TM 2.1 – Identification and Characterization of Potential Environmental Impacts Mitigation Measures Related to Intake and Discharge Facilities of Seawater Desalination Plants

Variable Salinity Desalination Demonstration Project
City of Corpus Christi

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Introduction

A preliminary overview of the potential environmental impacts and mitigation measures of several pre-determined sites as potential locations for intake and discharge facilities of seawater desalinization plants has been conducted. Below is a summary of those results. Also included in these analyses are matrices that further detail how the recommendations were derived, and there are lists of common species that would likely be impacted based on the current literature available. Certainly, as candidate site selection is conducted and refined, detailed assessments of species and habitat impacts as well as thorough site-specific analyses would need to be performed.

Intake Site Assessment

When considering locations for a desalinization intake site, multiple factors have to be examined. From an ecological standpoint, the biggest concerns are related to impacts that the desalination plant would have on the resident fauna. Two factors that have the most impact are impingement and entrainment. Impingement of larger fish, marine mammals, and sea turtles can reduce the spawning stock biomass due to an increased mortality rate. In addition, entrainment of smaller ichthyoplankton and eggs can reduce recruitment. Despite the known ecological impacts that construction of a desalinization plant creates, directed sampling pre- and post-construction would need to be conducted in order to measure the actual environmental impacts to the selected site. While specific detailed mitigation measures are beyond the scope of this report, all sites with the exception of 2A and 2B (the most environmentally diverse locations) would likely have similar mitigation measures.

Specifically for this study, six candidate intake assessment locations were chosen by Freese and Nichols, Inc. The Harte Research Institute, specifically the Fisheries and Ocean Health Lab was contracted to identify potential environmental impacts of specific intake structures listed for the following locations: two chosen near Broadway WWTP, two near the La Quinta Channel Extension, one offshore in the Gulf of Mexico, and one in the Viola Turning Basin in the Inner Harbor (Figure 1). In the following assessment, the key environmental intake topics of concern will be discussed:

- Impingement of marine life on screens
- Entrainment of marine life in desalinization plant
- Impacts on seagrass and other sensitive marine areas
- Visual impacts and disturbance of coastal uses
- Impacts on coastal wetlands
- Other environmental issues

Overall Recommendations: This section summarizes our opinions on the proposed designs and locations, focusing on those that would minimize the impact to resident fauna and limit degradation or loss of high quality habitat. Under the current proposed plan, the preferred intake type would be either the subsurface directional drilled or subsurface infiltration gallery intakes. Logistical limitations prevent all sites as candidates for these subsurface methods, and our recommendation considers these limitations. While benthic organisms would be impacted during the creation of the subsurface system, once created there would be no freestanding source from which fauna could be impinged or entrained. When taking into account both the sites proposed and the intake types at those locations, a directional drilled intake would be recommended at site 3A as the overall preferred location/intake type. Since the location is outside of Corpus Christi Bay, there would be less impact on ship navigation during construction. This site and intake type combination also would likely have the lowest overall effect on mortality (construction and daily operations). However, we do make alternative recommendations and provide our opinion on the pros and cons of each location. Overall, we recommend the following sites and intake type combinations (in order of preference):

1. Site 3A as a directional drilled intake
2. Site 3A as an infiltration gallery intake
3. Site 1A as a directional drilled intake
4. Site 1A as an infiltration gallery intake
5. Site 3A as a wedgewire intake
6. Site 1A as a wedgewire intake
7. Site 4A as an onshore open intake
8. Site 1B as an onshore open intake
9. Site 2A as an offshore directional drilled intake
10. Site 2A as an offshore infiltration gallery
11. Site 2B as an onshore surface intake

These recommendations are based strictly from an ecological perspective, and in some cases and may not be feasible for the specific plant designs proposed here. Specifically, subsurface intakes are effective if the installation requires less than 15 million-gallon-per-day (mgd) intake capacities (WateReuse Association 2011). For the current intake location assessment, the target capacity is 50 mgd. Given this, while subsurface intakes are ideal regarding their minimal impact to the local biota, they may also be impractical in this specific scenario. If the final design of the plant requires 50 mgd, the following sites and intake type combinations are recommended (in order of preference, omitting subsurface options):

1. Site 3A as a wedgewire intake
2. Site 1A as a wedgewire intake
3. Site 4A as an onshore open intake
4. Site 1B as an onshore open intake
5. Site 2B as an onshore surface intake

Site Specifics Recommendations

The following is a site by site breakdown of the potential environmental impacts due to the construction of a desalinization intake. An intake selection matrix (Table 1) contains site-specific details and other criteria used to determine these recommendations. A list of the marine nekton species in Corpus Christi Bay that could potentially be impacted has also been included (Table 2). Clearly, as facilities siting becomes more refined, detailed assessments would be needed to further elucidate site-specific impacts. These recommendations are presented by site number and not in order of preference.

Site 1: Near Broadway WWTP

Site 1A is located in the Corpus Christi Bay near Inner Harbor with submerged wedgewire, subsurface filtration gallery, or subsurface directional drilled intakes as the proposed types.

- **Impingement of marine life on screens**
  Constructing a submerged wedgewire intake would have a greater potential for impinging marine fauna as compared to a subsurface intake. A subsurface intake (either filtration gallery or directional drilled) would have the least amount of overall mortality since it does not protrude from the seafloor, so there is no concern of impingement for this type of intake.

- **Entrainment of marine life in desalinization plant**
  The wedgewire intake would likely increase marine life mortality on a daily operating basis as opposed to a subsurface intake because there is a greater potential for impinging marine fauna. With a subsurface intake the water is drawn

through the sand/gravel so most of the larvae and eggs in the water column would not filter through the seafloor and are not at risk for entrainment.

- **Impacts on seagrass and other sensitive marine areas**
  This location does not appear to have any type of limiting habitat (i.e., seagrasses) that would negatively impact the resident benthic fauna. If a subsurface intake was constructed it is possible that the motile species would be able to avoid the area during construction and potentially re-settle upon its completion.

- **Visual impacts and disturbance of coastal uses**
  Since it is submerged offshore, either of the intake options (wedgewire or submerged) present no concern regarding visual disturbances and minimal concern regarding navigational disturbances (e.g. shrimp trawls) in this area.

- **Impacts on coastal wetlands**
  There are no concerns about coastal wetlands due to the intake being submerged and offshore based on NWI maps for the surrounding area.

- **Other environmental issues**
  No other environmental issues have currently been identified at this time.

Site 1B is located in the Corpus Christi Bay Turning Basin - proposed to be an onshore surface intake using traveling screens.

