E+03
    582.44    -1.00    4.54   471.6 0.144E-01   4.11     17.52     4.54      0.43 .77327E+03
    759.63    -1.00    4.54   507.2 0.134E-01   4.11     18.98     4.54      0.43 .10095E+04
    936.83    -1.00    4.54   545.6 0.124E-01   4.11     20.49     4.54      0.43 .12458E+04
   1114.02    -1.00    4.54   586.6 0.116E-01   4.11     22.03     4.54      0.43 .14821E+04
   1291.22    -1.00    4.54   630.0 0.108E-01   4.11     23.61     4.54      0.43 .17183E+04
   1381.60    -1.00    4.54   653.2 0.104E-01   4.11     24.43     4.54      0.43 .18388E+04
 Cumulative travel time =       1838.8179 sec  (     0.51 hrs)

 CORMIX simulation has been TERMINATED at last prediction interval.
   Limiting distance (lmax) due to TIDAL REVERSAL has been reached.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  f. Mid MLLW flood to MHHW
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\f midMLLWfloodtoMHHW8inch port.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:34:06
****************************************************************************
SUMMARY OF INPUT DATA:
----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                         = unbounded
  Average depth                 HA      = 4.11 m
  Depth at discharge            HD      = 4.54 m
  Darcy-Weisbach friction factor F      = 0.0196
    Calculated from Manning's n         = 0.02
  Wind velocity                 UW      = 5.7 m/s
TIDAL SIMULATION at time        Tsim    = -1.2 hours
  Instantaneous ambient velocity UA     = 0.75 m/s
  Maximum tidal velocity        UaMAX   = 1 m/s
Rate of tidal reversal         dUA/dt = 0.625 (m/s)/hour
  Period of reversal            T       = 12.4 hours
  Stratification Type           STRCND = U
  Surface density               RHOAS  = 1012.74 kg/m^3
  Bottom density                RHOAB  = 1012.74 kg/m^3
----------------------------------------------------------------------------
DISCHARGE PARAMETERS:           Single Port Discharge
  Nearest bank                          = right
  Distance to bank              DISTB  = 1 m
  Port diameter                 D0      = 0.2032 m
  Port cross-sectional area     A0      = 0.0324 m^2
  Discharge velocity            U0      = 3.26 m/s
  Discharge flowrate            Q0      = 0.105613 m^3/s
  Discharge port height         H0      = 0.30 m
  Vertical discharge angle      THETA  = 10 deg
  Horizontal discharge angle    SIGMA  = 90 deg
  Discharge density             RHO0    = 998 kg/m^3
  Density difference            DRHO    = 14.7400 kg/m^3
  Buoyant acceleration          GP0     = 0.1427 m/s^2
  Discharge concentration       C0      = 6.79 mg/l
  Surface heat exchange coeff.  KS      = 0 m/s
  Coefficient of decay          KD      = 0 /s
----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m          Lm  = 0.78 m          Lb  = 0.04 m
  LM  = 3.66 m          Lm' = 99999 m         Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.0747 hours      Lu  = 12.56 m         Lmin= 0.18 m
----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0     = 19.12
  Velocity ratio                  R       = 4.34
----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                       = yes
  CMC concentration             CMC     = 1.04 mg/l
  CCC concentration             CCC     = 0.16 mg/l
  Water quality standard specified      = given by CCC value
  Regulatory mixing zone                = no
  Region of interest                    = 2000 m downstream
****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS    = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 4.54 m
****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0679 mg/l
  Dilution at edge of NFR              s = 100.0
  NFR Location:                        x = 37.45 m
    (centerline coordinates)           y = 3.18 m
                                       z = 4.54 m
```

```
  NFR plume dimensions:  half-width (bh) = 2.67 m
                          thickness (bv) = 2.67 m
Cumulative travel time:       46.6202 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 405.24 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 67.10 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                    x = 1381.60 m
                                    y = -1 m
                                    z = 4.54 m.
  For this condition BEFORE TIDAL REVERSAL, extensive re-entrainment
  of previously discharged is unlikely.
  To determine the minimum dilution, perform additional simulations
  after slack tide.
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                     x = 1.72 m
    (centerline coordinates)          y = 1.61 m
                                      z = 0.64 m
  Plume dimension:         half-width (bh) = 0.08 m
                            thickness (bv) = 0.08 m

 Computed distance from port opening to CMC location = 2.38 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.35 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 4.54 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                  = 0.16  mg/l
Corresponding dilution                 = 42.4
  Plume location:                     x = 25.09 m
    (centerline coordinates)          y = 3.03 m
                                      z = 2.45 m
 Computed horizontal distance from port opening to CCC location = 25.36
  Plume dimension:         half-width (bh) = 1.14 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                    CORMIX MIXING ZONE EXPERT SYSTEM
                Subsystem CORMIX1: Single Port Discharges
                        CORMIX Version 11.0GTH
                  HYDRO1 Version 11.0.0.0 April 2018
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       f. Mid MLLW flood to MHHW
 FILE NAME:         U:\...tyMixZn\Output\f midMLLWfloodtoMHHW8inch port.prd
 Time stamp:        09/06/2018--16:35:23

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =      4.11  HD    =      4.54
 Tidal Simulation at TIME =     -1.200 h
 PERIOD=    12.40 h UAmax =      1.000 dUa/dt=      0.625 (m/s)/h
 UA    =      0.750 F     =      0.020 USTAR =0.3712E-01
 UW    =      5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U          RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  =  RIGHT     DISTB =      1.00
 D0    =      0.203 A0    =      0.032 H0    =      0.30  SUB0  =      4.24
 THETA =     10.00  SIGMA =     90.00
 U0    =      3.257 Q0    =      0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02 GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS=  mg/l
 IPOLL =  1         KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00  M0    =0.3440E+00  J0    =0.1507E-01  SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =      3.66  Lm    =      0.78  Lb    =      0.04
                                       Lmp   =  99999.00  Lbp   =  99999.00
 Tidal:             Tu    =   0.0747 h Lu    =     12.559 Lmin  =      0.180
 Tidal Cutoffs (m): lmax  =  1381.603  xmax  =  8370.000  ymax  =   169.549

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12  R     =      4.34

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)       =    H2     1
 1  Applicable layer depth HS =    4.54    1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS=  mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   =  CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   2000.00  XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X         Y       Z         S       C         B        Uc        TT
     0.00      0.00    0.30      1.0 0.679E+01   0.10     3.257   .00000E+00

END OF MOD101: DISCHARGE MODULE
-------------------------------------------------------------------------------------------
-------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:            THETAE=      9.95  SIGMAE=     84.47
  LE    =      0.26  XE    =      0.01  YE    =      0.26  ZE    =      0.35

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X         Y       Z         S       C         B        Uc        TT
     0.00      0.00    0.30      1.0 0.679E+01   0.10     3.257   .00000E+00
     0.01      0.26    0.35      1.0 0.679E+01   0.11     3.257   .10622E-01
** CMC HAS BEEN FOUND **
```

The pollutant concentration in the plume falls below CMC value of 0.104E+01
in the current prediction interval.
This is the extent of the TOXIC DILUTION ZONE.

2.88	1.86	0.73	8.9	0.762E+00	0.51	0.155	.30218E+01
6.38	2.28	0.99	14.5	0.467E+00	0.66	0.088	.71645E+01
9.95	2.53	1.26	19.6	0.346E+00	0.77	0.067	.11529E+02
13.48	2.71	1.54	24.6	0.276E+00	0.87	0.055	.15917E+02
17.01	2.83	1.82	29.8	0.228E+00	0.95	0.048	.20353E+02
20.58	2.93	2.10	35.2	0.193E+00	1.04	0.042	.24881E+02
24.11	3.01	2.38	40.8	0.166E+00	1.12	0.038	.29379E+02

WATER QUALITY STANDARD OR CCC HAS BEEN FOUND
The pollutant concentration in the plume falls below water quality standard
or CCC value of 0.160E+00 in the current prediction interval.
This is the spatial extent of concentrations exceeding the water quality
standard or CCC value.

27.64	3.07	2.65	46.7	0.146E+00	1.20	0.034	.33898E+02
31.22	3.12	2.92	52.7	0.129E+00	1.28	0.032	.38492E+02
34.75	3.17	3.19	58.9	0.115E+00	1.35	0.029	.43019E+02

Cumulative travel time = 43.0189 sec (0.01 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B	TT
34.75	3.17	3.19	58.4	0.116E+00	1.35	.43019E+02

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
33.40	3.16	4.54	58.9	0.115E+00	0.00	0.00	4.54	4.54	.43019E+02
33.80	3.16	4.54	58.9	0.115E+00	1.68	0.84	4.54	2.86	.43019E+02
34.21	3.16	4.54	58.9	0.115E+00	1.99	1.19	4.54	2.55	.43019E+02
34.61	3.16	4.54	58.9	0.115E+00	2.19	1.46	4.54	2.35	.43019E+02
35.02	3.17	4.54	60.5	0.112E+00	2.33	1.69	4.54	2.21	.43379E+02
35.42	3.17	4.54	68.0	0.999E-01	2.44	1.88	4.54	2.10	.43919E+02
35.83	3.17	4.54	78.3	0.867E-01	2.53	2.06	4.54	2.01	.44459E+02
36.23	3.17	4.54	87.7	0.774E-01	2.59	2.23	4.54	1.95	.45000E+02
36.64	3.18	4.54	94.2	0.721E-01	2.63	2.38	4.54	1.91	.45540E+02
37.04	3.18	4.54	97.7	0.695E-01	2.66	2.53	4.54	1.88	.46080E+02
37.45	3.18	4.54	100.0	0.679E-01	2.67	2.67	4.54	1.87	.46620E+02

Cumulative travel time = 46.6203 sec (0.01 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

** End of NEAR-FIELD REGION (NFR) **

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

Plume Stage 1 (not bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
37.45	3.18	4.54	100.0	0.679E-01	2.67	2.67	4.54	1.87	.46620E+02
40.41	3.18	4.54	102.0	0.666E-01	2.56	2.83	4.54	1.98	.50574E+02
43.38	3.18	4.54	103.9	0.653E-01	2.47	3.00	4.54	2.07	.54527E+02
46.34	3.18	4.54	105.8	0.642E-01	2.39	3.16	4.54	2.15	.58480E+02
49.31	3.18	4.54	107.7	0.630E-01	2.32	3.31	4.54	2.22	.62434E+02
52.27	3.18	4.54	109.6	0.619E-01	2.26	3.47	4.54	2.28	.66387E+02
55.24	3.18	4.54	111.5	0.609E-01	2.20	3.62	4.54	2.34	.70340E+02
58.20	3.18	4.54	113.5	0.598E-01	2.15	3.76	4.54	2.39	.74294E+02
61.17	3.18	4.54	115.4	0.588E-01	2.11	3.90	4.54	2.43	.78247E+02
64.13	3.18	4.54	117.4	0.578E-01	2.08	4.04	4.54	2.46	.82200E+02
67.10	3.18	4.54	119.4	0.569E-01	2.04	4.18	4.54	2.50	.86154E+02

Cumulative travel time = 86.1535 sec (0.02 hrs)

Plume is ATTACHED to RIGHT bank/shore.
Plume width is now determined from RIGHT bank/shore.

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
67.10	-1.00	4.54	119.4	0.569E-01	2.04	8.37	4.54	2.50	.86154E+02
83.19	-1.00	4.54	128.3	0.529E-01	2.03	9.09	4.54	2.51	.10761E+03

```
     99.29     -1.00    4.54   138.2 0.491E-01   2.03     9.79    4.54    2.51 .12907E+03
    115.38     -1.00    4.54   149.1 0.455E-01   2.06    10.47    4.54    2.48 .15053E+03
    131.48     -1.00    4.54   161.2 0.421E-01   2.10    11.12    4.54    2.44 .17199E+03
    147.57     -1.00    4.54   174.4 0.389E-01   2.16    11.75    4.54    2.38 .19345E+03
    163.67     -1.00    4.54   188.9 0.360E-01   2.23    12.37    4.54    2.31 .21491E+03
    179.76     -1.00    4.54   204.6 0.332E-01   2.31    12.98    4.54    2.23 .23637E+03
    195.86     -1.00    4.54   221.6 0.306E-01   2.40    13.57    4.54    2.14 .25783E+03
    211.95     -1.00    4.54   240.0 0.283E-01   2.49    14.14    4.54    2.05 .27929E+03
    228.05     -1.00    4.54   259.7 0.261E-01   2.60    14.71    4.54    1.94 .30075E+03
 Cumulative travel time =        300.7504 sec  (    0.08 hrs)

END OF MOD141: BUOYANT AMBIENT SPREADING
-----------------------------------------------------------------------------------------------
 Bottom coordinate for FAR-FIELD is determined by average depth, ZFB =  0.43m
-----------------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.338E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.541E-01 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
       X         Y       Z        S        C         BV       BH       ZU      ZL         TT
    228.05     -1.00    4.54   259.7 0.261E-01   2.60    14.71    4.54    1.94 .30075E+03
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
    405.24     -1.00    4.54   439.1 0.155E-01   4.11    16.09    4.54    0.43 .53701E+03
    582.44     -1.00    4.54   471.6 0.144E-01   4.11    17.52    4.54    0.43 .77327E+03
    759.63     -1.00    4.54   507.2 0.134E-01   4.11    18.98    4.54    0.43 .10095E+04
    936.83     -1.00    4.54   545.6 0.124E-01   4.11    20.49    4.54    0.43 .12458E+04
   1114.02     -1.00    4.54   586.6 0.116E-01   4.11    22.03    4.54    0.43 .14821E+04
   1291.22     -1.00    4.54   630.0 0.108E-01   4.11    23.61    4.54    0.43 .17183E+04
   1381.60     -1.00    4.54   653.2 0.104E-01   4.11    24.43    4.54    0.43 .18388E+04
 Cumulative travel time =       1838.8179 sec  (    0.51 hrs)

