Wastewater Climate Change Plan

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EBMUD

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LIST OF ACRONYMS

AB	Assembly Bill
ART	Adapting to Rising Tides
BayCAN	Bay Area Climate Adaptation Network
BCDC	San Francisco Bay Conservation and Development Commission
CARB	California Air Resources Board
EBMUD	East Bay Municipal Utility District
EBRPD	East Bay Regional Park District
ECM	Energy Conservation Measures
EPA	United States Environmental Protection Agency
EPS	Effluent Pump Station
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
I/I	Inflow and Infiltration
IPS	Influent Pump Station
IPCC	Intergovernmental Panel on Climate Change
MHHW	Mean Higher High Water
MGD	Million Gallons per Day
MW	Megawatt
MWWTP	Main Wastewater Treatment Plant
NAS	Naval Air Station
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
PGS	Power Generation Station
POTW	Publicly Owned Treatment Works
PS	Pump Station
PSPS	Public Safety Power Shutoff
RCP	Representative Concentration Pathway
RWQCB	Regional Water Quality Control Board
SB	Senate Bill

SFEI	San Francisco Estuary Institute
SPUR	San Francisco Bay Area Planning and Urban Research Association
SWRCB	State Water Resources Control Board
TCR	The Climate Registry
WWF	Wet Weather Facility

EXECUTIVE SUMMARY

The effects of climate change – rising sea and groundwater levels, changing weather patterns, droughts, and the probability of coastal flooding – will increasingly impact the East Bay Municipal Utility District's (District) wastewater assets as global average temperatures change over time. Wastewater infrastructure is inherently connected to climate. Treatment plants tend to be located in low-lying, coastal areas because they provide a physical advantage, allowing wastewater to flow freely by gravity to the plants. Nearly all District wastewater facilities are within a short distance from the San Francisco Bay (Bay), increasing the likelihood of impacts as the climate changes, sea levels rise, and rainfall runoff volumes and intensity go up. The District has proactively considered the impacts of climate change and has been evaluating actions to understand, mitigate, and adapt to the risks associated with climate change. This report evaluates the degree and timing of the District's vulnerability to these risks posed by a changing climate, and identifies a path forward to adapt to these risks and protect wastewater facilities proactively.

CLIMATE MITIGATION STRATEGIES

The District has long been a leader in implementing projects and policies that reduce anthropogenic sources of climate change, including levels of atmospheric carbon dioxide and other greenhouse gases (GHGs). To reduce its contribution to global climate change, the District established an Energy Policy in 2003 that included goals for reducing indirect and direct GHG emissions by 2040. The Wastewater Department has undertaken a number of activities to help meet these goals. Activities have focused on the following areas:

- **Renewable Energy Production** – The Main Wastewater Treatment Plant (MWWTP) is a net-energy producer with the generation of biogas, a well-accepted mitigation measure for GHG emissions. In Fiscal Year 2018, the MWWTP generated almost 52,000 Megawatt hours (143 percent of the MWWTP's energy demand).
- **Energy Consumption Reduction** – Using less energy requires less generation of energy and results in lower GHG emissions. Based on various benchmarking studies, the energy management performance of the MWWTP exceeds that of nearly 75 percent of similar publicly owned treatment works (POTW).
- **Landfill Diversion** – The District accepts high-strength organic wastes for digestion at the MWWTP. This mitigation strategy produces renewable energy and reuses material that would otherwise decompose in an uncontrolled setting where it would release methane.
- **Biosolids Reuse** – Land applied biosolids provide nutrients for crops, sequester carbon, and reduce the demand for inorganic, chemical fertilizers resulting in net GHG emission reductions. In 2018, 10 percent was utilized as alternative daily cover at landfills, 13 percent was composted, and 77 percent was land applied at non-edible crop farm sites. In 2017, 51 percent was utilized as alternative daily cover at landfills and 49 percent was land applied at non-edible crop farm sites.

These activities have reduced the District's contribution of GHG emissions to the atmosphere and have demonstrated the District's leadership in the wastewater industry in reducing its carbon footprint.

VULNERABILITY ASSESSMENT

The District cannot rely on mitigation activities to stop the steady increase of GHGs to the atmosphere and the resulting increase in global average temperature. For this study, the District conducted a vulnerability assessment to identify which District wastewater facilities will be vulnerable to the effects of climate change. The effects of climate change were projected using conditions defined in the Representative Concentration Pathways (RCP) 8.5 scenario, as developed by the Intergovernmental Panel on Climate Change (IPCC). IPCC uses RCPs to describe the different degrees of climate change. RCP 8.5 assumes a business-as-usual scenario with no reduction in GHGs, and is the chosen basis for District-wide climate change adaptation-related analyses. The vulnerability assessment determined that the District largely avoids major impacts to wastewater infrastructure within the 30-year, long-term planning horizon (i.e., by 2050). However, there are potential impacts to some facilities in the following areas:

- **Sea Level Rise**
- **Groundwater Level Rise**
- **Local Climate and Weather Pattern Changes**
- **Local Power Outages Due to Pacific Gas and Electric (PG&E) Regional Wildfire Mitigation Plan**

Sea Level Rise. In the District Wastewater Department's 30-year forecast, the MWWTP is expected to avoid major inundation impacts due to rising sea level except during extreme (100-year) storm events. Even then, the storm-related inundation only reaches facilities that are not critical to the treatment process. By the end of the 30-year planning forecast (2050), remote facilities, including eight interceptor system pump stations (PS), the San Antonio Creek Wet Weather Facility (WWF), and the Dechlorination Facility will be at risk of flooding during extreme (100-year) storm events. These facilities could experience limited flooding during extreme tide and storm events even today, but only if there were low-likelihood events occurring simultaneously (e.g., extreme high tide coinciding with storms more extreme than 100-year storm events).

In addition to the flood inundation risk, there will be some moderate impacts to MWWTP and WWF operations. As the sea level rises gradually, the capacity of the District's Effluent Pump Station (EPS) will proportionately and incrementally decrease because it will be pumping against more pressure; a 12-inch rise in sea level corresponds to a 3 percent or 10 million gallons per day (MGD) reduction in discharge capacity, a 42-inch rise corresponds to an 8 percent or 25 MGD reduction. Similarly, the WWFs will each have incrementally decreased effluent discharge capacity. These impacts are moderate and manageable with cost effective alterations to existing equipment and limited improvements to equipment.

Groundwater Level Rise. Based on available groundwater data and a presumption that groundwater levels near the coast will rise at rates equal to sea level rise, inflow and infiltration

(I/I) to the District's interceptor system will incrementally increase if the condition of interceptor pipes remain the same as today's condition. Based on initial analysis, below-grade structures, such as tanks and channels, will not experience buoyancy forces large enough to cause negative impacts due to the existing design and weight of the structures.

Local Climate and Weather Pattern Changes. Local climate is projected to change in a few ways: increasing temperatures, greater rainfall intensity, shorter wet seasons, and potentially higher total local rainfall. The annual mean temperature in the Bay Area is expected to increase 4.4°F by 2050 and 7.2°F by 2100. Projections of future precipitation patterns are uncertain due to the number of variables that contribute to the distribution, frequency, and intensity of precipitation events in California. Projections of Bay Area local climate change used in the State of California Fourth Climate Change Assessment consistently show that winters will be shorter and with greater total rainfall, while summers will be longer and drier. Storm intensity will increase, and intense storms will become more frequent over a shorter time frame during the year.

The expected temperature increase will result in little to no discernible effect on the wastewater treatment process. The combination of higher temperatures coinciding with more infrequent rainfall could result in more frequent droughts, and corresponding water conservation measures. Reduction in indoor water use can result in lower flows to the wastewater collection system and higher concentrations of target constituents. More intense storms will result in changes to rainfall-caused I/I, resulting in changes to both peak wet weather flows and the duration of those peak flows.

Local Power Outages Due to PG&E Regional Wildfire Mitigation Plan. In February 2019, PG&E announced an expanded public safety power shutoff (PSPS) that may affect 5.4 million customers. PG&E implemented the PSPS Program in 2018 to proactively de-energize lines that transverse high fire hazard areas under extreme fire risk conditions during the summer and fall. PG&E intends to alert customers that a PSPS event could occur within 48 hours. There is a remote chance that the MWWTP and the wastewater pumping facilities could be affected.

The MWWTP is currently served by two PG&E power connections. Since 1985, the MWWTP has had power generation capability using digester gas that currently generates an average of 143 percent of the power needed at the plant. Excess power is sold to the Port of Oakland. In the unlikely event that both PG&E feed lines are shut down, it is anticipated that the MWWTP Power Generation Station (PGS) will generate sufficient power to keep critical plant functions operating. In addition, some facilities also have back-up generators that can provide power should the PGS be out of service or if it is not producing enough power.

At the various wastewater PSs in the interceptor system, there is equipment in place and portable equipment available to operate facilities in the event of power outages. Standby generators are on site to power critical functions and portable generators could be deployed if necessary. Temporary pumps and hoses are available to divert sewage around disabled pumps. In general, the MWWTP and sewage PSs are already well-positioned to operate through local or more widespread power outages.

CLIMATE ADAPTATION STRATEGIES

Given the vulnerabilities identified, the District has begun strategizing ways to adapt to a new normal, including higher sea levels and groundwater levels, more droughts, more intense weather events, and has identified ways of minimizing those impacts.

The District has identified four key areas to most effectively adapt to a changing climate:

- **Regional Collaboration.** First and foremost, the District must work with neighboring jurisdictions, regulators, and stakeholders to address sea level rise along the shore of the Bay. The District is largely not responsible for the shoreline features or infrastructure that could be used to slow or control the steady increase of sea levels, and therefore must work collaboratively with those with jurisdiction and ownership of these areas, such as cities, counties, flood control districts, the Port of Oakland, the State of California, and other agencies. The MWWTP is not immediately adjacent to the shore and models show that flood waters generally do not take a direct path from the Bay to the District's facilities, but rather flow through multiple jurisdictions and land owners. A joint effort is needed to ensure a solution for one agency does not worsen flooding for the District, and it will also likely be more cost effective to contribute to future collaborative adaptation infrastructure rather than for the District to react in isolation to protect our facilities.

- **Designing Modifications and Improvements.** District staff should consider accommodations for sea level rise during the design phase of each project, focusing on those facilities identified in this report as most vulnerable. Actions include elevating critical equipment above projected flood levels, requiring waterproof materials in areas at risk of flooding, or the ability to route flows around compromised system components.

- **Maintaining Updated Emergency Response Plans.** The emergency response plan for the MWWTP should include a plan for full inundation.

- **Monitoring of Climate Change-Related Parameters.** The District should continue monitoring key data points to track trends as global average temperatures increase. In particular, the District should update its vulnerability assessment of each time the IPCC updates its models with new climate data and produces new RCP 8.5 guidance.

LEGISLATION AND REGULATIONS

Legislation in California reflects the trend of the state leading the way on climate change in the United States. Many of the laws call for the reduction of GHG emissions, increase use of renewable and carbon-free electricity, and the diversion of wastes from landfills. These new regulations and legislation will affect how the District implements GHG reduction and climate change adaptation projects.

INDUSTRY PARTICIPATION

District staff participates actively on the local, state, and national levels with other agencies and professional organizations to discuss climate change and solutions. Local level organizations include the Bay Area Clean Water Agencies, Bay Area Climate Adaptation Network (BayCAN), San Francisco Bay Area Planning and Urban Research Association (SPUR), San Francisco Estuary Institute (SFEI), the Aquatic Science Center, and Bay Planning Coalition.

On the state and national level, District staff participates with the California Association of Sanitation Agencies and the National Association of Clean Water Agencies and the committees that focus on climate change and resiliency. The District is also a part of The Climate Registry (TCR), and is signing on to "We Are Still In," a group of over 3,500 organizations that commit to meeting the Paris Climate Agreement.

CONCLUSION

The District's wastewater facilities are situated such that the early effects of global climate change present a low risk to its critical processes and equipment. The effects are occurring gradually enough that the District has time to prepare for, monitor, and respond to them. Continuing regional collaboration efforts and long-term planning work, such as the Integrated MWWTP Master Plan, will allow adaptation with cost-effective solutions that will protect District assets and the community.

CHAPTER 1 - INTRODUCTION

Awareness of climate change and its effects has increased in recent years. At the same time, agencies have begun to recognize the need to specify how their facilities are vulnerable to the effects of climate change. The District has identified vulnerabilities and is developing strategies to mitigate those effects before they occur to ensure uninterrupted wastewater services to its customers. Given the location of District facilities in proximity to the San Francisco Bay (Bay), and the influence of weather on the District's wastewater operations, identifying the vulnerabilities subject to the effects of climate change is the critical first step to developing an adaptation plan.

A1.1 Purpose and Goals

This Climate Change Monitoring and Response Plan is an expansion of previous efforts by the District to assess the impacts of climate change on the District's facilities and operations and propose responses to those impacts. This document focuses on the Wastewater Department's facilities and operations and includes an assessment of the District's contribution to greenhouse gas (GHG) emissions, mitigations for reducing GHGs, an assessment of the District's vulnerability to climate change impacts, and identifies adaptation strategies. The vulnerability assessment summarizes the range of effects that District wastewater facilities are predicted to experience as global temperature climbs and sea levels rise. The purpose of the vulnerability assessment is to define the timing and extent of those effects, and adaptation strategies are being developed to respond to those vulnerabilities.

The goals of the Climate Change Monitoring and Response Plan are:

- Identify sources of GHG emissions from Wastewater sources
- Describe mitigations to reduce or minimize GHG emissions
- Identify the list of climate change effects on District wastewater facilities
- Identify the likely timing and extent of those effects (i.e., risk)
- Identify the consequences of those effects
- Identify next steps for the Wastewater Department

A1.2 Methodology

The climate change predictions were compiled from a review of recent data, literature, and research. IPCC, the United Nations body for assessing the science on climate change, uses RCPs to describe the different climate change scenarios.[1] Each RCP assumes a different level of GHG reductions. For planning purposes, the District uses the RCP 8.5 scenario. RCP 8.5 assumes a business-as-usual scenario with no reduction in GHGs.

Most of the information for the vulnerability assessment was compiled from the California Fourth Climate Change Assessment (Assessment) that was released in August 2018. The Assessment is composed of a statewide report, nine regional reports, and 44 technical reports that cover issues around California. The reports focus on regional vulnerabilities and adaptations

[1] Core Writing Team, Pachauri, & Meyer, 2014

based on two RCPs, one being RCP 8.5.[2] Reports specific to the Bay Area with topics relevant to District operations were reviewed.

Additional data was utilized from the San Francisco Bay Conservation and Development Commission (BCDC) Adapting to Rising Tides (ART) Project.

A1.3 District Framework

The District has proactively considered the impacts of climate change and has taken actions to understand, mitigate, and adapt to those impacts. The District's Strategic Plan and policies provide the framework for how the District does business. Both are approved and adopted by the District's Board of Directors. The Strategic Plan incorporates the District's mission and principles, and identifies its goals, strategies, objectives, and key performance indicators. The Strategic Plan influences and guides staff in the management and allocation of resources and assets. The policies establish guidelines and best practices for actions undertaken by the District.