- **Impingement of marine life on screens**
  The onshore traveling screen intake would impact the surrounding marine fauna. Depending on construction location and depth, fish and invertebrates are likely to become impinged in the screen and occasional cleaning would be necessary to ensure proper operation. The use of fish buckets would help limit this problem, but there are still problems with macroalgae potentially fouling the screens.

- **Entrainment of marine life in plant**
  Larval fish, eggs, and plankton would be entrained in a traveling screen intake. However, the habitat quality in this area is likely already impacted by industrialization, so it is unlikely that the mortality from entrainment would be enough to substantially impact any local populations.

- **Impacts on seagrass and other sensitive marine areas**

Due to the highly industrialized area it is unlikely to have any type of sensitive habitat types (i.e., seagrasses) to an extent that would negatively impact the resident benthic fauna, so it is possible that the motile species would be able to avoid the area during construction and potentially re-settle upon completion.

- **Visual impacts and disturbance of coastal uses**
  As with all surface intakes, this unit (or building housing the unit) would be visible. Most of the area surrounding the proposed site is heavily industrialized so despite the construction of the new intake, the general aesthetics of the area would not change. One other consideration is the addition of any debris or sedimentation to the barge canal during construction. A portion of the canal might need to be narrowed or closed, which could create problems for ships attempting to unload/load cargo in the surrounding area.

- **Impacts on coastal wetlands**
  While the shoreline would be impacted, there wetlands in the area are approximately 75 m from the so there would a slight potential for impacts on coastal wetlands.

- **Other environmental issues**
  No other environmental issues have currently been identified at this time.

Site 2: La Quinta Channel Extension

Site 2A is located west of Spoil Island with suggested intake types that include submerged infiltration gallery and submerged directional drilled. Follow-up inquires by Freese and Nichols, Inc. included a possible wedgewire screen intake at this site. For the same reasons as described below, this intake type would also be least favorable among the other site locations.

- **Impingement of marine life on screens**
  No concerns due to submerged intakes. For a wedgewire intake there would be a greater potential for impinging marine fauna as compared to a subsurface intake.

- **Entrainment of marine life in plant**
  No concerns due to submerged intakes. The wedgewire intake would have higher marine life mortality on a daily operating basis as opposed to a subsurface intake

- **Impacts on seagrass and other sensitive marine areas**

During construction, the mortality of benthic organisms would be subject to the greatest change in this system because of physical disturbance to the bottom sediments. The Spoil Island area is known to have seagrass habitats, sensitive for economically important species of sciaenids (e.g. red drum, spotted seatrout) and paralichthys (flounders). This area is also adjacent to sensitive fish nursery habitat and other areas that are important for a variety of marine life, including possible feeding areas for sea turtles and nesting sites for colonial waterbirds. Thus, these physical and geographical concerns lead to some reservations about these areas as candidate sites.

- **Visual impacts and disturbance of coastal uses**
  Since it is submerged, any of the intake options (infiltration gallery, directional drilled, or wedgewire intake) present no concern regarding visual disturbances and minimal concern regarding navigational disturbances (e.g. shrimp trawls) in this area. However, during construction of the infiltration gallery the shipping channel would be affected, since pipes need to be laid down in order to bring the water from the intake to the plant. A directional drill intake might be a better option since drilling can occur without impact to the shipping channel.

- **Impacts on coastal wetlands**
  While the area is not considered coastal wetlands, there are concerns about negatively impacting the seagrass and Spoil Island habitat if an intake were to be placed in this area.

- **Other environmental issues**
  Spoil Island has the potential to be a feeding and resting place for migrating birds, including the federally endangered Piping Plover (*Charadrius melodus)*. Altering the island or surrounding shoreline area could decrease the suitability for this area to provide necessary resources for migrating birds.

Site 2B is an onshore surface intake located on the shoreline of the channel extension.

- **Impingement of marine life on screens**
  With the close proximity to seagrasses, it is likely that a traveling screen intake would be a source of mortality for recreationally important species such as sciaenids and paralichthys.

- **Entrainment of marine life in plant**

In this location, larval fish, eggs, and plankton would become entrained. This area has the potential to for impacting the recruitment of recreationally important species (e.g. sciaenids and paralichthys) due to the relatively high habitat quality of the surrounding area.

- **Impacts on seagrass and other sensitive marine areas**
  This location is in close proximity to seagrass. Since many species use seagrass beds as recruitment areas, this site would not be recommended for development. Like site 2A, this area is also adjacent to some of the most sensitive fish nursery habitat and other areas that are important for a variety of marine life. Thus, these physical and geographical concerns lead to some reservations about these areas as candidate sites.

- **Visual impacts and disturbance of coastal uses**
  As with all surface intakes, this unit (or building housing the unit) would be visible. A portion of the canal might need to be narrowed or closed, which could create problems for ships attempting to unload/load cargo in the surrounding area.

- **Impacts on coastal wetlands**
  Approximately 60 acres of the entire shoreline at this location is classified as estuarine and marine wetlands according to the NWI map. Creating a surface intake would impact coastal wetlands by the need to create the intake system on the shoreline.

- **Other environmental issues**
  No other environmental issues have currently been identified.

Site 3: Mustang or Padre Islands

Site 3A is proposed to be located 2 miles offshore, with proposed intake types including submerged wedgewire, submerged infiltration gallery, and submerged directional drilled.

- **Impingement of marine life on screens**
  Constructing a submerged wedgewire intake would have greater potential for impinging marine fauna compared to a subsurface intake. Since this location is outside of Corpus Christi Bay, there is a greater variety of species that may become impinged in the intake. Although there would be mortality associated with the construction of a subsurface intake (either filtration gallery or directional drilled) there is no concern about impingement since it does not protrude from the seafloor. It is our opinion that this area would have the least impact based on our

criteria; however, it is also the least studied. If chosen, further detailed assessment would need to be performed at this area.

- **Entrainment of marine life in plant**
  The wedgewire intake would have the greatest potential for marine life mortality on a daily operating basis, compared to a subsurface intake where water that is drawn into the sediment is used. Since the water from a subsurface intake is drawn through the sand/gravel, larvae and eggs in the water column would not filter through the seafloor and would not be at risk for entrainment.

- **Impacts on seagrass and other sensitive marine areas**
  During construction, the benthic organisms would be the most likely effected in this system because of the physical disturbances to the bottom. This location does not appear to have any type of limiting habitat (i.e., seagrasses) that would negatively impact the resident benthic fauna, so it is possible that the motile species would be able to avoid the area during construction and potentially re-settle once construction is complete.