 CORMIX simulation has been TERMINATED at last prediction interval.
   Limiting distance (lmax) due to TIDAL REVERSAL has been reached.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
```

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                 Bay City Outfall
  DESIGN CASE:                   f. Mid MLLW flood to MHHW
  FILE NAME:                     U:\rstillmaker\2018\BayCityMixZn\Output\f midMLLWfloodtoMHHW8inch port.prd
  Using subsystem CORMIX1:      Single Port Discharges
  Start of session:              09/06/2018--16:35:23
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                            = unbounded
  Average depth                   HA       = 4.11 m
  Depth at discharge              HD       = 4.54 m
  Darcy-Weisbach friction factor  F        = 0.0196
    Calculated from Manning's n            = 0.02
  Wind velocity                   UW       = 5.7 m/s
TIDAL SIMULATION at time          Tsim     = -1.2 hours
  Instantaneous ambient velocity  UA       = 0.75 m/s
  Maximum tidal velocity          UaMAX    = 1 m/s
Rate of tidal reversal          dUA/dt = 0.625 (m/s)/hour
  Period of reversal              T        = 12.4 hours
  Stratification Type             STRCND = U
  Surface density                 RHOAS    = 1012.74 kg/m^3
  Bottom density                  RHOAB    = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Single Port Discharge
  Nearest bank                             = right
  Distance to bank                DISTB    = 1 m
  Port diameter                   D0       = 0.2032 m
  Port cross-sectional area       A0       = 0.0324 m^2
  Discharge velocity              U0       = 3.26 m/s
  Discharge flowrate              Q0       = 0.105613 m^3/s
  Discharge port height           H0       = 0.30 m
  Vertical discharge angle        THETA    = 10 deg
  Horizontal discharge angle      SIGMA    = 90 deg
  Discharge density               RHO0     = 998 kg/m^3
  Density difference              DRHO     = 14.7400 kg/m^3
  Buoyant acceleration            GP0      = 0.1427 m/s^2
  Discharge concentration         C0       = 6.79 mg/l
  Surface heat exchange coeff.    KS       = 0 m/s
  Coefficient of decay            KD       = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m          Lm  = 0.78 m          Lb  = 0.04 m
  LM  = 3.66 m          Lm' = 99999 m         Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.0747 hours      Lu  = 12.56 m         Lmin= 0.18 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0      = 19.12
  Velocity ratio                  R        = 4.34
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                          = yes
  CMC concentration               CMC      = 1.04 mg/l
  CCC concentration               CCC      = 0.16 mg/l
  Water quality standard specified         = given by CCC value
  Regulatory mixing zone                   = no
  Region of interest                       = 2000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 4.54 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0679 mg/l
  Dilution at edge of NFR              s = 100.0
  NFR Location:                        x = 37.45 m
    (centerline coordinates)           y = 3.18 m
                                       z = 4.54 m
```

```
  NFR plume dimensions:  half-width (bh) = 2.67 m
                          thickness (bv) = 2.67 m
Cumulative travel time:       46.6202 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 405.24 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 67.10 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                      x = 1381.60 m
                                      y = -1 m
                                      z = 4.54 m.
  For this condition BEFORE TIDAL REVERSAL, extensive re-entrainment
  of previously discharged is unlikely.
  To determine the minimum dilution, perform additional simulations
  after slack tide.
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                     x = 1.72 m
    (centerline coordinates)          y = 1.61 m
                                      z = 0.64 m
  Plume dimension:       half-width (bh) = 0.08 m
                          thickness (bv) = 0.08 m

 Computed distance from port opening to CMC location = 2.38 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.35 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 4.54 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                  = 0.16  mg/l
Corresponding dilution                 = 42.4
  Plume location:                     x = 25.09 m
    (centerline coordinates)          y = 3.03 m
                                      z = 2.45 m
 Computed horizontal distance from port opening to CCC location = 25.36
  Plume dimension:       half-width (bh) = 1.14 m
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                        CORMIX MIXING ZONE EXPERT SYSTEM
                  Subsystem CORMIX1: Single Port Discharges
                            CORMIX Version 11.0GTH
                   HYDRO1 Version 11.0.0.0 April 2018
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       g. High Water Slack
 FILE NAME:         U:\...BayCityMixZn\Output\g HighWaterSlack8inchport.prd
 Time stamp:        09/06/2018--16:37:07

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =      4.11  HD    =      4.99
 UA    =     0.000  F     =     0.020 USTAR =0.0000E+00
 UW    =     5.700  UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U          RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  = RIGHT      DISTB =      1.00
 D0    =     0.203  A0    =     0.032 H0    =      0.30  SUB0  =      4.69
 THETA =     10.00  SIGMA =     90.00
 U0    =     3.257  Q0    =     0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02  GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS= mg/l
 IPOLL =  1         KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00  M0    =0.3440E+00  J0    =0.1507E-01  SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =      3.66  Lm    =  99999.00  Lb    =  99999.00
                                       Lmp   =  99999.00  Lbp   =  99999.00

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12  R     =  99999.00

FLOW CLASSIFICATION
 11111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    H4-90  1
 1  Applicable layer depth HS =     4.99  1
 11111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS= mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   = CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   2000.00  XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X         Y        Z          S        C         B        Uc         TT
     0.00      0.00     0.30       1.0 0.679E+01   0.10     3.257    .00000E+00

END OF MOD101: DISCHARGE MODULE
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in weak crossflow.

 Zone of flow establishment:            THETAE=     10.00  SIGMAE=      90.00
  LE    =      1.02  XE    =      0.00  YE    =      1.00  ZE    =       0.48

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X         Y        Z          S        C         B        Uc         TT
     0.00      0.00     0.30       1.0 0.679E+01   0.10     3.257    .00000E+00
     0.00      1.00     0.48       1.0 0.679E+01   0.11     3.257    .91643E-02
     0.00      1.80     0.63       1.6 0.423E+01   0.19     2.407    .27278E+00
     0.00      2.58     0.81       2.3 0.289E+01   0.28     1.662    .68818E+00
     0.00      3.36     1.02       3.1 0.219E+01   0.37     1.277    .12524E+01
     0.00      4.13     1.29       3.9 0.175E+01   0.46     1.045    .19605E+01
     0.00      4.84     1.59       4.7 0.146E+01   0.54     0.899    .27597E+01
```

```
     0.00      5.55     1.96      5.5 0.123E+01   0.63     0.792   .37246E+01
     0.00      6.24     2.39      6.4 0.105E+01   0.72     0.715   .48046E+01
** CMC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below CMC value of 0.104E+01
   in the current prediction interval.
 This is the extent of the TOXIC DILUTION ZONE.
     0.00      6.88     2.88      7.4 0.913E+00   0.80     0.659   .59867E+01
     0.00      7.49     3.41      8.5 0.798E+00   0.89     0.618   .72580E+01
     0.00      8.05     3.99      9.6 0.704E+00   0.97     0.585   .86064E+01
 Cumulative travel time =          8.6064 sec  (    0.00 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

  Control volume inflow:
       X         Y        Z         S        C         B        TT
     0.00      8.05     3.99      9.6 0.704E+00   0.97 .86064E+01

 Profile definitions:
   BV = Gaussian 1/e (37%) vertical thickness
   BH = Gaussian 1/e (37%) horizontal half-width, normal to trajectory
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X         Y        Z         S        C         BV        BH       ZU       ZL        TT
    -0.01      8.05     4.99      9.6 0.704E+00   0.00      0.00     4.99     4.99 .86064E+01
    -0.01      8.25     4.99      9.8 0.693E+00   0.86      0.43     4.99     4.13 .91653E+01
    -0.01      8.44     4.99     10.2 0.666E+00   1.02      0.61     4.99     3.97 .97265E+01
    -0.01      8.63     4.99     10.8 0.631E+00   1.12      0.75     4.99     3.87 .10288E+02
    -0.01      8.83     4.99     11.4 0.596E+00   1.20      0.87     4.99     3.79 .10849E+02
    -0.00      9.02     4.99     12.0 0.567E+00   1.26      0.97     4.99     3.73 .11410E+02
    -0.00      9.22     4.99     12.5 0.545E+00   1.30      1.06     4.99     3.69 .11971E+02
    -0.00      9.41     4.99     12.8 0.530E+00   1.33      1.15     4.99     3.66 .12532E+02
    -0.00      9.60     4.99     13.1 0.520E+00   1.35      1.23     4.99     3.64 .13094E+02
    -0.00      9.80     4.99     13.2 0.515E+00   1.37      1.30     4.99     3.62 .13655E+02
     0.00      9.99     4.99     13.3 0.509E+00   1.37      1.37     4.99     3.62 .14216E+02
 Cumulative travel time =         14.2160 sec  (    0.00 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
 Discharge into STAGNANT AMBIENT environment:
   STEADY-STATE MIXING CONDITION IS NOT POSSIBLE in this zone, even though
   some ADDITIONAL DILUTION MAY OCCUR!
   Also, all far-field processes will be UNSTEADY.
 SIMULATION STOPS because of stagnant ambient conditions.
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges            End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  g. High Water Slack
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\g HighWaterSlack8inchport.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:37:07
****************************************************************************
SUMMARY OF INPUT DATA:
----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                               = unbounded
  Average depth                  HA     = 4.11 m
  Depth at discharge             HD     = 4.99 m
  Ambient velocity               UA     = 0 m/s
  Darcy-Weisbach friction factor F      = 0.0196
    Calculated from Manning's n         = 0.02
  Wind velocity                  UW     = 5.7 m/s
  Stratification Type            STRCND = U
  Surface density                RHOAS  = 1012.74 kg/m^3
  Bottom density                 RHOAB  = 1012.74 kg/m^3
----------------------------------------------------------------------------
DISCHARGE PARAMETERS:            Single Port Discharge
  Nearest bank                          = right
  Distance to bank               DISTB  = 1 m
  Port diameter                  D0     = 0.2032 m
  Port cross-sectional area      A0     = 0.0324 m^2
  Discharge velocity             U0     = 3.26 m/s
  Discharge flowrate             Q0     = 0.105613 m^3/s
  Discharge port height          H0     = 0.30 m
  Vertical discharge angle       THETA  = 10 deg
  Horizontal discharge angle     SIGMA  = 90 deg
  Discharge density              RHO0   = 998 kg/m^3
  Density difference             DRHO   = 14.7400 kg/m^3
  Buoyant acceleration           GP0    = 0.1427 m/s^2
  Discharge concentration        C0     = 6.79 mg/l
  Surface heat exchange coeff.   KS     = 0 m/s
  Coefficient of decay           KD     = 0 /s
----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m         Lm  = 99999 m        Lb  = 99999 m
  LM  = 3.66 m         Lm' = 99999 m        Lb' = 99999 m
----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0    = 19.12
  Velocity ratio                  R      = 99999
----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                       = yes
  CMC concentration              CMC    = 1.04 mg/l
  CCC concentration              CCC    = 0.16 mg/l
  Water quality standard specified      = given by CCC value
  Regulatory mixing zone                = no
  Region of interest                    = 2000 m downstream
****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H4-90 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 4.99 m
****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.5091 mg/l
  Dilution at edge of NFR              s = 13.3
  NFR Location:                        x = 0 m
    (centerline coordinates)           y = 9.99 m
                                       z = 4.99 m
  NFR plume dimensions:  half-width (bh) = 1.37 m
                         thickness (bv) = 1.37 m
Cumulative travel time:       14.2160 sec.
----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
```

```
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Because of the specified STAGNANT ambient conditions, there exists
  no steady-state far-field for this discharge.
  Unsteady circulations and pollutant buid-up may result in the far-field.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section does not contact bank in this simulation.
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                      x = 0 m
    (centerline coordinates)           y = 6.29 m
                                       z = 2.43 m
  Plume dimension:        half-width (bh) = 0.07 m
                           thickness (bv) = 0.07 m

 Computed distance from port opening to CMC location = 6.64 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
              Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 6.29 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
              HD = 4.99 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
              test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
The CCC for the toxic pollutant was not encountered within the predicted
  plume region.
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                     CORMIX MIXING ZONE EXPERT SYSTEM
                 Subsystem CORMIX1: Single Port Discharges
                           CORMIX Version 11.0GTH
                   HYDRO1 Version 11.0.0.0 April 2018
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:  Bay City Outfall
 Design case:      DEQ Accute Criteria 10th % Velocity
 FILE NAME:        U:\...r\2018\BayCityMixZn\Output\Accute10thVelocity.prd
 Time stamp:       09/06/2018--16:39:53

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =      4.11  HD    =      2.94
 Tidal Simulation at TIME =      1.000 h
 PERIOD=     12.40 h UAmax =      1.000 dUa/dt=      0.100 (m/s)/h
 UA    =     0.100 F     =      0.020 USTAR =0.4950E-02
 UW    =     5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U         RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  =  RIGHT     DISTB =       1.00
 D0    =     0.203 A0    =      0.032 H0    =      0.30  SUB0  =      2.64
 THETA =     10.00  SIGMA =     90.00
 U0    =     3.257 Q0    =      0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02  GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS=  mg/l
 IPOLL =  1         KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00  M0    =0.3440E+00  J0    =0.1507E-01  SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =      3.66  Lm    =      5.86  Lb    =     15.07
                                       Lmp   =  99999.00  Lbp   =  99999.00
 Tidal:             Tu    =   0.2535 h Lu    =    23.134  Lmin  =     0.180
 Tidal Cutoffs (m): lmax  =   162.886  xmax  =    57.296  ymax  =   312.311

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12  R     =     32.57

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    H4-90  1
 1  Applicable layer depth HS =     2.94  1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS=  mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   =  CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   2000.00  XMAX  =   2000.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S       C        B        Uc        TT
     0.00     0.00     0.30     1.0 0.679E+01   0.10     3.257   .00000E+00

END OF MOD101: DISCHARGE MODULE
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet/plume transition motion in weak crossflow.

 Zone of flow establishment:            THETAE=     10.00  SIGMAE=     89.26
  LE    =      0.92  XE    =      0.01  YE    =      0.90  ZE    =      0.46

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X        Y        Z        S       C        B        Uc        TT
     0.00     0.00     0.30     1.0 0.679E+01   0.10     3.257   .00000E+00
     0.01     0.90     0.46     1.0 0.679E+01   0.10     3.257   .59765E-02
     0.02     1.40     0.56     1.3 0.513E+01   0.16     2.908   .15156E+00
```

0.05	1.92	0.66	1.8	0.373E+01	0.22	2.118	.37085E+00
0.10	2.44	0.78	2.3	0.291E+01	0.28	1.659	.65847E+00
0.16	2.96	0.92	2.9	0.236E+01	0.34	1.358	.10152E+01
0.24	3.46	1.07	3.4	0.198E+01	0.41	1.145	.14419E+01
0.34	3.96	1.24	4.0	0.168E+01	0.47	0.986	.19394E+01
0.46	4.44	1.44	4.7	0.145E+01	0.54	0.862	.25084E+01
0.61	4.93	1.67	5.4	0.125E+01	0.61	0.760	.31831E+01
0.77	5.38	1.92	6.2	0.109E+01	0.68	0.681	.38992E+01

** CMC HAS BEEN FOUND **

The pollutant concentration in the plume falls below CMC value of 0.104E+01 in the current prediction interval.

This is the extent of the TOXIC DILUTION ZONE.

0.95	5.80	2.19	7.0	0.966E+00	0.75	0.619	.46454E+01

Cumulative travel time = 4.6454 sec (0.00 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

Control volume inflow:

X	Y	Z	S	C	B	TT
0.95	5.80	2.19	7.0	0.969E+00	0.75	.46454E+01

Profile definitions:
- BV = Gaussian 1/e (37%) vertical thickness
- BH = Gaussian 1/e (37%) horizontal half-width, normal to trajectory
- ZU = upper plume boundary (Z-coordinate)
- ZL = lower plume boundary (Z-coordinate)
- S = hydrodynamic centerline dilution
- C = centerline concentration (includes reaction effects, if any)
- TT = Cumulative travel time

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
0.64	5.12	2.94	7.0	0.966E+00	0.02	0.00	2.94	2.92	.46454E+01
0.74	5.32	2.94	7.0	0.966E+00	0.65	0.33	2.94	2.29	.46454E+01
0.83	5.53	2.94	7.0	0.966E+00	0.77	0.46	2.94	2.17	.46454E+01
0.92	5.73	2.94	7.0	0.966E+00	0.85	0.57	2.94	2.09	.46454E+01
1.02	5.94	2.94	7.1	0.959E+00	0.91	0.66	2.94	2.03	.50078E+01
1.11	6.15	2.94	7.3	0.928E+00	0.95	0.73	2.94	1.99	.55514E+01
1.20	6.35	2.94	7.6	0.888E+00	0.98	0.80	2.94	1.96	.60949E+01
1.29	6.56	2.94	7.9	0.854E+00	1.01	0.87	2.94	1.93	.66385E+01
1.39	6.77	2.94	8.2	0.833E+00	1.02	0.93	2.94	1.92	.71821E+01
1.48	6.97	2.94	8.3	0.822E+00	1.03	0.98	2.94	1.91	.77256E+01
1.57	7.18	2.94	8.3	0.814E+00	1.04	1.04	2.94	1.90	.82692E+01

Cumulative travel time = 8.2692 sec (0.00 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

BEGIN MOD155: WEAKLY DEFLECTED SURFACE/BOTTOM PLUME

SURFACE/BOTTOM PLUME into a crossflow

Profile definitions:
- BV = Gaussian 1/e (37%) vertical thickness
- BH = Gaussian 1/e (37%) horizontal half-width, normal to trajectory
- ZU = upper plume boundary (Z-coordinate)
- ZL = lower plume boundary (Z-coordinate)
- S = hydrodynamic centerline dilution
- C = centerline concentration (includes reaction effects, if any)
- TT = Cumulative travel time

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
1.57	7.18	2.94	8.3	0.814E+00	1.04	1.04	2.94	1.90	.82692E+01
2.42	8.03	2.94	12.4	0.547E+00	0.70	2.30	2.94	2.24	.13832E+02
3.31	8.87	2.94	14.9	0.455E+00	0.58	3.33	2.94	2.36	.19807E+02
4.23	9.72	2.94	16.9	0.403E+00	0.51	4.25	2.94	2.43	.26195E+02
5.18	10.57	2.94	18.5	0.367E+00	0.47	5.13	2.94	2.47	.32995E+02
6.17	11.41	2.94	20.0	0.340E+00	0.43	5.97	2.94	2.51	.40208E+02
7.19	12.26	2.94	21.3	0.319E+00	0.41	6.78	2.94	2.53	.47833E+02
8.25	13.11	2.94	22.5	0.302E+00	0.38	7.58	2.94	2.56	.55871E+02
9.34	13.96	2.94	23.6	0.288E+00	0.37	8.37	2.94	2.57	.64321E+02
10.47	14.80	2.94	24.7	0.275E+00	0.35	9.15	2.94	2.59	.73183E+02
11.63	15.65	2.94	25.7	0.264E+00	0.34	9.92	2.94	2.60	.82458E+02

Cumulative travel time = 82.4577 sec (0.02 hrs)

END OF MOD155: WEAKLY DEFLECTED SURFACE/BOTTOM PLUME

BEGIN MOD156: STRONGLY DEFLECTED SURFACE/BOTTOM PLUME

Profile definitions:
- BV = top-hat thickness, measured vertically
- BH = top-hat half-width, measured horizontally from bank/shoreline
- ZU = upper plume boundary (Z-coordinate)
- ZL = lower plume boundary (Z-coordinate)
- S = hydrodynamic centerline dilution
- C = centerline concentration (includes reaction effects, if any)
- TT = Cumulative travel time

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
11.63	15.65	2.94	25.7	0.264E+00	0.34	9.92	2.94	2.60	.82458E+02
15.02	16.72	2.94	25.8	0.263E+00	0.31	10.92	2.94	2.63	.11630E+03
18.40	17.70	2.94	26.0	0.262E+00	0.30	11.89	2.94	2.64	.15015E+03
21.79	18.61	2.94	26.1	0.260E+00	0.28	12.82	2.94	2.66	.18399E+03
25.17	19.47	2.94	26.2	0.259E+00	0.27	13.73	2.94	2.67	.21784E+03
28.56	20.28	2.94	26.3	0.258E+00	0.26	14.62	2.94	2.68	.25168E+03
31.94	21.04	2.94	26.4	0.257E+00	0.25	15.49	2.94	2.69	.28553E+03
35.32	21.77	2.94	26.5	0.256E+00	0.24	16.34	2.94	2.70	.31937E+03
38.71	22.46	2.94	26.7	0.255E+00	0.24	17.18	2.94	2.70	.35322E+03
42.09	23.13	2.94	26.8	0.254E+00	0.23	18.00	2.94	2.71	.38706E+03
45.48	23.77	2.94	26.9	0.253E+00	0.23	18.81	2.94	2.71	.42091E+03

Cumulative travel time = 420.9065 sec (0.12 hrs)

END OF MOD156: STRONGLY DEFLECTED SURFACE/BOTTOM PLUME

** End of NEAR-FIELD REGION (NFR) **

The initial plume WIDTH values in the next far-field module will be
CORRECTED by a factor 1.84 to conserve the mass flux in the far-field!
The correction factor is quite large because of the small ambient velocity
relative to the strong mixing characteristics of the discharge!
This indicates localized RECIRCULATION REGIONS and INTERNAL HYDRAULIC JUMPS.
Width predictions show discontinuities. Dilution values should be acceptable.