1.1.1 Strategic Plan

The Strategic Plan includes a strategy to maintain a Climate Change Monitoring and Response Plan to inform the District's planning efforts for future water supply, water quality, and infrastructure projects. Specific objectives include:

- Regularly review developing climate change science and create future scenarios that illustrate a range of potential impacts from key variables (temperature rise, sea level rise, precipitation, snow pack and runoff).
- Use the scenarios to identify infrastructure vulnerabilities and make cost-effective infrastructure investments and operational changes to adapt and mitigate impacts based on a range of foreseeable conditions (i.e., "no regrets" investments).
- Educate the public and policymakers on District and industry climate change concerns and interests, participate in research, and advocate for reasonable legislation and regulatory changes.

1.1.2 District Policies

There are two District policies already in place that have climate change-related actions. The Sustainability and Resilience Policy has an overarching objective to consider environmental, social, and economic impacts in the District's policies, programs, and work practices. It also establishes a specific objective for the District to identify and implement projects and plans that mitigate climate change impacts and reduce GHG emissions.

The Energy Policy calls for the District to promote and encourage practices to be carbon free for indirect GHG emissions and achieve a 50 percent reduction in direct GHG emissions compared to 2000 levels by 2040. The policy also encourages increasing use of renewable energy and minimizing reliance on fossil fuels. The District has been tracking and reporting GHG emissions since 2005.

[2] Bedsworth, Cayan, Franco, Fisher, & Ziaja 2018

The District has prepared a new Climate Action Policy which was approved by the Board of Directors in June 2019. The Climate Action Policy affirms the District's commitment to:

- Plan for climate change by applying the best available science to understand climate risks and implement adaptations and mitigation strategies to improve resilience
- Integrate climate science into the District's planning, design, and operations
- Complete an annual GHG emissions inventory and reduce GHG emissions
- Support legislation and regulations to address the impact of climate change
- Collaborate with utilities, agencies, researchers, regulators, and the community
- Educate the community and employees on the impacts of climate change
- Take a leadership role with respect to climate change

APPENDIX 1 - DISTRICT WASTEWATER FACILITIES

A1.1 Introduction

The District's Wastewater System serves approximately 685,000 people in the communities of Alameda, Albany, Berkeley, El Cerrito, Emeryville, Kensington, Oakland, Piedmont, and part of Richmond. This system includes one wastewater treatment plant, thirty-seven miles of pipeline, fifteen PSs, and three WWFs. The service area boundary and location of facilities is shown in Figure 0-1.

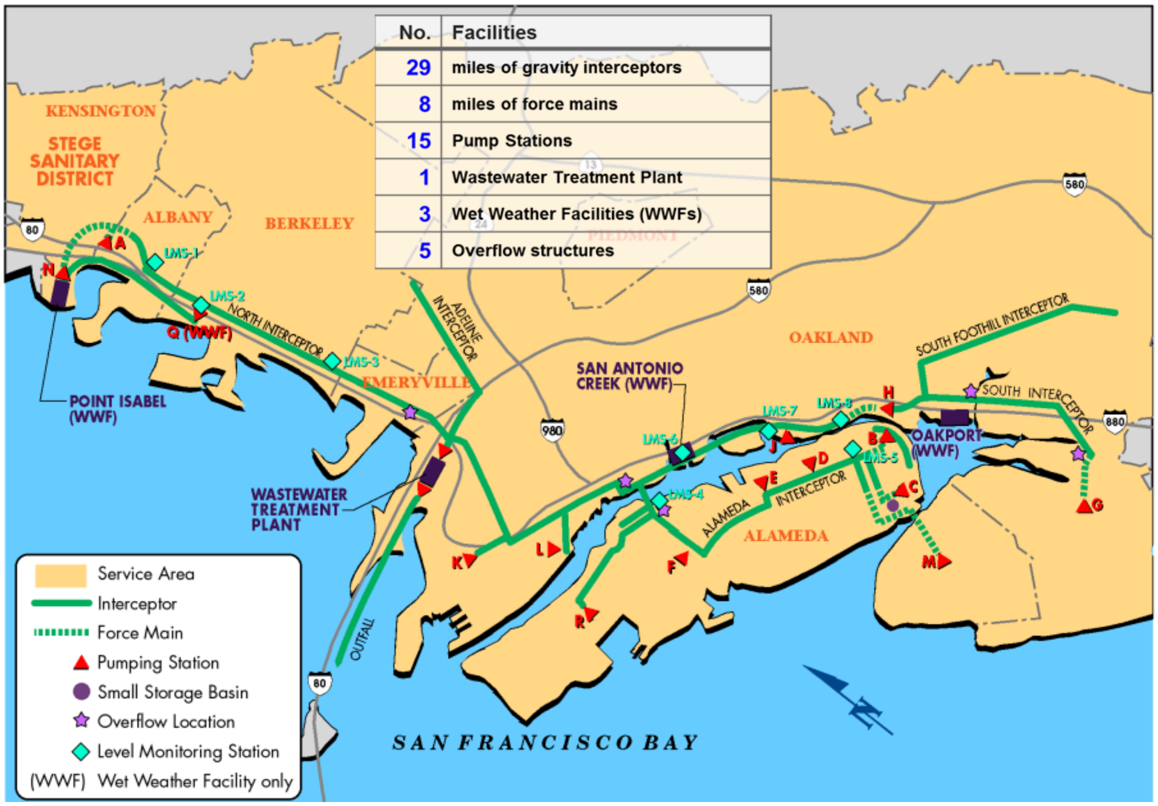

Figure 0-1. District Wastewater Facilities

The District's MWWTP is located at 2020 Wake Ave in Oakland, California. The site is bordered on the north by Interstate Highway 80 and the Bay, to the south by Engineers Road and areas zoned for industrial land uses, and to the west by Interstate Highway 880, the Union Pacific Railroad tracks, and the West Oakland community.

A1.2 Facility Information

The ground elevations for various locations of the District's wastewater structures at the MWWTP are shown in Table 0-1. The elevations were taken from record drawings of the facilities. The data is sorted from lowest to highest elevation. All elevations are at National Geodetic Vertical Datum of 1929 (NGVD 29) plus 100 feet to correspond to the District's Wastewater Facilities standard datum. Zero elevation at NGVD 29 corresponds to a mean sea level. Since many of the wastewater facilities are below ground, the 100 feet was added to the

District's Wastewater Facilities standard datum to avoid confusion from using negative elevations on drawings.

Also included for reference is the structures' elevation in comparison with the mean higher high water (MHHW) level of the closest National Oceanic and Atmospheric Administration (NOAA) station to the MWWTP. The MHHW is the average high tide water level and serves as the base level for the sea level rise scenarios that will be discussed in Chapter 4.

Within the MWWTP, the lowest elevations are at the southeast corner of the property near the Septage Receiving Station and Oxygenation Production Plant. A general elevation map of the MWWTP is shown in Figure 0-2.

Figure 0-2. Elevation map of MWWTP structures

Table 0-1. Elevations at MWWTP

No.	Structure/Process	Description of elevation location	Elevation (ft)	Feet above MHHW
1	Transition Structure	Ground level	105.5	2.1
2	Fats, Oil, Grease/High Strength Liquid Receiving Station	Drainage by truck unloading	105.5	2.1
3	Septage Receiving Station	Drain inlet	106.5	3.1
4	Transition Structure	Building slab/landing	108	4.6
5	Oxygen Production Plant	Ground level	108.25	4.8
6	Influent Pump Station (IPS)	Finished ground surface	108.5	5.1
7	Dechlorination Building	Ground level of building	108.87	5.4
8	Primary Sedimentation Control Building	Top of grade	109	5.6
9	Maintenance Center	Ground elevation	109	5.6
10	Dewatering Building	Ground elevation	109	5.6
11	PGS	Ground elevation	109.68	6.2
12	Field Service Building	Ground elevation	109.9	6.5
13	Digester Control Building	Bottom of stairs to building	110	6.6
14	Solid Liquid Waste Receiving Station	Ground elevation	110.2	6.8
15	PGS 2 Building	Ground elevation	110.5	7.1
16	East Bayshore Recycled Water Facility	Building elevation	110.5	7.1
17	Old Maintenance Building	Ground elevation	111	7.6
18	Administration Building/Lab	Ground elevation	112	8.6
19	Secondary Clarifiers	Top of clarifier	112	8.6
20	Plant Effluent Channel	Top of channel concrete	112	8.6
21	Operations Center	Ground floor elevation	112.25	8.8
22	Primary Influent Channels	Top of channel	113	9.6
23	Primary Effluent/Secondary Influent Channel	Top of channel	113	9.6
24	Oxygenation Tanks	Top of Settled Sewage Channel	113	9.6
25	Oxygen Production Plant	Building landing	113.2	9.8
26	EPS	Building entrance	113.5	10.1
27	East Bayshore Recycled Water Facility	Top of chlorine contact basin	114	10.6
28	Wet Weather Basins	Top of basins	114	10.6
29	Oxygenation Tank Buildings/ Reactors (North and South)	Building entrance	116	12.6

The area with the lowest elevation is the transition structure located in the vicinity of both the dechlorination building and the foot of the Bay Bridge. Both the transition structure and the dechlorination building are adjacent to Bay waters.

Elevations of the Wastewater remote facilities are show in Table 0-2. Since these locations are spread out throughout the service area, and are not necessarily close in proximity to the Oakland Middle Harbor NOAA station location, the elevation comparison to MHHW utilized the closest NOAA station to the facility. The NOAA reference stations elevations are listed in Table 0-3.

Table 0-2. Remote Facility Elevations

No.	Structure	Description of elevation location	NOAA Reference Station	Elevation (ft)	Feet to MHHW
1	PS A	Corner of building at ground level	Richmond Inner Harbor	107.5	4.1
2	PS B	Finished floor elevation	Alameda Naval Air Station (NAS)	107.5	3.9
3	PS C	Ground level in front of building	Alameda	104.5	0.8
4	PS D	Elevation at edge of station structure	Alameda NAS	111	7.5
5	PS E	Elevation at edge of station structure	Oakland Inner Harbor	108	4.5
6	PS F	Top of slab at entry to PS	Oakland Inner Harbor	108.5	5.0
7	PS G	Finished floor elevation at ground level	Alameda	103.5	-0.2
8	PS H	Ground level in front of building	Alameda	112.5	8.8
9	PS J	Elevation at edge of station structure	Alameda	114.5	10.8
10	PS K	Elevation at edge of station structure	Oakland Middle Harbor	110.5	7.0
11	PS L	Elevation at edge of station structure	Alameda NAS	108	4.5
12	PS M	Finished floor elevation	Alameda	104.75	1.1
13	PS Q	Corner of building at ground level	Berkeley SF Bay	110	6.5
14	PS R	Elevation at edge of station structure	Alameda NAS	108	4.5
15	Pt. Isabel WWF	Corner by IPS	Richmond Inner Harbor	110.75	7.4
16	Oakport WWF	Finished grade at corner of control building	Alameda	110.5	6.8
17	San Antonio Creek WWF (Main)	Corner of control building at ground level	Oakland Inner Harbor	109.5	6.0
18	San Antonio	Corner of building at	Oakland Inner	107	3.5

	Creek WWF – Dechlorination	ground level	Harbor		

Table 0-3. NOAA Station Elevations

No.	NOAA Reference Station	MHHW (Wastewater Datum)
1	Alameda	103.7
2	Alameda NAS	103.6
3	Berkeley SF Bay	103.5
4	Oakland Inner Harbor	103.5
5	Oakland Middle Harbor	103.5
6	Richmond Inner Harbor	103.4

APPENDIX 1 - CLIMATE CHANGE MITIGATION STRATEGIES

Global climate change began as a result of the increasing emissions of GHGs. In response, the District has developed mitigation strategies to reduce the carbon footprint associated with facility operations. While the District cannot have a significant impact on global climate change by itself, the District is committed to reducing its carbon footprint. The District established a policy in 2013 that included goals for reducing indirect and direct GHG emissions by 2040. The Wastewater Department has already undertaken a number of activities to help meet these reduction goals.[3]

A1.1 Wastewater GHG Emissions Sources

The District's wastewater GHG emissions come from four categories:

- Process emissions
- Purchased electricity
- Combustion of fossil fuels
- Fugitive refrigerants

The categories of process emissions, combustion of fossil fuels, and fugitive refrigerants are all direct sources—that is, the GHGs are emitted directly from Wastewater facilities. Purchase electricity is an indirect source, meaning the GHGs are emitted at a remote location—the power plants that generate electricity purchased by the District from the grid—but they are emitted as a result of District operations.

For estimating emissions resulting from wastewater facility operations, the District has used the Water Energy Nexus (WEN) protocol developed by The Climate Registry. The science of GHG emissions from wastewater is evolving, and recent changes made to the WEN protocol resulted in additional GHG emissions attributed to wastewater discharge. The District is accounting for these additional GHG emissions, and evaluating ways to mitigate these emissions as part of the Integrated MWWTP Master Plan.

1.1.3 Process emissions

Process emissions emanate from two locations in the wastewater process: in the secondary biological reactors and in the environment after discharge. The emissions result from the presence of nitrogen in the wastewater. Nitrogen in wastewater originates from people's diets, specifically protein rich foods. Nitrogen is also present in some high strength wastes that are accepted at the MWWTP, specifically protein-rich wastes like blood wastes. Natural biological processes driven by bacteria in the wastewater convert ammonia into nitrogen gas, a process which includes emissions of nitrous oxide (N_2O) as a byproduct, which is a potent GHG approximately 310 times more powerful than carbon dioxide. The current design of the MWWTP biological treatment system does not include methods for removing nitrogen from the wastewater, and as a result, nearly all of the nitrogen reaching the MWWTP passes through into the effluent and is discharged to the Bay. In the Bay, the same biological processes present in the

[3] Chakrabarti, Hake, De Lange & McCormick, 2011

wastewater produce the byproduct of nitrous oxide, but at greater rates than in a controlled wastewater treatment process. Implementation of a biological nutrient removal process would reduce N_2O emissions modestly, but would not eliminate them, and would result in the need to purchase additional grid electricity, which would result in additional indirect GHG emissions. The District is currently investigating the potential for implementing biological nutrient removal as part of the Integrate MWWTP Master Plan.

1.1.4 Purchased Electricity

The District also contributes to GHG emissions through purchased electricity that supplements the District's renewable power generation. Due to the fluctuations in biogas production at the MWWTP, power production varies over the course of a week, and during periods of low biogas production (typically Sunday through Tuesday), power production is not great enough to match or exceed plant power demand. As a result, power is drawn from the grid. The power is purchased through PG&E, but generated by Western Area Power Authority (WAPA), due to the lost cost. WAPA power is a portfolio of sources, including renewable hydroelectric generation, but also many fossil fuel-based sources. During wet weather events, more pumping is required at the MWWTP, and the resulting power demand exceeds power production, even at the maximum output.