- **Visual impacts and disturbance of coastal uses**
  Since it is submerged offshore, either of the intake options (wedgewire or submerged) present no concern regarding visual disturbances and minimal concern regarding navigational disturbances (e.g. shrimp trawls) in this area.

- **Impacts on coastal wetlands**
  Since this site is outside of Corpus Christi Bay, there are no concerns about negative impacts on coastal wetland.

- **Other environmental issues**
  No other environmental issues have currently been identified.

Site 4: ON Stevens WTP

This site is proposed to be located in the Viola Turning Basin, a heavily industrialized area at the end of the Corpus Christi Turning Basin. The proposed intake at this location is an onshore traveling screen surface.

- **Impingement of marine life on screens**
  This location is at the end of the Viola Turning Basin, which is not a favorable habitat for most species of recreational importance. Impingement would be a concern, but it is likely to be of mostly lower trophic level species (e.g. anchovies,

silversides) which can be found throughout the Corpus Christi Bay system. The potential for macroalgae to become impinged is a concern as well.

- **Entrainment of marine life in plant**
  The abundance of eggs, larval fish, or plankton that get entrained in the surface intake likely would not be as high as the other sites, since the location is so far from any source of inflow. This water may already be slightly more saline than other locations due to evaporation and extended flushing cycles, making it a harsher environment than the other listed sites.

- **Impacts on seagrass and other sensitive marine areas**
  This location does not appear to have any seagrass in the surrounding area.

- **Visual impacts and disturbance of coastal uses**
  As with all surface intakes, this unit (or building housing the unit) would be visible after construction. This channel was created as a shipping lane, so most of the area is already industrialized.

- **Impacts on coastal wetlands**
  Depending on location, there are approximately 30 acres of freshwater emergent wetlands that might be impacted during the creation of the surface intake.

- **Other environmental issues**
  No other environmental issues have currently been identified.

Discharge Facilities Assessment

When considering the locations for desalination plant discharge facilities, several factors need to be considered. The addition of brine concentrate can have environmental impacts on the marine community. As a result, the salinity tolerance of marine organisms need to be considered when determining the locations for Corpus Christi desalination plant discharge locations (Figure 2). Changes in salinity and temperature can have deleterious effects on many marine species, particularly those in early developmental stages. See Table 3 for a list of the marine species of bottom dwellers in Corpus Christi Bay that could potentially be impacted. Specifically for this study, five candidate discharge assessment locations were chosen by Freese and Nichols, Inc.

The Harte Research Institute, more specifically the Ecosystem Studies and Modeling Lab was contracted to identify potential environmental impacts of specific discharge structures to the surrounding environment.

Biomass, abundance, and diversity of the benthic community can be affected by salinity changes (Montagna et al. 2002, Van Diggelen 2014). The average salinity in the Corpus Christi Bay system since 1987 is about 35 ± 7 ppt. The estuarine macrobenthic community of Corpus Christi Bay would not likely be affected by a salinity increase within this range (Table 4, Montagna et al. 2013). However, brine plumes can create hypoxic or anoxic zones which disturb benthic communities and organisms in the water column. It is known that there is an interaction between salinity and dissolved oxygen (DO) concentration in Corpus Christi Bay, such that benthic communities decline dramatically as salinity increases to around 42 ppt and DO decreases to around 3 mg/L (Ritter and Montagna 1999). This effect could be heightened due to depressions in the bay bottom that are scattered throughout Corpus Christi Bay, which constrain mixing of bottom water, leading to hypoxia (Nelson 2012). In contrast the average DO in Corpus Christi Bay is 6.3 mg/L. Directed sampling before and after the construction of a discharge facility would be recommended in order to determine the actual environmental impacts to the selected sites.

Some of the proposed discharge sites are recorded as having evidence of contaminant-induced degradation of sediment quality from storm-water outfalls. Sampling would need to be conducted post-construction to monitor if there is any change in contaminant-induced degradation of sediment quality (Carr et al. 2000).

In the assessment the following key environmental intake issues will be discussed:

- Salinity tolerance of identified marine organisms in the mixing zone
- Marine organism salinity tolerances
- Target acceptable discharge salinity
- Mixing of brine concentrate and ambient seawater issues
- Ion imbalance of brine concentrate and ambient seawater mixing issues
- Toxicity of brine concentrate and ambient seawater mixing issues
- Estimate maximum velocity at edge of mixing zone safe for aquatic life
- Concentrate disposal impacts, diffusion, and transport

Overall recommendations: To limit the environmental impacts on resident fauna, it is our opinion that the preferred discharge type would be either submerged jet diffusers or a submerged pipe. Submerged jet diffusers would be the quickest method for dilution of effluent and the preferred way to avoid hypoxia. We recommend site 3A with submerged jet diffusers as the preferred location for a discharge facility. This combination would have the least environmental impact because the discharge would be entering into a deeper and more dynamic body of water. This site and discharge type combination also appears to have the lowest overall effect on mortality (construction and daily). Overall we recommend the following sites and discharge type combinations (in order of preference):

1. Site 3A as submerged jet diffusers
2. Site 3A as a submerged pipe
3. Site 1B as submerged jet diffusers
4. Site 1B as a submerged pipe
5. Site 4A as a surface open discharge pipe
6. Site 1A as a surface open discharge pipe – drainage ditch
7. Site 2A as submerged jet diffusers
8. Site 2A as a submerged pipe

The following is a site by site assessment of the key environmental issues from construction and operation of discharge facilities. Discharge selection matrix (Table 5) contains site-specific details and other criteria regarding to how these recommendations were determined.

Site 1: Near Broadway WWTP

Discharge location 1A is located in the Inner Harbor of Corpus Christi Bay. Corpus Christi Inner Harbor has been subject to refinery process water effluent discharge for over fifteen years. The proposed type of discharge infrastructure is a surface open discharge pipe – drainage ditch. Brine concentrate in an open-air ditch could evaporate further and become even more saline. Considering salinity alone, a discharge salinity of 2.0 parts per thousand (ppt) above ambient salinity (Table 4) would not have an effect on the marine community in the Inner Harbor. However, the conclusion from Hodges' 2015 report is that desalination brine in the ship channel would likely result in extended periods of hypoxia and anoxia. This location does not appear to have seagrass or other limiting habitat.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 28 and 42 ppt, with an average around 35 (Table 4).

- **Marine organism salinity tolerances**
  The Corpus Christi Bay system has natural salinities ranging from 28 - 42 ppt, with an average around 35 ppt (Van Diggelen and Montagna 2016). We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 42 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 42 ppt (Table 4), just above the average salinity of the bay system.

