EXHIBIT 16

Development of a "dead zone" from the proposed Inner Harbor desalination outfall

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The City of Corpus Christi's permit application, CORMIX modeling, and the subsequent response to the TCEQ RFI do not, as a matter of science, provide confidence that the planned installation of the Inner Harbor desalination plant will be protective of water quality and ecosystem health. Specifically, the best state-of-the science indicates that the proposed desalination outfall will create a persistent vertical salinity gradient in both the Inner Harbor (IH) and the Corpus Christi Bay Ship Channel (SC). This vertical salinity gradient will inhibit replenishment of dissolved oxygen to the bottom waters, creating a hypoxic (low oxygen) "dead" zone along the bottom of the IH and SC, and possibly in Nueces Bay. The RFI specifically asked the applicant to consider "salinity gradients," but the approach presented in the response to the RFI used global mass balance arguments (i.e., total increase in salinity), which are irrelevant in the creation of local salinity gradients. Such local salinity gradients (i) can be produced with only small local salinity differences, and (ii) their persistence can cause hypoxia (low dissolved oxygen). The applicant does *not* address salinity gradients in any substantive form for the IH, the SC, or potential impacts to Nueces Bay.

Three key concepts are needed to understand the fate and impact of desalination brine effluent in the "far field" --- i.e., beyond the near-field mixing of the diffuser and plume that are modeled by CORMIX:

1. Higher salinity water (i.e., the far-field effluent) is heavier and forms a layer beneath lighter lower salinity water unless energy is applied for mixing. We call such layers "stratification."
2. Stratified water does not have a transport path from the surface to the bottom unless mixing energy is applied to raise heavier water up and stir it with the lighter water. The existence of stratification is sufficient evidence that the mixing energy is not connecting the surface and bottom waters.
3. Only water at the surface can obtain oxygen from the atmosphere; for bottom waters that are not mixed up to the surface, dissolved oxygen (DO) will slowly decline due to Sediment Oxygen Demand (SOD) of biological processes along the bottom. Thus, persistent stratification that isolates bottom waters leads to persistent low DO, i.e., "hypoxia."

In general, hypoxia occurs when the wind and tidal current mixing energy cannot keep up with the rate at which the effluent inflow reinforces salinity gradients. This idea can be understood by a cartoon of the evolution of an effluent plume in a typical desalination design with an offshore outfall, as shown in Figure 1 on the next page, and as explained below.

After near-field mixing by a well-sited outfall diffuser, the effluent plume (as in Fig. 1) flows downhill along a sloped bottom so that the plume velocity (inertia) creates mixing energy within the plume and *entrains* lighter water (i.e., pulls in and mixes lighter ambient water with the heavier water of the plume). This is the "inertial far field" in Fig. 1. The entrainment of lighter ambient water weakens the plume (reduces its salinity), increases its thickness, and reduces its velocity. *Entrainment* provides DO renewal to the plume water, which can prevent or limit

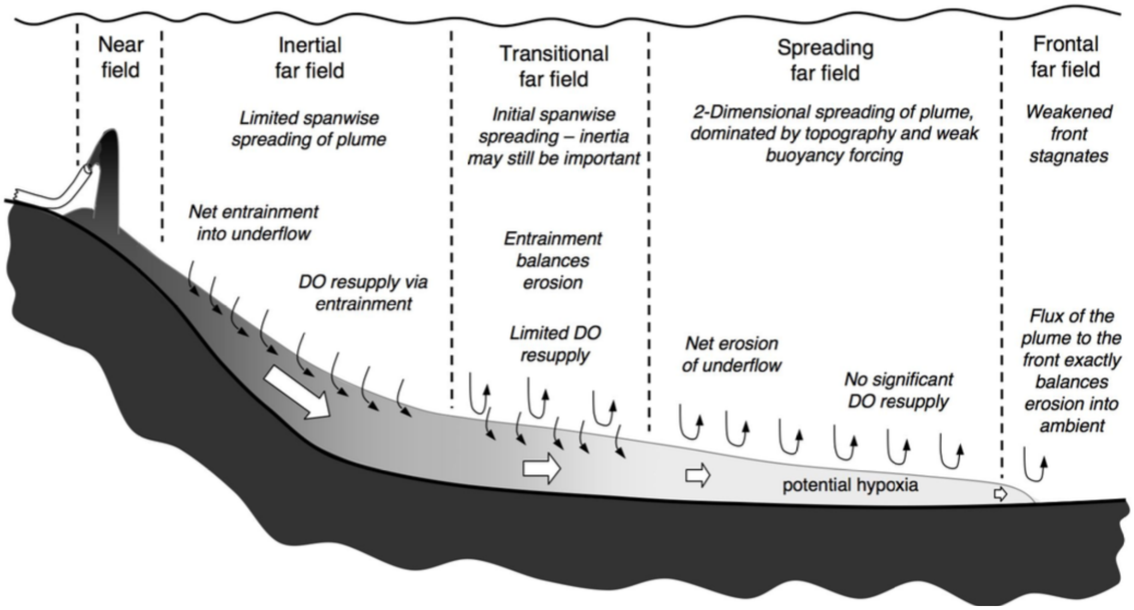

Figure 1: Effluent plume evolution in the far field for offshore brine disposal (from Hodges, 2010).

