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WHITE PAPER
CORPUS CHRISTI SEAWATER DESALINATION
RECEIVING WATER SALINITY CRITICAL DILUTIONS
CITY OF CORPUS CHRISTI

STATE OF TEXAS
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EXECUTIVE SUMMARY

The City of Corpus Christi is considering development of a municipal seawater treatment project to provide for a long-term, drought-proof and sustainable water supply. The project consists of two separate plants to serve the area. One plant will use water from the Corpus Christi Inner Harbor (Inner Harbor) and one plant will withdraw water from the La Quinta Channel. Figure ES-1 depicts the approximate proposed location for each plant along with proposed discharge locations.

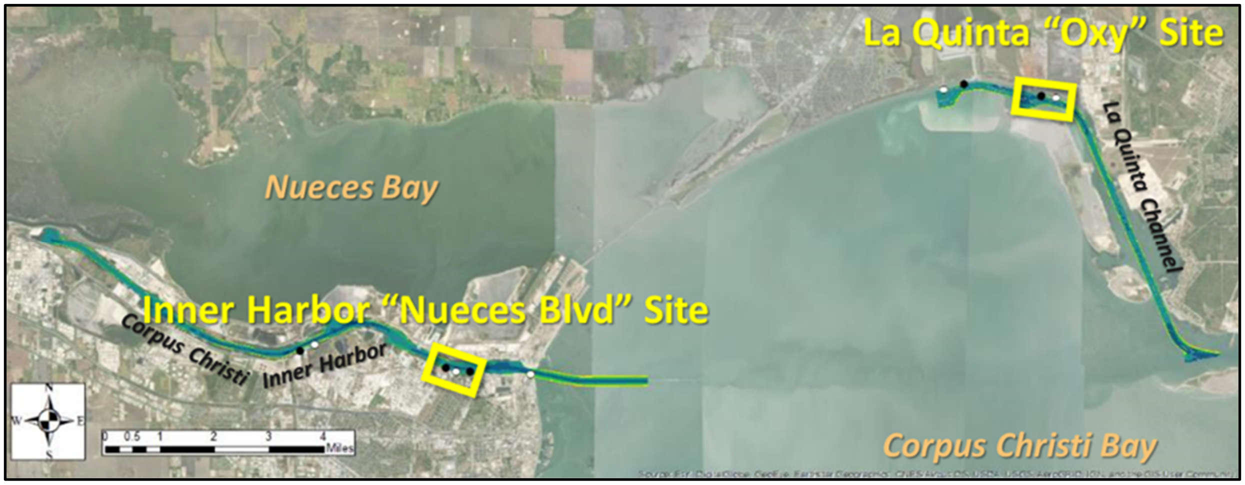

Figure ES-1. Possible Sites for Desalination Plants on the
Corpus Christi Inner Harbor and La Quinta Ship Channel

The Inner Harbor plant would be designed to produce 30 million gallons per day (MGD) of potable water while producing an effluent volume from 36 to 52 MGD (depending on percent recovery) (see Table ES-1). The La Quinta Channel plant would produce 40 MGD with effluent volumes ranging from 47 to 69 MGD (depending on percent recovery). Table ES-1 provides relevant details about each plant. Effluent volumes in the table are associated with the proposed production rates of 30 MGD and 40 MGD for the Inner Harbor and La Quinta sites respectively. Initial discharge volumes may be less.

The unique nature of this project requires a significant level of cooperation with the Texas Commission on Environmental Quality and other state and federal agencies. This is particularly the case with implementation of environmental requirements and policies aimed at protection of marine aquatic and plant life from desalination disposal by-products.

This white paper addresses the scientific basis for establishing critical dilutions for salinity in the zone of initial dilution (ZID), aquatic life mixing zone (MZ) and human health mixing zone (HHMZ). This paper makes recommendations based on guidance from environmental agencies and organizations, the experience of existing desalination projects, and literature review of salinity ranges tolerated by marine organisms.

The zone of initial dilution establishes criteria for acute toxicity testing and the aquatic life mixing zones establishes criteria for chronic toxicity testing. It is proposed that salinities of 42 parts per thousand (ppt) at the edge of the ZID and 35 ppt at the edge of the aquatic life mixing zone are safe and protective concentrations for marine life.