In this design case, the discharge is located CLOSE TO BANK/SHORE.
Some lateral boundary interaction occurs at end of the near-field.
This may be related to a design case with a very LOW AMBIENT VELOCITY.
The dilution values in one or more of the preceding zones may be too high.
Carefully evaluate results in near-field and check degree of interaction.

Consider locating outfall further away from bank or shore.
In the next prediction module, the plume centerline will be set
to follow the bank/shore.

BEGIN MOD141: BUOYANT AMBIENT SPREADING

Plume is ATTACHED to RIGHT bank/shore.
Plume width is now determined from RIGHT bank/shore.

Profile definitions:
BV = top-hat thickness, measured vertically
BH = top-hat half-width, measured horizontally in Y-direction
ZU = upper plume boundary (Z-coordinate)
ZL = lower plume boundary (Z-coordinate)
S = hydrodynamic average (bulk) dilution
C = average (bulk) concentration (includes reaction effects, if any)
TT = Cumulative travel time

Plume Stage 2 (bank attached):

X	Y	Z	S	C	BV	BH	ZU	ZL	TT
45.48	-1.00	2.94	26.9	0.252E+00	0.49	59.29	2.94	2.45	.42091E+03
162.80	-1.00	2.94	34.6	0.204E+00	0.43	91.85	2.94	2.51	.15941E+04

Cumulative travel time = 1594.1165 sec (0.44 hrs)

CORMIX simulation has been TERMINATED at last prediction interval.
Limiting distance (lmax) due to TIDAL REVERSAL has been reached.

END OF MOD141: BUOYANT AMBIENT SPREADING

CORMIX1: Single Port Discharges End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  DEQ Accute Criteria 10th % Velocity
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\Accute10thVelocity.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:39:53
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = unbounded
  Average depth                   HA     = 4.11 m
  Depth at discharge              HD     = 2.94 m
  Darcy-Weisbach friction factor  F      = 0.0196
    Calculated from Manning's n          = 0.02
  Wind velocity                   UW     = 5.7 m/s
TIDAL SIMULATION at time          Tsim   = 1 hours
  Instantaneous ambient velocity  UA     = 0.1 m/s
  Maximum tidal velocity          UaMAX  = 1 m/s
Rate of tidal reversal          dUA/dt = 0.1 (m/s)/hour
  Period of reversal              T      = 12.4 hours
  Stratification Type             STRCND = U
  Surface density                 RHOAS  = 1012.74 kg/m^3
  Bottom density                  RHOAB  = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Single Port Discharge
  Nearest bank                           = right
  Distance to bank                DISTB  = 1 m
  Port diameter                   D0     = 0.2032 m
  Port cross-sectional area       A0     = 0.0324 m^2
  Discharge velocity              U0     = 3.26 m/s
  Discharge flowrate              Q0     = 0.105613 m^3/s
  Discharge port height           H0     = 0.30 m
  Vertical discharge angle        THETA  = 10 deg
  Horizontal discharge angle      SIGMA  = 90 deg
  Discharge density               RHO0   = 998 kg/m^3
  Density difference              DRHO   = 14.7400 kg/m^3
  Buoyant acceleration            GP0    = 0.1427 m/s^2
  Discharge concentration         C0     = 6.79 mg/l
  Surface heat exchange coeff.    KS     = 0 m/s
  Coefficient of decay            KD     = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m          Lm  = 5.86 m           Lb  = 15.07 m
  LM  = 3.66 m          Lm' = 99999 m          Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.2535 hours     Lu  = 23.13 m          Lmin= 0.18 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0    = 19.12
  Velocity ratio                  R      = 32.57
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = yes
  CMC concentration               CMC    = 1.04 mg/l
  CCC concentration               CCC    = 0.16 mg/l
  Water quality standard specified       = given by CCC value
  Regulatory mixing zone                 = no
  Region of interest                     = 2000 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS    = H4-90 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 2.94 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.2539 mg/l
  Dilution at edge of NFR              s = 26.7
  NFR Location:                        x = 45.48 m
    (centerline coordinates)           y = 23.77 m
                                       z = 2.94 m
```

```
  NFR plume dimensions:  half-width (bh) = 18.81 m
                          thickness (bv) = 0.23 m
Cumulative travel time:      420.9063 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 45.48 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                        x = 162.80 m
                                        y = -1 m
                                        z = 2.94 m.
  For this condition AFTER TIDAL REVERSAL, mixed water from the previous
  half-cycle becomes re-entrained into the near field of the discharge,
  increasing pollutant concentrations compared to steady-state predictions.
  A pool of mixed water formed at slack tide will be advected downstream
  in this phase.
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                       x = 0.84 m
    (centerline coordinates)            y = 5.54 m
                                        z = 2.02 m
  Plume dimension:        half-width (bh) = 0.05 m
                           thickness (bv) = 0.05 m

 Computed distance from port opening to CMC location = 5.86 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
              Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 5.60 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
              HD = 2.94 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
              test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
The CCC for the toxic pollutant was not encountered within the predicted
  plume region.
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
1111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                       CORMIX MIXING ZONE EXPERT SYSTEM
                  Subsystem CORMIX1: Single Port Discharges
                            CORMIX Version 11.0GTH
                    HYDRO1 Version 11.0.0.0 April 2018
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:    Bay City Outfall
 Design case:        DEQ Accute Criteria 90th % Velocity
 FILE NAME:          U:\...r\2018\BayCityMixZn\Output\Accute90thVelocity.prd
 Time stamp:         09/06/2018--16:42:24

ENVIRONMENT PARAMETERS (metric units)
 Bounded section
 BS    =    560.00 AS    =   2016.00 QA    =   1814.40  ICHREG= 1
 HA    =      3.60 HD    =      2.74
 Tidal Simulation at TIME =     2.000 h
 PERIOD=    12.40 h UAmax =     1.000 dUa/dt=      0.450 (m/s)/h
 UA    =     0.900 F     =     0.020 USTAR =0.4554E-01
 UW    =     5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U          RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  =  RIGHT     DISTB =      1.00
 D0    =     0.203 A0    =     0.032 H0    =      0.30  SUB0  =      2.44
 THETA =     10.00  SIGMA =     90.00
 U0    =     3.257 Q0    =     0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02  GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS= mg/l
 IPOLL =  1         KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00  M0    =0.3440E+00  J0    =0.1507E-01  SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =      3.66  Lm    =      0.65  Lb    =      0.02
                                       Lmp   =  99999.00  Lbp   =  99999.00
 Tidal:             Tu    =   0.0930 h Lu    =     14.013 Lmin  =      0.180
 Tidal Cutoffs (m): lmax  =  2529.561  xmax  =  1031.324  ymax  =**********

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12  R     =      3.62

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)      =    H2     1
 1  Applicable layer depth HS =    2.74   1
 1  Limiting Dilution S =QA/Q0= 17180.70  1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS= mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   =  CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   5600.00  XMAX  =   5600.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S       C        B        Uc         TT
     0.00     0.00     0.30     1.0 0.679E+01   0.10    3.257   .00000E+00

END OF MOD101: DISCHARGE MODULE
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:             THETAE=      9.93  SIGMAE=      83.37
  LE    =      0.11  XE    =      0.01  YE    =      0.11  ZE    =       0.32

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X        Y        Z        S       C        B        Uc         TT
     0.00     0.00     0.30     1.0 0.679E+01   0.10    3.257   .00000E+00
```

```
      0.01      0.11    0.32      1.0 0.679E+01   0.11     3.257   .63274E-02
      1.75      1.26    0.57      6.2 0.109E+01   0.39     0.199   .15633E+01
** CMC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below CMC value of 0.104E+01
   in the current prediction interval.
 This is the extent of the TOXIC DILUTION ZONE.
      3.97      1.60    0.70     10.0 0.682E+00   0.50     0.104   .37547E+01
      6.20      1.81    0.83     12.9 0.525E+00   0.57     0.077   .60399E+01
      8.44      1.97    0.97     15.7 0.433E+00   0.63     0.064   .83655E+01
     10.68      2.08    1.11     18.3 0.371E+00   0.69     0.055   .10715E+02
     12.92      2.18    1.25     20.9 0.324E+00   0.73     0.049   .13082E+02
     15.16      2.26    1.39     23.6 0.288E+00   0.78     0.045   .15461E+02
     17.40      2.33    1.54     26.3 0.258E+00   0.83     0.041   .17850E+02
     19.64      2.38    1.68     29.1 0.234E+00   0.87     0.038   .20248E+02
     21.88      2.43    1.83     31.9 0.213E+00   0.91     0.035   .22644E+02
 Cumulative travel time =          22.6442 sec  (     0.01 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

  Control volume inflow:
       X         Y       Z        S        C        B        TT
     21.88      2.43    1.83     31.2 0.218E+00   0.91 .22644E+02

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

       X         Y       Z        S        C        BV       BH       ZU       ZL        TT
     20.97      2.42    2.74     31.9 0.213E+00   0.00     0.00     2.74     2.74 .22644E+02
     21.24      2.43    2.74     31.9 0.213E+00   1.13     0.57     2.74     1.61 .22644E+02
     21.52      2.43    2.74     31.9 0.213E+00   1.34     0.81     2.74     1.40 .22644E+02
     21.79      2.43    2.74     31.9 0.213E+00   1.48     0.99     2.74     1.26 .22644E+02
     22.07      2.43    2.74     32.8 0.207E+00   1.58     1.14     2.74     1.16 .22847E+02
     22.34      2.44    2.74     36.8 0.184E+00   1.65     1.28     2.74     1.09 .23152E+02
     22.61      2.44    2.74     42.4 0.160E+00   1.71     1.40     2.74     1.03 .23456E+02
**WATER QUALITY STANDARD OR CCC HAS BEEN FOUND**
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.160E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     22.89      2.44    2.74     47.5 0.143E+00   1.75     1.51     2.74     0.99 .23761E+02
     23.16      2.45    2.74     51.0 0.133E+00   1.78     1.61     2.74     0.96 .24065E+02
     23.44      2.45    2.74     52.9 0.128E+00   1.80     1.71     2.74     0.94 .24370E+02
     23.71      2.45    2.74     54.1 0.125E+00   1.80     1.80     2.74     0.94 .24674E+02
 Cumulative travel time =          24.6740 sec  (     0.01 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
-----------------------------------------------------------------------------------------------
BEGIN MOD141: BUOYANT AMBIENT SPREADING

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 1 (not bank attached):
       X         Y       Z        S        C        BV       BH       ZU       ZL        TT
     23.71      2.45    2.74     54.1 0.125E+00   1.80     1.80     2.74     0.94 .24674E+02
     27.41      2.45    2.74     56.0 0.121E+00   1.69     2.00     2.74     1.05 .28788E+02
     31.11      2.45    2.74     57.8 0.118E+00   1.60     2.18     2.74     1.14 .32901E+02
     34.82      2.45    2.74     59.6 0.114E+00   1.54     2.36     2.74     1.20 .37015E+02
     38.52      2.45    2.74     61.5 0.110E+00   1.48     2.53     2.74     1.26 .41128E+02
     42.22      2.45    2.74     63.5 0.107E+00   1.44     2.69     2.74     1.30 .45242E+02
     45.92      2.45    2.74     65.5 0.104E+00   1.41     2.85     2.74     1.33 .49355E+02
     49.63      2.45    2.74     67.7 0.100E+00   1.39     3.01     2.74     1.35 .53469E+02
     53.33      2.45    2.74     70.0 0.971E-01   1.37     3.16     2.74     1.37 .57582E+02
     57.03      2.45    2.74     72.3 0.939E-01   1.36     3.31     2.74     1.38 .61696E+02
     60.73      2.45    2.74     74.9 0.907E-01   1.35     3.45     2.74     1.39 .65809E+02
 Cumulative travel time =          65.8091 sec  (     0.02 hrs)

-----------------------------------------------------------------------------------------------
 Plume is ATTACHED to RIGHT bank/shore.
   Plume width is now determined from RIGHT bank/shore.

 Plume Stage 2 (bank attached):
       X         Y       Z        S        C        BV       BH       ZU       ZL        TT
```

```
     60.73     -1.00     2.74     74.9 0.907E-01   1.35      6.90     2.74     1.39 .65809E+02
     65.08     -1.00     2.74     77.5 0.876E-01   1.37      7.07     2.74     1.37 .70634E+02
     69.42     -1.00     2.74     80.2 0.847E-01   1.39      7.23     2.74     1.35 .75458E+02
     73.76     -1.00     2.74     83.0 0.818E-01   1.41      7.40     2.74     1.33 .80283E+02
     78.10     -1.00     2.74     85.9 0.790E-01   1.44      7.56     2.74     1.30 .85107E+02
     82.44     -1.00     2.74     89.0 0.763E-01   1.46      7.72     2.74     1.28 .89932E+02
     86.79     -1.00     2.74     92.1 0.737E-01   1.49      7.88     2.74     1.25 .94756E+02
     91.13     -1.00     2.74     95.3 0.712E-01   1.52      8.03     2.74     1.22 .99581E+02
     95.47     -1.00     2.74     98.7 0.688E-01   1.55      8.19     2.74     1.19 .10441E+03
     99.81     -1.00     2.74    102.1 0.665E-01   1.58      8.34     2.74     1.16 .10923E+03
    104.16     -1.00     2.74    105.7 0.642E-01   1.61      8.49     2.74     1.13 .11405E+03
 Cumulative travel time =        114.0546 sec  (     0.03 hrs)

END OF MOD141: BUOYANT AMBIENT SPREADING
-----------------------------------------------------------------------------------------------
 Bottom coordinate for FAR-FIELD is determined by average depth, ZFB = -0.86m
-----------------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)    = 0.250E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.312E-01 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
        X         Y        Z        S        C        BV       BH       ZU       ZL        TT
    104.16     -1.00     2.74    105.7 0.642E-01   1.61      8.49     2.74     1.13 .11405E+03
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
    653.74     -1.00     2.74    249.6 0.272E-01   3.60     11.49     2.74    -0.86 .72467E+03
   1031.32     -1.00     2.74    273.2 0.249E-01   3.60     13.12     2.74    -0.86 .11442E+04
 Cumulative travel time =       1144.1807 sec  (     0.32 hrs)

 CORMIX simulation has been TERMINATED at last prediction interval.
   Limiting time due to TIDAL REVERSAL as per (xmax) has been reached.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  DEQ Accute Criteria 90th % Velocity
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\Accute90thVelocity.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:42:24
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = bounded
  Width                         BS       = 560 m
  Channel regularity            ICHREG = 1
  Ambient flowrate              QA       = 1814.40 m^3/s
  Average depth                 HA       = 3.6 m
  Depth at discharge            HD       = 2.74 m
  Darcy-Weisbach friction factor  F      = 0.0205
    Calculated from Manning's n          = 0.02
  Wind velocity                 UW       = 5.7 m/s
TIDAL SIMULATION at time        Tsim     = 2 hours
  Instantaneous ambient velocity  UA     = 0.9 m/s
  Maximum tidal velocity        UaMAX    = 1 m/s
Rate of tidal reversal          dUA/dt = 0.45 (m/s)/hour
  Period of reversal            T        = 12.4 hours
  Stratification Type           STRCND = U
  Surface density               RHOAS    = 1012.74 kg/m^3
  Bottom density                RHOAB    = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:           Single Port Discharge
  Nearest bank                           = right
  Distance to bank              DISTB    = 1 m
  Port diameter                 D0       = 0.2032 m
  Port cross-sectional area     A0       = 0.0324 m^2
  Discharge velocity            U0       = 3.26 m/s
  Discharge flowrate            Q0       = 0.105613 m^3/s
  Discharge port height         H0       = 0.30 m
  Vertical discharge angle      THETA    = 10 deg
  Horizontal discharge angle    SIGMA    = 90 deg
  Discharge density             RHO0     = 998 kg/m^3
  Density difference            DRHO     = 14.7400 kg/m^3
  Buoyant acceleration          GP0      = 0.1427 m/s^2
  Discharge concentration       C0       = 6.79 mg/l
  Surface heat exchange coeff.  KS       = 0 m/s
  Coefficient of decay          KD       = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m          Lm  = 0.65 m          Lb  = 0.02 m
  LM  = 3.66 m          Lm' = 99999 m          Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.0930 hours      Lu  = 14.01 m          Lmin= 0.18 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0    = 19.12
  Velocity ratio                R        = 3.62
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = yes
  CMC concentration             CMC      = 1.04 mg/l
  CCC concentration             CCC      = 0.16 mg/l
  Water quality standard specified       = given by CCC value
  Regulatory mixing zone                 = no
  Region of interest                     = 5600 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 2.74 m