- **Mixing of brine concentrate and ambient seawater issues**
  It is unknown how the mixing of warm brine concentrate would affect the bay system, but it could lead to hypoxia. It would be recommended that the concentrate be brought as close as possible to ambient seawater temperature before being released.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Research is needed to verify the potential impacts of brine concentrate mixing with seawater.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  Warm temperatures of brine plumes may affect marine species, particularly animals in early developmental stages. This site does not appear to have seagrass habitat, so there is little concern for brine concentrate affecting sensitive nursery grounds.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  At the seafloor there are sluggish currents ranging from 0.01 - 0.25 meters per second (m/s) (Powell et al. 2007). The current velocity in Corpus Christi Bay is variable and wind driven at the surface. Current speed is probably very sluggish at this particular site. Brine discharged at a high velocity would promote more mixing but could negatively impact flora and fauna. We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 0.5 m/s (Powell et al. 2007).

- **Concentrate disposal impacts, diffusion and transport**
  The target acceptable discharge salinity would need to be close to 35 ppt, and no higher than 42 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A brine plume at this site would probably lead to hypoxia.

Discharge location 1B is located in Corpus Christi Bay in the Ship Channel near Harbor Bridge. The proposed types of discharge infrastructure are submerged pipe and submerged jet diffusers. This site has previously been described as a depositional zone for material coming from the Inner Harbor (Carr et al. 1998). A submerged pipe would release a brine plume at the sediment surface of the bay. This pipe would be subject to fouling by sessile marine organisms such as serpulid worms and tunicates. Discharge location 1B may experience more wind-driven mixing than location 1A, potentially mixing up the brine plume released from a submerged pipe. However, hypoxia could still develop from the brine plume. Submerged jet diffusers are an alternative discharge type that prevents the formation of dense brine plumes. Turbidity from jet diffusers can cause developmental and filtration problems in bivalves because it is generally known that filter feeders can be clogged in highly turbid environments.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 28 and 42 ppt, with an average around 35.

- **Marine organism salinity tolerances**
  The Corpus Christi Bay system has natural salinities ranging from 28 - 42 ppt, with an average around 35 ppt. We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 42 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 42 ppt. It would be easier to reach the target acceptable discharge salinity using submerged jet diffusers.

- **Mixing of brine concentrate and ambient seawater issues**
  It is unknown how the mixing of warm brine concentrate would affect the bay system. It would be recommended that the concentrate be brought as close as possible to ambient seawater temperature before being released. A submerged pipe would create a brine plume at the sediment surface, which could lead to hypoxia if not thoroughly mixed in. Submerged jet diffusers would be the preferred option to achieve optimal mixing of brine concentrate and seawater.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Sessile organisms would be subject to stress from ion imbalance as they cannot relocate. Submerged jet diffusers would be the preferred option to promote mixing and dilution of brine concentrate and seawater.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  Warm temperatures of brine plumes may affect marine species, particularly animals in early developmental stages. This site does not appear to have seagrass habitat, so there is little concern for brine concentrate affecting sensitive nursery grounds at this site. Research is needed to verify the toxicological effects of brine concentrate mixing with seawater.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 0.5 m/s (Powell et al. 2007). Although marine life would only be exposed to diffuser jet turbulence for short bursts of time, on the order of seconds, we recommend conducting laboratory studies to determine a velocity that minimizes shear stress mortality (Foster et al. 2013).

- **Concentrate disposal impacts, diffusion, and transport**
  The target acceptable discharge salinity would need to be close to 35 ppt, and no higher than 42 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A brine plume at this site could lead to hypoxia. Submerged jet diffusers would be the preferred option to achieve optimal mixing of brine concentrate and seawater.

Site 2: La Quinta Channel Extension

Discharge location 2A is located southwest of La Quinta Channel Extension in Corpus Christi Bay. The proposed types of discharge infrastructure are submerged pipe and submerged jet diffusers. Nearby tidal flats, salt marshes, and seagrass beds are inhabited by protected bird species and used as recruitment areas by recreationally important fish species. Green sea turtles, bottlenose dolphins, and manatees have been observed in La Quinta Channel. Hypoxia or anoxia would occur as a result of submerged pipe brine plume discharge. This site would have the most severe environmental impacts and would not be recommended for the construction of a discharge facility.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 28 and 42 ppt, with an average around 35.

- **Marine organism salinity tolerances**
  The Corpus Christi Bay system has natural salinities ranging from 28 - 42 ppt, with an average around 35 ppt. We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 42 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 42 ppt. It would be easier to reach the target acceptable discharge salinity using submerged jet diffusers.

- **Mixing of brine concentrate and ambient seawater issues**
  Submerged jet diffusers dilute and disperse brine through rapid mixing, decreasing the possibility or extent of hypoxic zones.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Sessile organisms would be subject to stress from ion imbalance as they cannot relocate. Submerged jet diffusers would be the preferred option to promote mixing and dilution of brine concentrate and seawater.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  Warm temperatures of brine plumes may affect marine species, particularly those in early developmental stages. This site has seagrass habitat that is potentially a recruitment area for many estuarine species. Discharge from a submerged pipe could be particularly detrimental by causing hypoxia. Submerged jet diffusers could create turbidity, affecting the phytoplankton community and shading out seagrass. A discharge facility at this site could have severe environmental impacts. More research is needed to verify the toxicological effects of brine concentrate mixing with seawater.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  If the submerged jet diffuser was installed at the bottom of the 35 foot trench, as proposed, a velocity of 2 - 3 fps at the edge of the mixing zone would be acceptable. However, if the submerged jet diffuser was installed at the average seafloor depth of about 3 meters, there could be severe environmental impacts, as mentioned above. We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 0.5 m/s (Powell et al. 2007). Although marine life would only be exposed to diffuser jet turbulence for short bursts of time, on the order of seconds, we recommend conducting laboratory studies to determine a velocity that minimizes shear stress mortality (Foster et al. 2013).

- **Concentrate disposal impacts, diffusion, and transport**
  The target discharge salinity would need to be close to 35 ppt, and no higher than 42 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A brine plume at this site would probably lead to hypoxia. A submerged pipe is also subject to fouling by sessile marine organisms such as serpulid worms and tunicates. Submerged jet diffusers

would be the preferred option to achieve optimal mixing of brine concentrate and seawater.

Site 3: Mustang Island or Padre Island

Discharge location 3A is located 2 miles offshore of either Mustang Island or Padre Island. The proposed types of discharge infrastructure are submerged pipe or submerged jet diffusers. This is the preferred choice for a discharge site because the brine effluent would be rapidly mixed into the ambient seawater and have the least environmental impact. Kemp's ridley, loggerhead, green and leatherback turtles as well as bottlenose dolphins have been recorded at this site. It is unlikely that these species would be affected by the discharge.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 32 and 36 ppt, with an average of 35 ppt.