Proposed facility capacities, critical dilutions for salinities, and resulting impacts on effluent salinities in the mixing zones of the discharges are summarized in Table ES-1.

Table ES-1
Proposed Critical Dilutions for Corpus Christi Seawater Desalination Project

	Inner Harbor		**La Quinta Channel**	
Water Production (MGD)	30		40	
Percent Recovery[1]	40	50	40	50
Average Daily Effluent Volume (MGD)	51.47[2]	35.17	68.62[3]	46.90
Effluent Salinity (parts per thousand)	49.9[4]	58.4[4]	50.0[5]	58.5[5]
Critical Dilution (%) 50 feet from discharge (edge of Zone of Initial Dilution)	56	38	56	38
Salinity (parts per thousand) 50 feet from discharge (edge of ZID) based on critical dilutions	42	42	42	42
Critical Dilution (%) 200 feet from discharge (edge of MZ)	18	13	18	13
Salinity (ppt) 200 feet from discharge (edge of MZ) based on critical dilutions	35	35	35	35

[1] Percent recovery for the reverse osmosis membranes will range from 40% to 50%.

[2] Inner Harbor - average daily 52 MGD and maximum daily 62 MGD at 40% recovery.

[3] La Quinta Channel – average daily 69 MGD and maximum daily 83 MGD.

[4] Based on ambient average salinity in the Inner Harbor of 31.59 ppt.

[5] Based on ambient average salinity in the La Quinta Channel of 31.65 ppt.

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Acronyms and Abbreviations

°F	degrees Fahrenheit
CDP	Carlsbad Desalination Plant
CWA	Clean Water Act
EPA	U.S. Environmental Protection Agency
GLO	Texas General Land Office
HB	House Bill
HHZ	human health mixing zone
LC_{50}	Lethal Concentration 50% percent survival
MGD	million gallons per day
MZ	aquatic life mixing zone
NPDES	National Pollutant Discharge Elimination System
Ocean Plan	2015 California Ocean Plan
ppt	parts per thousand
RO	reverse osmosis
SMSFP	Smithsonian Marine Station at Fort Pierce
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TPDES	Texas Pollutant Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TU	Toxicity Unit
TUa	Acute Toxicity Unit
WET	Whole Effluent Toxicity
ZID	zone of initial dilution

1.0 INTRODUCTION

The City of Corpus Christi is considering development of a municipal seawater treatment project to provide for a long-term, drought-proof and sustainable water supply. The project consists of two separate plants to serve the area. One plant will withdraw water from the Corpus Christi Inner Harbor (Inner Harbor) and one plant will use water from the La Quinta Channel. The Inner Harbor plant would be designed to produce 30 million gallons per day (MGD) of potable water while the effluent volume would range from 36 to 52 MGD (depending on percent recovery) (see Table 1 below). The La Quinta Channel plant would produce 40 MGD with effluent volumes ranging from 47 to 69 MGD (depending on percent recovery). Table 1 provides relevant details about each plant. The effluent volumes indicated in the table represent proposed production rates of 30 MGD and 40 MGD for the Inner Harbor and La Quinta sites respectively. Initial discharge volumes may be less.

Table 1
Anticipated Corpus Christi Seawater Desalination Project Brine Discharge Composition

Parameter	Inner Harbor		La Quinta Channel	
Water Production (MGD)	30		40	
Percent Recovery[1]	40	50	40	50
Average Daily Effluent Volume (MGD)	51.47[2]	35.17	68.62[3]	46.90
Effluent Salinity (parts per thousand [ppt])	49.9[4]	58.4[4]	50.0[5]	58.5[5]
Effluent Temperature (Increase) (degrees Fahrenheit [°F])	< 1.5	< 1.5	< 1.5	< 1.5
Dissolved Oxygen (percent saturation)	≥ 100	≥ 100	≥ 100	≥ 100
pH	6-9	6-9	6-9	6-9

[1] Percent recovery for the reverse osmosis membranes will range from 40% to 50%.
[2] Inner Harbor - average daily 52 MGD and maximum daily 62 MGD at 40% recovery.
[3] La Quinta Channel – average daily 69 MGD and maximum daily 83 MGD.
[4] Based on ambient average salinity in the Inner Harbor of 31.59 ppt.
[5] Based on ambient average salinity in the La Quinta Channel of 31.65 ppt.