development of hypoxia. If the plume reaches a flatter region along the bottom it spreads out horizontally, becoming thinner and slower. However, in this "spreading far field" the velocity of the plume *cannot* generate sufficient mixing energy to entrain ambient water, which means the DO in the plume cannot be renewed and its salinity cannot be further reduced. The eventual destruction of the plume occurs as the mixing energy from the waters above (e.g., wind, waves, currents) progressively *erodes* the plume --- thinning it until it disappears. The difference between *entrainment* (in the inertial region) and *erosion* (in the spreading region) is critical --- entrainment directly reduces salinity and *increases* DO in the plume, whereas erosion is simply scraping away successive layers of the plume *without reducing the salinity or resupplying the DO in the remaining plume*. Thus, in the spreading region the bottom SOD will continue to consume DO in the plume without renewal. Once the DO levels in the plume drop below the hypoxic threshold, hypoxia will persist until the plume is completely dissipated.

In general, a well-sited outfall is one where the time-of-travel for the effluent in the spreading region is sufficiently small such that the SOD cannot deplete the effluent DO before it reaches the plume frontal far field in Fig. 1. If the ambient mixing energy is low the time-of-travel must be short to prevent hypoxia. In Corpus Christi Bay the best science indicates the time interval to create hypoxia in a spreading plume can be as low as 24 hours (Hodges, 2010; Hodges et al., 2011). Note that well-designed *offshore* diffusers (i.e., outside a bay, as in Fig. 1) can be ideally sited such that the plume dissipates on the slopes of the inertial far field while DO resupply is still present, making hypoxia less likely.

The challenge for effluent disposal in the Inner Harbor is that the inertial and transitional far-field regions of Fig. 1 do not exist; i.e., the near-field mixing connects directly to a spreading far field, as shown in Fig. 2. This spreading far field transports the stratified effluent plume inward into the IH and outward into the SC. Given the breadth and depth of the IH and SC, along

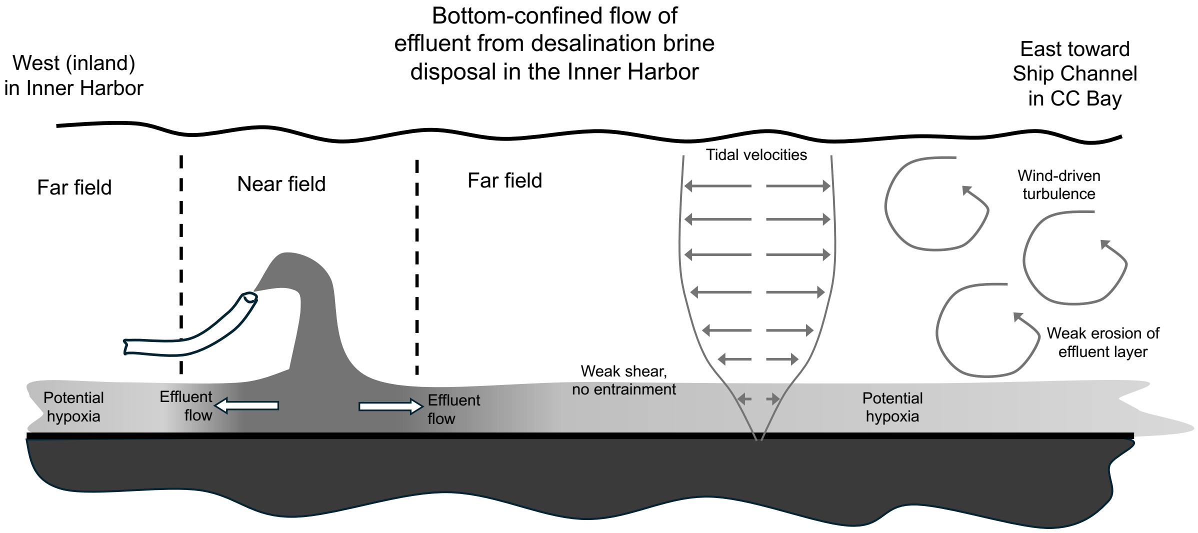

Figure 2: Near and far field effluent plumes for the Inner Harbor brine outfall.

with the effluent plume salinity at the edge of near field mixing, it can be shown that (i) the velocity of the plume will be small, and (ii) the plume velocity *cannot* generate mixing energy for substantial entrainment. Thus, after the near-field mixing the plume salinity will *not* be significantly reduced and the plume DO will *not* be significantly renewed. Whether or not hypoxia develops depends upon (i) the SOD rate consuming DO, and (ii) the rate at which tidal velocities and wind can erode (destroy) the plume and limit its horizontal extent.