  Limiting Dilution S = (QA/Q0)+ 1.0 = 17180.7

*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
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  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.1255 mg/l
  Dilution at edge of NFR              s = 54.1
  NFR Location:                        x = 23.71 m
    (centerline coordinates)           y = 2.45 m
                                       z = 2.74 m
  NFR plume dimensions:  half-width (bh) = 1.80 m
                          thickness (bv) = 1.80 m
Cumulative travel time:       24.6740 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 653.74 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in bounded section contacts one bank only at 60.73 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                       x = 1031.32 m
                                       y = -1 m
                                       z = 2.74 m.
  For this condition AFTER TIDAL REVERSAL, mixed water from the previous
  half-cycle becomes re-entrained into the near field of the discharge,
  increasing pollutant concentrations compared to steady-state predictions.
  A pool of mixed water formed at slack tide will be advected downstream
  in this phase.
************************ TOXIC DILUTION ZONE SUMMARY ***********************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                      x = 1.90 m
    (centerline coordinates)           y = 1.29 m
                                       z = 0.58 m
  Plume dimension:       half-width (bh) = 0.03 m
                          thickness (bv) = 0.03 m

 Computed distance from port opening to CMC location = 2.31 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.29 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 2.74 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                    = 0.16  mg/l
Corresponding dilution                   = 42.4
  Plume location:                      x = 22.62 m
    (centerline coordinates)           y = 2.44 m
                                       z = 2.74 m
 Computed horizontal distance from port opening to CCC location = 22.88
  Plume dimensions:      half-width (bh) = 1.40 m
                          thickness (bv) = 1.71 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
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CORMIX1 PREDICTION FILE:
111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                   CORMIX MIXING ZONE EXPERT SYSTEM
              Subsystem CORMIX1: Single Port Discharges
                        CORMIX Version 11.0GTH
                  HYDRO1 Version 11.0.0.0 April 2018
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       DEQ Chronic Criteria 50th % Velocity (Ebb)
 FILE NAME:         U:\...18\BayCityMixZn\Output\Chronic50thVelocityEbb.prd
 Time stamp:        09/06/2018--16:43:45

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =      4.11 HD    =      2.94
 Tidal Simulation at TIME =     2.100 h
 PERIOD=    12.40 h UAmax =     1.000 dUa/dt=      0.238 (m/s)/h
 UA    =     0.500 F     =      0.020 USTAR =0.2475E-01
 UW    =     5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U          RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  = RIGHT      DISTB =      1.00
 D0    =     0.203 A0    =      0.032 H0     =      0.30  SUB0  =      2.64
 THETA =     10.00  SIGMA =     90.00
 U0    =     3.257 Q0    =      0.106       =0.1056E+00
 RHO0  =  998.0000  DRHO0 =0.1474E+02  GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS=  mg/l
 IPOLL = 1          KS    =0.0000E+00  KD    =0.0000E+00

FLUX VARIABLES (metric units)
Q0    =0.1056E+00 M0    =0.3440E+00  J0    =0.1507E-01  SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =      3.66  Lm    =      1.17  Lb    =      0.12
                                      Lmp   =  99999.00  Lbp   =  99999.00
 Tidal:             Tu    =   0.1422 h Lu    =    17.325  Lmin  =      0.180
 Tidal Cutoffs (m): lmax  =  1469.837  xmax  =   601.606  ymax  =    233.886

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12  R     =      6.51

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)       =     H2    1
 1  Applicable layer depth HS =   2.94    1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS=  mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   =  CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   5600.00  XMAX  =   5600.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X         Y        Z         S       C          B        Uc         TT
      0.00      0.00     0.30      1.0 0.679E+01   0.10     3.257    .00000E+00

END OF MOD101: DISCHARGE MODULE
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:            THETAE=      9.98  SIGMAE=      86.31
  LE    =      0.51  XE    =       0.02  YE    =      0.51  ZE    =       0.39

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X         Y        Z         S       C          B        Uc         TT
      0.00      0.00     0.30      1.0 0.679E+01   0.10     3.257    .00000E+00
      0.02      0.51     0.39      1.0 0.679E+01   0.11     3.257    .66510E-02
      0.37      1.53     0.59      2.6 0.264E+01   0.27     1.249    .47274E+00
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     1.22      2.22     0.77      5.6 0.122E+01   0.46     0.429   .15043E+01
** CMC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below CMC value of 0.104E+01
   in the current prediction interval.
 This is the extent of the TOXIC DILUTION ZONE.
     2.28      2.63     0.92      8.6 0.791E+00   0.59     0.237   .29921E+01
     3.35      2.91     1.06     11.2 0.609E+00   0.69     0.170   .46374E+01
     4.44      3.12     1.19     13.5 0.502E+00   0.76     0.137   .63853E+01
     5.56      3.29     1.33     15.8 0.429E+00   0.83     0.116   .82454E+01
     6.66      3.42     1.47     18.0 0.377E+00   0.89     0.103   .10102E+02
     7.80      3.54     1.61     20.2 0.336E+00   0.94     0.093   .12042E+02
     8.90      3.64     1.75     22.4 0.304E+00   1.00     0.086   .13958E+02
    10.00      3.73     1.89     24.5 0.277E+00   1.05     0.080   .15894E+02
 Cumulative travel time =          15.8941 sec  (     0.00 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

  Control volume inflow:
      X         Y        Z         S        C         B        TT
    10.00      3.73     1.89     24.4 0.279E+00   1.05 .15894E+02

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

      X         Y        Z         S        C         BV        BH        ZU        ZL        TT
     8.96      3.69     2.94     24.5 0.277E+00   0.00      0.00      2.94      2.94 .15894E+02
     9.27      3.71     2.94     24.5 0.277E+00   1.32      0.67      2.94      1.62 .15894E+02
     9.59      3.72     2.94     24.5 0.277E+00   1.57      0.94      2.94      1.37 .15894E+02
     9.90      3.73     2.94     24.5 0.277E+00   1.73      1.15      2.94      1.21 .15894E+02
    10.22      3.74     2.94     25.2 0.269E+00   1.84      1.33      2.94      1.10 .16316E+02
    10.53      3.75     2.94     28.3 0.240E+00   1.93      1.49      2.94      1.01 .16943E+02
    10.84      3.76     2.94     32.6 0.208E+00   2.00      1.63      2.94      0.94 .17570E+02
    11.16      3.78     2.94     36.6 0.186E+00   2.05      1.76      2.94      0.89 .18197E+02
    11.47      3.79     2.94     39.2 0.173E+00   2.08      1.88      2.94      0.86 .18824E+02
    11.78      3.80     2.94     40.7 0.167E+00   2.10      2.00      2.94      0.84 .19451E+02
    12.10      3.81     2.94     41.6 0.163E+00   2.11      2.11      2.94      0.83 .20078E+02
 Cumulative travel time =          20.0782 sec  (     0.01 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH
-----------------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
-----------------------------------------------------------------------------------------------
BEGIN MOD141: BUOYANT AMBIENT SPREADING

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 1 (not bank attached):
      X         Y        Z         S        C         BV        BH        ZU        ZL        TT
    12.10      3.81     2.94     41.6 0.163E+00   2.11      2.11      2.94      0.83 .20078E+02
**WATER QUALITY STANDARD OR CCC HAS BEEN FOUND**
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.160E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
    14.98      3.81     2.94     43.2 0.157E+00   1.89      2.44      2.94      1.05 .25845E+02
    17.86      3.81     2.94     44.5 0.153E+00   1.73      2.75      2.94      1.21 .31612E+02
    20.75      3.81     2.94     45.7 0.149E+00   1.61      3.04      2.94      1.33 .37379E+02
    23.63      3.81     2.94     46.7 0.145E+00   1.51      3.32      2.94      1.43 .43146E+02
    26.51      3.81     2.94     47.7 0.142E+00   1.43      3.59      2.94      1.51 .48914E+02
    29.40      3.81     2.94     48.7 0.140E+00   1.36      3.85      2.94      1.58 .54681E+02
    32.28      3.81     2.94     49.5 0.137E+00   1.30      4.10      2.94      1.64 .60448E+02
    35.16      3.81     2.94     50.4 0.135E+00   1.25      4.35      2.94      1.69 .66215E+02
    38.05      3.81     2.94     51.2 0.133E+00   1.21      4.58      2.94      1.73 .71982E+02
    40.93      3.81     2.94     52.1 0.130E+00   1.17      4.81      2.94      1.77 .77749E+02
 Cumulative travel time =          77.7488 sec  (     0.02 hrs)

-----------------------------------------------------------------------------------------------
 Plume is ATTACHED to RIGHT bank/shore.
   Plume width is now determined from RIGHT bank/shore.

 Plume Stage 2 (bank attached):
      X         Y        Z         S        C         BV        BH        ZU        ZL        TT
    40.93     -1.00     2.94     52.1 0.130E+00   1.17      9.63      2.94      1.77 .77749E+02
    95.18     -1.00     2.94     63.0 0.108E+00   1.04     13.53      2.94      1.90 .18624E+03
```

```
   149.42    -1.00    2.94    78.0 0.871E-01   1.06    16.93    2.94    1.88 .29473E+03
   203.66    -1.00    2.94    98.0 0.693E-01   1.16    20.01    2.94    1.78 .40321E+03
   257.91    -1.00    2.94   123.5 0.550E-01   1.31    22.87    2.94    1.63 .51170E+03
   312.15    -1.00    2.94   154.8 0.439E-01   1.51    25.57    2.94    1.43 .62019E+03
   366.40    -1.00    2.94   191.9 0.354E-01   1.74    28.12    2.94    1.20 .72868E+03
   420.64    -1.00    2.94   235.2 0.289E-01   2.00    30.57    2.94    0.94 .83717E+03
   474.89    -1.00    2.94   284.6 0.239E-01   2.29    32.92    2.94    0.65 .94566E+03
   529.13    -1.00    2.94   340.4 0.199E-01   2.60    35.19    2.94    0.34 .10541E+04
   583.37    -1.00    2.94   402.7 0.169E-01   2.94    37.39    2.94    0.00 .11626E+04
 Cumulative travel time =       1162.6353 sec  (    0.32 hrs)

END OF MOD141: BUOYANT AMBIENT SPREADING
-----------------------------------------------------------------------------------------
 Bottom coordinate for FAR-FIELD is determined by average depth, ZFB = -1.17m
-----------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.147E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.188E+00 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
      X         Y        Z         S       C         BV       BH       ZU       ZL        TT
   583.37    -1.00    2.94   402.7 0.169E-01   2.94    37.39    2.94    0.00 .11626E+04
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
   601.61    -1.00    2.94   410.6 0.166E-01   2.98    37.69    2.94   -0.04 .11991E+04
 Cumulative travel time =       1199.0968 sec  (    0.33 hrs)

 CORMIX simulation has been TERMINATED at last prediction interval.
   Limiting time due to TIDAL REVERSAL as per (xmax) has been reached.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
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CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  DEQ Chronic Criteria 50th % Velocity (Ebb)
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\Chronic50thVelocityEbb.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:43:45
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = unbounded
  Average depth                  HA      = 4.11 m
  Depth at discharge             HD      = 2.94 m
  Darcy-Weisbach friction factor F       = 0.0196
    Calculated from Manning's n          = 0.02
  Wind velocity                  UW      = 5.7 m/s
TIDAL SIMULATION at time         Tsim    = 2.1 hours
  Instantaneous ambient velocity UA      = 0.5 m/s
  Maximum tidal velocity         UaMAX   = 1 m/s
Rate of tidal reversal          dUA/dt = 0.2381 (m/s)/hour
  Period of reversal             T       = 12.4 hours
  Stratification Type            STRCND = U
  Surface density                RHOAS   = 1012.74 kg/m^3
  Bottom density                 RHOAB   = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:            Single Port Discharge
  Nearest bank                           = right
  Distance to bank               DISTB   = 1 m
  Port diameter                  D0      = 0.2032 m
  Port cross-sectional area      A0      = 0.0324 m^2
  Discharge velocity             U0      = 3.26 m/s
  Discharge flowrate             Q0      = 0.105613 m^3/s
  Discharge port height          H0      = 0.30 m
  Vertical discharge angle       THETA   = 10 deg
  Horizontal discharge angle     SIGMA   = 90 deg
  Discharge density              RHO0    = 998 kg/m^3
  Density difference             DRHO    = 14.7400 kg/m^3
  Buoyant acceleration           GP0     = 0.1427 m/s^2
  Discharge concentration        C0      = 6.79 mg/l
  Surface heat exchange coeff.   KS      = 0 m/s
  Coefficient of decay           KD      = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m        Lm  = 1.17 m         Lb  = 0.12 m
  LM  = 3.66 m        Lm' = 99999 m        Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.1422 hours     Lu  = 17.32 m        Lmin= 0.18 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number FR0     = 19.12
  Velocity ratio                 R       = 6.51
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = yes
  CMC concentration              CMC     = 1.04 mg/l
  CCC concentration              CCC     = 0.16 mg/l
  Water quality standard specified       = given by CCC value
  Regulatory mixing zone                 = no
  Region of interest                     = 5600 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 2.94 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.163 mg/l
  Dilution at edge of NFR              s = 41.6
  NFR Location:                        x = 12.10 m
    (centerline coordinates)           y = 3.81 m
                                       z = 2.94 m
```

```
  NFR plume dimensions:  half-width (bh) = 2.11 m
                          thickness (bv) = 2.11 m
Cumulative travel time:       20.0782 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 1085.04 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 40.93 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                    x = 601.61 m
                                    y = -1 m
                                    z = 2.94 m.
  For this condition AFTER TIDAL REVERSAL, mixed water from the previous
  half-cycle becomes re-entrained into the near field of the discharge,
  increasing pollutant concentrations compared to steady-state predictions.
  A pool of mixed water formed at slack tide will be advected downstream
  in this phase.
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                   x = 1.53 m
    (centerline coordinates)        y = 2.36 m
                                    z = 0.82 m
  Plume dimension:        half-width (bh) = 0.07 m
                           thickness (bv) = 0.07 m