- **Marine organism salinity tolerances**
  The Gulf of Mexico has natural salinities ranging from 32 - 36 ppt, with an average around 35 ppt. We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 36 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 38 ppt. It would be easier to reach the target acceptable discharge salinity using submerged jet diffusers.

- **Mixing of brine concentrate and ambient seawater issues**
  The discharge of brine concentrate from a submerged pipe is expected to mix well with ambient seawater. Submerged jet diffusers would be the preferred option for quickest dilution and least environmental impact.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  It is not anticipated that there would be issues with brine concentrate toxicity at this site. Effluent would be thoroughly mixed in through wind-driven mixing and tidal currents.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Sessile organisms would be subject to stress from ion imbalance as they cannot relocate.

Submerged jet diffusers would be the preferred option to promote mixing and dilution of brine concentrate and seawater.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  The average current velocity near Bob Hall Pier is between 0.5 and 1.0 m/s. The current velocity offshore at this discharge site changes every day. We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 1.5 m/s (Powell et al. 2007).

- **Concentrate disposal impacts, diffusion and transport**
  The target discharge salinity would need to be close to 35 ppt, and no higher than 36 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A submerged pipe is also subject to fouling by sessile marine organisms such as serpulid worms and tunicates. Submerged jet diffusers would be the preferred option to achieve optimal mixing of brine concentrate and seawater.

Site 4: ON Stevens WTP

Discharge location 4A is at the Tule Lake Turning Basin in the Inner Harbor of Corpus Christi Bay. The proposed discharge infrastructure is a surface open discharge pipe. Considering salinity alone, a discharge salinity of 2.0 ppt above ambient salinity would not have an effect on the marine community in the Inner Harbor. However, the conclusion from Hodges' 2015 report is that desalination brine released in the ship channel would likely result in extended periods of hypoxia and anoxia. This location does not appear to have seagrass or other limiting habitat.

- **Salinity tolerance of identified marine organisms in the mixing zone**
  The salinity tolerance of marine organisms in the mixing zone is between approximately 28 and 42 ppt, with an average around 35 ppt.

- **Marine organism salinity tolerances**
  The Corpus Christi Bay system has natural salinities ranging from 28 - 42 ppt, with an average around 35 ppt. We know that the resident marine species can tolerate salinities within this range; however, further studies are needed to determine the effects of a localized salinity increase greater than 42 ppt.

- **Target acceptable discharge salinity**
  The target acceptable discharge salinity would need to be 35 - 42 ppt.

- **Mixing of brine concentrate and ambient seawater issues**

A surface open discharge pipe would release brine concentrate directly into the bay. The dense concentrate would settle at the bottom of the harbor and cause hypoxia.

- **Ion imbalance of brine concentrate and ambient seawater mixing issues**
  The concentration of copper, calcium, chlorine, and anti-scalants in the brine concentrate would need to be determined before its impact can be assessed. Fish, plankton, and benthic fauna can experience toxic effects from the bioaccumulation of metals. Sessile organisms would be subject to stress from ion imbalance as they cannot relocate.

- **Toxicity of brine concentrate and ambient seawater mixing issues**
  Warm temperatures of brine plumes may affect marine species, particularly animals in early developmental stages. This site does not appear to have seagrass habitat or recreational fish species, so there is little concern for brine concentrate affecting sensitive nursery grounds.

- **Estimate maximum velocity at edge of mixing zone safe for aquatic life**
  At the seafloor there are sluggish currents ranging from 0.01 - 0.25 m/s. The current velocity in Corpus Christi Bay is variable and wind driven at the surface. Current speed is probably very sluggish at this particular site. Brine discharged at a high velocity would promote more mixing but could negatively impact flora and fauna. We estimate the maximum velocity at the edge of mixing zone safe to aquatic life to be no more than 0.5 m/s (Powell et al. 2007).

- **Concentrate disposal impacts, diffusion, and transport**
  The target acceptable discharge salinity would need to be close to 35 ppt, and no higher than 42 ppt. Field and laboratory studies would need to be conducted to investigate the environmental impacts of warm brine plumes with high concentration of heavy metals. A brine plume at this site would probably lead to hypoxia.

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Figure 1. Intake Assessment Locations

Figure 2. Discharge Assessment Locations

Table 1. ***Intake type and site location recommendations. A total impact score is given for each intake and the sites are color coded by recommendation level.***

Intake Matrix	Site 3A Mustang or Padre Islands	Site 1A CC Bay by CC Harbor	Site 4A Viola Turning Basin	Site 1B CC Turning Basin, Inner Harbor	Site 2A West of Spoil Island	Site 2B Shoreline near La Quinta Channel
Subsurface Intake			N/A	N/A		N/A
Impingement of Marine Life	0	0	N/A	N/A	0	N/A
Entrainment of Marine Life	0	0	N/A	N/A	0	N/A
Impacts on Submerged Aquatic Vegetation	2	2	N/A	N/A	3	N/A
Impacts on Other Sensitive Marine Areas	0	0	N/A	N/A	3	N/A
Visual Impacts	0	0	N/A	N/A	2	N/A
Disturbances of Coastal Uses	1	2	N/A	N/A	2	N/A
Impacts on Coastal Wetlands	0	0	N/A	N/A	3	N/A
Other Environmental Issues	0	0	N/A	N/A	2	N/A
Total Impact Score	**3**	**4**	N/A	N/A	**15**	N/A
Off-shore, Open Intake			N/A	N/A		N/A
Impingement of Marine Life	2	2	N/A	N/A	3	N/A
Entrainment of Marine Life	2	2	N/A	N/A	3	N/A
Impacts on Submerged Aquatic Vegetation	2	2	N/A	N/A	3	N/A
Impacts on Other Sensitive Marine Areas	0	0	N/A	N/A	3	N/A
Visual Impacts	0	0	N/A	N/A	2	N/A
Disturbances of Coastal Uses	1	2	N/A	N/A	2	N/A
Impacts on Coastal Wetlands	0	0	N/A	N/A	3	N/A
Other Environmental Issues	0	0	N/A	N/A	2	N/A
Total Impact Score	**7**	**8**	N/A	N/A	**21**	N/A
On-shore, Open Intake	N/A	N/A			N/A	
Impingement of Marine Life	N/A	N/A	3	3	N/A	3
Entrainment of Marine Life	N/A	N/A	3	3	N/A	3
Impacts on Submerged Aquatic Vegetation	N/A	N/A	1	1	N/A	3
Impacts on Other Sensitive Marine Areas	N/A	N/A	0	0	N/A	3
Visual Impacts	N/A	N/A	2	2	N/A	3
Disturbances of Coastal Uses	N/A	N/A	0	1	N/A	3
Impacts on Coastal Wetlands	N/A	N/A	2	2	N/A	3
Other Environmental Issues	N/A	N/A	0	0	N/A	2
Total Impact Score	N/A	N/A	**11**	**12**	N/A	**23**