Computations based on the approach in Hodges et al., (2011) indicate that shear velocities (i.e., the vertical gradients of horizontal velocity) from tidal currents are too small to create entrainment mixing[1]. Furthermore, even with steady winds of 20+ mph, the erosion time for the plume will be 3-30 days (depending on the initial plume thickness). To re-emphasize, isolation times of 24 hours can cause hypoxia in Corpus Christi Bay (Hodges, 2010; Hodges et al 2011). Thus, the best available science indicates that the proposed IH desalination outfall will lead to persistent hypoxia in the IH and SC.

The fundamental problem is that the proposed outfall siting is in a relatively flat location (IH) with little ambient mixing energy. The complete destruction of the far-field effluent plume will require days to weeks under most conditions. Any portion of the channel bottom that is isolated by the plume for more than 24 hours is likely to become hypoxic. Thus, the far-field effluent plume within the IH and SC will constitute a large dead zone.

The above conclusions are based on the best available science using known process scales[2] to evaluate outcomes. To improve upon this science requires a detailed multi-dimensional computer model that captures vertical mixing physics and stratification, including wind, waves,

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[1] The technical argument is that the Richardson Number is much greater than 1/4 so mixing is suppressed by the potential energy gradient of the stratification.

[2] For example, the energy generated at a given wind speed, energy required for mixing based on density gradients. The process scales and computation methods are provided in Hodges (2010) and Hodges et al (2011).

and velocity shear that energize both entrainment and erosion[3]. Such a model should be validated against a real-world plume (e.g., the high salinity outflow from Oso Bay, as studied in Hodges et al., 2011). Importantly, the computer model must have sufficiently fine grid resolution in the vertical dimension to correctly capture entrainment and erosion[4]. The driving boundary conditions for the computer model are the vertical salinity gradient and mixed effluent flow at the edge of the near field, which are functions of the effluent production rate and near-field mixing[5].

Based on the best available science, the following facts are beyond dispute:

1. ***Far-field evolution of the effluent plume and possible development of a hypoxic dead zone depends on the effluent transport rate, the vertical salinity gradient, and the wind/current mixing energy from the ambient water that progressively erodes the plume.***
2. ***The overall mass balance of the broader bay (as presented by the applicant in answer to the RFI on salinity gradient issues) is entirely irrelevant to development of salinity gradients and their dead-zone consequences.***
3. ***From the two points above, the applicant has not provided sufficient evidence that the proposed outfall location is protective of ecosystem health.***

Furthermore, as a matter of expert opinion based on the information I have reviewed, I doubt that there is any configuration of diffusers and outfall placement in the Inner Harbor that can avoid development of a far-field stratified effluent plume, hypoxia, and ecosystem harm to the IH and SC. The lack of an inertial far-field mixing regime at this location renders this location inappropriate for the applicant's proposal.

Citations (available on request):

Hodges, B.R., (2010) "The importance of mixing and isolation time for desalination brine discharge," *Proceedings of the International Engineering Conference on Hot Arid Regions*, pp. 235-240, Al-Ahsa Kingdom of Saudi Arabia, Mar. 1-2, 2010.

Hodges, B.R, J.E. Furnans, and P.S. Kulis, (2011). "Case Study: A thin-layer gravity current with implications for desalination brine disposal," *ASCE Journal of Hydraulic Engineering*, 137(3):356-371, Mar. 2011. http://doi.org/10.1061/(ASCE)HY.1943-7900.0000310

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[3] The QUAL-TX model does not meet this standard. The QUAL-TX model is a one-dimensional model that represents processes along the length of a river or channel and cannot represent the vertical compartmentalization of processes that occur with stratification.

[4] At the outfall, the effluent plume itself must be resolved with 15-20 grid cells in the vertical. As the plume erodes, at least 5 or more vertical grid cells should be maintained over the entire plume length. Furthermore, the modeler must conduct a grid resolution study to ensure that numerical diffusion (model error) is not dominating the turbulent mixing model. These steps are required because modeling without sufficient vertical grid resolution will lead to an error known as "numerical diffusion" that causes artificial mixing and dissipation of the plume. Such numerical diffusion will cause hypoxic areas to be underestimated.

[5] This boundary condition *might b*e computable by a model such as CORMIX --- if properly configured (CORMIX experts should weigh in on this issue).

Permit Documents reviewed:

- 2022.12.01 RFI.pdf
- 2023.04.10 RFI Response.pdf
- 2023.05.08 Revision to RFI Response.pdf
- 2023.10.16 Diffuser Review Memo.pdf
- 2023.10.18 Critical Conditions Memo.pdf
- 2023.10.18 Modeling Memo.pdf
- 2023.11.07 Standards Memo.pdf
- Discharge - Inner Harbor - Draft Permit and ED Decision.pdf
- Discharge - Inner Harbor - Updated 11.29.21 Permit Application.pdf
- Inner_Harbor_along_channel_velocities_20210207_0638.xlsx
- InnerHarbor_CORMIX_Modeling_Technical_Memorandum.pdf