Desal on Demand

By Steven Gong & Lisa Henthorne

An environmental overview of offshore mobile seawater desalination systems

The concept of mobile seawater desalination systems presents a novel approach to delivering large volumes of desalinated water on demand. The water may be sent to onshore industrial or municipal clients for strategic contingency planning and emergency relief or to offshore oil and gas clients to meet water treatment and reuse needs (see Figure 1 on page 5).

Water Standard (WS) developed seawater desalination vessels (SDVs) as an alternative solution to challenges faced by traditional land-based water treatment plant implementation and in response to the world's ever increasing demand for water. They are designed to provide a fully integrated desalination plant on a mobile platform. The platform incorporates state-of-the-art power generating facilities, raw seawater intakes, membrane treatment facilities and proprietary concentrate disposal infrastructure.

To help address the potential environmental concerns of using a tanker-type vessel for onshore municipal and industrial clients, WS retained CH2M Hill in 2009 to perform preliminary environmental impact assessments (PEIAs) for SDV projects in Cyprus and northwestern Australia. Although SDVs can produce a wide range of water supply capacities ranging from 10,000 to 100,000 cu meters per day (cmd), the conceptual SDV evaluated during these preliminary studies was to have a potable water production capacity of 50,000 cmd. The PEIAs were prepared to address key desalination topics identified by the World Health Organization and United Nations Environmental Programme.

A synthesis report was prepared comparing the environmental impacts associated with SDVs to those normally associated with land-based desalination systems. The analysis found the SDV approach to be favorable in several areas, including source water intake, concentrate management and disposal, product water conveyance and overall project construction impacts. The PEIA findings and synthesis report included those benefits outlined in this article.

SDV Infrastructure & Environmental Concerns

Key concerns identified for an SDV included construction and operational effects of seawater intakes, product water conveyance ashore and concentrate/wastewater discharge.

Intakes. Seawater intake structures typically are designed to minimize intake of materials suspended in the water column and thereby minimize "impingement and entrainment" (I/E) impacts on aquatic organisms to the extent possible. The conceptual design plans for the subject SDV included T-screen intakes positioned near the bow of the ship's hull at approximately 8 meters below the water surface. This position is below the water surface to avoid potential intake of floating algae, surface pollutants and debris.

Fine meshed screens and low-velocity inflow pumps would be used to minimize I/E impact. Multiple intake structures would produce the desired cumulative inflow rates while achieving compliance with inflow velocity specifications currently applied to power plant cooling water intakes in the U.S. (less than 0.15 meters per second). With the hull-based intake system, there would be no construction effects on the marine environment at the deployment site. Operational effects of the intake system would be minimized through the outlined application of intake designs.

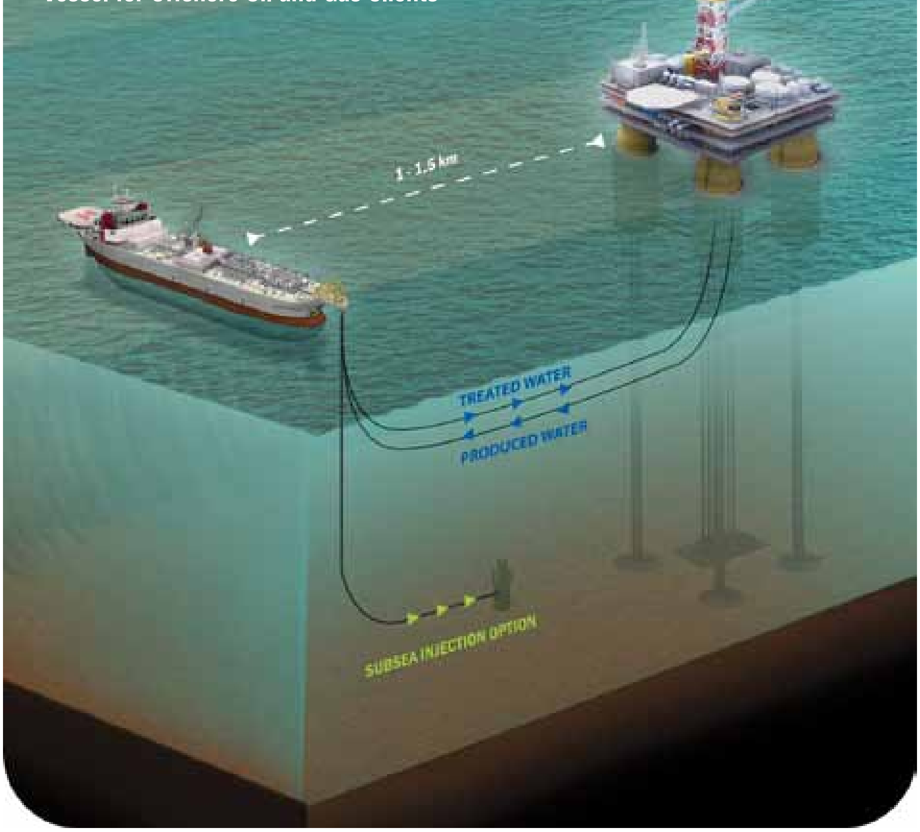
Conveyance. As envisioned for this investigation, the SDV system would require a single pipeline to convey product water ashore. For long-term services, a permanent pipeline likely would be installed below the seabed surface through standard trenching or directional drilling technologies. Alternatives for short-term water supply services might consist of flotation-provided pipeline systems. In either scenario, construction effects would be short-term and temporary. Operational effects would be similarly negligible.