The discharge from the Corpus Christi Desalination Project will consist of brine effluent from the reverse osmosis (RO) process, backwash from the pre-treatment process, supernatant and decant from sludge processing, and antiscalants. Free chlorine will be neutralized prior to discharge. The anticipated temperature of the discharged brine will not be higher than 1.5°F above temperature of the seawater source. This temperature increase results from the transfer of heat via pipeline infrastructure and the heat produced by the pumps. A very small volume of chemicals used for cleaning and biocide (NSF 60 approved) will also be discharged in the effluent.

The maximum recorded salinity in the Corpus Christi Inner Harbor, Water Quality Segment 2484, from Texas Commission on Environmental Quality (TCEQ) Surface Water Quality Monitoring (SWQM) Station

13430 is 41.7 ppt. The maximum recorded salinity in Corpus Christi Bay, Water Quality Segment 2481, from SWQM Station 13409 is 40.5 ppt. Average salinity over the period-of-record for both stations is 32 ppt. Data for these values were obtained from the TCEQ's Texas Surface Water Quality database.

This white paper provides the scientific basis for establishing critical dilution limits for salinity in the relevant mixing zones. Given limited experience in Texas regarding permitting of seawater desalination facilities, national and international permitting guidance, relevant case studies and literature on salinity ranges occupied by marine organisms were examined. Based on this review, recommendations were developed for mixing zones in bays, estuaries and wide tidal rivers following the TCEQ Procedures to Implement the Texas Surface Water Quality Standards (RG-194) (TCEQ, 2010).

Three dilution zones are considered: zone of initial dillution (ZID), aquatic life mixing zone (MZ), and, human health mixing zone (HHMZ). Dilution signifies the percentage of effluent volume as a fraction of the total volume of water contained at the edge of each mixing zone.

Zone of initial Dilution (ZID)

The ZID is marked by a 50-foot radius measured from the discharge (TCEQ, 2010). The salinity criteria for this zone is set in terms of acute toxicity to aquatic organisims. For the ZID, the acute toxicity limitation is determined by the "lethal concentration 50 (LC_{50})" for exposure of test species to effluent at the critical dilution. The LC_{50} is the concentration of effluent that will allow survival of 50 percent of the individuals in toxicity test.

Mysid shrimp and Inland Silverside are the standard marine species recommended for toxicity testing (TCEQ, 2010). The standard acute toxicity test is a 48-hour exposure as described in "Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms", fifth edition (U.S. Environmental Protection Agency [EPA]-821-R-02-012) or its most recent update.

Aquatic Life Mixing Zone (MZ)

The MZ is the volume encompassed by a 200-foot radius in all directions from the discharge. Criteria for this zone are created relative to chronic toxicity limitations. Chronic toxicity refers to development of adverse effects as the result of long-term exposure to a toxicant and is measured at the edge of the MZ. The chronic toxicity test is a 7-day survival and growth test using Mysid shrimp and Inland Siliverside in accordance with "Short-Term Methods for Estimating the Chronic Toxicity of Effluent and Receiving Waters to Marine and Estuarine Organisms," third edition (EPA-821-R-02-014) or its most recent update.

Human Health Mixing Zone (HHZ)

The HHZ is captured within a 400-foot radius from the discharge point. Human health criteria apply at the edge of zone. Critical dilutions for mixing zones in bays, estuaries and wide tidal rivers may be determined using CORMIX modeling of effluent (TCEQ, 2010).

2.0 BACKGROUND FOR CRITICAL DILUTION APPROACH

A number of studies and data reviews have been conducted supporting use of a critical dilution approach in limiting the salinity of desalination facilities' discharges to marine waters. The American Water Works Association (2004) suggested brine discharges to lower salinity waters should be discouraged if the discharges increase the salinity at the discharge point by 10 percent or more.