Impact Factor:	Recommendation Key (based on the impact factor scores)
0 - No Impact	Preferred
1 - Minimal Impact	Alternative
2 - Moderate Impact	Least Favorable
3 - Severe Impact	Not Applicable

Table 2. ***Preliminary list of fish and invertebrates that could potentially be impacted by local intake systems. Further study is needed before a site specific list can be created.***

Fish		**Crustaceans**	
Common Name	**Scientific Name**	**Common Name**	**Scientific Name**
American Halfbeak	*Hyporhamphus meeki*	Blue Crab	*Callinectes sapidus*
Atlantic Brief Squid	*Lolliguncula brevis*	Gulf Crab	*Callinectes similis*
Atlantic Bumper	*Chloroscombrus chrysurus*	Brown Shrimp	*Farfantepenaeus aztecus*
Atlantic Croaker	*Micropogonias undulatas*	Pink Shrimp	*Farfantepenaeus duorarum*
Bay Anchovy	*Anchoa mitchilli*	White Shrimp	*Litopenaeus setiferus*
Black Drum	*Pogonias cromis*	Cleaner Shrimp	*Hippolytidae*
Blue Fish	*Pomatomus saltatrix*	Grass Shrimp	*Palaemonidae*
Code Goby	*Gobiosoma robustum*	Mysid Shrimp	*Mysidae*
Darter Goby	*Ctenogobius boleosoma*		
Feather Blenny	*Hypsoblennius hentz*		
Green Goby	*Microgobius thalassinus*		
Gulf Flounder	*Paralichthys albigutta*		
Gulf Menhaden	*Brevoortia patronus*		
Hogchoaker	*Trinectes maculatas*		
Inshore Lizardfish	*Synodus foetens*		
Ladyfish	*Elops saurus*		
Lizardfish	*Synodontidae sp.*		
Naked Goby	*Gobiosoma bosc*		
Pinfish	*Lagodon rhomboides*		
Pipefish	*Syngnathidae sp.*		
Puffer Fish	*Tetradontidae sp.*		
Red Drum	*Sciaenops ocellatus*		
Sand Seatrout	*Cynoscion arenarius*		
Sea Robin	*Triglidae sp.*		
Shrimp eel	*Ophichthus gomesii*		
Silver Perch	*Bairdiella chrysoura*		
Silversides	*Menidia sp.*		
Skilletfish	*Gobiesox strumosus*		
Southern Flounder	*Paralichthys lethostigma*		
Spot Croaker	*Leiostomus xanthurus*		
Spotfin Mojarra	*Eucinostomus argenteus*		
Spotted Seatrout	*Cynoscion nebulosus*		
Striped Mullet	*Mugil cephalus*		
Stripped Burrfish	*Chilomycterus schoepfi*		
Tarpon	*Megalops atlanticus*		

Table 3. ***Marine species list of bottom dwellers for Corpus Christi Bay. Adapted from Table 12 of Sediment Quality Assessment of Storm Water Outfalls and other Selected Sites in the Corpus Christi Bay National Estuary Program Study Area. Corpus Christi Bay National Estuary Program - CCBNEP-32, September 1998.***

Phylu	**Class/Order**	Species
Anthozoa		unidentified Anthozoans
Turbellaria		unidentified Turbellaria
Nermertinea		*Phoronis architecta*
Mollusca	Gastropoda	*Acteocina canaliculata*
		Cyclinella tenuis
		Crepidula sp
		Crepidula plana
		unidentified Vitrinellidae
		Caecum pulchellum
		Nassarius acutus
		Nassarius vibex
		Anachis obesa
		Pyrgiscus sp.
	Pelecypoda	unidentified Pelecypoda
		Nuculana acuta
		Aligena texasiana
		Mysella planulata
		Mulinia lateralis
		Abra aequalis
		Cumingia tellinoides
		Tagelus divisus
		Anomalocardia auberiana
		Chione cancellata
		Lyonsia hyalina floridana
		Periploma margaritaceum
Annelida	Polychaeta	*Malmgreniella taylori*
		Paleanotus heteroseta
		Paramphinome jeffreysii
		Mystides rarica
		Eteone heteropoda
		Cabira incerta
		Ancistrosyllis groenlandica
		Sigambra sp.
		Gyptis vittata
		Microphthalmus abberrans
		Syllis cornuta
		Exogone sp.
		Brania clavata
		Sphaerosyllis sp. A

Phylu	**Class/Order**	Species
Annelida	Polychaeta	unidentified Syllidae
Annelida	Polychaeta	*Ceratonereis irritabilis*
		Laeonereis culveri
		unidentified Nereidae
		Glycinde solitaria
		Lysidice ninetta
		Diopatra cuprea
		Onuphis eremita
		Lumbrineris parvapedata
		Drilonereis magna
		Schistomeringos rudolphi
		Schistomeringos sp. A
		Polydora ligni
		Paraprionospio pinnata
		Apoprionospio pygmaea
		Prionospio heterobranchia
		Scolelepis texana
		Spiophanes bombyx
		Spio pettiboneae
		Polydora socialis
		Streblospio benedicti
		Polydora caulleryi
		Polydora sp.
		Magelona pettiboneae
		Magelona phyllisae
		Magelona rosea
		Spiochaetopterus costarum
		Tharyx setigera
		Cossura delta
		Haploscoloplos foliosus
		Scolopus rubra
		Haploscoloplos sp.
		Naineris sp. A
		Aricidea fragilis
		Cirrophorus lyra
		Aricidea catharinae
		Paraonis fulgens
		Armandia agilis
		Armandia maculata
		Capitella capitata
		Notomastus latericeus
		Notomastus cf. latericeus