Power purchases are also required at all of the District's remote wastewater facilities, which include the three wet weather facilities, fourteen pump stations, the Dechlorination Facility, and Transition Structure. Depending on the location, power is purchased from either PG&E, East Bay Community Energy (EBCE), Marin Clean Energy (MCE), or Alameda Municipal Power (AMP). Purchased electricity has higher GHGs than the District's self-generated renewable energy. The exact emissions varies by power supply source, and typically power suppliers provide emissions factors for their entire portfolio for users to estimate their demands on a per kilowatt-hour (kWh) basis.

1.1.5 Combustion of Fossil Fuels

The District's wastewater operations use relatively small amounts of diesel fuel and natural gas that contribute to GHGs, however many of these uses are unavoidable without major changes to current operations. First, the Districts PGS combustion engines require the use of a small amount of diesel fuel, also referred to as pilot fuel, to start the engines. This requirement is due to the design of the engines. They are compression ignition engines, meaning they have no spark plugs to ignite the fuel when it enters the engine's cylinders, and instead rely on the phenomenon where diesel fuel will self-ignite at the appropriate high pressure, due to the chemical composition of diesel fuel. The District uses approximately 10,000 gallons of diesel fuel for this purpose each year.

Combustion of fossil fuels also includes natural gas use at District wastewater facilities for heating water for domestic use.

1.1.6 Fugitive Refrigerators

The District's wastewater facilities have a variety of small-scale HVAC units and refrigerators that utilize refrigerants that act as GHGs. GHG inventory calculations assume that this refrigeration equipment has small, unavoidable leaks over time, and so include emissions factors for these GHG leaks. However, calculations for the specific refrigeration units utilized at District wastewater facilities show that this contribution is very low—approximately 0.1% of overall GHG emissions from wastewater facilities.

1.1.7 Estimates 2018 GHG Emission from Wastewater

2018 is the first year that the WEN protocol has been used by the District to calculate GHGs from wastewater facilities. The results of that calculation are shared in Table 3-1 below.

Table 0-1 – 2018 GHG Emissions Inventory for EBMUD Wastewater

Category	**GHG Emissions (MT CO2e per year)**	**Percentage of Total Emissions**
Process Emissions	10,738	79%
Purchased Electricity	1,718	13%
Fossil Fuel Combustion	1,126	8%
Fugitive Refrigerants	20	0.1%
Total	**13,601**	**100%**

A1.2 Ongoing GHG Mitigation Efforts

1.1.8 Renewable Energy Production

Producing renewable energy to offset fossil fuel energy use is a well-accepted mitigation measure for GHG emissions. The District generates on-site renewable energy at the MWWTP. The District has three 2.15 megawatt (MW) internal combustion engine-generators that were installed in 1985. Prior to 2002, the average generation was around 2.5 MW.

In 2002, the District began the Resource Recovery Program to accept trucked low-strength and high-strength waste at the MWWTP to generate more biogas. To maximize use of the biogas and energy production, the District installed a 4.5 MW biogas turbine in 2011. With the addition of the turbine, the net generating capacity of the MWWTP increased to 11 MW. With the increase of biogas produced, the MWWTP produces enough energy to power the entire facility and sells the excess renewable energy back to the energy grid. The MWWTP became the first net-energy producing POTWs in North America in 2012. In Fiscal Year 2018, the MWWTP generated almost 52,000 Megawatt hour, the equivalent of 143 percent of the MWWTP's demand.

1.1.9 Reduce Energy Consumption

Reducing energy consumption is another means to mitigate climate change. Various measures have been implemented to reduce on-site energy demand at the MWWTP. Specific demand reduction projects include:

- Implementing oxygen production control
- Installing more efficient aeration equipment
- Upgrading power distribution and sub-metering
- Installing an activated sludge selector
- Upgrading the grit removal system
- Installing more efficient lighting

The MWWTP Energy System Master Plan was completed in 2012 with a main focus of identifying, screening, and recommending a range of energy conservation measures (ECMs). Twenty-three ECMs were recommended for implementation. A number of the ECMs were implemented and found that while there was some minor energy use reduction, any projects resulting in large reductions in energy use had already been completed in past efforts.

The Energy System Master Plan also included review of various benchmarking studies. Most of the studies compared energy intensity, the amount of electricity used per volume of wastewater, of various POTWs. One study by the United States Environmental Protection Agency (EPA) ranked the MWWTP's energy intensity percentile between the 70th and 76th percentiles, which meant energy management performance at the MWWTP exceeded nearly 3/4 of similar POTWs. The MWWTP scored favorably in values from other benchmarking studies as well, with energy intensity falling on the low end for secondary treatment plants in California. These studies support the findings on how much energy reduction work has already been accomplished at the MWWTP.

1.1.10 Landfill Diversion

Digestion of high-strength organic wastes, such as food waste, represents a climate change mitigation strategy by (1) producing renewable energy, which offsets fossil fuel energy production, and by (2) diverting material that would otherwise decompose in an uncontrolled setting (e.g., a landfill or open lagoon) and release methane, a much more potent GHG than carbon dioxide. Even though landfill gas is increasingly captured and used for energy generation, or at a minimum flared, the capture rate may be quite low. A literature review reported a landfill gas capture rate range of 14 to 75 percent[4] and the EPA estimates indicate less than 60 percent for the national average (2011). For food waste, which is readily degraded, much of the methane may escape prior to closure of the landfill cell, so the capture rate would be even lower. Various high strength wastes are digested at the MWWTP, some of which may have otherwise decomposed in a lagoon or landfill and lead to uncontrolled methane emissions. By controlling and destroying methane emissions from these high-strength wastes, overall GHG potential is significantly reduced.

1.1.11 Biosolids Reuse

Land applied biosolids provide nutrients for crops, sequester carbon, and reduce the demand for inorganic, chemical fertilizers resulting in net GHG emissions reductions. Biosolids produced at the MWWTP are 100 percent beneficially reused. In 2018, 10 percent was utilized as alternative daily cover at landfills, 13 percent was composted, and 77 percent was land applied at non-edible crop farm sites. Land application as a soil amendment provides nitrogen and therefore reduces the need for fossil fuel-based fertilizers and the energy required to produce those fertilizers. In addition, land application significantly increases soil carbon storage, making it an effective means of carbon sequestration.

[4] Eddy, 2009

APPENDIX 1 - VULNERABILITIES

A1.1 Introduction

Climate models use different scenarios to predict future conditions. The IPCC uses RCPs to describe the different scenarios.[5] For planning purposes, the District uses the RCP 8.5 scenario. RCP 8.5 assumes a business-as-usual scenario with no reduction in GHGs.

The State of California released its Assessment in August 2018. It focused on regional vulnerabilities and adaptations based on two RCPs, one being RCP 8.5.[6] The following chapter summarizes vulnerabilities that are likely to affect the District's wastewater facilities, which are discussed in the Assessment and other reports.

A1.2 Sea Level Rise

Sea level rise manifests as different water level elevations depending on the physical attributes of the shoreline. Sea level rise projections for the entire California coast do not necessarily translate directly to similar levels within the Bay. Similarly within the Bay, sea level rise varies due to vertical land movement from seismic activity, sediment compaction, marsh accretion, and groundwater fluctuations from subsidence. All sea level rise scenarios shown in this report are taken from the MHHW level. The MHHW is the average high tide water level. For reference, the MHHW at the closest NOAA station to the MWWTP, Oakland Middle Harbor, has an equivalent elevation of 103.45 feet per the Wastewater standard datum. All current projections also assume that no new shoreline infrastructure, such as sea walls or wetland restoration, will be implemented in the intervening time.

Based on RCP 8.5 projections, sea level is expected to rise approximately 16 inches by 2050.[7] For the year 2100, a sea level rise of 54 inches is expected along the California coast.[8] For the Bay Area, the 2050 sea level rise range is projected to be 4.7 to 24 inches. The 2100 range of values is 16.5 to 65.7 inches. Sea level rise projections are summarized in Table 0-1.

Table 0-1. Sea Level Rise Projections (RCP 8.5)

Year	2030	2050	2100
California Coast	2-12 inches	12-16 inches	54 inches
San Francisco Bay Area	2-12 inches	5-24 inches	16-66 inches

Using data provided by BCDC as part of the ART Project, maps were prepared to provide a visual assessment of the effect of sea level rise at the MWWTP. The ART Alameda County Shoreline Vulnerability Assessment[9] developed an approach where one map can represent different sea level rise and storm surge scenarios. The same map can represent any combination of reasons for the given increased sea level, for example, a 54-inch sea level rise with no storm,

[5] Core Writing Team, Pachauri, & Meyer, 2014
[6] Bedsworth, Cayan, Franco, Fisher, & Ziaja 2018
[7] San Francisco Bay Conservation and Development Commission (BCDC), 2012
[8] Bedsworth et al., 2018
[9] BCDC, 2015

and a 24-inch sea level rise with a 10-year storm, or a 12-inch sea level rise with a 100-year storm would all result in the same map.

It is also important to note that sea level rise leads to a permanent rise in water level or inundation. Storm surge would only result in a temporary water level rise until the event has passed.

1.1.12 <u>2050 Sea Level Rise</u>

For 2050, the water level along the California coast is projected to be 12 to 16 inches. Within the Bay, the water level is projected to be from 5 to 24 inches, with 12 inches being most likely. Figure 0-1 shows the effect of a 12-inch mean sea level rise at the MWWTP.

Figure 0-1. 12-inch Sea Level Rise in 2050 at MWWTP

As seen in the figure, a sea level rise of 12 inches will have no effect on the MWWTP. When considering the entire wastewater service area (Figure 0-2), there is more of an impact to District wastewater facilities. The transition structure, which extends into the Bay, would see an increase in water level of approximately one foot along the sides of the building, with greater impacts during high tide. The structure itself is elevated 2.5 feet above the ground so instrumentation and equipment inside the structure would be unaffected. The roadway to the structure would not be flooded by such a rise in sea level, so staff would still be able to drive to the facility. A close-up view of the transition structure at 12 inches of sea level rise can be seen in Figure 0-7.

Rising sea level will also reduce the peak flow capacity of the EPS. The reduction in EPS peak flow capacity will not reduce the ability to discharge treated effluent in normal conditions. The peak capacity of EPS will be reduced by five to ten percent, potentially up to 30 MGD, due to the pumps needing to push against an additional 12 inches of pressure head. During peak flow events, this condition will reduce the ability to discharge peak flows, potentially resulting in more conditions when the WWFs must be activated if flow through the MWWTP has reached maximum capacity.

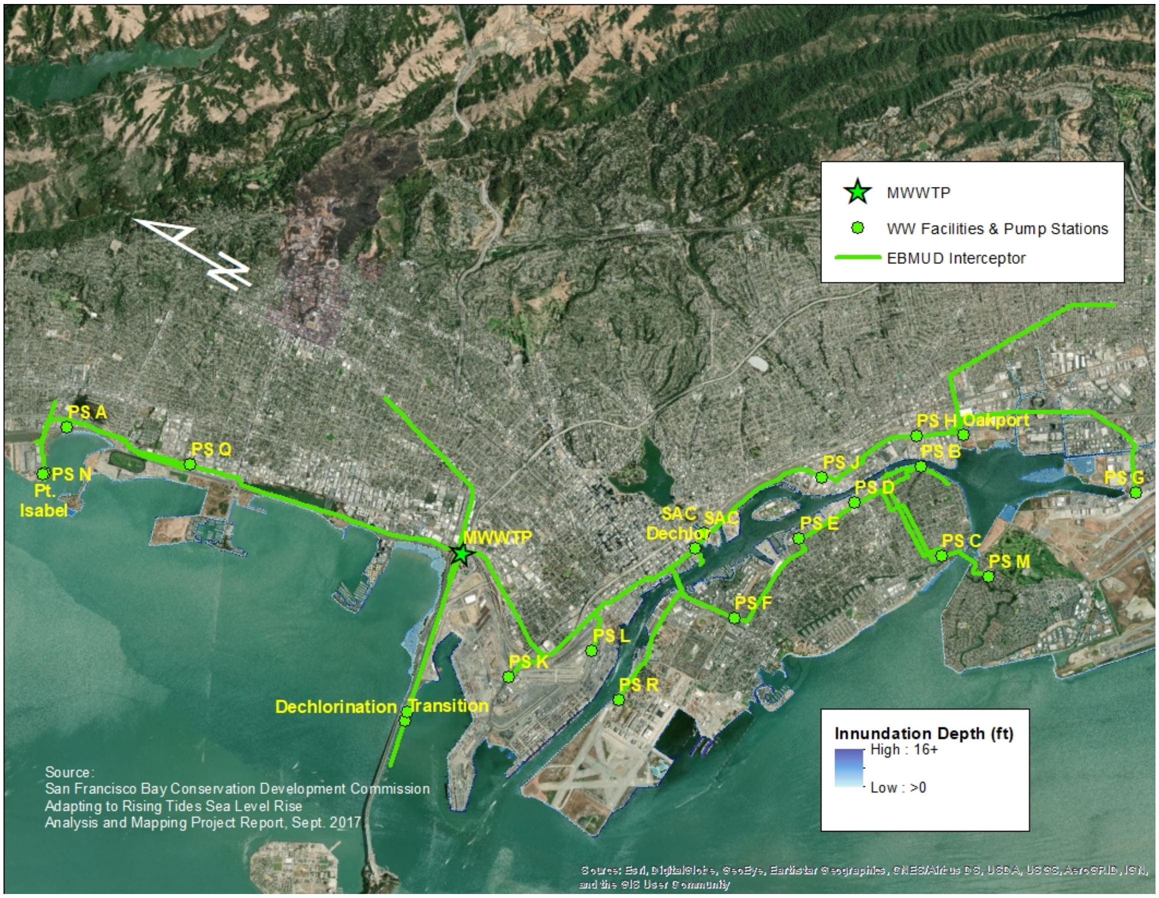

Figure 0-2. 12-inch Sea Level Rise in 2050 over entire service area

When the 12-inch sea level rise is coupled with a 100-year storm with extreme tide condition, the MWWTP will experience flooding as seen in Figure 0-3. An extreme tide in terms of this study is the combination of a storm surge and high tide resulting in an unusually high temporary water level. This scenario is equivalent to a 52-inch sea level rise with no storm surge. The Maintenance Building would experience flooding of approximately one to three feet. Flood water to the MWWTP appears to travel via the Port of Oakland and the Union Pacific Railroad tracks. Near the foot of the Bay Bridge, the transition structure would have approximately two and a half feet of water around it. The dechlorination facility would also have approximately one foot of water above ground surface along the south side of the building. Access to the underground injection station at the dechlorination facility is from the north so it should be protected from the storm surge.