 Computed distance from port opening to CMC location = 2.86 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.81 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 2.94 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY **********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                 = 0.16  mg/l
Corresponding dilution                = 42.4
  Plume location:                   x = 13.53 m
    (centerline coordinates)        y = 3.81 m
                                    z = 2.94 m
 Computed horizontal distance from port opening to CCC location = 14.30
  Plume dimensions:       half-width (bh) = 2.27 m
                           thickness (bv) = 1.99 m
********************* FINAL DESIGN ADVICE AND COMMENTS *********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

```
CORMIX1 PREDICTION FILE:
111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
                       CORMIX MIXING ZONE EXPERT SYSTEM
                   Subsystem CORMIX1: Single Port Discharges
                             CORMIX Version 11.0GTH
                     HYDRO1 Version 11.0.0.0 April 2018
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
CASE DESCRIPTION
 Site name/label:   Bay City Outfall
 Design case:       DEQ Chronic Criteria 50% Velocity (Flood)
 FILE NAME:         U:\...\BayCityMixZn\Output\Chronic50thVelocityFlood.prd
 Time stamp:        09/06/2018--16:45:12

ENVIRONMENT PARAMETERS (metric units)
 Unbounded section
 HA    =      4.11  HD    =       4.74
 Tidal Simulation at TIME =     -1.000 h
 PERIOD=    12.40 h UAmax =      1.000 dUa/dt=      0.500 (m/s)/h
 UA    =     0.500 F     =      0.020 USTAR =0.2475E-01
 UW    =     5.700 UWSTAR=0.6815E-02
 Uniform density environment
 STRCND= U          RHOAM = 1012.7400

DISCHARGE PARAMETERS (metric units)
 BANK  = RIGHT      DISTB =       1.00
 D0    =     0.203 A0    =      0.032 H0    =       0.30  SUB0  =       4.44
 THETA =     10.00  SIGMA =      90.00
 U0    =     3.257 Q0    =      0.106      =0.1056E+00
 RHO0  = 998.0000  DRHO0 =0.1474E+02 GP0   =0.1427E+00
 C0    =0.6790E+01  CUNITS= mg/l
 IPOLL = 1          KS    =0.0000E+00 KD    =0.0000E+00

FLUX VARIABLES (metric units)
 Q0    =0.1056E+00 M0    =0.3440E+00 J0    =0.1507E-01 SIGNJ0=      1.0
 Associated length scales (meters)
 LQ    =      0.18  LM    =       3.66  Lm    =       1.17  Lb    =       0.12
                                        Lmp   =  99999.00  Lbp   =  99999.00
 Tidal:             Tu    =   0.0867 h Lu    =     13.529 Lmin  =      0.180
 Tidal Cutoffs (m): lmax  =   793.855  xmax  =  5580.000  ymax  =   182.641

NON-DIMENSIONAL PARAMETERS
 FR0   =     19.12  R     =       6.51

FLOW CLASSIFICATION
 111111111111111111111111111111111111111111
 1  Flow class (CORMIX1)       =    H2    1
 1  Applicable layer depth HS =    4.74   1
 111111111111111111111111111111111111111111

MIXING ZONE / TOXIC DILUTION / REGION OF INTEREST PARAMETERS
 C0    =0.6790E+01  CUNITS= mg/l
 NTOX  =  1         CMC   =0.1040E+01  CCC   =  CSTD
 NSTD  =  1         CSTD  =0.1600E+00
 REGMZ =  0
 XINT  =   5600.00  XMAX  =   5600.00

X-Y-Z COORDINATE SYSTEM:
    ORIGIN is located at the bottom and below the center of the port:
         1.00 m  from the RIGHT bank/shore.
    X-axis points downstream, Y-axis points to left, Z-axis points upward.
NSTEP =  10 display intervals per module
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN MOD101: DISCHARGE MODULE

       X        Y        Z        S      C        B        Uc        TT
      0.00     0.00     0.30     1.0 0.679E+01  0.10     3.257   .00000E+00

END OF MOD101: DISCHARGE MODULE
---------------------------------------------------------------------------------------------
---------------------------------------------------------------------------------------------
BEGIN CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION

 Jet-like motion in weak crossflow.

 Zone of flow establishment:             THETAE=       9.98  SIGMAE=      86.31
  LE    =      0.51  XE    =       0.02  YE    =       0.51  ZE    =       0.39

 Profile definitions:
   B = Gaussian 1/e (37%) half-width, normal to trajectory
   S = hydrodynamic centerline dilution
   C = centerline concentration (includes reaction effects, if any)
  Uc = Local centerline excess velocity (above ambient)
  TT = Cumulative travel time

       X        Y        Z        S      C        B        Uc        TT
      0.00     0.00     0.30     1.0 0.679E+01  0.10     3.257   .00000E+00
      0.02     0.51     0.39     1.0 0.679E+01  0.11     3.257   .10946E-01
      1.17     2.19     0.76     5.5 0.124E+01  0.46     0.440   .14712E+01
```

```
** CMC HAS BEEN FOUND **
 The pollutant concentration in the plume falls below CMC value of 0.104E+01
   in the current prediction interval.
 This is the extent of the TOXIC DILUTION ZONE.
      3.26      2.89     1.05      11.0 0.616E+00   0.68     0.173   .45394E+01
      5.44      3.27     1.31      15.7 0.434E+00   0.82     0.118   .80807E+01
      7.64      3.53     1.59      20.0 0.339E+00   0.94     0.094   .11810E+02
      9.79      3.72     1.86      24.3 0.280E+00   1.04     0.081   .15564E+02
     12.00      3.87     2.15      28.7 0.236E+00   1.13     0.071   .19471E+02
     14.20      3.99     2.43      33.3 0.204E+00   1.22     0.064   .23432E+02
     16.41      4.09     2.71      38.0 0.179E+00   1.31     0.059   .27435E+02
**WATER QUALITY STANDARD OR CCC HAS BEEN FOUND**
 The pollutant concentration in the plume falls below water quality standard
   or CCC value of 0.160E+00 in the current prediction interval.
 This is the spatial extent of concentrations exceeding the water quality
   standard or CCC value.
     18.62      4.17     2.99      42.9 0.158E+00   1.39     0.054   .31472E+02
     20.78      4.24     3.26      47.8 0.142E+00   1.47     0.050   .35433E+02
 Cumulative travel time =          35.4333 sec  (     0.01 hrs)

END OF CORJET (MOD110): JET/PLUME NEAR-FIELD MIXING REGION
-----------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------
BEGIN MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH

  Control volume inflow:
      X         Y        Z         S       C         B        TT
     20.78      4.24     3.26      47.6 0.143E+00   1.47 .35433E+02

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

      X         Y        Z         S       C         BV       BH       ZU       ZL        TT
     19.31      4.21     4.74      47.8 0.142E+00   0.00     0.00     4.74     4.74 .35433E+02
     19.75      4.22     4.74      47.8 0.142E+00   1.85     0.93     4.74     2.89 .35433E+02
     20.19      4.23     4.74      47.8 0.142E+00   2.19     1.31     4.74     2.55 .35433E+02
     20.63      4.23     4.74      47.8 0.142E+00   2.41     1.61     4.74     2.33 .35433E+02
     21.08      4.24     4.74      49.1 0.138E+00   2.57     1.86     4.74     2.17 .36023E+02
     21.52      4.25     4.74      55.2 0.123E+00   2.69     2.08     4.74     2.05 .36907E+02
     21.96      4.25     4.74      63.6 0.107E+00   2.78     2.27     4.74     1.96 .37790E+02
     22.40      4.26     4.74      71.3 0.952E-01   2.85     2.46     4.74     1.89 .38674E+02
     22.84      4.27     4.74      76.6 0.887E-01   2.90     2.63     4.74     1.84 .39558E+02
     23.28      4.27     4.74      79.4 0.855E-01   2.93     2.79     4.74     1.81 .40441E+02
     23.73      4.28     4.74      81.3 0.836E-01   2.94     2.94     4.74     1.80 .41325E+02
 Cumulative travel time =          41.3249 sec  (     0.01 hrs)

END OF MOD131: LAYER BOUNDARY/TERMINAL LAYER APPROACH
-----------------------------------------------------------------------------------------
** End of NEAR-FIELD REGION (NFR) **
-----------------------------------------------------------------------------------------
BEGIN MOD141: BUOYANT AMBIENT SPREADING

 Profile definitions:
   BV = top-hat thickness, measured vertically
   BH = top-hat half-width, measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic average (bulk) dilution
   C  = average (bulk) concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 1 (not bank attached):
      X         Y        Z         S       C         BV       BH       ZU       ZL        TT
     23.73      4.28     4.74      81.3 0.836E-01   2.94     2.94     4.74     1.80 .41325E+02
     26.46      4.28     4.74      83.2 0.817E-01   2.75     3.21     4.74     1.99 .46786E+02
     29.19      4.28     4.74      84.9 0.800E-01   2.60     3.47     4.74     2.14 .52247E+02
     31.92      4.28     4.74      86.5 0.785E-01   2.47     3.72     4.74     2.27 .57708E+02
     34.65      4.28     4.74      88.0 0.772E-01   2.36     3.96     4.74     2.38 .63169E+02
     37.38      4.28     4.74      89.4 0.759E-01   2.27     4.19     4.74     2.47 .68630E+02
     40.11      4.28     4.74      90.8 0.748E-01   2.19     4.42     4.74     2.55 .74091E+02
     42.84      4.28     4.74      92.2 0.737E-01   2.11     4.64     4.74     2.63 .79552E+02
     45.57      4.28     4.74      93.5 0.727E-01   2.05     4.86     4.74     2.69 .85013E+02
     48.30      4.28     4.74      94.7 0.717E-01   1.99     5.07     4.74     2.75 .90474E+02
     51.03      4.28     4.74      96.0 0.708E-01   1.94     5.28     4.74     2.80 .95935E+02
 Cumulative travel time =          95.9350 sec  (     0.03 hrs)

-----------------------------------------------------------------------------------------
 Plume is ATTACHED to RIGHT bank/shore.
   Plume width is now determined from RIGHT bank/shore.

 Plume Stage 2 (bank attached):
      X         Y        Z         S       C         BV       BH       ZU       ZL        TT
     51.03     -1.00     4.74      96.0 0.708E-01   1.94    10.56     4.74     2.80 .95935E+02
    124.99     -1.00     4.74     119.3 0.569E-01   1.65    15.58     4.74     3.09 .24386E+03
```

```
   198.96     -1.00     4.74    151.8 0.447E-01   1.66      19.88      4.74      3.08 .39179E+03
   272.92     -1.00     4.74    196.2 0.346E-01   1.81      23.75      4.74      2.93 .53971E+03
   346.88     -1.00     4.74    254.4 0.267E-01   2.06      27.33      4.74      2.68 .68764E+03
   420.85     -1.00     4.74    327.4 0.207E-01   2.37      30.69      4.74      2.37 .83556E+03
   494.81     -1.00     4.74    416.3 0.163E-01   2.75      33.87      4.74      1.99 .98349E+03
   568.77     -1.00     4.74    522.0 0.130E-01   3.18      36.92      4.74      1.56 .11314E+04
   642.73     -1.00     4.74    645.3 0.105E-01   3.66      39.84      4.74      1.08 .12793E+04
   716.70     -1.00     4.74    787.0 0.863E-02   4.18      42.65      4.74      0.56 .14273E+04
   790.66     -1.00     4.74    947.8 0.716E-02   4.74      45.38      4.74      0.00 .15752E+04
 Cumulative travel time =         1575.1919 sec  (     0.44 hrs)

END OF MOD141: BUOYANT AMBIENT SPREADING
-----------------------------------------------------------------------------------------------
 Due to the attachment or proximity of the plume to the bottom, the bottom
   coordinate for the FAR-FIELD differs from the ambient depth, ZFB = 0 m.
 In a subsequent analysis set "depth at discharge" equal to "ambient depth".
-----------------------------------------------------------------------------------------------
BEGIN MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT

  Vertical diffusivity (initial value)   = 0.236E-01 m^2/s
  Horizontal diffusivity (initial value) = 0.243E+00 m^2/s

 Profile definitions:
   BV = Gaussian s.d.*sqrt(pi/2) (46%) thickness, measured vertically
      = or equal to layer depth, if fully mixed
   BH = Gaussian s.d.*sqrt(pi/2) (46%) half-width,
        measured horizontally in Y-direction
   ZU = upper plume boundary (Z-coordinate)
   ZL = lower plume boundary (Z-coordinate)
   S  = hydrodynamic centerline dilution
   C  = centerline concentration (includes reaction effects, if any)
   TT = Cumulative travel time

 Plume Stage 2 (bank attached):
      X         Y        Z         S         C        BV        BH        ZU        ZL         TT
   790.66     -1.00     4.74    947.8 0.716E-02   4.74      45.38      4.74      0.00 .15752E+04
 Plume interacts with BOTTOM.
 The passive diffusion plume becomes VERTICALLY FULLY MIXED within this
   prediction interval.
   793.84     -1.00     4.74    948.9 0.716E-02   4.74      45.44      4.74      0.00 .15816E+04
 Cumulative travel time =         1581.5564 sec  (     0.44 hrs)

 CORMIX simulation has been TERMINATED at last prediction interval.
   Limiting distance (lmax) due to TIDAL REVERSAL has been reached.

END OF MOD161: PASSIVE AMBIENT MIXING IN UNIFORM AMBIENT
-----------------------------------------------------------------------------------------------
-----------------------------------------------------------------------------------------------
CORMIX1: Single Port Discharges              End of Prediction File
11111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111111
```

```
CORMIX SESSION REPORT:
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
                      CORMIX MIXING ZONE EXPERT SYSTEM
                          CORMIX Version 11.0GTH
                       HYDRO1:Version-11.0.0.0  April,2018
SITE NAME/LABEL:                Bay City Outfall
  DESIGN CASE:                  DEQ Chronic Criteria 50% Velocity (Flood)
  FILE NAME:                    U:\rstillmaker\2018\BayCityMixZn\Output\Chronic50thVelocityFlood.prd
  Using subsystem CORMIX1:     Single Port Discharges
  Start of session:             09/06/2018--16:45:12
*****************************************************************************
SUMMARY OF INPUT DATA:
-----------------------------------------------------------------------------
AMBIENT PARAMETERS:
  Cross-section                          = unbounded
  Average depth                   HA     = 4.11 m
  Depth at discharge              HD     = 4.74 m
  Darcy-Weisbach friction factor  F      = 0.0196
    Calculated from Manning's n          = 0.02
  Wind velocity                   UW     = 5.7 m/s
TIDAL SIMULATION at time          Tsim   = -1 hours
  Instantaneous ambient velocity  UA     = 0.5 m/s
  Maximum tidal velocity          UaMAX  = 1 m/s
Rate of tidal reversal          dUA/dt = 0.5 (m/s)/hour
  Period of reversal              T      = 12.4 hours
  Stratification Type             STRCND = U
  Surface density                 RHOAS  = 1012.74 kg/m^3
  Bottom density                  RHOAB  = 1012.74 kg/m^3
-----------------------------------------------------------------------------
DISCHARGE PARAMETERS:             Single Port Discharge
  Nearest bank                           = right
  Distance to bank                DISTB  = 1 m
  Port diameter                   D0     = 0.2032 m
  Port cross-sectional area       A0     = 0.0324 m^2
  Discharge velocity              U0     = 3.26 m/s
  Discharge flowrate              Q0     = 0.105613 m^3/s
  Discharge port height           H0     = 0.30 m
  Vertical discharge angle        THETA  = 10 deg
  Horizontal discharge angle      SIGMA  = 90 deg
  Discharge density               RHO0   = 998 kg/m^3
  Density difference              DRHO   = 14.7400 kg/m^3
  Buoyant acceleration            GP0    = 0.1427 m/s^2
  Discharge concentration         C0     = 6.79 mg/l
  Surface heat exchange coeff.    KS     = 0 m/s
  Coefficient of decay            KD     = 0 /s
-----------------------------------------------------------------------------
DISCHARGE/ENVIRONMENT LENGTH SCALES:
  LQ  = 0.18 m         Lm  = 1.17 m          Lb  = 0.12 m
  LM  = 3.66 m         Lm' = 99999 m         Lb' = 99999 m
UNSTEADY TIDAL SCALES:
  Tu  = 0.0867 hours     Lu  = 13.53 m          Lmin= 0.18 m
-----------------------------------------------------------------------------
NON-DIMENSIONAL PARAMETERS:
  Port densimetric Froude number  FR0    = 19.12
  Velocity ratio                  R      = 6.51
-----------------------------------------------------------------------------
MIXING ZONE / TOXIC DILUTION ZONE / AREA OF INTEREST PARAMETERS:
  Toxic discharge                        = yes
  CMC concentration               CMC    = 1.04 mg/l
  CCC concentration               CCC    = 0.16 mg/l
  Water quality standard specified       = given by CCC value
  Regulatory mixing zone                 = no
  Region of interest                     = 5600 m downstream
*****************************************************************************
HYDRODYNAMIC CLASSIFICATION:
  *------------------------*
  | FLOW CLASS   = H2 |
  *------------------------*
  This flow configuration applies to a layer corresponding to the full water
  depth at the discharge site.
  Applicable layer depth = water depth = 4.74 m
*****************************************************************************
MIXING ZONE EVALUATION (hydrodynamic and regulatory summary):

-----------------------------------------------------------------------------
X-Y-Z Coordinate system:
  Origin is located at the BOTTOM below the port/diffuser center:
    1 m from the right bank/shore.
  Number of display steps NSTEP = 10 per module.
-----------------------------------------------------------------------------
NEAR-FIELD REGION (NFR) CONDITIONS :
Note: The NFR is the zone of strong initial mixing.  It has no regulatory
  implication.  However, this information may be useful for the discharge
  designer because the mixing in the NFR is usually sensitive to the
  discharge design conditions.
  Pollutant concentration at NFR edge  c = 0.0836 mg/l
  Dilution at edge of NFR              s = 81.3
  NFR Location:                        x = 23.73 m
    (centerline coordinates)           y = 4.28 m
                                       z = 4.74 m
```

```
  NFR plume dimensions:  half-width (bh) = 2.94 m
                          thickness (bv) = 2.94 m
Cumulative travel time:      41.3250 sec.
-----------------------------------------------------------------------------
Buoyancy assessment:
  The effluent density is less than the surrounding ambient water
  density at the discharge level.
  Therefore, the effluent is POSITIVELY BUOYANT and will tend to rise towards
  the surface.
-----------------------------------------------------------------------------
FAR-FIELD MIXING SUMMARY:
  Plume becomes vertically fully mixed at 1271.59 m downstream.
-----------------------------------------------------------------------------
PLUME BANK CONTACT SUMMARY:
  Plume in unbounded section contacts nearest bank at 51.03 m downstream.
-----------------------------------------------------------------------------
UNSTEADY TIDAL ASSESSMENT:
 Because of the unsteadiness of the ambient current during the tidal
  reversal, CORMIX predictions have been TERMINATED at:
                                      x = 793.84 m
                                      y = -1 m
                                      z = 4.74 m.
  For this condition BEFORE TIDAL REVERSAL, extensive re-entrainment
  of previously discharged is unlikely.
  To determine the minimum dilution, perform additional simulations
  after slack tide.
************************ TOXIC DILUTION ZONE SUMMARY ************************
Recall: The TDZ corresponds to the three (3) criteria issued in the USEPA
  Technical Support Document (TSD) for Water Quality-based Toxics Control,
  1991 (EPA/505/2-90-001).
  Criterion maximum concentration (CMC)  = 1.04  mg/l
Corresponding dilution                   = 6.528846
The CMC was encountered at the following plume position:
  Plume location:                     x = 1.51 m
    (centerline coordinates)          y = 2.35 m
                                      z = 0.81 m
  Plume dimension:       half-width (bh) = 0.10 m
                          thickness (bv) = 0.10 m

 Computed distance from port opening to CMC location = 2.84 m.
 CRITERION 1: This location is within 50 times the discharge length scale of
             Lq = 0.18 m.
 +++++ The discharge length scale TEST for the TDZ has been SATISFIED. ++++++

 Computed horizontal distance from port opening to CMC location = 2.80 m.
 CRITERION 2: This location is within 5 times the ambient water depth of
             HD = 4.74 m.
 ++++++++++ The ambient depth TEST for the TDZ has been SATISFIED. ++++++++++

 CRITERION 3: No RMZ has been defined. Therefore, the Regulatory Mixing zone
             test for the TDZ cannot be applied.

 The diffuser discharge velocity is equal to 3.26 m/s.
 This exceeds the value of 3.0 m/s recommended in the TSD.

 *** All three CMC criteria for the TDZ are SATISFIED for this discharge. ***
********************** REGULATORY MIXING ZONE SUMMARY ***********************
No RMZ has been specified.
However:
The CCC was encountered at the following plume position:
The CCC for the toxic pollutant was encountered at the following
  plume position:
  CCC                                  = 0.16  mg/l
Corresponding dilution                 = 42.4
  Plume location:                     x = 18.40 m
    (centerline coordinates)          y = 4.16 m
                                      z = 2.96 m
 Computed horizontal distance from port opening to CCC location = 19.05
  Plume dimension:       half-width (bh) = 1.39 m
********************* FINAL DESIGN ADVICE AND COMMENTS **********************
REMINDER:  The user must take note that HYDRODYNAMIC MODELING by any known
  technique is NOT AN EXACT SCIENCE.
Extensive comparison with field and laboratory data has shown that the
  CORMIX predictions on dilutions and concentrations (with associated
  plume geometries) are reliable for the majority of cases and are accurate
  to within about +-50% (standard deviation).
As a further safeguard, CORMIX will not give predictions whenever it judges
  the design configuration as highly complex and uncertain for prediction.
```