Phylu	**Class/Order**	Species
Annelida	Polychaeta	*Mediomastus ambiseta*
		unidentified Capitellidae
Annelida	Polychaeta	*Branchioasychis americana*
		Clymenella torquata
		Asychis elongata
		Euclymene sp. B
		Axiothella mucosa
		Axiothells sp. A
		unidentified Maldanidae
		Isolda pulchella
		Melinna maculata
		unidentified Terebellidae
		Fabricia sp. A
		Chone sp.
		Megalomma bioculatum
		Pomatoceros americanus
		Eupomatus dianthus
		Eupomatus protulicola
Oligochaeta		unidentified Oligochaetes
Sipuncula		*Phascolion strombi*
Crustacea	Branchiopoda	*Latonopsis occidentalis*
	Ostracoda	*Sarsiella texana*
		Sarsiella zostericola
	Copepoda	*Pseudodiaptomus coronatus*
	Branchiura	*Argissa hamatipes*
	Malacostraca	*Pagurus annulipes*
		Pagurus longicarpus
		Pinnixa sp.
		Megalops
	Cumacea	*Leptocuma* sp.
	Amphipoda	unidentified Amphipoda
		Ampelisca sp. B
		Ampelisca abdita
		Synchelidium americanum
		Erichthonias brasiliensis
		Corophium ascherusicum
		Corophium louisianum
		Microprotopus sp.
		Grandidierella bonnieroides
		Batea catharinensis
		Listriella clymenellae
		Caprellidae sp.

Phylu	**Class/Order**	Species
	Amphipoda	*Amphilochus* sp.
Crustacea	Isopoda	*Xenanthura brevitelson*
		Idotea montosa
Crustacea	Tanaidacea	*Leptochelia rapax*
Echinodermata	Ophiuroidea	unidentified Ophiuroidea
	Holothuroidea	*Thyome mexicana*
Chordata	Urochordata	unidentified Ascidiacea
	Hemichordata	*Schizocardium* sp.

Table 4. Selected references for salinity effects on estuarine macrobenthic and epibenthic organisms.

Authors	**Organism(s) Studied**	**Study Location**	**Salinity Tolerance Results**
Chadwick & Feminella (2001)	Burrowing mayfly *Hexagenia limbata*	USA (Alabama)	Laboratory bioassays showed that *H. limbata* nymphs could survive elevated salinities (LC50 of 6.3 ppt at 18 °C, 2.4 ppt at 28 °C). Similar growth rates at 0,2,4, & 8 ppt.
Saoud & Davis (2003)	Juvenile brown shrimp *Farfantepenaeus aztecus*	USA (Alabama)	Growth significantly higher at salinities of 8 & 12 ppt than at salinities of 2 and 4 ppt.
Tolley et al. (2006)	Oyster reef communities of decapod crustaceans & fish	USA (Florida)	Upper stations (~20 ppt) and stations near high-flow tributaries (6-12 $m^3 s^{-1}$) were typified by decapod *Eurypanopeus depressus* & gobiid fishes. Downstream stations (~30 ppt) and stations near low-flow tributaries (0.2-2 $m^3 s^{-1}$) were typified by decapods *E*
Montagna et al. (2008a)	Southwest Florida mollusc communities	USA (Florida)	*Corbicula fluminea*, *Rangia cuneata*, & *Neritina usnea* only species to occur < 1 psu. *R. cuneata* good indicator of mesohaline salinity zones with tolerence to 20 psu. Gastropod *N. usnea* common in fresh to brackish salinities. *Polymesoda caroliniana*
Montague & Ley (1993)	Submersed vegetation & benthic animals	USA (Florida)	Mean salinity ranged from ~11-31 ppt. Standard deviation of salinity was best environmental correlate of mean plant biomass and benthic animal diversity. Less biota at stations with greater fluctuations in salinity. For every 3 ppt increase in standard

Authors	**Organism(s) Studied**	**Study Location**	**Salinity Tolerance Results**
Rozas et al. (2005)	Estuarine macrobenthic community	USA (Louisiana)	Increased density and biomass with increases in freshwater inflow and reduced salinities. Salinity ranged from 1-13 psu.
Finney (1979)	Harpacticoid copepods *Tigriopus japonicus*, *Tachidius brevicornis*, *Tisbe sp.*	USA (Maryland)	All species tested for response to salinities from 0-210 ppt. *Tigriopus* became dormant at 90 ppt died at 150 ppt. *Tachidius* became dormant at 60 ppt, died at 150 ppt. *Tisbe* died shortly after exposure to 45 ppt.
Kalke & Montagna (1991)	Estuarine macrobenthic community	USA (Texas)	Chironomid larvae & polychaete *Hobsonia florida*: increased densities after freshwater inflow event (1-5 ppt). Mollusks *Mulinia lateralis & Macoma mitchelli:* increased densities & abundance during low flow event (~20 ppt). *Streblospio benedicti* & *Medioma*
Keiser & Aldrich (1973)	Postlarval brown shrimp *Penaeus aztecus*	USA (Texas)	Shrimp selected for salinities between 5-20 ppt.
Montagna et al. (2002b)	Estuarine macrobenthic community	USA (Texas)	Macrofauna increased abundances, biomass & diversity with increased inflow; decreased during hypersaline conditions. Macrofaunal biomass & diversity had nonlinear bell-shaped relationship with salinity: maximum biomass at ~19 ppt
Zein-Eldin (1963)	Postlarval brown shrimp	USA (Texas)	In laboratory experiments with temperatures 24.5-26.0 °C, postlarvae grew equally well in salinities of 2-40 ppt.

Authors	**Organism(s) Studied**	**Study Location**	**Salinity Tolerance Results**
	Penaeus aztecus		
Zein-Eldin & Aldrich (1965)	Postlarval brown shrimp *Penaeus aztecus*	USA (Texas)	In laboratory experiments with temperatures < 15 °C, postlarval survivial decreased in salinities < 5 ppt.
Allan et al. (2006)	Caridean shrimp *Palaemon peringueyi*	South Africa	At constant salinity of 35 ppt, respiration rate increased with increased temperature. At constant temperature of 15 °C, respiration rate increased with increased salinity.
Ferraris et al. (1994)	Snapping shrimp *Alpheus viridari*, Polychaete *Terebellides parva*, sipunculan *Golfingia cylindrata*	Belize	Organisms subjected to acute, repeated exposure to 25, 35, or 45 ppt. *A. viridari* hyperosmotic conformer at decreased salinity, but osmoconformer at increased saliniry. *G. cylindrata* always osmoconformer. *T. parva* always osmoconformer; decreased survival.
Lercari et al. (2002)	Sandy beach macrobenthic community	Uruguay	Abundance, biomass, species richness, diversity & evenness significantly increased from salinity of ~6 ppt to salinity of ~25 ppt.
Chollett & Bone (2007)	Estuarine macrobenthic community	Venezuela	Immediately after heavy rainfall (~25 psu), spionid polychaetes showed large increases in density & richness versus normal values (~41 psu).