The World Health Organization (2007) recognized salinity varies naturally around plus or minus 10 percent of the average annual natural salinity and suggested the "10 percent increment above ambient ocean salinity" threshold is a conservative measure of aquatic life tolerance to elevated salinity. The actual salinity tolerance of most marine organisms is usually significantly higher than this level (World Health Organization, 2007).

2.1 RELEVANT EXISTING SEAWATER DESALINATION PLANT PERMITS

The largest and most recently built municipal seawater desalination plant in the United States is in California which has an EPA issued National Pollutant Discharge Elimination System (NPDES) permit. There is an industrial plant in Texas designed to incorporate seawater desalination which has been issued a Texas Pollutant Discharge Elimination System (TPDES) permit but has not begun operating.

2.1.1 California: Claude "Bud" Lewis Carlsbad Desalination Plant

The Claude "Bud" Lewis Carlsbad Desalination Plant (CDP) is in Carlsbad, California and began operating in December 2015, producing 50 MGD of drinking water for the San Diego region (San Diego County Water Authority, 2019). The CDP originally used cooling water from the adjacent Encina Power Station. Cooling water discharged from the power station averaged approximately 576 MGD and exceeded 304 MGD over 99 percent of the time. Because the CDP was expected to use 100 MGD of the Encina Power Station cooling water as source water, the 54 MGD discharge from CDP was expected to combine with an average discharge flow of 476 MGD from Encina Power Station prior to discharge into the Pacific Ocean.

The original Encina Power Station National Pollutant Discharge Elimination System (NPDES) Permit (CA0109223) assigned an initial dilution of 15.5:1 (6.45 percent) to the existing Encina Power Station discharge. Seawater ambient salinity averaged 33.5 ppt in the area. The expected brine concentrate discharge produced by the desalination plant was 67 ppt based on a 50 percent recovery rate and 99.6 percent salt rejection. The expected salinity of the blended power plant cooling water and desalination plant discharge was 40.1 ppt based on a minimum Encina Power Station influent flow of 304 MGD and CDP discharge of 54 MGD (California Regional Water Quality Control Board, 2007).

The Encina Power Station closed in December 2018 and in order to meet the 15.5:1 NPDES dilution requirement, the Encina Power Station influent pumping operations were continued. More efficient intake and discharge facilities will be constructed. This transition will be implemented in three phases:

- Temporary Operations – NRG Energy, which owns Encina Power Station, will continue to operate the water circulation pumps while an interim intake system is constructed.
- Interim Operations – Expected to begin in mid-2020, this phase uses new fish-friendly pumps as a replacement for the existing circulation pumps. A new, permanent screened intake system also will be designed and built during this phase of operation. The new intake will rely on innovative technology, including 1-millimeter mesh screens to enhance marine life protection.
- Permanent Operations – The new screened-intake system should be operational in late 2023, achieving the best available technology to minimize impacts to marine life in full compliance with the 2015 California Ocean Plan Amendment (Ocean Plan) (State of California, 2015). Once permanent operations begin, the CDP will be the first to comply with the 2015 Ocean Plan Amendment.

CDP's NPDES permit sets salinity limits of an average daily salinity of 40.0 ppt and an average hourly salinity of 44.0 ppt as measured at the permit monitoring location. Whole Effluent Toxicity (WET) testing was conducted for the CDP in 2007. Acute toxicity bioassay testing used standard Top Smelt test organisms (*Atherinops affinis*) and the brine concentrate in conformance with the NPDES permit requirements for the CDP and the following results were identified:

1) The No Observed Effect Concentration of the test occurred at 42 ppt;
2) The Lowest Observed Effect Concentration was 44 ppt;
3) The plant was well below the applicable toxicity limit for salinity of 46 ppt;
4) The No Observed Effect Time for 60 ppt concentration was 2 hours, while the Lowest Observed Effect Time for the 60 ppt concentration was 4 hours (meaning that for a short period of time the species may be exposed to salinity as high as 60 ppt without any observed effect); and
5) The NPDES performance Toxicity Unit (TU) goal of 0.765 was 48 ppt (California Regional Water Quality Control Board, 2007). The salinity related toxicity threshold for short-term exposure is shown in Table 2 (California Regional Water Quality Control Board, 2007).