SHN Geotechnical Drilling Work Scope – Bandon, OR

Subsurface Investigation

SHN is to retain the services of an Oregon licensed C-57 drilling subcontractor to advance one (1) geotechnical boring to a depth of approximately 100 feet or refusal (whichever is shallowest) with a truck-mounted rotary wash drilling rig. Mud rotary drilling methods are required in anticipation of the presence of fully saturated loose historic fill materials and soft fine-grained sediments underlying the fill materials.

Borehole advancement by mud rotary drilling is achieved by rapid rotation of a drill bit which is mounted at the end of drill pipe. In this method, mud is pumped down the drill pipe and out through the ports in the drill bit. The drill bit cuts the formation into small pieces, called cuttings, which are removed by pumping drilling fluid, called mud, through the drill pipe, out the drill bit and up the annulus between the borehole and drill pipe. The drilling fluid is also used to cool the drill bit and stabilize the borehole wall and prevent fluid loss into the formation. The drilling fluid then flows up the annular space between the borehole walls and the drill pipe carrying cuttings in suspension to the surface. The cuttings are then discharged onto a metal screen placed over the mud tub for viewing, sampling, and logging.

The boring will be centrally located in the proposed building footprint to delineate the thickness of historic fill materials and determine the depth suitably dense foundation load bearing materials. The boring will be closed with Portland cement grout slurry from the bottom of the borehole to the ground surface using the tremie method. All drilling fluid and drill cuttings will be contained in 55-gallon drums, and left on-site. Disposal of the drummed materials will be left to the discretion of the Project Owner.

SHN will supervise the drilling of the geotechnical boring, perform laboratory testing on selected samples to characterize material strength and index properties. The soil and laboratory data will be utilized to develop recommendations for ground improvements and deep foundation support of the proposed structure.

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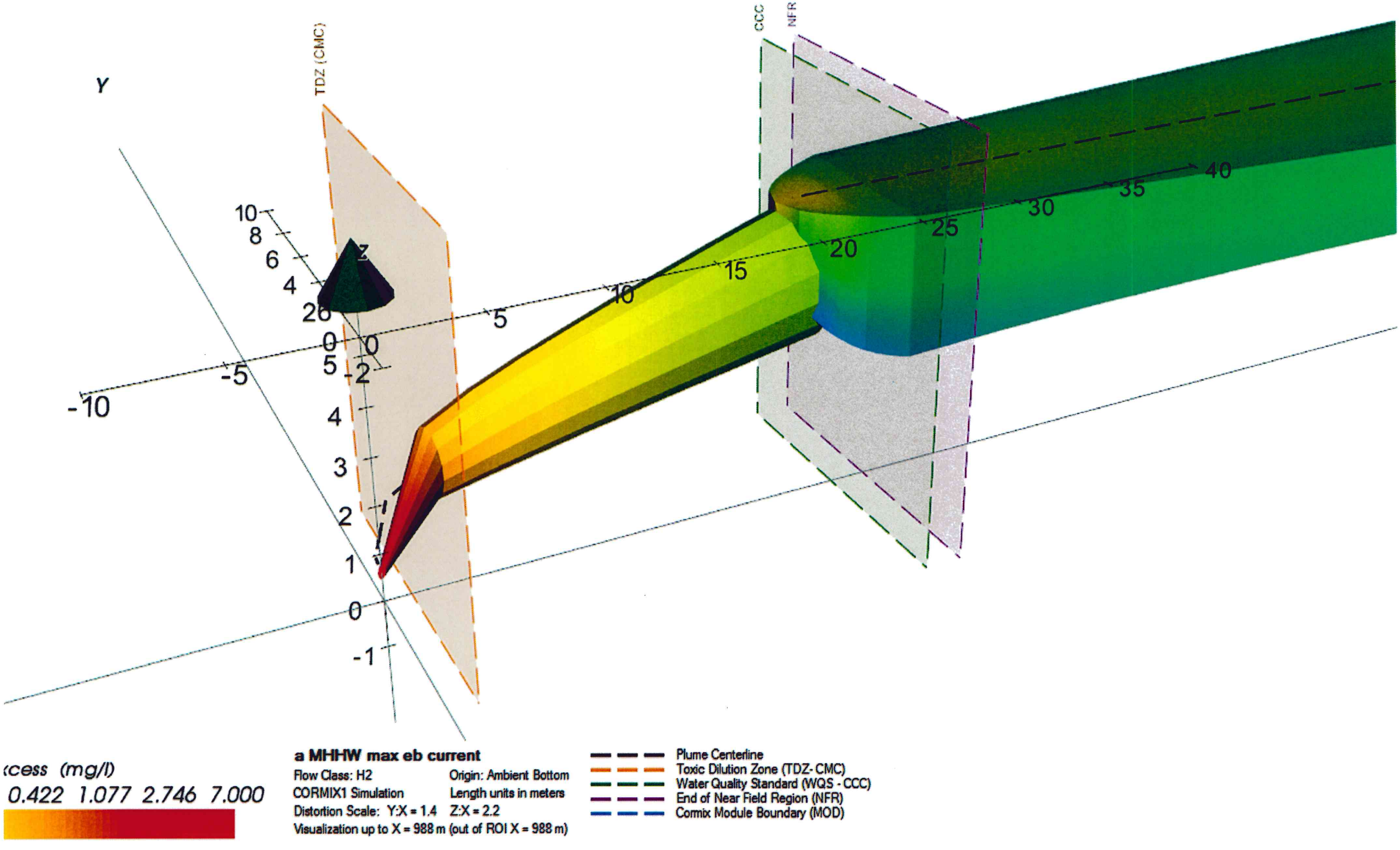
Y
TDZ (CMC)
CCC
NFR
Z
-10
-5
0
5
10
15
20
25
30
35
40
10
8
6
4
2
0
-2
5
4
3
2
1
0
-1
ɛcess (mg/l)
0.422 1.077 2.746 7.000
a MHHW max eb current
Flow Class: H2
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 1.4 Z:X = 2.2
Visualization up to X = 988 m (out of ROI X = 988 m)
Plume Centerline
Toxic Dilution Zone (TDZ-CMC)
Water Quality Standard (WQS - CCC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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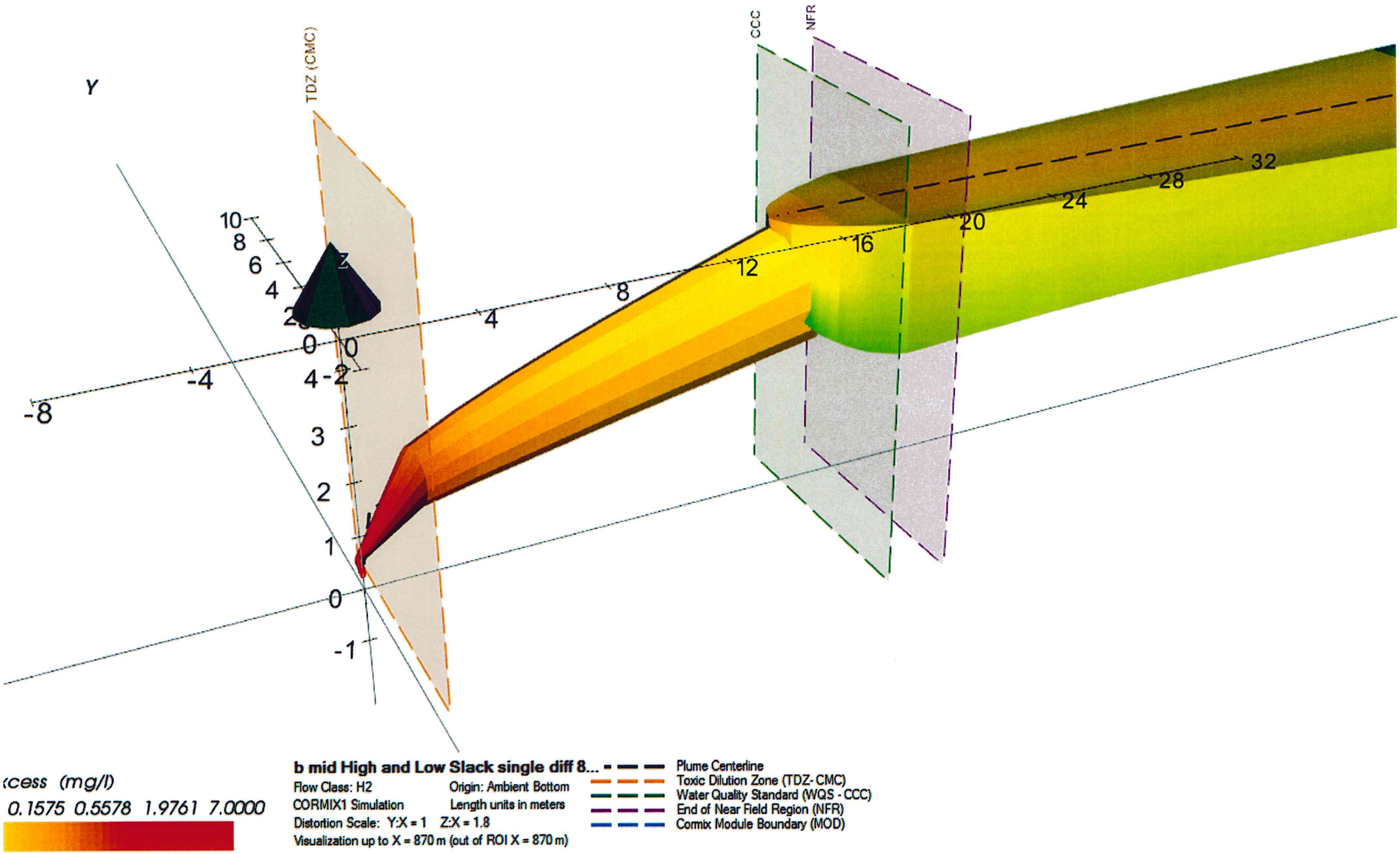

Y
TDZ (CMC)
CCC
NFR
32
28
24
20
16
12
8
4
-4
-8
10
8
6
4
0
-2
3
2
1
0
-1
Z
cess (mg/l)
0.1575 0.5578 1.9761 7.0000
b mid High and Low Slack single diff 8...
Flow Class: H2
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 1 Z:X = 1.8
Visualization up to X = 870 m (out of ROI X = 870 m)
Plume Centerline
Toxic Dilution Zone (TDZ- CMC)
Water Quality Standard (WQS - CCC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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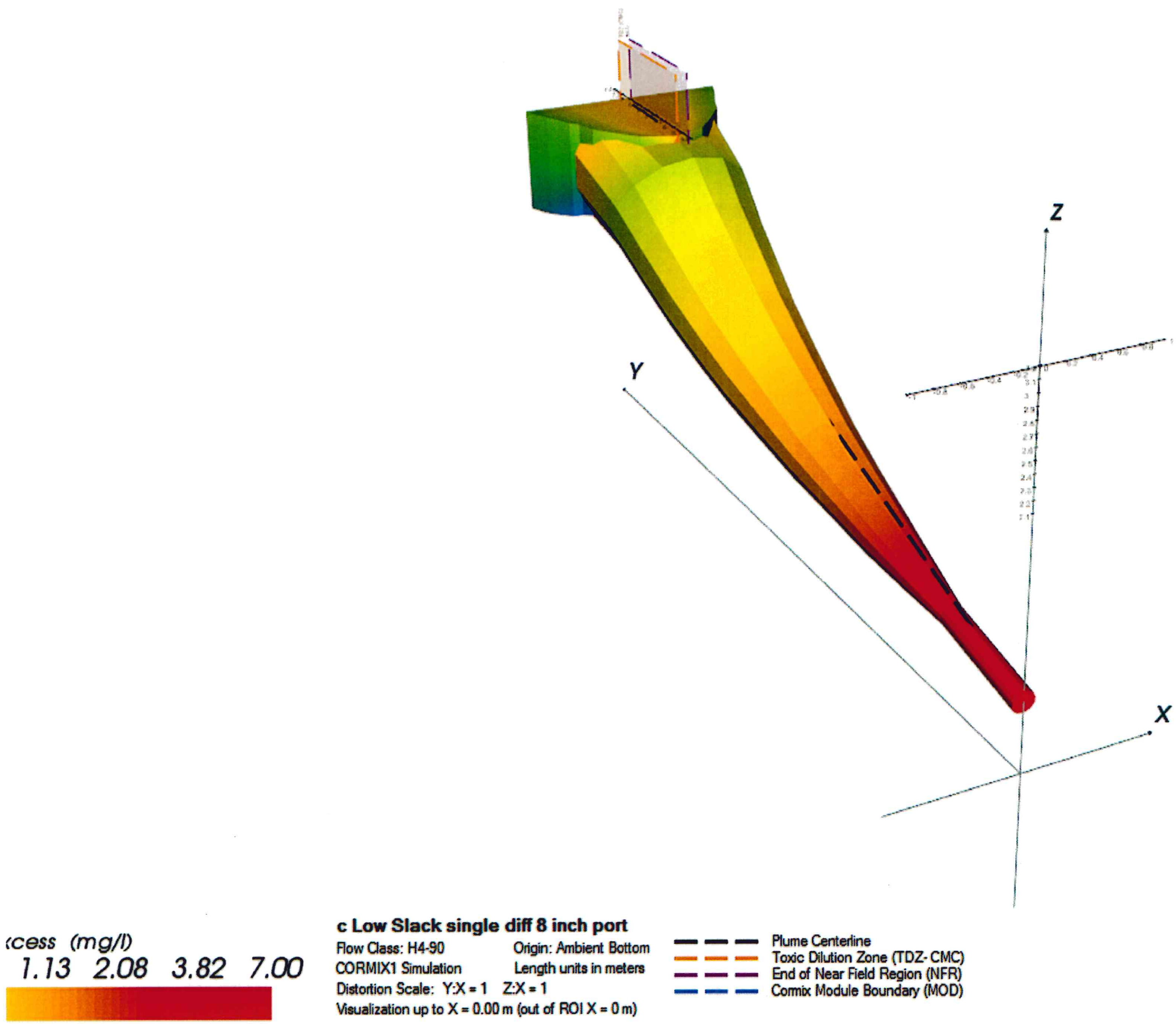