Figure 0-3. 12-inch Sea Level in 2050 with 100-year storm

In examining the same scenario over the entire service area, portions of the District's wastewater interceptor south of Emeryville, within Oakland and Alameda, will experience flooding. PSs A, C, E, F, G, L, M, and R are located in areas with flooding during this scenario. The San Antonio Creek WWF and dechlorination building also would be flooded. In addition, the peak discharge flow capacity of the San Antonio Creek WWF would be reduced due to the additional 12 inches of pressure head that must be pushed against. A reduction in peak capacity at San Antonio Creek would reduce its ability to relieve the South Interceptor. Approximate flood levels at the affected facilities are listed in Table 4-2.

Table 0-2. 2050 Approximate Flood Level Projections with 100-year storm

Facility	Flood Depth (feet)
PS A	2.0
PS C	2.5
PS E	0.1
PS F	0.7
PS G	7
PS L	0.3
PS M	2.7
PS R	1.4
San Antonio Creek WWF	0.3
San Antonio Creek dechlorination building	1.5

1.1.13 2100 Sea Level Rise

By 2100, the California coast is expected to see a sea level rise of 54 inches. In the Bay Area, the range is expected to be 16.5 to 65.7 inches, with 36 inches being the most likely scenario. Figure 0-4 shows the effect of a 36-inch sea level rise across the wastewater service area.

The MWWTP is not affected by floodwaters from a 36-inch sea level rise. The transition structure, however, will be affected and may start to see water entering the facility. Portions of the roadway leading up to the transition structure will likely be flooded. The water level will also be close to ground level at the dechlorination facility. It is possible that with wind or wave action, water could approach the door of the facility or start to block the roadway.

The flow capacity of EPS will be reduced due to the pumps needing to push against an additional 36 inches of pressure head.

Most of the wastewater facilities in the interceptor system will be unaffected, but PS A, G, M, and R and the San Antonio Creek WWF dechlorination building will have some flooding. Approximate flood levels at the affected facilities are listed in Table 0-3.

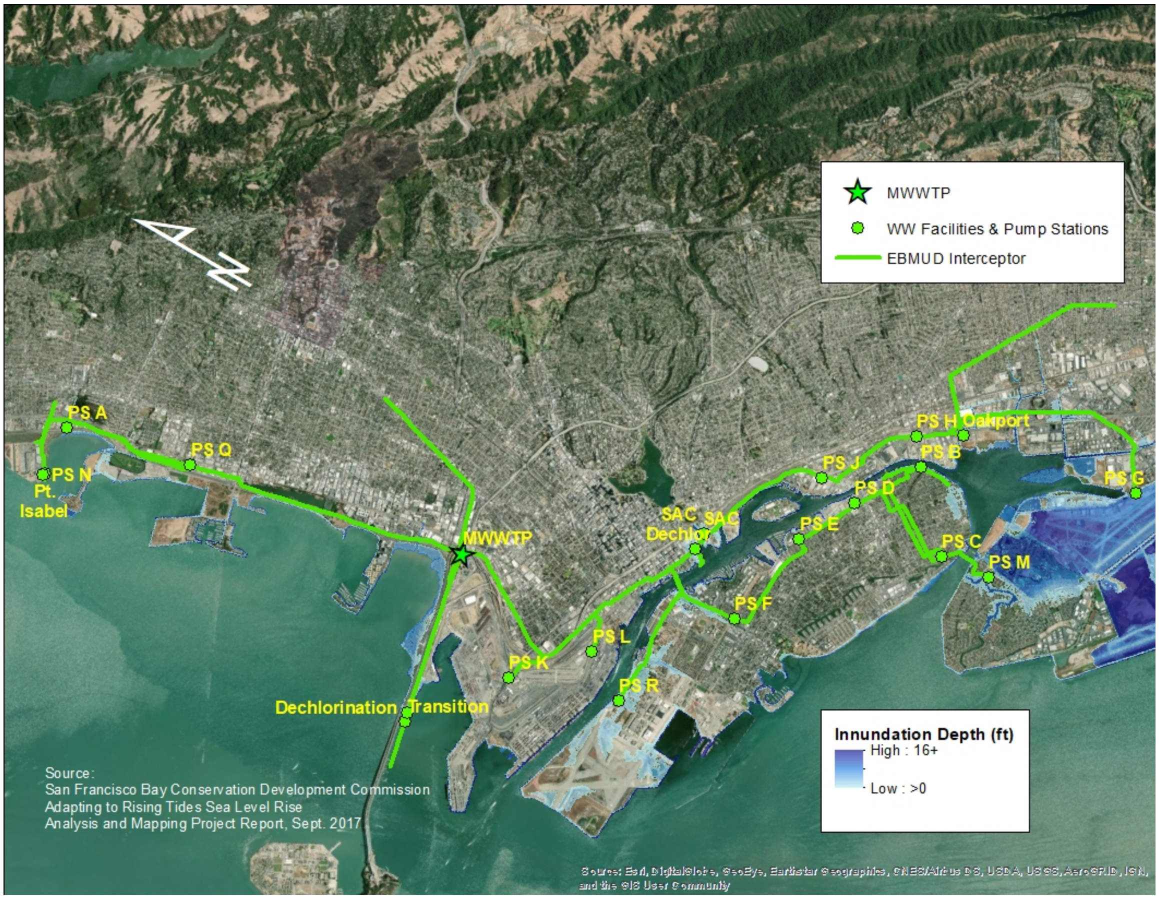

Figure 0-4. 36-inch Sea Level Rise in 2100

Table 0-3. 36-inch Sea Level Rise Flood Level Projections

Facility	Flood Depth (feet)
Pump Station A	0.5
Pump Station G	5.5
Pump Station M	0.5
Pump Station R	0.4
San Antonio Creek dechlorination building	0.1

To compare the base 2100 sea level rise scenario with the worst case 2100 scenario, Figure 0-5 shows the effect of the high range sea level rise with a 100 year extreme tide condition or the equivalent of an 84-inch sea level rise. Most of the MWWTP will be affected with some flooding.

Figure 0-5. 42-inch Sea Level Rise with 100-year storm in 2100

Looking at the same scenario over the entire service area, as seen in Figure 0-6, the majority of the District's wastewater facilities south of Emeryville will experience some flooding. The worst of the flooding will be near the Oakland Airport and Bay Farm Island. Much of Alameda will also be flooded. The majority of the District's wastewater PSs are in locations where there will be flooding. Many sections of the South and Alameda Interceptors will have one or more feet of water above the existing ground surface elevation. In the north part of the service area, PS A will experience flooding. The Emeryville portion of the North Interceptor will also have one or two feet of water above the existing ground surface elevation. The Point Isabel WWF will not be flooded, but the roadway leading to the facility is at risk of flooding. Approximate flood levels at the affected remote facilities are listed in Table 0-4.

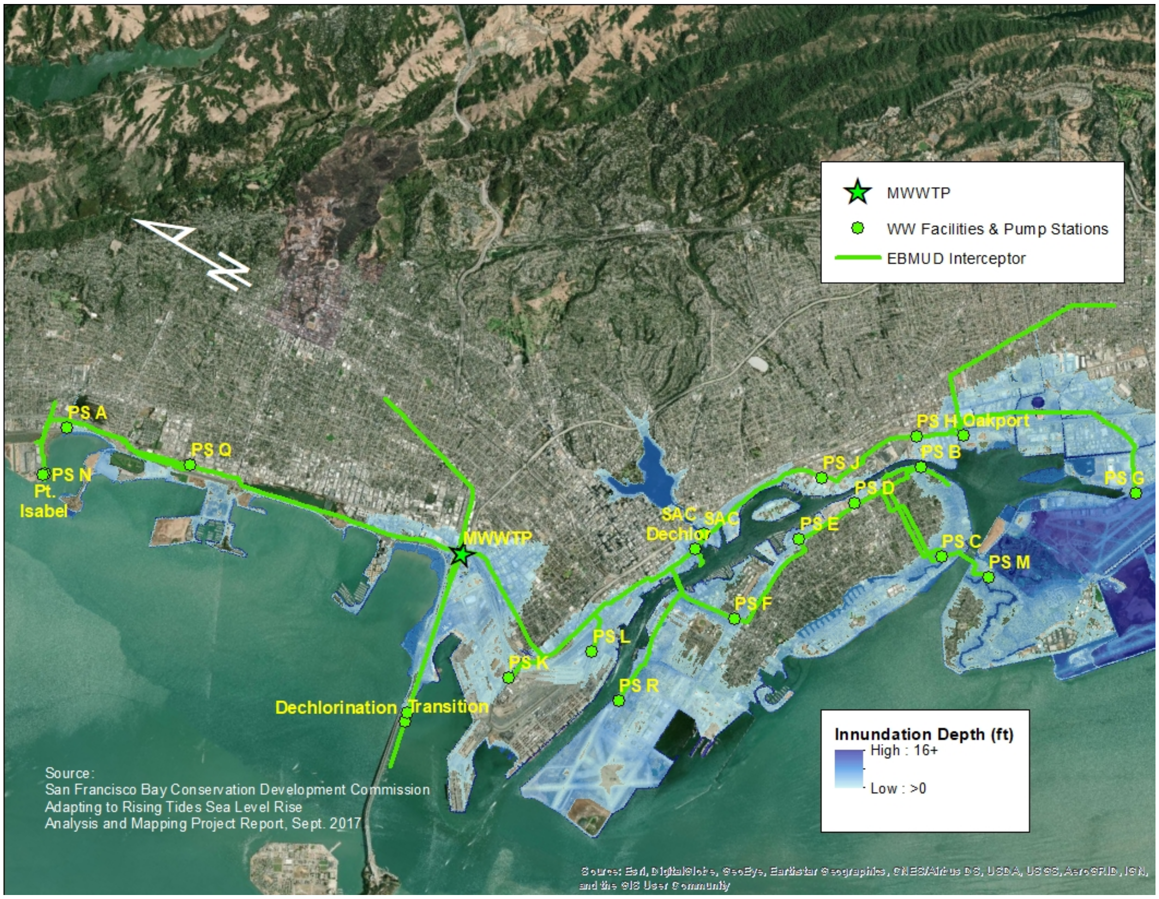

Figure 0-6. 42-inch Sea Level Rise with 100-year storm in 2100

Table 0-4. 42-inch Sea Level Rise with 100-year Storm Flood Level Projections

Facility	Flood Depth (feet)
Pump Station A	4
Pump Station B	1
Pump Station C	3.5
Pump Station D	0.5
Pump Station E	2.5
Pump Station F	3.5
Pump Station G	10
Pump Station K	0.5
Pump Station L	3
Pump Station M	5
Pump Station R	4
Oakport WWF	0.5
San Antonio Creek WWF	2.5
San Antonio Creek dechlorination building	4

Side-by-side comparisons of the different sea level rise scenarios at specific structures are shown in Figure 0-7 to Figure 0-10 below.

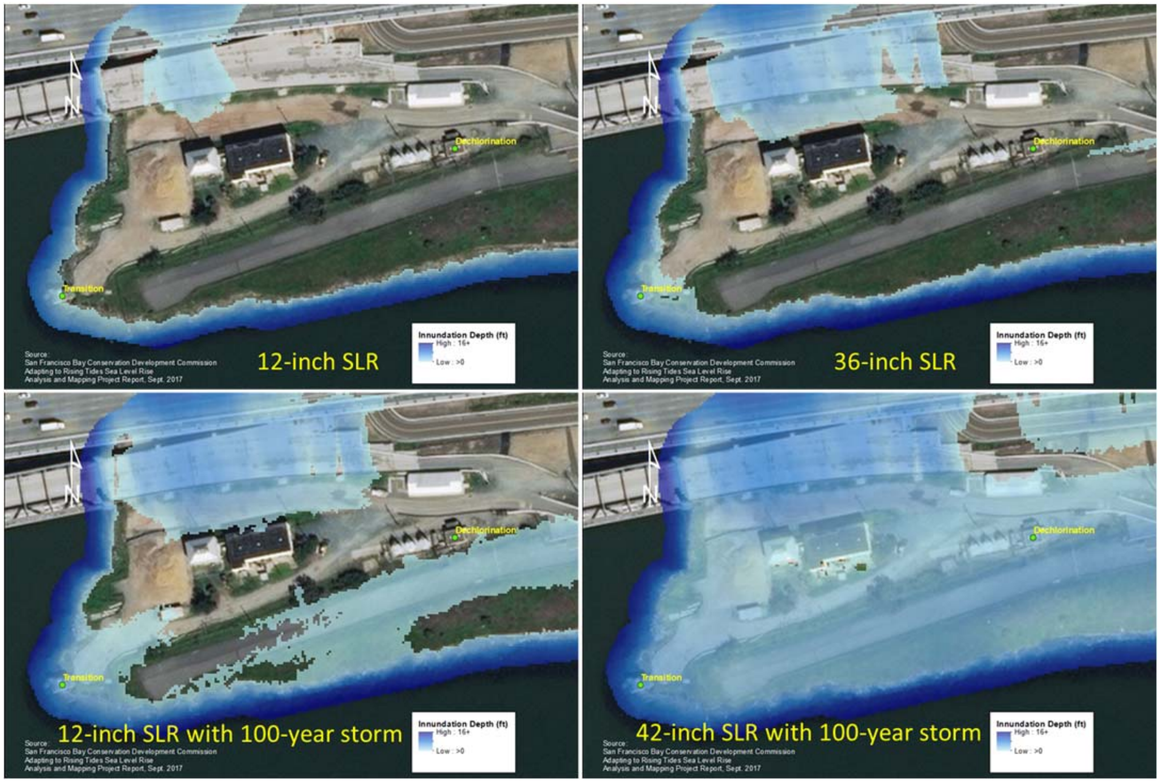

Figure 0-7. Dechlorination Station and Transition Structure at various sea level rise scenarios