Table 2
Salinity and 96-Hour Exposure Acute Toxicity of Desalination Plant Concentrate Survival Rates for Top Smelt

Concentrate Salinity (ppt)	Test Species Survival (percent of total)	Acute Toxicity of Concentrate (TU)
33.5 (Control)	100.0	0.00
36	95.0	0.41
38	90.0	0.59
40	95.0	0.41
42	97.5	0.23
44	85.0	0.69
46	87.5	0.65

Concentrate Salinity (ppt)	Test Species Survival (percent of total)	Acute Toxicity of Concentrate (TU)
48	80.0	0.77
50	55.0	0.97
52	62.5	0.93
54	45.0	1.02
56	55.0	0.97
58	65.0	0.91
60	37.5	1.06

Source: California Regional Water Quality Control Board (2007).
Note: TU = Log (100 percent - Percent Survival)/1.7
Desalination NPDES permit TU performance goal = 0.765
Ambient average salinity is 33.5 ppt.

2.1.2 Corpus Christi, Texas M&G Resins USA, LLC

M&G Resins USA, LLC in Corpus Christi, Texas was issued a TPDES Permit WQ 0005019000 on October 23, 2014 with an expiration date of June 1, 2017 to discharge 9.4 MGD of RO brine concentrate and pretreatment waste into the Corpus Christi Inner Harbor, Water Quality Segment 2484. The permit was amended and re-issued on April 19, 2016 to allow a discharge of 18.9 MGD with expiration on June 1, 2020 and again amended and re-issued on October 26, 2017 to allow a discharge of 38.5 MGD with expiration on June 1, 2022.

The permit was transferred from M&G Resins USA, LCC to Corpus Christi Polymers, LLC on February 28, 2019. The operator, Water Cycle, LLC, anticipates start of operations in summer 2020.

The TPDES permit includes the following requirements:

- Average daily discharge: 38.5 MGD;
- Maximum daily discharge: 49.9 MGD;
- ZID: 50 feet radius from discharge, acute toxicity criteria apply at edge of ZID;
- Mixing Zone: 200 feet radius from discharge, chronic toxicity criteria apply at edge of mixing zone;
- The Critical Dilution in the mixing zone was defined as 13 percent effluent; and
- 24-hour acute toxicity was defined at 100 percent effluent.

The critical dilution at the MZ was determined using the jet plume equation (TCEQ, 2010).

2.2 WATEREUSE ASSOCIATION SEAWATER CONCENTRATE DISPOSAL

The Watereuse Association (Watereuse) is a national trade association focused on advancing the reuse of water in the U.S. A Watereuse study determined that the main environmental issue with desalination plant discharge is the impact of elevated salinity on the environment. Ocean water salinity typically varies between 33 ppt and 35 ppt and seawater desalination plants produce concentrate salinities 1.5 to 2 times greater than salinities of the seawater source. A site investigation of a number of existing full-scale seawater desalination plants operating in the Caribbean completed by scientists from the University of South Florida and the South Florida Water Management District in 1998 has concluded that salinity levels of 45 ppt to 57 ppt in seawater concentrate discharges have not caused statistically significant changes in the aquatic environment in the area (WateReuse, 2011).

Figure 1, adapted from Pillard et al. (1999) and included in WateReuse (2011), shows the 48-hour salinity tolerances for three marine species present in Corpus Christi Bay. The mysid shrimp test indicates a 48-hour, 50 percent survival in salinities slightly over 42 ppt. Mysid shrimp tend to live near the bay bottom. Limited mortality occurred at salinities just above 36 ppt. The Inland Silverside, which is typically found in the open waters of the bay above the bottom, has a 48-hour, 50 percent survival at a salinity of 44 ppt with limited mortality at lower salinity.