Authors	**Organism(s) Studied**	**Study Location**	**Salinity Tolerance Results**
Dahms (1990)	Harpacticoid copepod *Paramphiascel la fulvofasciata*	Germany (Helgoland)	After 2 hours, no mortality in salinities of 25-55 ppt. Almost all displayed dormant behavior < 20 ppt and > 55 ppt.
McLeod & Wing (2008)	Bivalves *Austrovenus stutchburyi* & *Paphies australis*	New Zealand	Sustained exposure (> 30 d) to salinity < 10 ppt significantly decreased survivorship.
Rutger & Wing (2006)	Esturaine macroinfaunal community	New Zealand	Infaunal community in low salinity regions (2-4 ppt) showed low species richness & abundance of bivalves, decapods, & Orbiniid polychaetes, but high abundance of amphipods & Nereid polychaetes compared to higher salinity regions (12-32 ppt).
Drake et al. (2002)	Estuarine macrobenthic community	Spain	Species richness, abundance, and biomass decreased in the upstream direction, positively correlated with salinity. Highly significant spatial variation in macrofaunal communities along the salinity gradient. Salinity range: 0-40 ppt.
Normant & Lamprecht (2006)	Benthic amphipod *Gammarus oceanicus*	Baltic Sea	Low salinity basin (5-7 psu). Physiological performance examined from 5-30 psu. Feeding & metabolic rates decreased with increasing salinity; nutritive absorption increased. Faeces productoin & ammonia excretion rates decreased strongly from lowest to

Table 5. Discharge matrix

Discharge Matrix	Site 3A Mustang or Padre Islands	Site 1B CC Turning Basin, Inner Harbor	Site 4A Tule Lake Turning Basin	Site 1A CC Bay by CC Harbor	Site 2A SW of La Quinta Channel
Surface Open Discharge Drainage Ditch					
Marine Species in Estimated Mixing Zone	N/A	N/A	N/A		N/A
Organisms in Water Column	N/A	N/A	N/A	1	N/A
Bottom Dwellers	N/A	N/A	N/A	1	N/A
Endangered Species	N/A	N/A	N/A	0	N/A
Salinity Tolerance of Identified Organisms in Mixing Zone	N/A	N/A	N/A	2	N/A
Target Acceptable Discharge Salinity	N/A	N/A	N/A	3	N/A
Mixing of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	N/A	2	N/A
Ion Imbalance of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	N/A	2	N/A
Toxicity of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	N/A	3	N/A
Estimate Maximum Velocity at Edge of Mixing Zone, Safe to Aquatic Life	N/A	N/A	N/A	1	N/A
Other Environmental Issues	N/A	N/A	N/A	2	N/A
Total Impact Score	N/A	N/A	N/A	17	N/A
Off-shore, Submerged Pipe Discharge					
Marine Species in Estimated Mixing Zone			N/A	N/A	
Organisms in Water Column	0	1	N/A	N/A	3
Bottom Dwellers	1	1	N/A	N/A	3
Endangered Species	0	0	N/A	N/A	1
Salinity Tolerance of Identified Organisms in Mixing Zone	1	1	N/A	N/A	3
Target Acceptable Discharge Salinity	1	1	N/A	N/A	3
Mixing of Brine Concentrate and Ambient Seawater Mixing Issues	0	2	N/A	N/A	3
Ion Imbalance of Brine Concentrate and Ambient Seawater Mixing Issues	0	1	N/A	N/A	3
Toxicity of Brine Concentrate and Ambient Seawater Mixing Issues	1	2	N/A	N/A	3
Estimate Maximum Velocity at Edge of Mixing Zone, Safe to Aquatic Life	0	1	N/A	N/A	2
Other Environmental Issues	1	1	N/A	N/A	3
Total Impact Score	5	11	N/A	N/A	27
Impact Factor:			Recommendation Key (based on the impact factor scores)		
0 - No Impact			Preferred		
1 - Minimal Impact			Alternative		
2 - Moderate Impact			Least Favorable		
3 - Severe Impact			Not Applicable		

Table 5 (cont). Discharge matrix

Discharge Matrix		Site 3A Mustang or Padre Islands	Site 1B CC Turning Basin, Inner Harbor	Site 4A Tule Lake Turning Basin	Site 1A CC Bay by CC Harbor	Site 2A SW of La Quinta Channel
Off-shore, Submerged Jet Diffusers Discharge						
	Marine Species in Estimated Mixing Zone			N/A	N/A	
	Organisms in Water Column	0	1	N/A	N/A	3
	Bottom Dwellers	1	1	N/A	N/A	3
	Endangered Species	0	0	N/A	N/A	1
	Salinity Tolerance of Identified Organisms in Mixing Zone	1	1	N/A	N/A	3
	Target Acceptable Discharge Salinity	1	1	N/A	N/A	3
	Mixing of Brine Concentrate and Ambient Seawater Mixing Issues	0	2	N/A	N/A	3
	Ion Imbalance of Brine Concentrate and Ambient Seawater Mixing Issues	0	1	N/A	N/A	3
	Toxicity of Brine Concentrate and Ambient Seawater Mixing Issues	1	2	N/A	N/A	3
	Estimate Maximum Velocity at Edge of Mixing Zone, Safe to Aquatic Life	0	1	N/A	N/A	2
	Other Environmental Issues	1	1	N/A	N/A	3
	Total Impact Score	5	11	N/A	N/A	27
Surface Open Discharge Pipe						
	Marine Species in Estimated Mixing Zone	N/A	N/A		N/A	N/A
	Organisms in Water Column	N/A	N/A	1	N/A	N/A
	Bottom Dwellers	N/A	N/A	1	N/A	N/A
	Endangered Species	N/A	N/A	0	N/A	N/A
	Salinity Tolerance of Identified Organisms in Mixing Zone	N/A	N/A	2	N/A	N/A
	Target Acceptable Discharge Salinity	N/A	N/A	2	N/A	N/A
	Mixing of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	3	N/A	N/A
	Ion Imbalance of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	2	N/A	N/A
	Toxicity of Brine Concentrate and Ambient Seawater Mixing Issues	N/A	N/A	3	N/A	N/A
	Estimate Maximum Velocity at Edge of Mixing Zone, Safe to Aquatic Life	N/A	N/A	2	N/A	N/A
	Other Environmental Issues	N/A	N/A	1	N/A	N/A
	Total Impact Score	N/A	N/A	17	N/A	N/A
	Impact Factor:				Recommendation Key (based on the impact factor scores)	
	0 - No Impact				Preferred	
	1 - Minimal Impact				Alternative	
	2 - Moderate Impact				Least Favorable	
	3 - Severe Impact				Not Applicable	