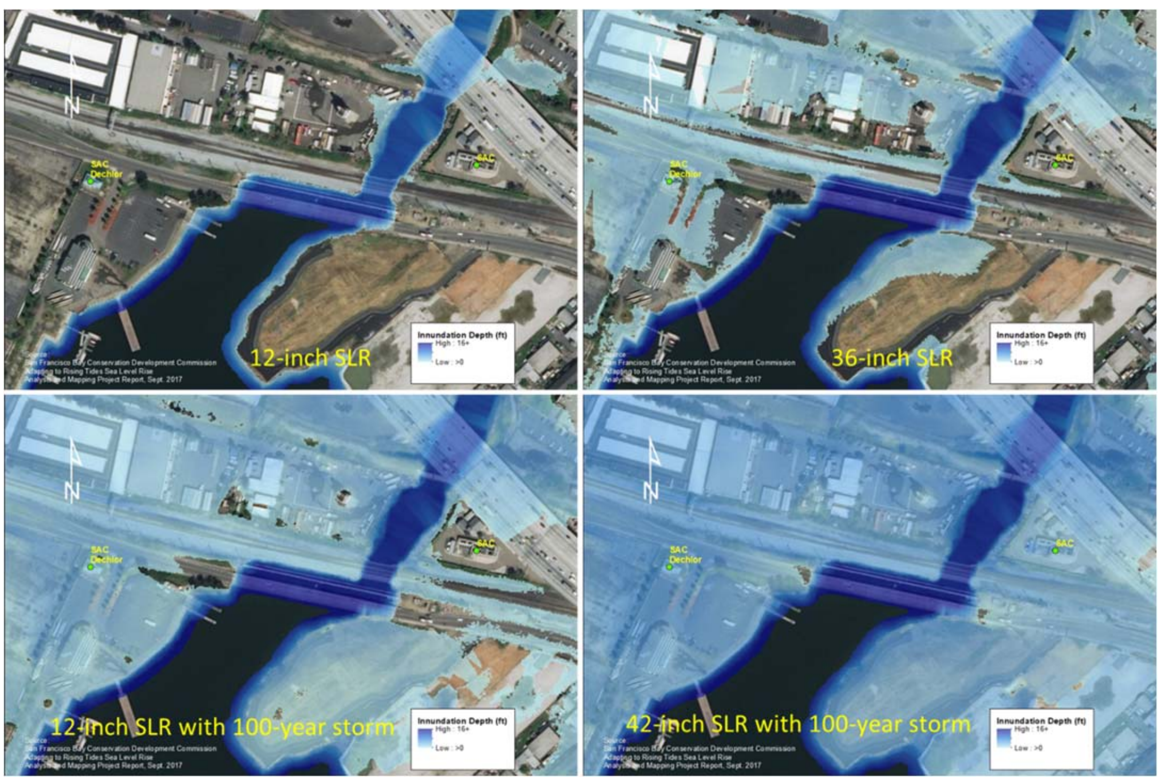

Figure 0-8. San Antonio Creek WWF at various sea level rise scenarios

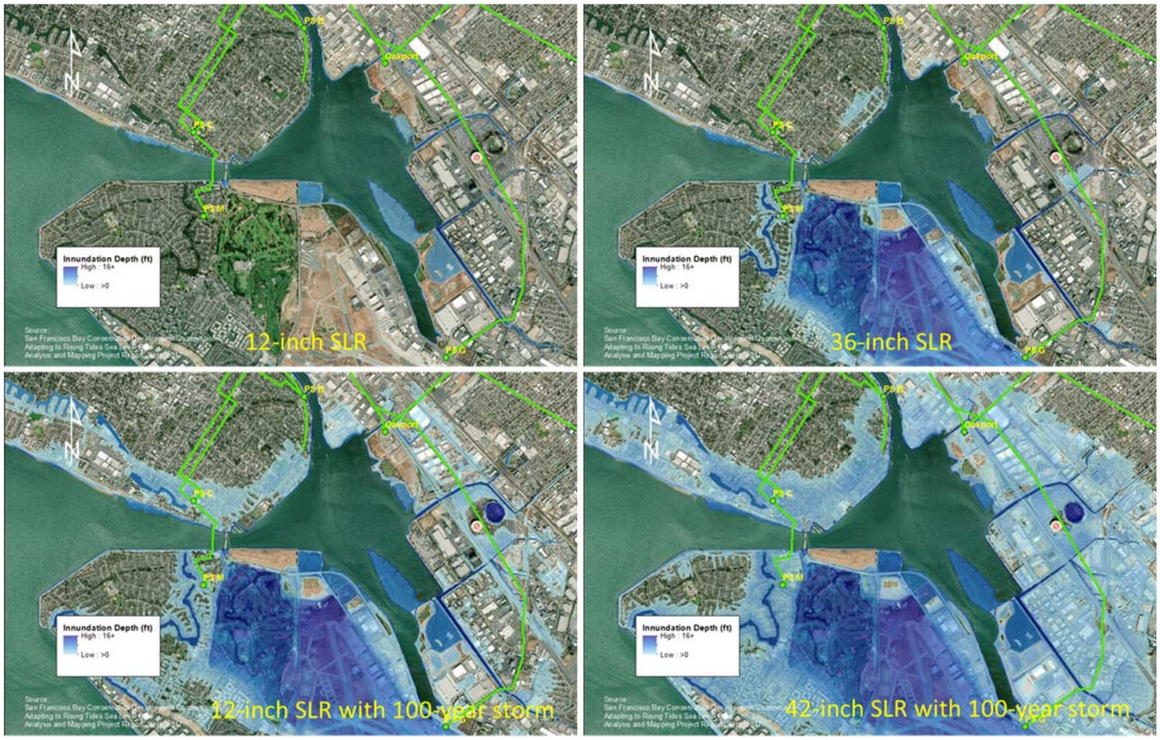

Figure 0-9. San Leandro Bay at various sea level rise scenarios

Figure 0-10. North Interceptor at various sea level rise scenarios

The main conclusion from the sea level rise assessment is that District facilities have low risk of impacts based on 2050 sea level rise scenario projections. The majority of District facilities are at low risk in the base 2100 sea level rise scenario. There will not be any permanent inundation at

District facilities aside from the transition structure, PS G, and the San Antonio Creek dechlorination building up to the 2100 predictions.

Only when storm surge is added to the 2050 and 2100 sea level rise projections are District facilities in danger of flooding. In 2050, only a 100-year storm would be large enough to cause minor flooding at the MWWTP, but likely would not impede operation of the facility. In 2100, a smaller 2-year storm could cause minor flooding with minor impacts to the MWWTP while a larger 100-year storm could cause major flooding and likely halt operations temporarily. A key item to reiterate is that storm surge is temporary flooding. Once the storm has passed and flood waters subside, facilities can resume operation.

A1.3 Groundwater Rise

The groundwater table is expected to rise in part as a result of sea level rise. Studies to date have assumed a linear rise in the groundwater table with sea level (i.e., a 12-inch rise in sea level would increase the groundwater table by 12 inches) for areas within 6/10th of a mile from the coast.[10] Current groundwater levels in Alameda County were approximated in a study based on the maximum measured groundwater table height from the past 20 years of well sampling.[11] The height of the groundwater table was interpolated for areas between the well locations. However, modeling for groundwater rise is not yet as extensive as models for sea level rise and there are some areas with no data.

Based on the current estimated levels and assuming a 1:1 linear rise in groundwater, Figure 0-11 shows the approximate depth to groundwater at the MWWTP, and indicates that two areas at the MWWTP have shallow groundwater tables. The roadway leading to the Mandela gate is a known low point and is already subject to flooding during rain. The other location where groundwater is particularly shallow is near the blend tanks; however, it is believed that this reading is no longer accurate because the area was likely under construction when the ground surface elevation survey was completed by the United States Geological Survey.

Assuming a linear rise in groundwater, by 2050 the groundwater table would rise approximately one foot. Based on the approximate level to groundwater shown in Figure 0-11, there are no new locations at the MWWTP where groundwater would surface. There are no concerns about below grade structures being lifted out of the ground. This type of event was discussed in the seismic reports prepared in the 1980s. Since the MWWTP is already located in an area with a high water table and the existing structures are fairly heavy, new buoyancy of the buildings is not a concern.

By 2100, the groundwater table could potentially rise 36 inches. MWWTP areas of concern for groundwater rise in 2100 would also be vulnerable to the projected 2100 sea level rise. These areas are namely the Maintenance Center and the eastern boundary of the MWWTP, adjacent to the railroad tracks. The depth of the groundwater table in this area ranges from three to five feet, which is comparable to the expected amount of sea level rise. There is potential for groundwater seepage and minor flooding in these low areas. As sea level rises, the potential for groundwater seepage also increases. Building buoyancy is also not a concern for this time frame.

[10] Hummel, Berry, & Stacey, 2018 and Plane & Hill, 2017
[11] Plane & Hill, 2017

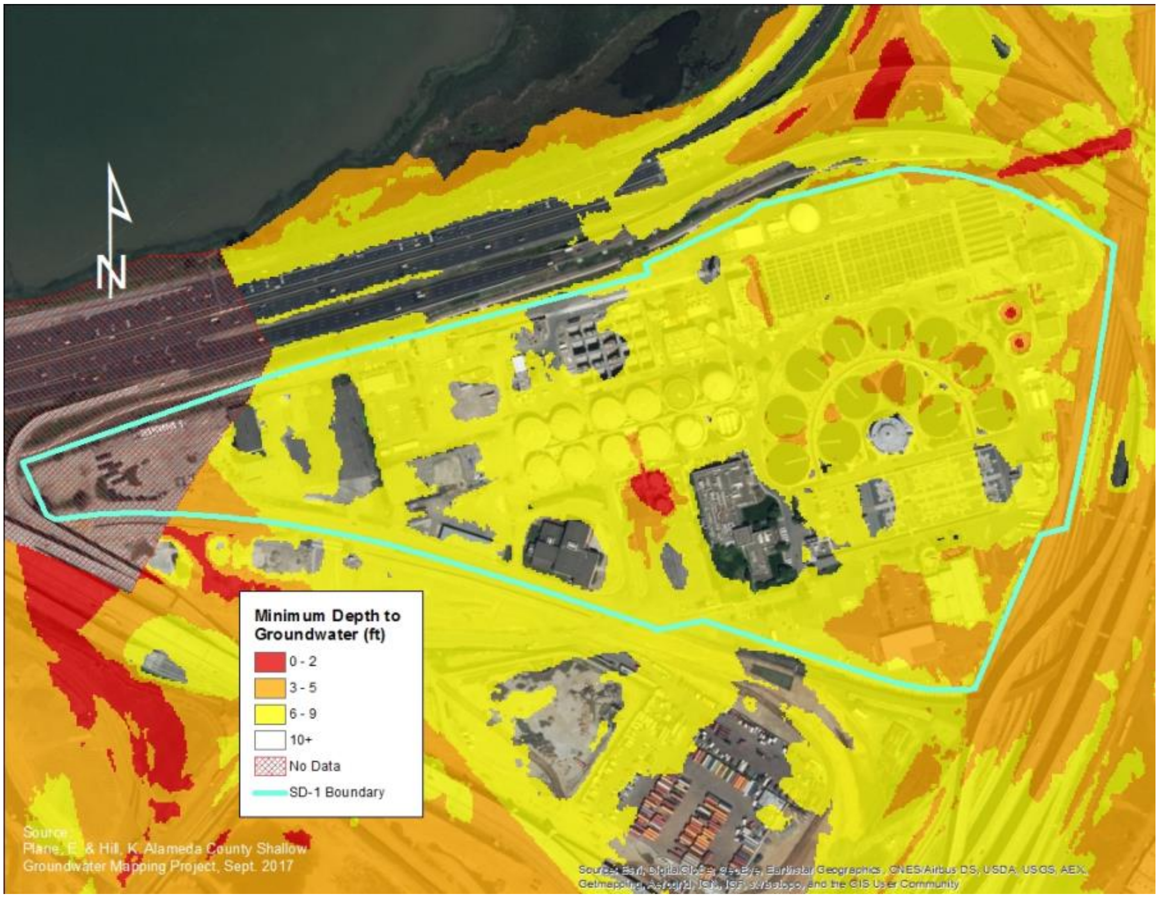

Figure 0-11. Depth to Groundwater at MWWTP

Figure 0-12 shows the approximate depth to groundwater for the wastewater service area. Additional Figures 3-13 to 3-15 provide a closer view of the groundwater levels around select portions of the interceptors. Portions of the interceptor are located in areas with high water tables. If the interceptors are not properly maintained there is potential for increased I/I due to increased water pressures from the rising groundwater table. However, the interceptors are already below the groundwater table so they already have a risk of I/I.

The District continues to rehabilitate the interceptors as planned in the capital budget. Sections of the interceptor with fairly high water tables, especially in Alameda, were recently rehabilitated several years ago. I/I is less of a concern in these areas in the short-term. Some sections of concern for the South Interceptor along 3rd Street are either under construction or in design for future rehabilitation.

