Spring 2021

Sea Level Rise Planning for the Arcata Wastewater Treatment Facility

Katelyn Brady

Fiona Connor

Kevin Ohm

Sea Level Rise Planning for the Arcata Wastewater Treatment Facility

Humboldt State University
ENGR 492: Capstone Design

Katelyn Brady, Fiona Connor, Kevin Ohm
Spring 2021

Introduction

The AWTF faces substantial impacts from Sea Level Rise (SLR) over the course of the next 80 years. Specifically, extreme SLR projections in California are 1.0 ft, 2.7 ft, and 10.2 ft by 2030, 2050, and 2100, respectively (California Coastal Commission 2018). Since there is an open channel between the Pacific Ocean and Humboldt Bay, as sea levels rise, Humboldt Bay will rise as well. High tides will pose a great risk for flooding at the AWTF, as it is located on the edge of Humboldt Bay and is only protected from 3 to 6 feet of SLR (Laird 2013).

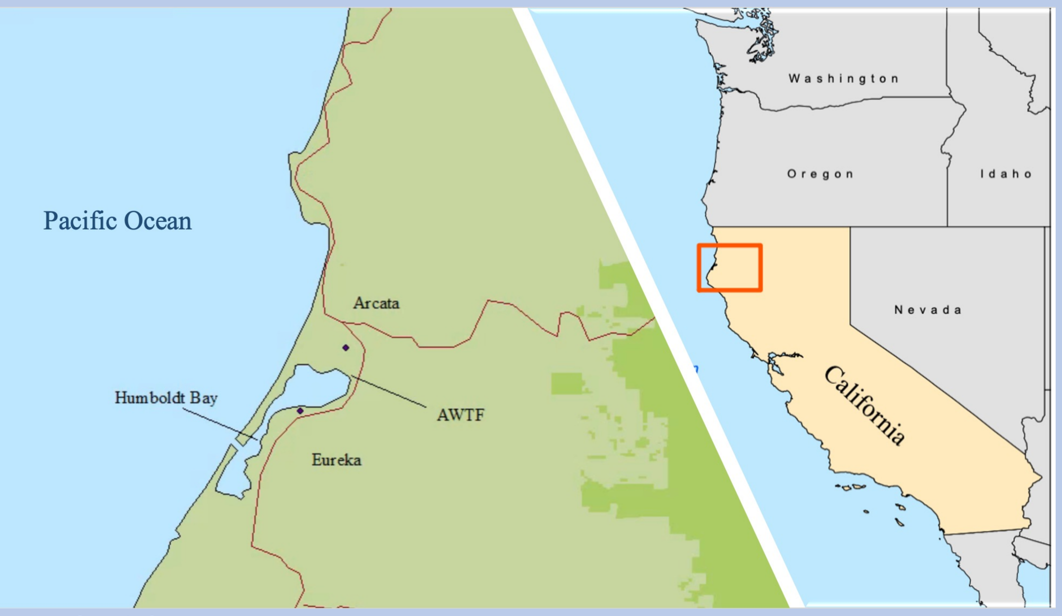

Figure 1 (left): Small and Large-Scale Geographic Orientation of Project Location (Katelyn Brady 2021 ArcMap).

Objective

The objective of this project is to provide resilient design options for the future of the Arcata Wastewater Treatment Facility (AWTF) in order to withstand the effects of severe SLR projections for 2100.

Constraints and Criteria

Table 1: Design Constraints

Constraint
Withstand extreme SLR projection of 10.2 feet for 2100
Effluent water quality parameters must not exceed NPDES permit limits.
Do not disrupt the habitat of endangered species currently present in Arcata.
Meet increased wastewater flows from projected 2100 Arcata population.