Z
Y
X
‹cess (mg/l)
1.13 2.08 3.82 7.00
c Low Slack single diff 8 inch port
Flow Class: H4-90
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 1 Z:X = 1
Visualization up to X = 0.00 m (out of ROI X = 0 m)
Plume Centerline
Toxic Dilution Zone (TDZ- CMC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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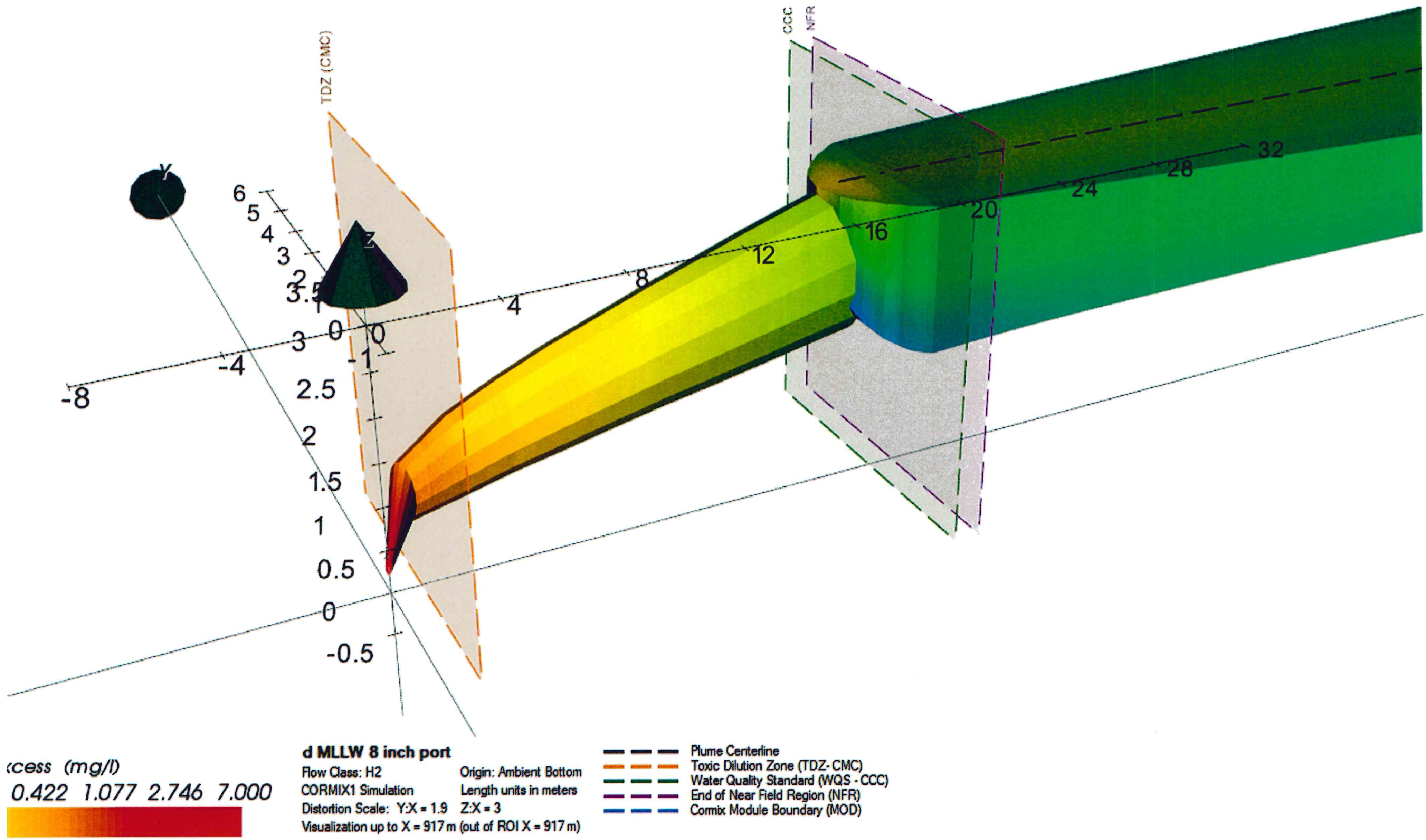

TDZ (CMC)
CCC
NFR
Y
Z
-8
-4
0
4
8
12
16
20
24
28
32
6
5
4
3
2
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
ːcess (mg/l)
0.422 1.077 2.746 7.000
d MLLW 8 inch port
Flow Class: H2
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 1.9
Z:X = 3
Visualization up to X = 917 m (out of ROI X = 917 m)
Plume Centerline
Toxic Dilution Zone (TDZ- CMC)
Water Quality Standard (WQS - CCC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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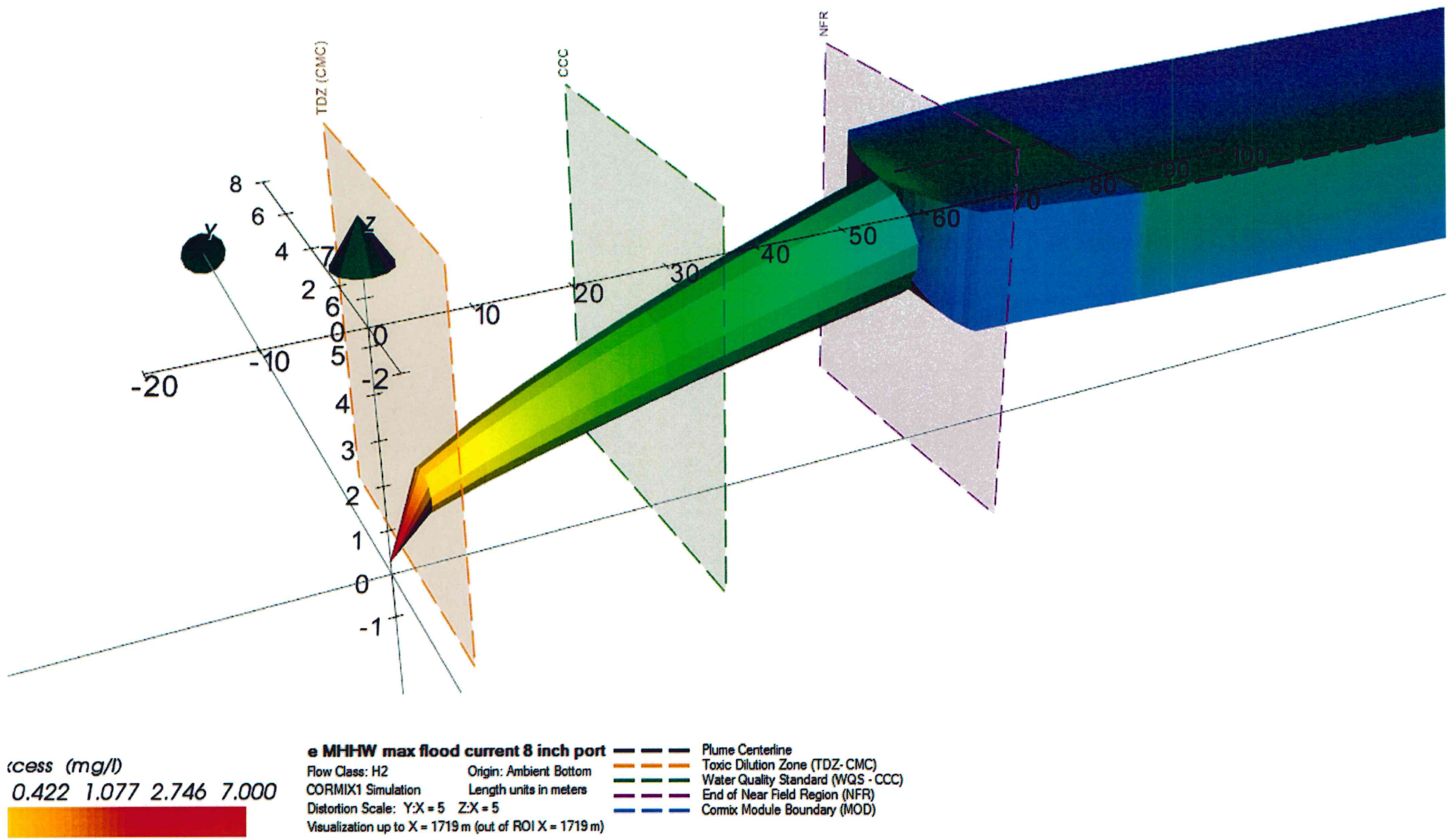

TDZ (CMC)
CCC
NFR
-20
-10
0
10
20
30
40
50
60
70
80
90
100
8
6
4
2
y
z
ːcess (mg/l)
0.422 1.077 2.746 7.000
e MHHW max flood current 8 inch port
Flow Class: H2
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 5 Z:X = 5
Visualization up to X = 1719 m (out of ROI X = 1719 m)
Plume Centerline
Toxic Dilution Zone (TDZ- CMC)
Water Quality Standard (WQS - CCC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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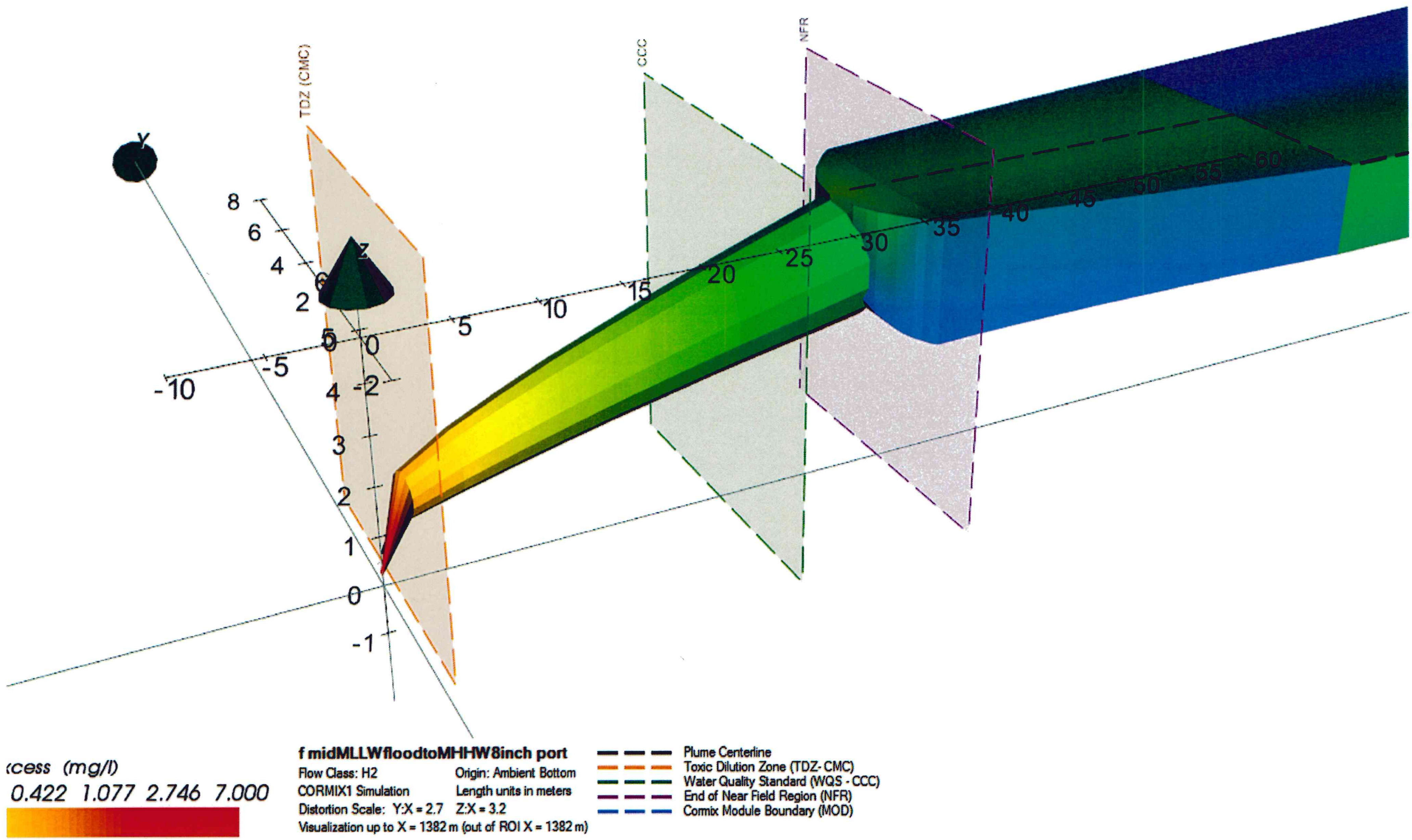
TDZ (CMC)
CCC
NFR
-10
-5
0
5
10
15
20
25
30
35
40
45
50
55
60
8
6
4
2
-2
-1
1
3
x
y
z
ıcess (mg/l)
0.422 1.077 2.746 7.000
f midMLLWfloodtoMHHW8inch port
Flow Class: H2
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 2.7 Z:X = 3.2
Visualization up to X = 1382 m (out of ROI X = 1382 m)
Plume Centerline
Toxic Dilution Zone (TDZ- CMC)
Water Quality Standard (WQS - CCC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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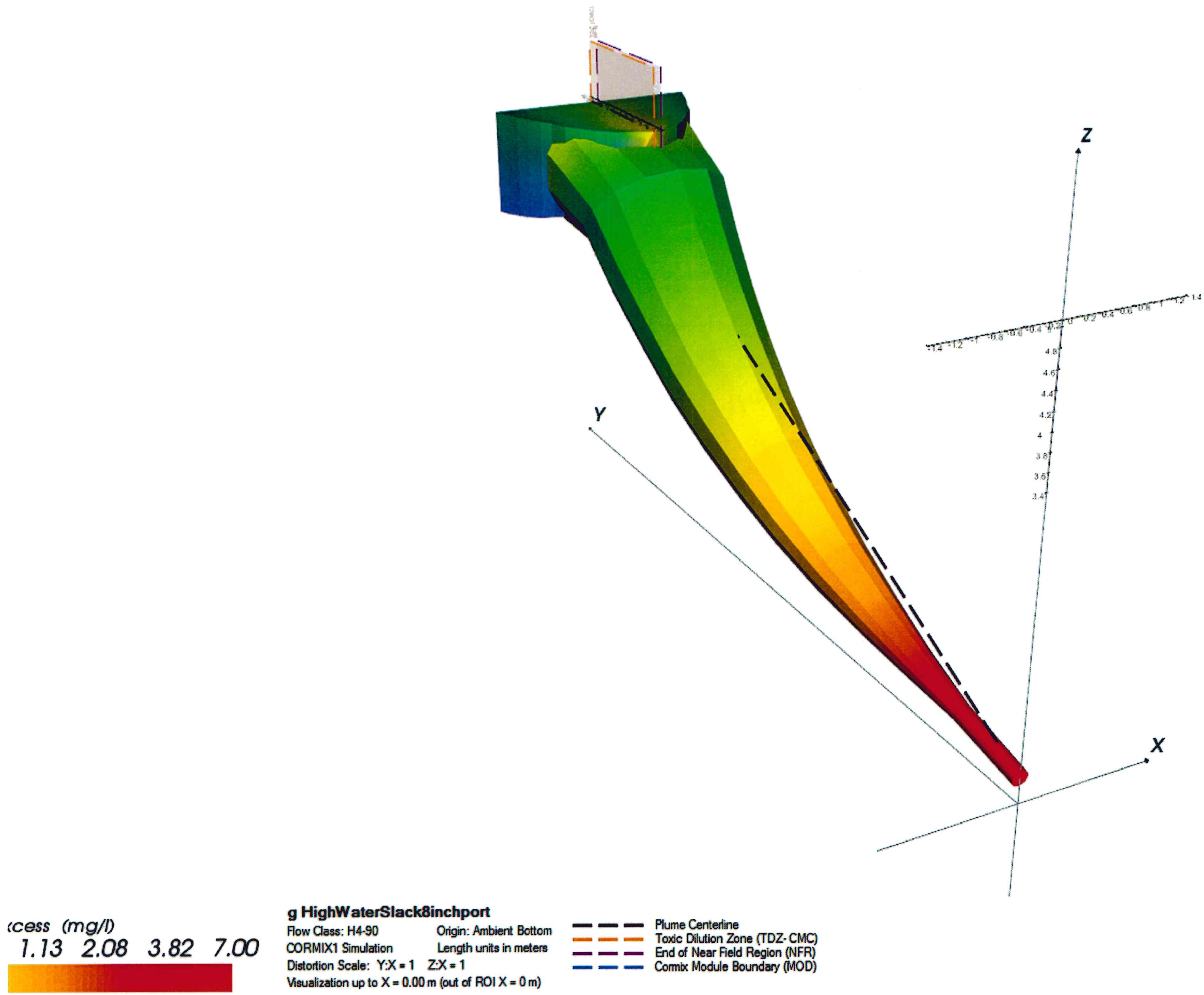
Z
X
Y
‹cess (mg/l)
1.13 2.08 3.82 7.00
g HighWaterSlack8inchport
Flow Class: H4-90
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 1 Z:X = 1
Visualization up to X = 0.00 m (out of ROI X = 0 m)
Plume Centerline
Toxic Dilution Zone (TDZ-CMC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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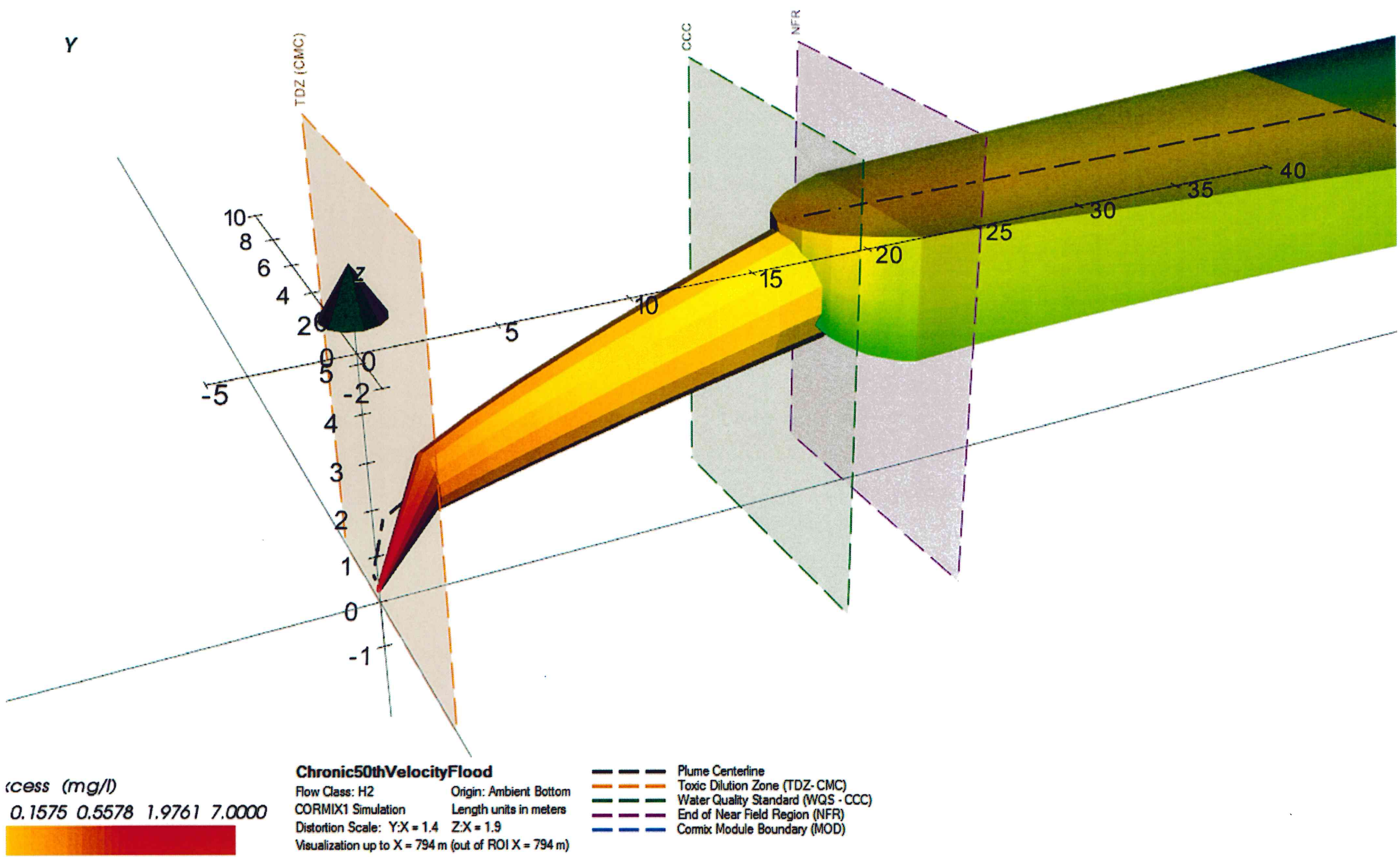
Y
TDZ (CMC)
CCC
NFR
Z
-5
5
10
15
20
25
30
35
40
10
8
6
4
2
0
-2
-1
1
3
кcess (mg/l)
0.1575 0.5578 1.9761 7.0000
Chronic50thVelocityFlood
Flow Class: H2
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 1.4 Z:X = 1.9
Visualization up to X = 794 m (out of ROI X = 794 m)
Plume Centerline
Toxic Dilution Zone (TDZ- CMC)
Water Quality Standard (WQS - CCC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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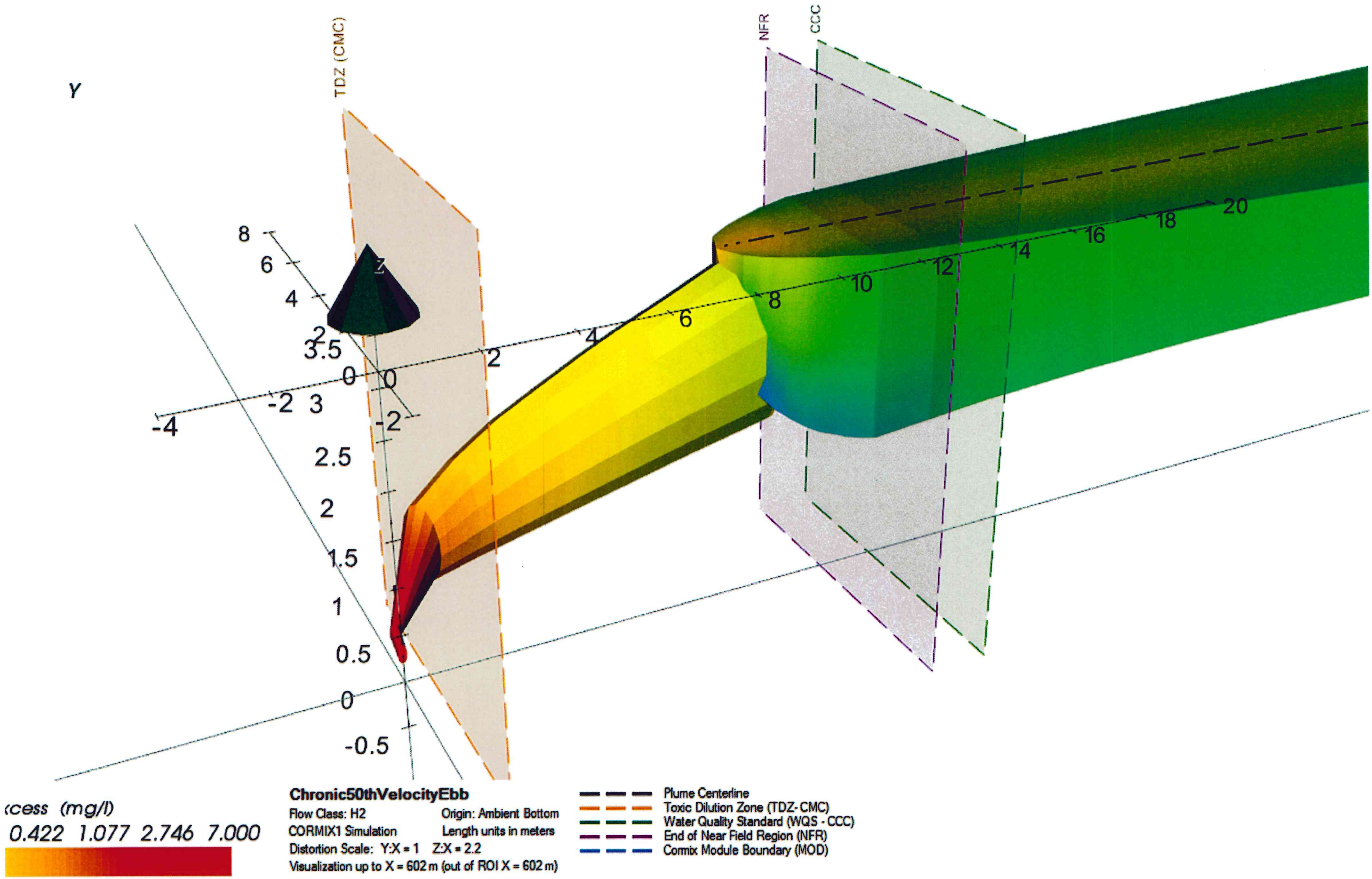

