Technical Report 0694

Management of Brine Discharges to Coastal Waters Recommendations of a Science Advisory Panel – Prepared for the State Water Resources Control Board

Scott Jenkins, Jeffrey Paduan, Philip Roberts, Daniel Schlenk and Judith Weis

EXECUTIVE SUMMARY

A panel of five experts in diverse fields related to brine disposal in the ocean was convened to advise the State Water Resources Control Board on best practices for brine disposal in support of the development of an amendment to the Ocean Plan. The brine concentrates can result from desalination of brackish groundwater, recycling domestic wastewater, and especially desalination of seawater. The potential of seawater desalination to provide potable water in the state is growing rapidly, with many plants currently proposed or in the planning stage. The state presently has no regulations on brine discharges and each plant is considered on a case-by-case basis.

The panel reviewed extensive material, including peer-reviewed journal articles, articles in the gray literature, NPDES permits that have been issued, various regulations from around the world, and results of monitoring studies, and heard presentations about experience with operating discharges.

From these reviews it is apparent that concentrate can be disposed of with minimal environmental effects if properly executed. Desirable methods of discharge include co-disposal with heated cooling water from power plants or domestic wastewater, or from a multiport diffuser if "pure" brine is released. Discharges with rapid initial dilution into areas of good flushing result in impacts that extend only a few tens of meters from the discharge. Conversely, poorly implemented disposal schemes with low initial dilution in poorly flushed areas can cause widespread alterations of community structure in seagrass, coral reef, and soft-sediment systems.

Extensive literature on the toxic effects of concentrates was reviewed. The effects (or lack thereof) of desalination concentrate vary widely, depending on the organism, site, the biotic community at the site, the nature of the concentrate, and to what degree it is dispersed. It appears that benthic infaunal communities and sea grasses are the most sensitive; some communities seem to be tolerant of effects of up to 10 psu increases, while others are affected by increases of only 2-3 psu. None of the studies reviewed indicated any impacts of elevated salinity levels less than 2-3 psu. It should be noted, however, that very few peer-reviewed studies have evaluated sublethal effects of desalination discharges either in the laboratory or in the field. It should also be noted that few studies have evaluated "worst-case" embayment scenarios and chronic impacts on demersal vertebrates, particularly those which have significant life history behaviors (i.e., reproduction, migration) driven by salinity variations. For example, embayments with limited flushing may have thresholds lower in anadromous fish such as salmonids or estuarine demersal flatfish, which undergo saltwater acclimation and significant endocrine alterations. Additional and long-term studies are needed on sublethal endpoints such as reproduction and on different types of concentrates and mixtures with antiscalants and other chemicals associated with RO.

We also reviewed regulations and standards that have been applied around the world. These range from salinity increments within 1 ppt, 5%, or absolute levels such as 40 ppt. These limits typically apply at the boundary of a mixing zone whose dimensions are of order 50 to 300 m around the discharge.

Because discharges can be designed to result in rapid initial dilution around the discharge, we recommend that they be regulated by a mixing zone approach wherein the water quality regulations are met at the mixing zone boundary. The mixing zone should encompass the near field processes, defined as those influenced hydrodynamically by the discharge itself. These processes typically occur within a few tens of meters from the discharge, therefore we conservatively recommend that the mixing zone extend 100 m from the discharge structure in all directions and over the whole water column.

Based on the studies of effects of brine discharges we recommend an incremental salinity limit at the mixing zone boundary of no more than 5% of that occurring naturally in the waters around the discharge. Expressing the limit as a percentage increase allows for natural variability in the background waters. For most California open coastal waters this increment will be about 1.7 ppt; for a typical seawater desalination plant where the brine is concentrated by a factor of roughly two times, this corresponds to a dilution of about 20:1, which should be readily achievable. The dilution is the combination of in-pipe dilution in the case of co-discharges, and near field mixing. In addition to the salinity requirement, the discharge should meet toxicity and other requirements in the Ocean Plan at the edge of the mixing zone.

Co-discharges with power plant cooling water or domestic effluent can be positively buoyant, i.e. less dense than the receiving water. In that case, the regulatory framework of the Ocean Plan should be sufficient for protection of beneficial uses. Near field models should be re-run, however, to account for the increase in effluent density and flow rates on plume behavior.

The preferred methods of discharge are from a multiport diffuser for “raw” effluents, or co-disposal with power plant cooling water or domestic wastewater that results in significant in-pipe dilution. These discharges can be either a shoreline surface discharge (if positively buoyant) or through an existing multiport diffuser. Shoreline discharge of raw effluent is discouraged due to slow near field mixing and potentially high exposures of benthic organisms to elevated salinity.

In computing near field dilutions of negatively buoyant discharges from diffusers, conservative assumptions should be applied: that ocean currents do not increase dilution, and the seabed is flat and horizontal. To account for possible reductions in dilution in areas of poor flushing, estimates of overall flushing of the discharge site should be made to ensure that the dilution requirement at the edge of the mixing zone is still met.

No specific mathematical models are endorsed, but it is recommended that calculations be made using either tested semi-empirical equations available in the literature or by integral mathematical models based on entrainment assumptions. Mathematical models should be validated, and attention should be made to special conditions that occur with typical negatively buoyant discharges such as reduction in dilution due to Coanda effects and jet merging in the case of multiport diffusers.

Because of uncertainties in plume modeling and predicting the biological effects of the discharges, a field monitoring program should be used. Monitoring should include pre-discharge conditions and continue after discharge has begun to evaluate changes in the ecosystem. We recommend that the receiving water monitoring programs be based on Before-After Control-Impact (BACI) monitoring that includes multiple reference locations, samples at various distances from the discharge, and repeated sampling over time. The effluent should also be monitored for specified physical and chemical parameters.

Full Text

ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/694_BrinePanelReport.pdf