Table 2: Design Criteria and Weights

Criterion	Weight
Community Value and Engagement	8
Noise and Odor	3
Life Cycle Cost	10
Technical Complexity	8
Adaptability to increases in future SLR predictions	10
Net Energy Use	8
Estuary and Tidal Ecosystems	6
Groundwater Recharge	8
Mechanical Land Use	5

Decision Process

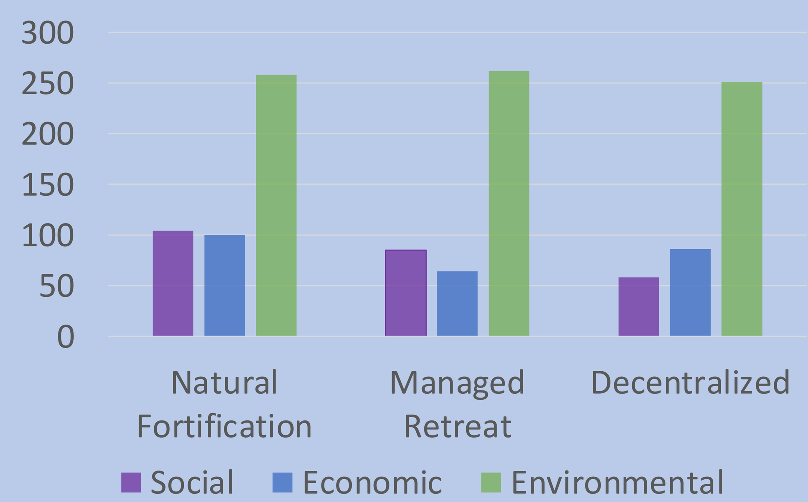

Figure 2. Scoring for each alternative.

The three alternatives evaluated were replacing the Arcata Wastewater Treatment Facility (AWTF) with a Decentralized Treatment system, protecting the AWTF with as much Natural Fortification as possible, and a partial relocation of the AWTF with Managed Retreat

Preferred Alternative: Natural Fortification

The Natural Fortification alternative (Figure 3) consists of six main components: 1) The build-up of existing revetments to provide 10 feet of protection along with living shorelines to attenuate wave energy and prevent land subsidence (Figure 4) A living dike in the mud flat region East of the Oxidation Ponds (Figure 5) A secondary Enhancement Wetland system, the "String of Pearls", which will handle a portion of the additional ➔ influent flow as population increase (Figure 6) A groundwater recharge infiltration basin, which will be used seasonally to mitigate against saltwater intrusion into the Arcata Bottoms farms (Figure 7) A tide gate and pumping system for the Janes Creek and Humboldt Bay connection (Figure 8); and 6) Another tide gate and pumping system for the Jolly Giant Creek and Humboldt Bay connection (Figure 9).

Figure 3: Natural Fortification alternative map (Fiona Connor 2021).

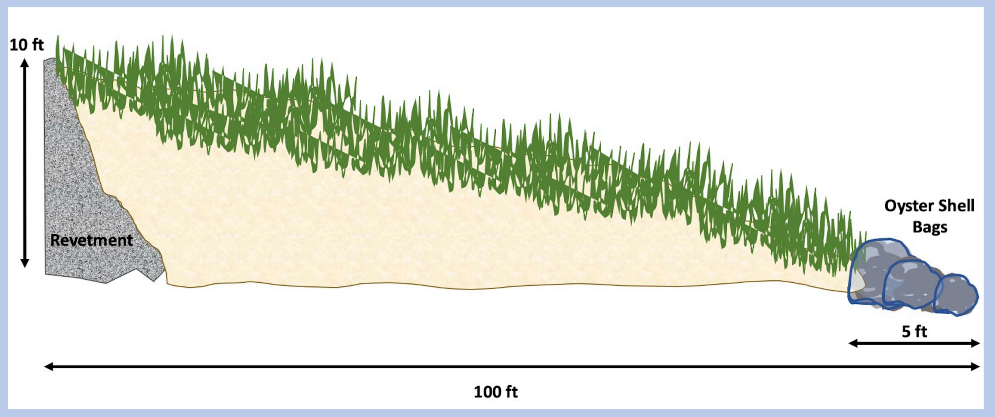

Figure 4: Cross section of living shoreline. Not to scale (Fiona Connor 2021).