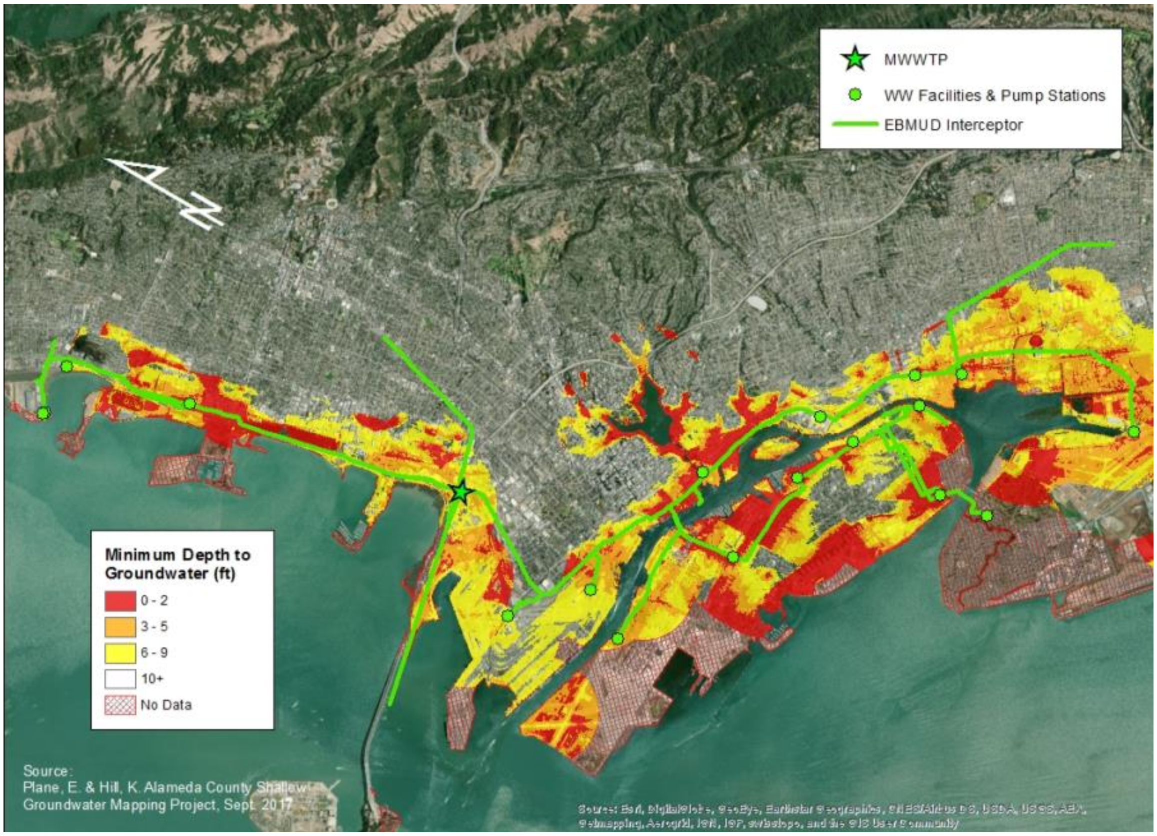

Figure 0-12. Depth to Groundwater in Service Area

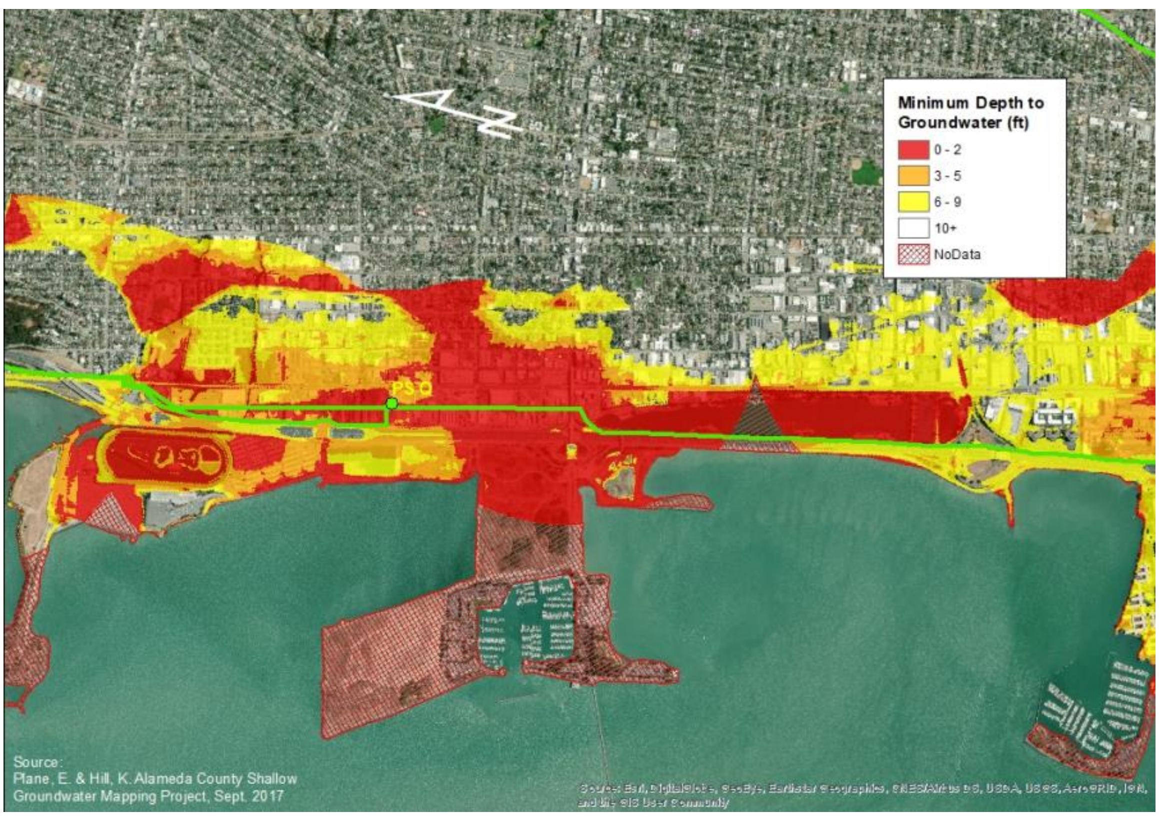

Figure 0-13. Depth to Groundwater Along the North Interceptor

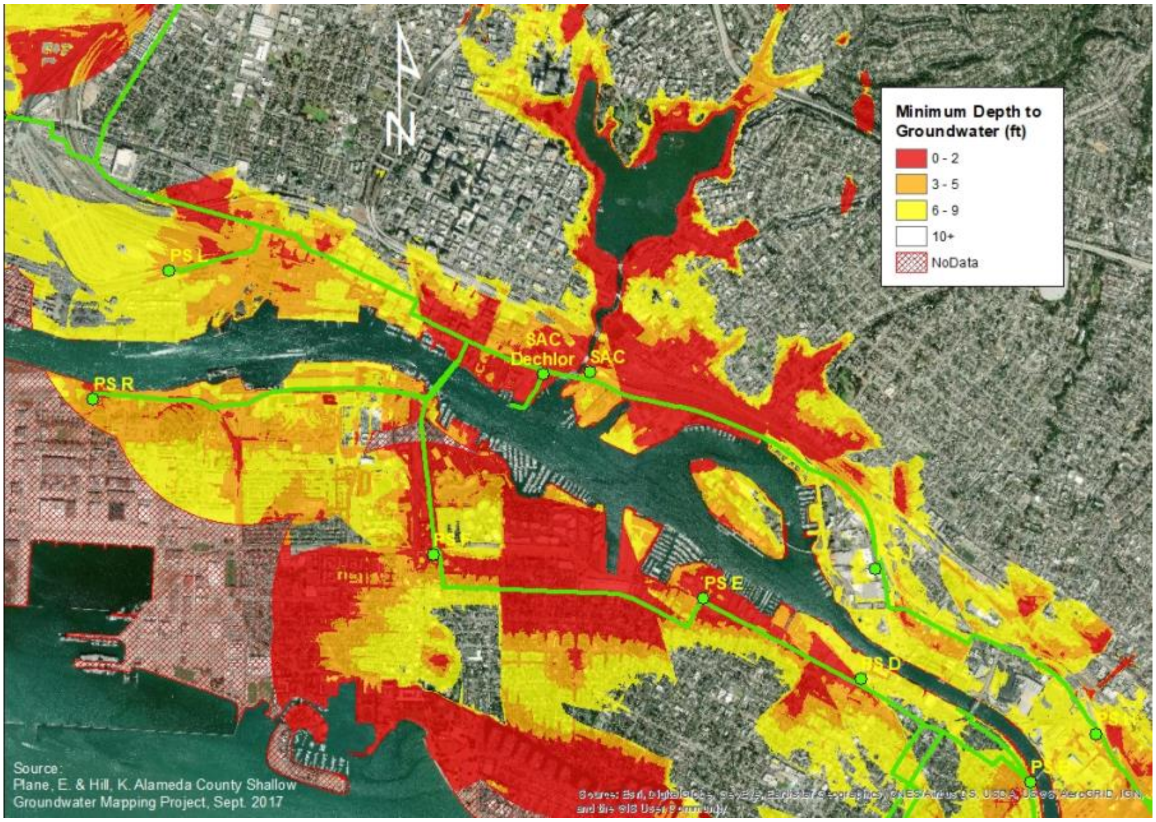

Figure 0-14. Depth to Groundwater Along the Alameda and South Interceptors

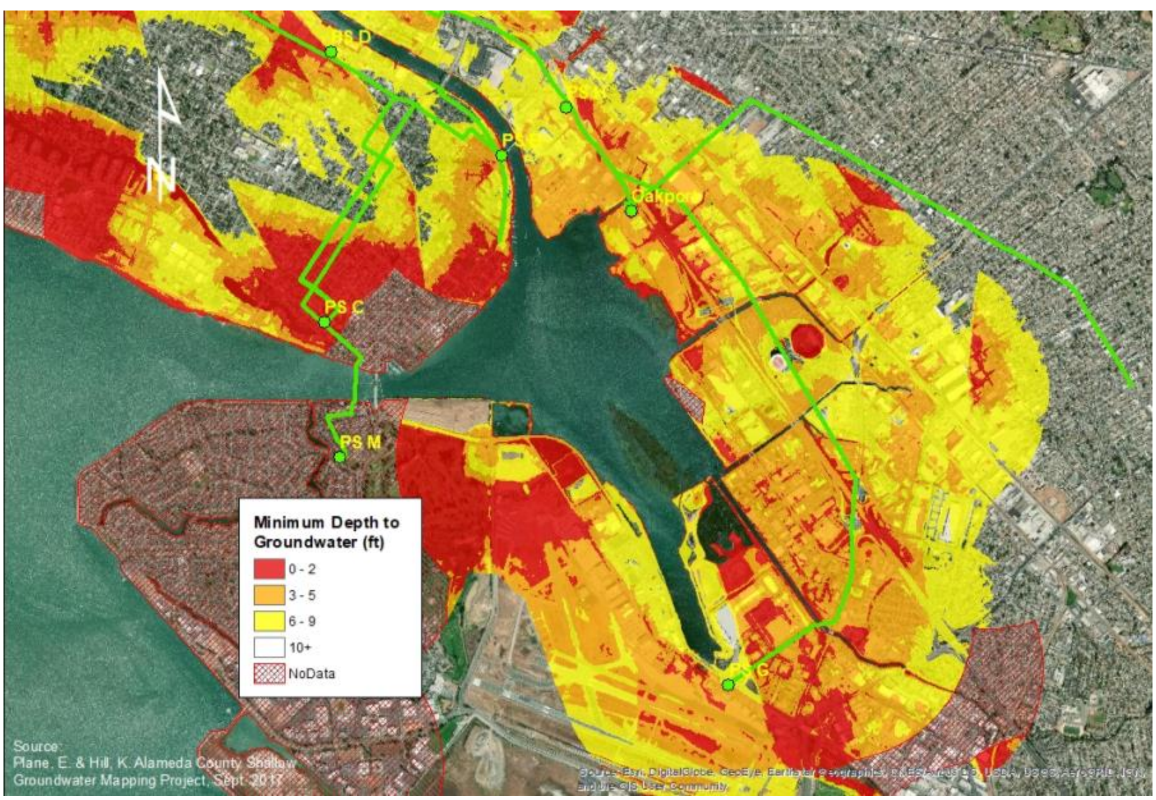

Figure 0-15. Depth to Groundwater Along the Alameda and South Interceptors

A1.4 Temperature

The annual average temperature is expected to increase as climate change progresses. From 1950 to 2005, the overall average temperature over all the counties in the Bay Area increased by 1.7°F. The average maximum temperature during this time period ranged from 67.5°F to 71.9°F. Under RCP 8.5, the projected temperature increases for the Bay Area[12] are listed in Table 0-5 for the mid-century and end-of-century time frames. It should also be noted that the temperature projections do not account for any future changes in fog and sea breeze so the values reflect the current fog and sea breeze cooling patterns.

Table 0-5. Temperature Increase Projections (RCP 8.5)

Year Range	2040-2069	2070-2100
Annual Mean Temperature Change	+4.4°F	+7.2°F
Average Hottest Day of the Year Temperature Increase	-	+6.3°F (coast) to +10°F (inland)

More research and data collection is needed to determine exactly how the temperature increase will affect the wastewater treatment process. However, the magnitude of the projected temperature increase is expected to result in little to no discernible effect on the wastewater treatment process. Temperature increase may have an effect on energy usage as more energy may be needed to cool processes and buildings.

A1.5 Precipitation

California is located between two regions of North America. The northern region is expected to have an increase in precipitation, while the southern region is expected to have a decrease. Because of this split, it is difficult to predict how future precipitation levels will trend in California. California's precipitation levels are also difficult to predict due to the fluctuations between very wet and very dry years. California has the largest year-to-year precipitation variability across the contiguous United States.[13] Average projections show a small increase in annual precipitation (4.6 inches per year) by the end of the century (2070-2100) relative to the baseline period of 1976 to 2005.[14]

California precipitation projections are uncertain with climate change.[15] Computer models agree that summers will be longer and drier and winters will be shorter and wetter (i.e. more rain will fall between November to March rather than the shoulder months of September, October, April, and May). Winter precipitation is projected to increase up to 20 percent. Spring and autumn precipitation is projected to decrease up to 20 percent. Daily extreme precipitation values are projected to increase 15 to 20 percent.[16] Various models, however, do not agree on the quantity of precipitation expected annually, change in intensity of individual storms, or the frequency at

[12] Ackerly, Jones, Stacey, & Riordan, 2018
[13] He, Schwarz, Lynn, & Anderson, 2018
[14] Ackerley et al., 2018
[15] Ackerly et al., 2018 and Swain, Langenbrunner, Neelin, & Hall, 2018
[16] Pierce, Kalansky, & Cayan, 2018

which more intense storms will occur. Current models have not even been able to accurately mimic recent extreme storm events when using historical rainfall data.

Overall, precipitation is expected to decrease in frequency while at the same time increasing in intensity. Extreme precipitation events are expected to occur more frequently. A once-in-20-year storm could become a once-in-7-year or more frequent storm.[17] A once-in-200 year storm could occur every 40 to 50 years by 2100 under RCP 8.5.[18]

The combination of higher temperatures coinciding with more infrequent rainfall could result in more frequent droughts and corresponding water conservation measures. Reduction in indoor water use can result in lower flows to the wastewater collection system and higher concentrations of target constituents. More intense storms will result in changes to rainfall dependent I/I, resulting in changes to both peak wet weather flows and the duration of those peak flows.

A1.6 Local Power Outages Due to PG&E Regional Wildfire Mitigation Plan.

In February 2019, PG&E announced an expanded PSPS that may affect 5.4 million customers. PG&E implemented the PSPS Program in 2018 to proactively de-energize lines that transverse high fire hazard areas under extreme fire risk conditions during the summer and fall. PG&E aims to alert customers when a PSPS event could occur within 48 hours. There is a remote chance that the MWWTP and the wastewater pumping facilities could be affected.

The MWWTP is currently served by two PG&E power connections. The MWWTP has used digester gas to generate power since 1985, and currently generates an average of 143 percent of the power needed at the plant. Excess power is sold to the Port of Oakland. In the unlikely event that both PG&E feed lines are shut down, it is anticipated that the MWWTP PGS will generate sufficient power to keep the critical plant functions operating. In addition, some facilities have back-up generators to provide power should the PGS be out of service or if it is not producing enough power.

Various wastewater PSs in the interceptor system have facilities in place and portable equipment available to continue operating in the event of power outages. Critical facilities have standby generators on site, and portable generators could be deployed if necessary. Temporary pumps and hoses are also available to divert sewage around disabled pumps. In general, the MWWTP and sewage PSs are already well-positioned to operate through local or more widespread power outages. The duration of a PSPS is unknown at this time, so further evaluation is needed to address the District's ability to manage outages of several days or even weeks.

[17] Ackerly et al., 2018
[18] Swain, Langenbrunner, Neelin, & Hall, 2018

APPENDIX 1 - CLIMATE CHANGE ADAPTATION STRATEGIES

The greatest potential impact on District wastewater facilities is flooding due to combined sea level rise and storm surges. The rising groundwater level results in relatively low risk of impacts. While temperature and precipitation changes are potentially impactful, the effect of these changes on operation of the wastewater system will depend largely on how climatic changes occur. The District's wastewater conveyance and treatment system can support variations in temperature and flow so it may take long periods of time before these changes have an impact. The low relative risk that the District faces and the gradual manifestation of these changes allow the District to proactively adapt to them by focusing on the following key approaches:

- Regional Collaboration
- Effective Long-term Planning
- Consideration of Climate Change Vulnerabilities in Design
- Emergency Response Planning
- Monitoring of Climate Change-related Modeling and Parameters

A1.1 Regional Collaboration

The most effective way for the District to proactively adapt to climate change impacts is through regional collaboration with the cities, agencies, regulators, and stakeholders in the region. The Bay Area is a very densely populated region with many critical infrastructure assets, valued environmental resources, and popular recreational amenities within the shoreline area. While the MWWTP is near the Bay, so are state-owned highways, Port of Oakland (Port) facilities, City of Oakland streets and neighborhoods, and East Bay Regional Park District (EBRPD) parks and facilities. Maps showing future projected flood waters created by the ART Project show that flood waters enter over EBRPD-, Port-, and Caltrans-owned lands prior to inundating the West Oakland area. Flooding would affect access to the Bay Bridge, restrict rail and truck traffic from the Port, displace residents, and potentially cause the release of untreated wastewater. If these inundation effects occur, the region would be severely affected economically, socially, and environmentally.