2.3 WORLD HEALTH ORGANIZATION

Desalination for Safe Water Supply, Guidance for the Health and Environmental Aspects Applicable to Desalination (World Health Organization, 2007):

> *Aquatic life salinity tolerance threshold*
>
> Many marine organisms are naturally adapted to changes in seawater salinity. These changes occur seasonally and are mostly driven by the evaporation rate from the ocean surface, by rain/snow deposition and runoff events and by surface water discharges. The natural range of seawater salinity fluctuations could be determined based on information from sampling stations located in the vicinity of the discharge and operated by national, state or local agencies and research centers responsible for ocean water quality monitoring. Typically, the range of natural salinity fluctuation is at least ±10 percent of the average annual ambient seawater salinity concentration. The "10% increment above ambient ocean salinity" threshold is a conservative measure of aquatic life tolerance to elevated salinity. The actual salinity tolerance of most marine organisms is usually significantly higher than this level.

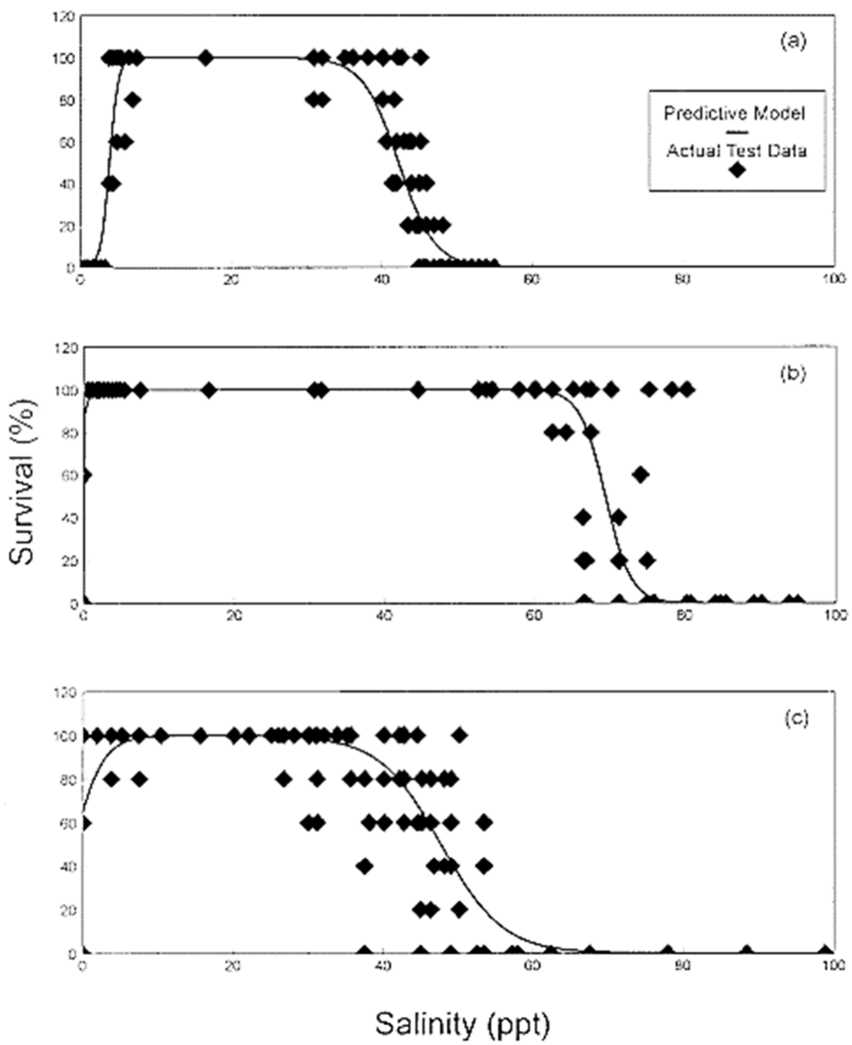

Fig. 1. Forty-eight-hour survival of (a) *Mysidopsis bahia*, (b) *Cyprinodon variegatus*, and (c) *Menidia beryllina* exposed to balanced saline solutions. Each diamond represents 1 to 20 data points, depending on the number of studies conducted at any given salinity and the consistency of organism response at that salinity.