TDZ (CMC)
NFR
CCC
Y
Z
ccess (mg/l)
0.422 1.077 2.746 7.000
Chronic50thVelocityEbb
Flow Class: H2
Origin: Ambient Bottom
CORMIX1 Simulation
Length units in meters
Distortion Scale: Y:X = 1 Z:X = 2.2
Visualization up to X = 602 m (out of ROI X = 602 m)
Plume Centerline
Toxic Dilution Zone (TDZ- CMC)
Water Quality Standard (WQS - CCC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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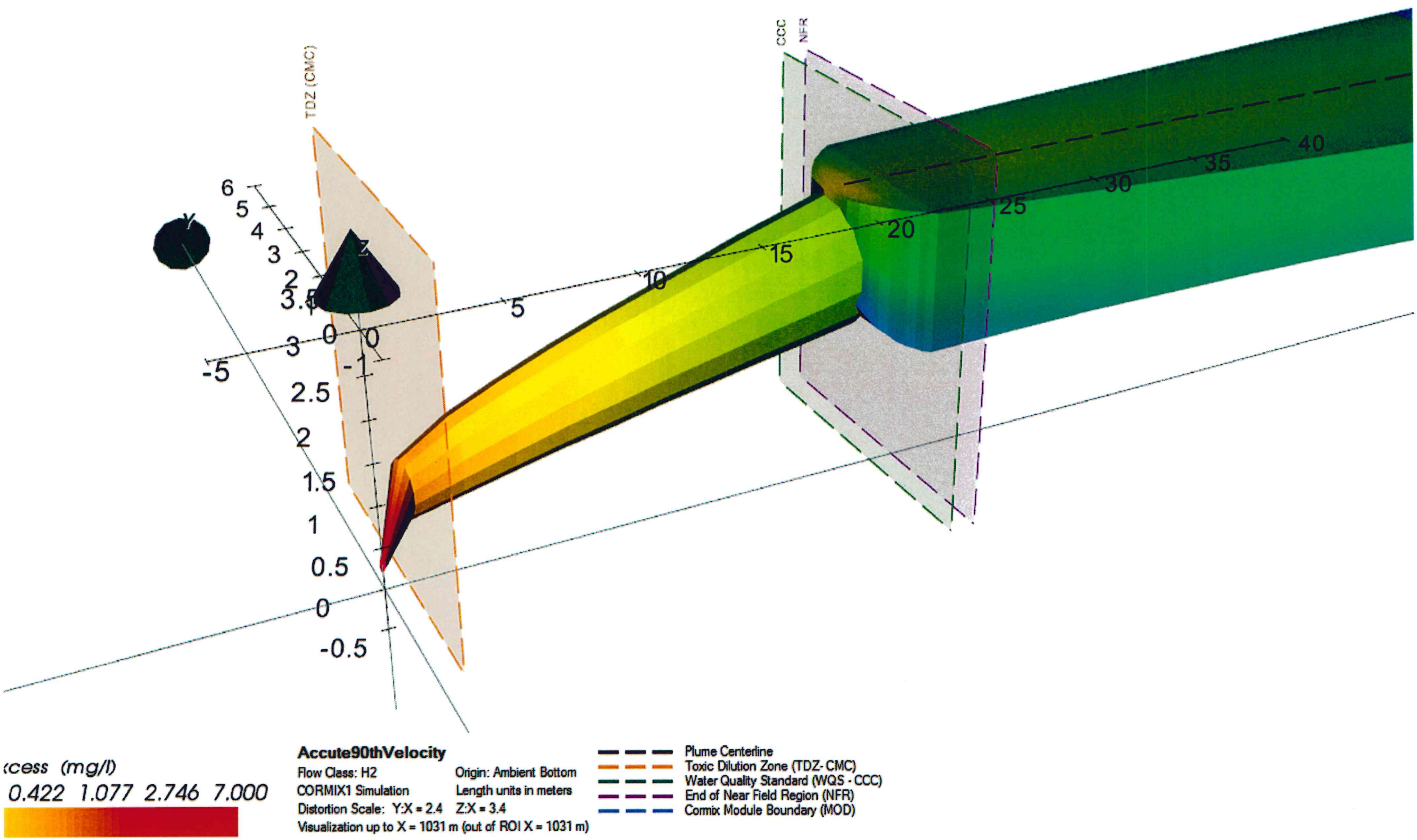
TDZ (CMC)
CCC
NFR
Y
Z
5
10
15
20
25
30
35
40
-5
6
5
4
3
2
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0
0
xcess (mg/l)
0.422 1.077 2.746 7.000
Accute90thVelocity
Flow Class: H2
CORMIX1 Simulation
Distortion Scale: Y:X = 2.4
Visualization up to X = 1031 m (out of ROI X = 1031 m)
Origin: Ambient Bottom
Length units in meters
Z:X = 3.4
Plume Centerline
Toxic Dilution Zone (TDZ- CMC)
Water Quality Standard (WQS - CCC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)

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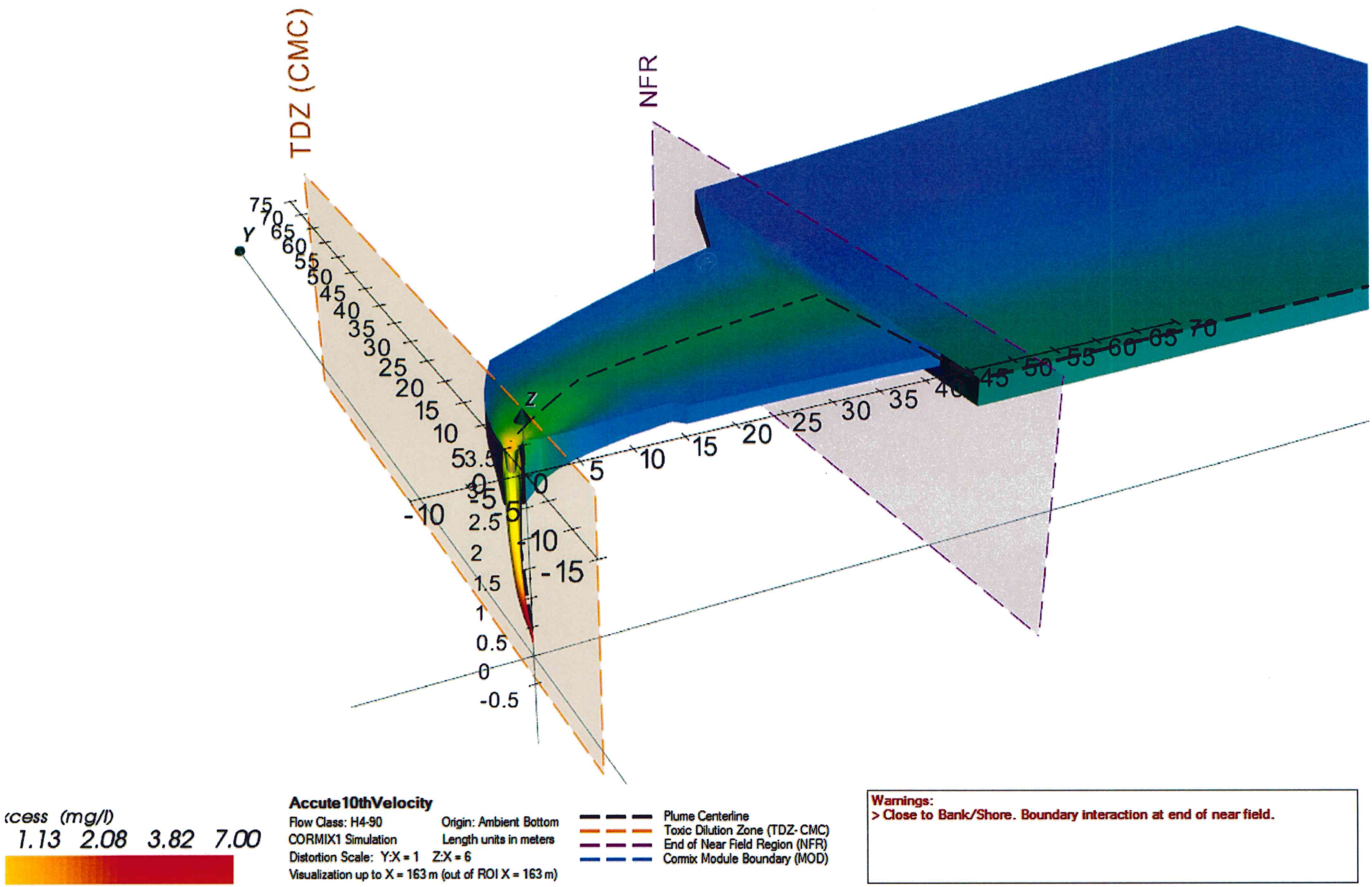
TDZ (CMC)
NFR
Y
Z
Excess (mg/l)
1.13 2.08 3.82 7.00
Accute10thVelocity
Flow Class: H4-90
CORMIX1 Simulation
Distortion Scale: Y:X = 1 Z:X = 6
Visualization up to X = 163 m (out of ROI X = 163 m)
Origin: Ambient Bottom
Length units in meters
Plume Centerline
Toxic Dilution Zone (TDZ-CMC)
End of Near Field Region (NFR)
Cormix Module Boundary (MOD)
Warnings:
> Close to Bank/Shore. Boundary interaction at end of near field.

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