Because the effects would be so wide-spread and impactful, all the effected parties have a responsibility to work together, rather than produce piecemeal solutions that in aggregate would be more expensive and potentially result in a worse overall performance. The MWWTP could protect itself from inundation by using flood barriers, but simply blocking the rising waters does not eliminate the hazard, and could in fact make the problem worse for the District neighbors. In addition, if the roadways surrounding the MWWTP are flooded, there would be no way to effectively operate the plant or to transport staff, equipment, and chemicals to support operations.

Representatives from all affected agencies, cities, counties, regulators, and other stakeholders in the Bay Area have been involved in the ART Project. BCDC is currently compiling a list of critical Bay Area assets to determine how to best protect them from sea level rise. EBMUD staff will continue to participate in the BCDC effort to develop adaptation strategies for these areas. The District is also working with other organizations that have been established to help Bay Area agencies with climate change adaptation strategies, such as the BayCAN, SPUR, and SFEI.

The District is also collaborating with the seven satellite agencies in the wastewater service area to address high wet weather flows and reduce I/I in the collection system. All of the agencies and the District are bound by the terms of a consent decree to reduce wet weather flows and eliminate discharges from the District's three WWFs. While the WWFs are operated by the District, the District cannot reduce flows without cooperation from the satellite agencies. Each agency contributes I/I into the system so each agency, along with the District, must complete a list of projects and tasks as part of the consent decree by December 31, 2035. Since 2015, the District has spent over $7.7 million to identify sources of I/I in the satellite agencies' collection systems.

Although the consent decree required by the EPA for reasons unrelated to climate change, the work being undertaken to reduce I/I now ensures there is more capacity available in the system to handle the increased rainfall intensities expected in the future.

A1.2 Effective Long-term Planning

The District's core responsibilities related to long-term planning of capital infrastructure assets must consider the effects of climate change. The worst effects of climate change are expected to occur decades into the future; because of this, the District has the opportunity to plan for them by managing its infrastructure effectively. This includes ensuring that facilities are in good condition and meet existing and future operational performance objectives. The District must continue to identify existing vulnerabilities and effectively prioritize improvements and replacement. Considering modes of failure in each of its facilities, and proactively identifying ways to minimize the likelihood of those failures, is a critical aspect of the planning and prioritization process. This process should include types of failure modes and the effects climate change might have on those modes. The expected life of new assets should consider the effects of climate change in their design and construction.

The District's MWWTP Master Plan is currently in progress, with the likelihood that many of the recommendations will include facilities expected to exist 50 or even 100 years from now. The Master Plan will consider the potential for sea level rise and other climate change impacts in its recommendations.

A1.3 Consideration of Climate Change Vulnerabilities in Design

Sea level rise is potentially the greatest climate change threat to wastewater facilities. The most common strategies to address sea level rise are to accommodate, protect or retreat. The main options for the District's wastewater facilities are to accommodate or protect facilities from sea level rise. Retreat is not a viable option for the MWWTP. Based on storm surge and sea level rise projections, the location of District facilities and available land along the bay, there is no location where the MWWTP could relocate without also redesigning the entire interceptor system and acquiring substantial acreage to accommodate relocated facilities.

The most likely action for the District at this stage is accommodating for sea level rise and temporary flooding. The District is not at immediate risk of inundation but temporary flooding may be an issue by 2050, particularly for remote assets that are closest to the shoreline, such as PSs, WWFs, the dechlorination facility, and the transition structure. Suggested actions to consider for projects in the design phase include:

- For facilities in the immediate vicinity of the Bay, consider the asset's expected life span and sea level rise when proposing new structures and equipment; elevate sensitive components or equipment above anticipated flood levels.
- Require use of waterproof and/or corrosion resistant materials in areas at risk of flooding.
- Add redundancy or increase capacity to re-route flows around compromised system components.
- Improve the ability to operate remotely, ensuring access to backup power or portable pumps.
- Institute operational changes to reduce system complexity, eliminate key vulnerable components, or minimize cost to maintain and repair systems.
- Reinforce above ground infrastructure to reduce the risk of erosion, undermining, and toppling.
- Consider relocating critical elements that are necessary for the continuity of utility services to areas that are not at risk of sea level rise and storm events.
- Increase the rate of interceptor rehabilitation to reduce amount of I/I in the system.

Consideration of climate change vulnerabilities will be incorporated into each project design. The above list will be compiled into a set of climate change design guidelines for engineers to incorporate when designing a new project or retrofitting existing facilities. Due to the varying locations of each project and different functions at each facility, not all actions will be applicable for each project.

The protection of facilities is also a viable option for the future. Temporary or permanent flood barriers can be installed to protect against floodwaters as the sea level rises. Self-closing flood barriers are newer options that are activated automatically without requiring energy or human intervention. However, flood barriers for wastewater facilities should be considered a last resort. The MWWTP would require a flood barrier over a mile and a half long to fully surround the facility. The Federal Emergency Management Agency (FEMA) estimates that a 4-foot high floodwall costs $140 per linear foot. The cost of a barrier would be at least $2 million for the MWWTP, without including the cost of the land or relocation of any utilities along the barrier path.

A1.4 Emergency Response Planning

Based on sea level rise projections, the MWWTP is not expected to see any flooding through 2050 except when paired during extreme storm conditions. Any flooding is expected to be temporary until the storm and tides subside. A Tsunami Response Plan exists for the Dechlorination Building and Transition structure that includes a complete inundation scenario. However, the response plan for the MWWTP assumes minimal flooding and much of the MWWTP will be accessible. The current plan will likely suffice for a 2050 scenario, but will not suffice for a 2100 storm surge scenario with full inundation of the MWWTP. An updated emergency response plan should address staff safety and removal of floodwaters in case of full inundation of the MWWTP. A contingency plan should address operation of the facility during the flooding, if possible, and recovery of processes when the flooding subsides.

Potential storm flooding is also a risk for remote facilities. A future flood response plan and contingency plan will be prepared for these facilities. The flood response plan should address which facilities will be inaccessible and potentially non-operational due to flood waters, and what temporary protections should be put in place. The contingency plan should address the process to bring facilities back online.

A1.5 Monitoring of Climate Change-related Modeling and Parameters

Analysis of the effects of climate change in this report is based on global climate modeling prepared by the scientists and engineers working for the IPCC. The IPCC produces an Assessment Report which is updated on an irregular schedule. The most recent is the Fifth Assessment Report, published in 2014, which is the basis for this District plan. The Sixth Assessment Report is scheduled for release in 2022. The District should update its vulnerability assessment to confirm the timeline and potential impacts to its facilities when the Sixth Assessment Report is released.

While climate change is not expected to drastically change the treatment process, it would be advantageous to track its effect on the composition of flows into the MWWTP over time. Trends can be used to provide evidence on how the plant and collection system is being affected over a larger time period, and provide an opportunity to respond before an upset occurs.

The District can proactively respond to climate change impacts if the right data is collected early, allowing for recognition of trends and appropriate responses over time. For example, increased conductivity is a potential sign of salt water intrusion, which could occur with groundwater rise and the location of the interceptors near the bay.

Recommended data points to regularly monitor are:

- Ambient temperature
- Collection system conductivity
- Collection system flows
- Influent wastewater constituent concentrations
- Energy usage
- Energy generation
- Incoming hydrogen sulfide levels
- Volatile solids to digesters

While many of the listed data points are already collected to monitor effluent quality or process efficiency, these data points will also be beneficial for future tracking of climate change effects and provide evidence if there is an impact. Extended monitoring of these parameters is required to establish trends.

APPENDIX 1 - LEGISLATION AND REGULATIONS

The State of California is known for leading the way on climate change in the United States. Legislation in California reflects this trend. This section will focus on legislation or regulations that have been signed into law. This section will not discuss potential legislation or regulations currently under review or development because their content may change before being ratified.

A1.1 Passed Legislation

The following are bills that have been passed in California that potentially require the most changes to District operations.

Assembly Bill (AB) 32, passed in 2006, requires California to return to 1990 levels of GHG emissions by 2020. It also establishes a mandatory reporting system to track and monitor GHG emission levels. The MWWTP is required to report GHG emissions under the mandatory reporting system but it is exempt from the cap limit since the majority of the emissions are from the use of digester gas, a biogenic source of which emissions are excluded.

The Short-lived Climate Pollutant Reduction Implementation, Senate Bill (SB) 1383, established reduction targets to reduce emissions of short-lived climate pollutants. This law calls for a 40 percent methane reduction by 2030 (relative to 2013 levels) and organic waste diversion from landfills with a 50 percent reduction by 2020 and a 75 percent reduction by 2025. The law was adopted in 2019, will become effective in 2022, and will be enforceable by 2024. It is expected that landfills may stop accepting biosolids since it contains organics and is considered a clean waste stream that can be diverted.

The Community Air Protection Program was established by the California Air Resources Board (CARB) under AB 617. AB 617 was signed into law in 2017. The program's goal is to reduce exposure in communities most impacted by air pollution by working with the local air districts. CARB's first steps are to assess community exposure, establish criteria for air monitoring, identify sources, and devise strategies for emissions reduction. Next steps are to establish emission reduction targets and schedules, and enforcement programs. The local air districts would submit annual progress reports to CARB. The Bay Area Air Quality Management District is currently assessing the West Oakland area as part of this law. New regulations resulting from this assessment that could affect the MWWTP are still to be determined.

AB 341 focusing on Solid Waste Diversion was passed into law in 2011. The purpose of this law is to reduce GHG emissions by diverting commercial solid waste to recycling efforts. The law set a goal to recycle 75 percent of solid waste by 2020. The law also called for an unquantified reduction of organics to landfills. Like SB 1383, it is expected that landfills may stop accepting biosolids since it contains organics and can be diverted elsewhere.

The Clean Energy Bill (SB 100) was signed into law in 2018. The law sets three targets for California:

- 50 percent of California's electricity portfolio must come from renewables by 2026
- 60 percent of California's electricity portfolio must come from renewables by 2030
- 100 percent carbon-free electricity by 2045

The key difference of the third goal is the requirement for carbon-free versus renewable energy. Renewable energy sources consist of solar, wind, geothermal, biomass, small hydro, renewable methane, ocean wave or thermal, or fuel cells using renewable fuels. Large hydroelectric dams, considered carbon-free sources but not renewable, would count towards meeting the 2045 target. As a producer of biomethane, the District could see increased demand or benefits.

The Biomethane Procurement Program (SB 1440), signed into law in 2018, authorizes the state to adopt a biomethane procurement program. The law requires the biomethane procurement targets or goals to be cost-effective, the biomethane to be injected into pipelines in California, and the capture or production of the biomethane to directly result in environmental benefits to California. With this law, the District could see increased demand or benefits for biomethane produced at the MWWTP.

A1.2 Other Rules and Regulations

Executive Order B-55-18 by Governor Jerry Brown in September 2018 set a California statewide goal to achieve carbon neutrality as soon as possible, and no later than 2045, and achieve and maintain net negative emissions thereafter.

The California State Water Resources Control Board (SWRCB) adopted a resolution (Resolution No. 2017-0012) for a comprehensive response to climate change in March 2017. The resolution calls for the Regional Water Quality Control Boards (RWQCBs) to help the CARB assess opportunities for reducing methane emissions from landfills through organic waste diversion, co-digestion or composting. The RWQCBs also must make recommendations to the SWRCB on the need to modify permits and other regulatory requirements to reduce vulnerability of wastewater infrastructure to flooding, storm surge, and sea level rise.

APPENDIX 1 - INDUSTRY PARTICIPATION

District staff participates on the local, state, and national levels with other agencies and professional organizations to discuss climate change and solutions. On the local level, as stated previously, District staff is working with SFEI, SPUR, the Aquatic Science Center, Bay Planning Coalition, and other organizations to discuss climate change adaptation strategies in the Bay Area. Staff involvement varies from to being a participating member to being on the Board of Directors. On the state and national level, District staff participates with the California Association of Sanitation Agencies and the National Association of Clean Water Agencies and the committees that focus on climate change and resiliency.

In the past year, the District has participated in several new climate change activities, including joining BayCAN and TCR, and signing on to "We Are Still In."

BayCAN is part of the Alliance of Regional Collaboratives for Climate Adaptation network and is focused on addressing the challenges posed by climate adaptation in the Bay Area region. BayCAN's focus includes climate vulnerabilities associated with coastal inundation from sea level rise and storms, wastewater and storm water management impacts, public health effects, ecosystem vulnerability, changing vulnerability associated with wildfires, and climate justice issues.

TCR is a non-profit organization governed by states and Canadian provinces and territories. TCR designs and operates voluntary and compliance-based GHG reporting programs globally and assists organizations in measuring, reporting, and verifying the carbon in their operations in order to manage and reduce it. The District is on the advisory group reviewing draft GHG Water/Energy Nexus protocols.

"We Are Still In" was established to create a network of individuals and organizations to share climate actions across the United States and show the world that the groups stand by the Paris Climate Agreement. "We Are Still In" has approximately 2,788 signatories, including 37 counties and 249 cities. Within the District's service area, Alameda and Contra Costa Counties, and the cities of Alameda, Berkeley, Emeryville, Oakland, and Richmond are signatories.

APPENDIX 1 - CONCLUSION

The District evaluated climate change effects using the RCP 8.5 scenario. RCP 8.5 assumes there will be no reduction in GHGs. The District, along with many other utilities and industries, is working to reduce GHGs by 2030 and 2045. Therefore, RCP 8.5 serves as a worst-case scenario for GHGs.

The climate change impact with the greatest potential to affect the District's wastewater facilities is sea level rise. Although sea level rise of some magnitude is inevitable, its gradual nature allows the District time to plan a response before major impacts occur. Even with the worst-case RCP 8.5 scenario, effects are not expected until the end of the 30-year planning outlook (2050). Even by the year 2100, assuming no change to current shoreline barriers, the MWWTP would not experience permanent inundation due to sea level rise and will only experience flooding in the event of a storm surge. The 2050 sea level rise predictions indicate that the MWWTP will flood only if there is combination of both high tide and a 100-year storm. All new projects and retrofits will need to take this information into consideration.