Figure 1. Whole Effluent Toxicity Salinity Tests on Marine Organisms
(Mortality of three widespread marine species in response to salinity variation, where mortality is quantified in percent survival on the vertical axis in response to salinity [ppt]on horizontal axis. Reproduced from Pillard et al. (1999) in WateReuse (2011).

3.0 SALINITY TOLERANCES OF SELECTED CORPUS CHRISTI BAY SPECIES

A literature search of salinity tolerances of fish, shellfish and seagrass found in Corpus Christi Bay was conducted. The optimum salinity range, with the salinity maximum in parenthesis, is presented in Table 3.

Table 3
Salinity Tolerance of Select Fish and Crustacean Species in the Corpus Christi Bay Area

		Optimum Salinity Range (Salinity Maximum) (ppt)		
Common Name	Scientific Name	Larvae	Juveniles	Adults
American Oyster	*Crassostrea virginica*	10-35 (39)	10-30 (44)	10-30 (44)
Brown Shrimp	*Farfantepenaeus aztecus*	24-36 (40-69)	10-20 (45)	24-39 (45)
White Shrimp	*Litopenaeus setiferus*	0.4-37 (N/A)	2-15 (41)	>27 (40)
Mysid Shrimp	*Americamysis bahia*	–	–	20-43 (N/A)
Blue Crab	*Callinectes sapidus*	12-36 (43)	2-21 (N/A)	<10-33 (67)
Stone Crab	*Menippe* sp.	15-25 (27)	<4-34 (40)	>13 (N/A)
Gray Snapper	*Lutjanus griseus*	0-66 (67)	0-66 (67)	0-48 (67)
Sheepshead	*Archosargus probatocephalus*	5-25 (45)	0.3-44 (45)	0.3-44 (45)
Spotted Seatrout	*Cynoscion nebulosus*	20-35 (50)	8-25 (48)	20-25 (45)
Atlantic Croaker	*Micropogonias undulatus*	15-36 (N/A)	0.5-20 (40)	6-20 (70)
Black Drum	*Pogonias cromis*	9-34 (36)	9-26 (80)	9-26 (80)
Red Drum	*Sciaenops ocellatus*	8-36 (50)	20-40 (50)	20-40 (50)
Southern Flounder	*Paralichthys lethostigma*	10-30 (N/A)	2-37 (60)	20-30 (60)
Inland Silverside	*Menidia beryllina*	0-30 (2-8)	0-32 (N/A)	0-120 (N/A)

Sources: Pattillo et al. (1997); Guillory et al. (2001); Saoud and Davis (2003); Serrano (2008); EPA (2009); Gulf Marine States Fisheries Commission (2012); Baggett et al. (2014); Doerr et al. (2016); Hijuelos et al. (2016); Odell et al. (2017).

A literature search of select plant species salinity tolerances in the Corpus Christi Bay area was conducted. The optimum salinity range with the salinity maximum in parenthesis is presented in Table 4. All of these species can tolerate high salinity conditions. Kültz (2015) reported most fish found in estuaries which experience wide ranges in salinity can tolerate salinities up to 60 ppt.

Table 4
Salinity Tolerance of Select Plant Species in Corpus Christi Bay Area

Common Name	Scientific Name	Optimum Salinity Range (Salinity Maximum) (ppt) California Coastal Conservancy (2019) and Stachelek and Dunton (2013)	Koch et al. (2007)**	SMSFP (2019a-d), Irlandi (2006), Alleman and Hester (2010)
Smooth Cordgrass	*Spartina alterniflora*	10-30 (50-60)	–	–
Turtlegrass*	*Thalassia testudinum*	–	14-62 (45)	>20-48 (60)
Shoalgrass*	*Halodule wrightii*	–	5-45 (45)	5-39 (60)
Clovergrass	*Halophila engelmannii*	–	–	5-35 (74)
Manatee Grass*	*Syringodium filiforme*	–	5-45 (45)	20-35 (45)
Black Mangrove	*Avicennia germinans*	–	–	24-48 (96)

Sources: Irlandi (2006); Koch et al. (2007); Alleman and Hester (2010); Stachelek and Dunton (2013); California Coastal Conservancy (2019); Smithsonian Marine Station at Fort Pierce (SMSFP, 2019a-d).