Concentrate management. The key byproduct of any membrane-based desalination system is a concentrate roughly twice the salinity of the raw seawater. Discharge of this brine back to the ocean is the typical means of disposal. Pretreatment residuals represent an additional byproduct, and for an SDV these would be mixed in with the concentrate prior to discharge to the ocean. The concentrate management system on the conceptual SDV would consist of onboard wastewater storage, from which the concentrate and residuals would be pumped to the tanker stern and discharged through paired outfall pipes oriented perpendicular to the ship's axis. The discharge pipes would be located approximately 3 meters below the water surface and fitted with diffuser nozzles to increase the discharge velocity and the effectiveness of discharge dispersion into the water column.

Discharge dilution modeling was conducted on behalf of WS to support SDV discharge system design. The modeling documented that the concentrate discharge would comply with the World Bank's guidelines for salty wastewater discharges to the marine environment. In subsequent modeling evaluations, a more conservative benchmark was applied during discharge system conceptual design. Modeling results predicted that with proper design elements, the discharge system would achieve salinity levels within 3% of background concentrations within 100 meters of the point of discharge.

Concentrate discharge from the ship does not require any outfall-related construction impacts on the marine environment. With appropriate focus on outfall discharge system and diffuser design, a return to near-ambient salinity concentrations is achievable within short distances from the points of discharge. Discharge effects would be limited to a small mixing zone around the discharge pipes, and dilution should be rapid as the concentrate mixes with the water column.

Figure 1. Seawater Desalination Vessel for Offshore Oil and Gas Clients



Additional Considerations

Other environmental considerations were identified when preparing the PEIAs.

Mooring systems. In the SDV scenarios envisioned within nearshore waters, SDV project viability will require the establishment of what essentially is a permanent mooring system, allowing the ship to remain safely tethered to the water supply conveyance system carrying product water ashore. Offshore mooring systems needed would be comparable to those routinely used for temporary mooring of ships waiting offshore of port facilities prior to loading/offloading. Construction effects would be short-term and localized. Operational effects would be limited in spatial and temporal terms to periods of ship attachment and detachment from the mooring facilities.

Noise. SDV design concepts remain under refinement, but it is clear that facility operations will require continuous operation of a variety of pump systems on board the ship. The cumulative noise production from these mechanical systems coupled with onboard power generation would result in noise penetration of the ship hull into the water environment. Ship-related noise can be substantially higher in magnitude than natural sources, and the effects of that noise may affect the behaviors and/or the physiology of fish and other wildlife species. In siting an SDV project, it is important to understand the local and regional ecological systems to avoid location in strategically important migratory corridors.

Shading. Ship presence, if in a shallow coastal habitat, could result in shading effects on seabed flora and fauna. In locations where the bottom communities include sea grasses, macroalgal-dominated communities, corals or other hard-bottom systems, light penetration to the bottom is important for sustaining biological integrity. The shadow cast by the SDV could reduce light penetration to the bottom, reducing photosynthetic productivity by bottom-associated vegetation.

Localized hydrodynamics and wave energy. A ship or barge in a shallow coastal habitat represents a substantive physical presence. The potential for associated altered wave and surface current conditions exists, and it could be significant enough to cause localized changes in sediment erosion or transport along the seabed. A typical SDV draft should be approximately 10 meters, so ship presence in a shallow coastal environment could affect localized water movement and associated energy dissipation. These natural forces are important factors that native plant and animal communities are adapted to, and potential effects would warrant site-specific consideration.

A New Alternative

As looming water shortages threaten communities, agriculture and industry, new perspective is necessary. The reviews highlighted in this article support that SDVs are a viable solution to addressing water scarcity in coastal areas in need of potable or industrial water supply augmentation, as an alternative to traditional membrane-based water treatment plants on shore. SDVs could address short-term demands, such as providing interim supply while permanent onshore facilities are planned, sited, designed, permitted and constructed. They also could meet emergency needs following natural disasters or other emergency scenarios.

Several projects are under development, particularly for offshore oil and gas industry applications. Meanwhile, research and testing continue, and results are favorable for SDVs providing long-term arrangements where onshore water supply infrastructure development is not technically or economically feasible or cannot meet offshore facility needs. MT

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