Even though the MWWTP is not in immediate risk to sea level rise in the near future, the District can begin taking action now. It is anticipated that District facilities will experience potential flooding. Infrastructure neighboring the MWWTP that is owned by Caltrans and the Port of Oakland will also be subject to sea level rise flooding. The District can begin working proactively and cooperatively with these agencies to devise solutions that will protect all assets in the area without worsening conditions for any stakeholder. Pooling of resources between the agencies may also produce a superior, more cost-effective solution.

The District will continue to collaborate with the seven satellite agencies in the wastewater service area to address high wet weather flows and reduce I/I in the collection system. The consent decree stipulations to reduce wet weather flows and eliminate discharges from the District's three WWFs is not only a requirement from the EPA but is also applicable to the impacts of precipitation, including greater storm intensities from climate change.

An ongoing awareness and proactive consideration of the effects of climate change will be part of the District's long term planning process, with regular updates as information becomes available. Doing so will ensure an effective response and allow the District to meets its strategic objectives, protect the environment, and serve its ratepayers now and into the future.

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APPENDIX 1 - PLANNING AND DESIGN GUIDELINES FOR SEA LEVEL RISE

A1.1 Introduction

These guidelines describe the process which project managers should undertake to determine if and how their project should be designed to address sea level rise (SLR). These guidelines are specific for Wastewater facilities. The general purpose of a project is to make modifications or improvements to a District facility or asset, so that is the ideal time to examine and address the potential effects of sea level rise. Designing for SLR is not a one-size-fit-all solution for all District facilities. The design will depend on location, function and projected lifespan of the facility or asset. These guidelines can be used during the design process or during the planning process to determine if a project should take place at a specific site.

All SLR estimates in these guidelines are based on the current most likely estimate of 12 inches in 2050 and 36 inches in 2100 for the Bay Area. The upper range SLR estimate is 24 inches in 2050 and 66 inches in 2100. These estimates do not include storm surge, or what is considered temporary inundation. SLR is permanent inundation, representing where the daily water level will be in the future. The Wastewater Climate Change Plan (June 2019) addresses sea level rise and provides further details on various climate model scenarios.

The expected amount of SLR will vary around San Francisco Bay due to geographic features. These values are based on the Intergovernmental Panel on Climate Change's (IPCC) 2014 Fifth Assessment Report and the 2018 San Francisco Bay Area Summary Report from California's Fourth Climate Change Assessment. SLR estimates for these Planning and Design Guidelines will be updated when the IPCC issues a new assessment.

The main ways to respond to sea level rise are to protect, accommodate and retreat. Protect is to protect the asset from the rising water level. Accommodate is to modify the asset to handle the rising water level. Retreat is to allow the water to take over and relocate the asset. Recommendations to design for sea level rise will run along these themes.

A1.2 Process

The project manager should complete the SLR Checklist, located at the end of these guidelines, to determine what height of SLR to design for the project location. In order to complete the checklist, the project manager should have information such as the remaining or future functional lifespan of the asset. A SLR Calculator was also developed to help with the calculation portion of the checklist. A link to the calculator is included in the checklist.

After the SLR calculation portion, the checklist lists additional questions to collect information for assessing how the asset will fare with regards to exposure, sensitivity, and adaptability. A description of these terms follows in the next section. The answers to the checklist questions will help guide what plan of action should be taken for the project with regards to sea level rise. The results can be discussed with the User Group and management to determine in what manner sea level rise is to be addressed for that specific project.

A1.3 Key Terms

A1.3.1 Exposure

Exposure is the degree to which an asset is susceptible to sea level rise or storm surge impacts. Exposure can be determined from knowing the asset's elevation and comparing it with estimated sea level rise and inundation mapping for the asset's expected lifespan. The main exposure value that project managers are looking for is the amount of inundation expected at the project site. Assets not expected to see any inundation in their lifespan will not need to make design adjustments due to sea level rise.

It is recommended to use the anticipated end of the useful life to calculate the associated sea level rise with the project that is being planned or designed. Assets that have a medium or high level of adaptability can consider using the mid-point of the assets anticipated lifespan to calculate the associated sea level rise.

A1.3.2 Sensitivity

Sensitivity is an asset's ability to recover after a flooding event. Sensitivity can also be used to measure the impact to the surrounding area if the asset is damaged or lost. Degree of sensitivity ranges from minimal impact or no impact to the full loss of the asset. The SLR Calculator will be able to provide some estimates of expected inundation levels to assist the sensitivity determination.

With the expected level of inundation, the project manager should be able to answer the following questions to determine the level of sensitivity:

- What impact would flooding have on the asset?
- Would the asset be able to function during and after a flooding event?
- Would the asset be forced to temporarily or permanently shut down during flooding?
- Would the asset be a complete loss after flooding?
- What is the impact to the surrounding area if the asset is lost?
- Is a back-up asset available?

Lower sensitivity is typically desired. For projects with higher sensitivity assets, modifications or plans should be made to try to lower the sensitivity level if possible.

A1.3.3 Adaptability

Adaptation is the asset's ability to adapt to sea level rise impacts without significant modification or intervention. The initial adaptation assessment should be done evaluating the asset's current state or with the planned project. To determine the asset's level of adaptability, the project manager should be able to answer the following questions:

- Can the asset tolerate SLR without intervention or modification?
- Is the asset able to adapt to the expected level of inundation?
- Would major or minor modifications be needed to adapt?

- Can the function of the asset be restored after a flooding event without replacement?

It should be noted that an asset does not have to be designed with a high level of adaptability. Adaptability, however, is a factor that can provide additional implementation options for future projects at the site.

A1.3.4 Life of Asset

The expected life of the asset is an important factor to consider in the SLR impacts evaluation. If the asset is not expected to be utilized beyond the time frame where inundation is predicted, the asset can have a low sensitivity or adaptation capability. If an asset is expect to have a longer lifespan with some exposure potential, more attention will need to be paid to its sensitivity and adaptation capability. General guidelines for the design life of an asset are provided below as guidance:

Table A1. Design Life for Asset by Category*

Asset Type	Sub-type	Design Life (years)
Civil	Building Structures	50
	Basins, Tanks, and Channels	50
Mechanical	Pumps	20
	Valves	20
	Motors	20
	Blowers	20
	Chemical Feed	15
Electrical	Motor Control Centers	30
	Control Equipment	20
Instrumentation	Meters, Analyzers	10

*For additional information on design life, please see the Infrastructure Renewal Task Report, completed in 2020, from the Integrated Master Plan for the Main Wastewater Treatment Plant.

A1.4 Risk Analysis

Based on the results and answers given in the SLR checklist, the table below is provided to help guide the project design. The table is meant to provide a quick reference for the project manager on the potential level of effort needed to address climate change impacts.

Table A2. SLR Risk Analysis

	Sensitivity			Adaptability		
Exposure	Low	Medium	High	Low	Medium	High
Low	Likely no design modifications needed.	Likely no design modifications needed.	Likely no design modifications needed.	Likely no design modifications needed.	Likely no design modifications needed.	Likely no design modifications needed.
Medium	Plan for potential repairs after flooding	Plan for loss of function and potential repairs after flooding	Consider relocation or raising elevation	Design modifications for sea level rise	Some minor design modifications for sea level rise may be needed.	Likely no design modifications needed.
High	Plan for repairs after flooding	Plan for repairs after flooding	Consider relocation or raising elevation	Design modifications for sea level rise	Some minor design modifications for sea level rise may be needed.	Some minor design modifications for sea level rise may be needed.

Table Legend:
Red = High Risk. Major modifications may be needed.
Orange = Moderate Risk. Moderate modifications may be needed.
Yellow = Minor Risk. Minor changes or repairs may be needed.
Green = Little or no risk.

To determine the level of exposure from the checklist, a low exposure project is not vulnerable to any permanent inundation but may have some temporary flooding from storm surge. A medium exposure project is vulnerable to permanent inundation based on the upper range SLR scenario but not the most likely SLR scenario. A high exposure project would be subject to permanent inundation and/or temporary flooding at the most likely SLR scenario.

A1.5 Design Considerations

For projects with high risk, the first decision is to determine if the asset can be relocated. If the asset cannot be relocated, it must be determined how to adequately protect the asset from flooding. It should be determined approximately how long the asset can be out of service before it becomes a major problem to the treatment process or surrounding community. Potential options include raising sensitive equipment above the flood line or switching to submersible equipment. An alternatives assessment may be needed if there needs to be a decision on relocating the facility versus replacement of the facility when it gets flooded.

For projects with moderate or minor risk, it should be determined approximately how long the asset can be down before it becomes a major problem. Some flooding at the site may be expected. It should be decided what equipment needs to be protected and what equipment is acceptable to be replaced if it is damaged by flooding. There could also be emergency response plans to provide temporary protection of the site if the risk is just from storm surge or a temporary bypass of the site until the flooding subsides.

For projects with little or no risk, no major design work is needed but the sites should have an emergency flood response plan.

In general, there is not a requirement to have projects designed to a point so they have a low exposure, low sensitivity and high adaptability with regards to SLR. Meeting these levels are ideal, but potentially cost-prohibitive for the project. The checklist and guidelines are meant to provide project managers a reference point assessment on how the projects will fare with respect to SLR impacts. With this information, the project manager can decide in conjunction with management and the user group what would be acceptable risks and appropriate mitigation measures for that project.

A1.6 Examples

The following are recent examples of projects that have looked at the impacts of SLR at the project site and made modifications to the project design.

A1.6.1 Example Project 1:

The Pump Station M is located in the city of Alameda. Alameda is expected to be very susceptible to sea level rise. Relocation of the pump station is not an option so the pump station would have to accommodate sea level rise. For the design of the rehabilitation project, the project manager checked sea level rise simulations at the pump station location. Estimations showed approximately one foot of sea level rise at that location. With this information, it was decided to make all below-ground equipment submersible and raise all electrical equipment at least one foot off the ground.

A1.6.2 Example Project 2:

The dechlorination station located near the foot of the Bay Bridge is expected to see several feet of sea level rise. As there are no current plans to change the dechlorination process, the facility must stay where it is presently located. A new emergency generator is planned to be installed at the facility. To be prepared for eventual flooding, the new generator is being placed four feet above the existing ground level.

It should be noted that while the entire facility will eventually be at risk for flooding, the entire facility is not being elevated or protected at this time. The current strategy only protects the assets included in the project currently in design, with the intent for later projects to design protections for additional assets. This plan gradually makes accommodations for SLR at the facility and spreads out the capital costs over a longer length of time. Based on the current estimates, permanent inundation is not expected until 2100, so there is time to plan additional strategies on how the rest of the facility will be protected.

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Sea Level Rise Checklist

Project Name:

Project Manager:

Date Prepared:

Project Description:

1. **What is the project site location or nearest Wastewater facility location?** ________
2. **What is projected functional life span of the project/asset?** ________ (The functional life span is period of time for which the structure can still meet the purposes for which it was constructed. Equipment or features within the asset can be replaced or rehabilitated during this time.)
3. **What is the expected construction completion year?** ________
4. **What is the lowest ground elevation at the project site (in feet)?** ________

Provide the answers to questions 5-15 below after using the Sea Level Rise calculator at W:\nab\MWWTP Master Plan\Reports\E40 Climate Change Adaptation Plan\Design guidelines\SLR calculator.xlsx. Elevations provided by this calculator are in the Wastewater Datum (NVGD1929+100).

5. What is the planning horizon? ________ (Construction completion year + functional life span = Planning horizon year)
6. What is the most likely estimate of sea level rise at the end of planning horizon year? ________ ft
7. What is the upper range estimate of sea level rise at the end of planning horizon year? ________ ft
8. What is the current Mean Higher High Water (MHHW) level for the project site? ________ ft

Sea Level Rise (SLR) Vulnerability – Permanent Inundation

9. What is the amount of sea level rise needed to result in permanent inundation at the project site? ________ ft
10. Is the site vulnerable to permanent inundation using the most likely SLR scenario? _____
    a. If yes, the project is at risk and requires design considerations that address the most likely SLR level.

b. If no, the project is not at risk to the most likely SLR scenario. Assess upper range SLR scenario.

11. Is the site vulnerable to permanent inundation using the upper range SLR scenario? ____

a. If yes, the project should be able to adapt to SLR but does not have to design to the upper range SLR level.

b. If no, the project is not at risk to the upper range SLR scenario. Assess temporary flooding risk.

Storm Surge Vulnerability – Temporary Inundation

12. Subtract the amount of a 100 year storm (3.5 ft) from the amount of SLR for permanent inundation.________ ft

13. Is the site vulnerable to a 100-year storm surge today? ________

14. Is the project at risk of temporary flooding with the most likely SLR scenario? ________

a. If yes, the project should be designed to handle temporary flooding in the future.

b. If no, the project is not at risk for flooding based on the most likely sea level rise estimate. Assess upper range SLR scenario.

15. Is the project at risk of temporary flooding with the upper range SLR scenario? ________

a. If yes, the project should anticipate temporary flooding in the future but does not have to design to the upper range estimate at this point.

b. If no, the project is not at risk of temporary flooding.

After completing section requiring the SLR calculator, answer the following questions to complete the risk analysis on the project's response to SLR:

1. **Sensitivity Analysis** – What is the project's level of sensitivity to flooding (temporary and permanent)?

____ Low Sensitivity – Minimal impact to the project/asset. The project/asset would be able to function during and/or after the flooding event.

____ Medium Sensitivity – Moderate impact. There may be some loss of function during and/or after the flooding event. Minor repairs may be needed to restore to full functionality.

____ High Sensitivity – Complete loss of the project/asset with major impacts to operations, public health and/or safety.

2. **Adaptation Capability –** What is the project's/asset's ability to adapt to higher levels of sea level rise?

____ Low Capability – The project/asset cannot withstand flooding without major modifications. Damages would be expected with flooding.

____ Medium Capability – The project/asset may have some damage from flooding. Impacts can be mitigated with moderate modifications.

____ High Capability – Project/asset can accommodate flooding with no damages or need to make modifications.

The following qualitative questions should be answered to decide if an alternatives assessment is needed. Is the anticipated risk high enough that an alternative to the proposed project should be considered?

3. What is the expected level of damage to the project asset from flooding?

____ Low – Asset will have no damage or only require minor repairs.

____ Medium – Asset would require full replacement or expensive repairs.

____ High – Asset is not replaceable or repairable.

4. What is the level of disruption if the asset is out of service or a loss?

____ Low – Little or no disruption in service.

____ Medium – Project/asset would have a disruption in service but the function is not critical to operations, safety or public health.

____ High – A disruption in service would impact operations, safety or public health.

5. What are the costs to replace or repair the project/asset?

____ Low – Little or no cost to return to service.

____ Medium – Moderate costs to repair/replace.

____ High – High costs to replace asset or high secondary costs due to the asset's disruption of service.

Post Analysis Considerations –

1. Can the project/asset be relocated to another site with less or no flooding risk? Include costs estimates if possible.

____

____

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2. Can the project tolerate temporary flooding? If no, can the project be designed to accommodate flooding? Include costs estimates if possible.

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3. Can the project tolerate permanent flooding? If no, can the project be designed to accommodate flooding? Include costs estimates if possible.

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