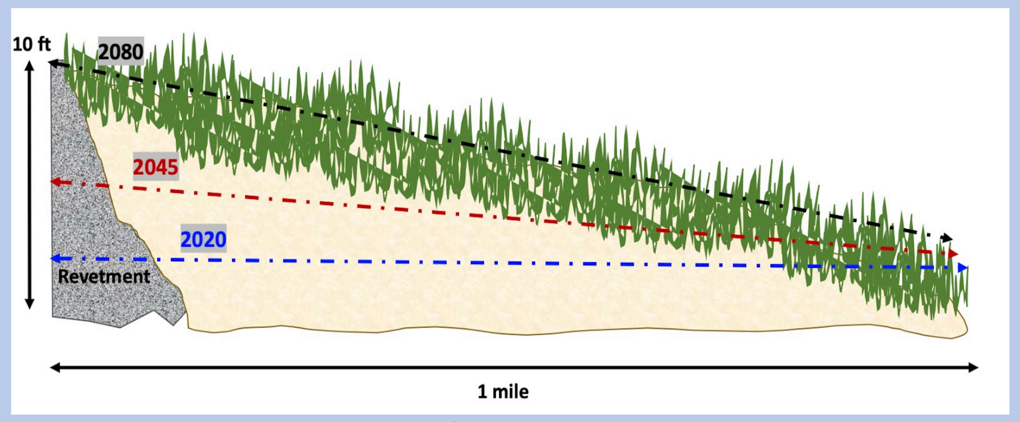

Figure 5: Conceptual cross section depicting the growth of the Living Dike. Total 10.2 feet of protection will be provided by 2080. Not to scale (Fiona Connor 2021).

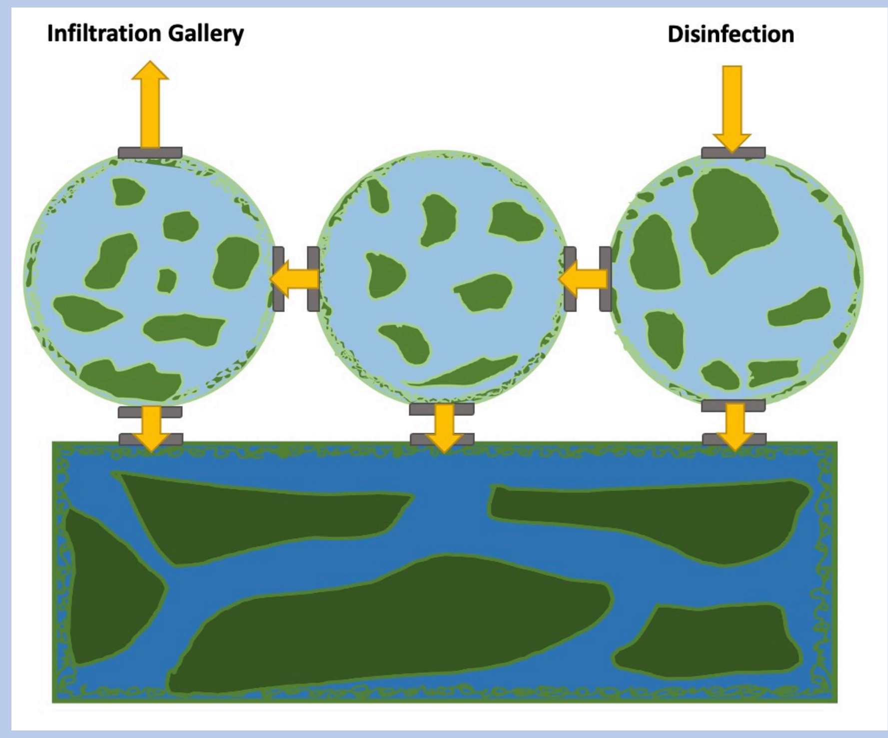

Figure 6: String of Pearls. Not to scale (Fiona Connor 2021)

Figure 7: Proposed location of Groundwater Recharge Infiltration Basin (Katelyn Brady).