* These seagrasses show different thresholds to hypersalinity based on the rate of salinity increase. Under pulsed hypersaline conditions, such as effluent discharges of reverse osmosis operations, it is predicted that seagrass would have a significantly lower salt threshold compared to those in evaporative basins. Threshold levels dropped 20 ppt to 45 ppt (Koch et al., 2007).

** Values presented are pulsed ranges.

4.0 RECOMMENDED SALINITY CRITICAL DILUTIONS FOR CORPUS CHRISTI DESALINATION PROJECT

Recommendations for the Corpus Christi Desalination Project for receiving water critical dilutions for salinity are based on accepted limits at other facilities in the U. S, literature review of marine organisms' salinity tolerances, and consistency with the TCEQ Surface Water Quality Standards for bays, estuaries, and wide tidal rivers (TCEQ, 2010).

It is proposed that the ZID use an acute toxicity (LC_{50}) salinity tolerance of 42 ppt, which is a conservative value supported by the Pillard et al. (1999) salinity studies referenced here, the Carlsbad desalination project salinity tolerance testing, and its NPDES permit, and is consistent with the literature review for salinity tolerances for local species in Corpus Christi Bay.

It is proposed that the MZ use a chronic toxicity salinity tolerance of 35 ppt. Many marine organisms are naturally adapted to variation in salinity. These changes occur seasonally and are mostly driven by freshwater inflows, storms and tidal fluctuations. The Nueces River is one of the largest contributors of freshwater into Corpus Christi Bay. Historical salinity in the La Quinta area of Corpus Christi Bay varied between 14.6 and 40.6 ppt. The historic average ambient salinity for the Inner Harbor site is 31.59 ppt and for the La Quinta site is 31.65 ppt. The World Health Organization referenced in this report states a "10% increment above ambient ocean salinity" threshold is a conservative measure of aquatic life tolerance to elevated salinity (World Health Organization, 2007). The actual salinity tolerance of most marine organisms is usually significantly higher than this level. This "10% Rule" is supported by the American Water Works Association Committee report on managing brine from RO membranes (American Water Works Association, 2004) and the WateReuse Association Seawater Concentrate Disposal White Paper (WateReuse, 2011), Carlsbad desalination plant published toxicity testing and is consistent with the literature review for salinity tolerances for local species in Corpus Christi Bay.

The salinity values for acute toxicity of 42 ppt at the ZID and for chronic toxicity of 35 ppt at the MZ were used to determine the critical dilutions for the Inner Harbor and La Quinta sites under the operating conditions of 40 percent and 50 percent recovery rates. The RO system operating at a 40 percent recovery rate would produce more discharge flow but at a lower salinity concentration than when operating at a 50 percent recovery rate (lower discharge volume but higher salinity). Table 5 presents the calculated values for the critical dilutions at the ZID and MZ for both possible RO system operating conditions.

Table 5
Proposed Critical Dilutions for Corpus Christi Seawater Desalination Project

	Inner Harbor		La Quinta Channel	
Plant Water Production (MGD)	30		40	
Percent Recovery[1]	40	50	40	50
Effluent Volume (MGD)	51.47[2]	35.17	68.62[3]	46.90
Effluent Salinity (ppt)	49.9[4]	58.4[4]	50.0[5]	58.5[5]
Critical Dilution (%) 50 feet from discharge (edge of ZID)	56	38	56	38
Salinity (ppt) 50 feet from discharge (edge of ZID) based on critical dilutions	42	42	42	42
Critical Dilution (%) 200 feet from discharge (edge of MZ)	18	13	18	13
Salinity (ppt) 200 feet from discharge (edge of MZ) based on critical dilutions	35	35	35	35

[1]Percent recovery for the reverse osmosis membranes will range from 40% to 50%.
[2]Inner Harbor - average daily 52 MGD and maximum daily 62 MGD at 40% recovery
[3]La Quinta Channel – average daily 69 MGD and maximum daily 83 MGD
[4]Based on ambient average salinity in the Inner Harbor of 31.59 ppt.
[5]Based on ambient average salinity in the La Quinta Channel of 31.65 ppt.

5.0 REFERENCES

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