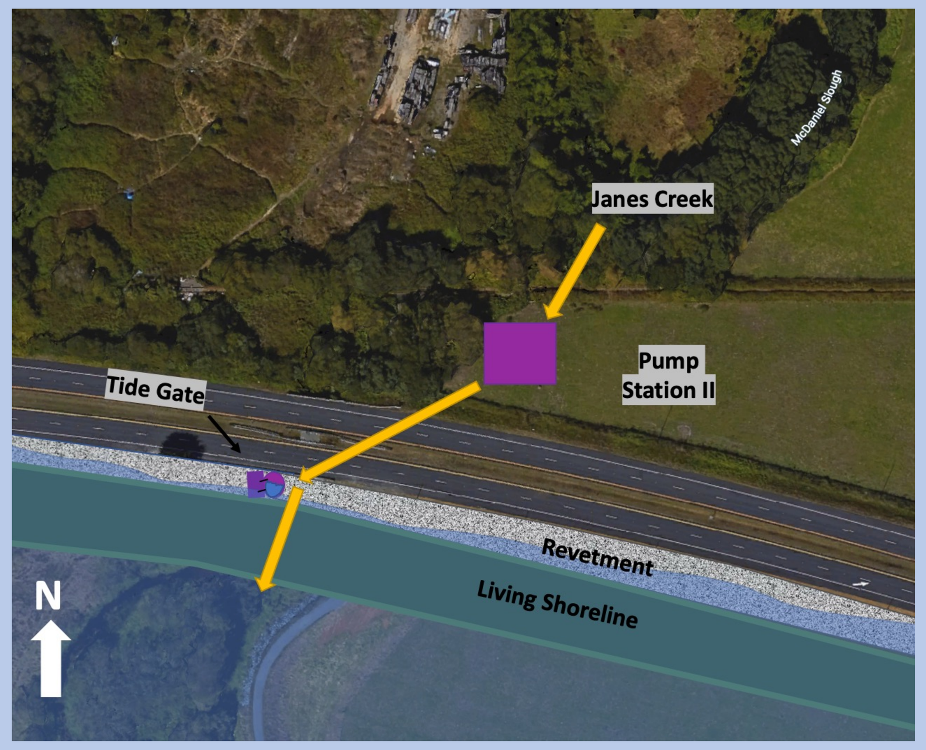

Figure 8: Janes Creek Tide Gate System. Not to scale (Fiona Connor 2021).

Figure 9: Jolly Giant Creek Tide Gate System. Not to scale (Fiona Connor 2021).

Cost Analysis

The estimated capital cost of the design is **$27,437,000**. Annual Operation and Maintenance (O&M) costs and power usage will change throughout the design lifecycle. Annual O&M goes down over time as the living dike will not require sediment addition after 2070. Power usage goes up as SLR increases and tide gate pumps are in use.

Table 3. Average annual O&M and power until 2100

Years	Average Annual Cost (USD)	Annual Power (MWh)
2021-2050	$754,200	289
2051-2075	$627,100	347
2076-2100	$106,900	505

Sensitivity Analyses

The fortification of or retreat from the levees in front of the String of Pearls is assumed to occur in conjunction with Highway 255 SLR planning. The existing levees provide six feet of protection (Laird 2013). A sensitivity analysis was performed to determine when the dikes and therefore, String of Pearls, will be breached without intervention (Table 4). The large gap between estimates (75 years) reflects the uncertainty in sea level rise planning.

Table 4: Approximate year with six feet of SLR based on low, medium-high, and extreme estimates for SLR (CCC 2018).

Risk Aversion	Year with 6 ft SLR
Low	2150
Medium-High	2095
Extreme	2075

A sensitivity analysis on the energy cost to pump 9, 18, and 36 MGD flows from the McDaniel Slough and 0.2, 0.4, and 0.8 MGD flows over Highway 255. The results of this are shown in Table 5 below.

Table 5. Cost to pump water from Janes Creek and Jolly Giant Creek over highway 255

Janes Creek		Jolly Giant Creek	
Flow Rate (MGD)	Annual Cost ($/year)	Flow Rate (MGD)	Annual Cost ($/year)
9.7	$11,890	0.2	$250
19.4	$23,780	0.4	$500
38.8	$47,560	0.8	$1,000

A third and final sensitivity analysis was conducted on the seasonal variation uncertainty in the extraction and recharge rates of groundwater. Based on the assumptions made through case study values, seasonal variation resulted in two proposed recharge rates (Table 6).

Table 6. Recommended Recharge Rates Based on Seasonal Variation.

	Summer	Winter
Precipitation (inches)	5.85	34.48
Recharge (MGD)	0.17	1.0

Acknowledgements

Josephine Archibald, Tesfa Yacob, Bob Gearheart, Doby Class, David Couch, Bella Waters, HSU ERE Department

References