INLAND FACILITY	Finance
Concentrate Management	Evaporation Ponds

Summary of Issues | Strategies | Benefits & Costs | Key Uncertainties | Additional Resources

KEY POINT: *Costs associated with concentrate disposal via evaporation ponds are typically excessive for all but the smallest plants.*

SUMMARY OF ISSUES

- Evaporation ponds are a low-technology but high-cost approach to concentrate management, where the concentrate is pumped into a shallow lined pond and allowed to evaporate naturally using solar energy.
- With little economy of scale (due to substantial land requirements), evaporation ponds are generally only feasible for small volume concentrates. The largest municipal plant discharging to evaporation ponds has a capacity of 1.5 MGD. All the others have capacities of less than 0.4 MGD (Mickley 2004).
- The design (and associated costs) of evaporation pond systems are driven by the net evaporation rate in the area (climate), concentrate volume, and the salinity of the concentrate, which determines the useful life of the ponds. Major cost factors include (Mickley 2006):
  - Land costs
  - Earthwork
  - Pond lining
  - Miscellaneous costs
  - Operation and maintenance (O&M)
- **Land Costs.** The cost of land can vary greatly from site to site. Costs vary not only from city to city but also in the vicinity of a particular municipality itself. Land costs can easily vary by a factor of 10 or more, depending on the exact location near the city. In general, however, the cost of land at locations appropriate for evaporation ponds is a small percentage of total cost (Mickley 2006).
- **Earthwork**. Like the cost of land itself, the cost of earthwork is very site specific, depending on whether the terrain is flat or hilly, rocky or sandy, forested or clear, etc. If the location of the desal plant is fixed by the proximity of the water source, or by the

locus of the demand for the desalinated water, the evaporation pond must be located reasonably close by. Typical earthwork features include (Mickley 2006):

- Land clearing
- Perimeter dikes
- Baffle dikes (optional)
- Dike covers

- **Liners**. Because the potential for ground water contamination exists with any evaporation pond, most States require impervious liners of clay or synthetic membranes. Liners substantially increase the cost of evaporation ponds. Where the waste discharged to the pond can be verified as nonhazardous and the ground water in the area is of poor quality or substantially distant from the pond, or both, a single liner may be acceptable. However, if the water has the potential to contain even trace amounts of hazardous substances, or high-quality groundwater exists in shallow aquifers nearby, double-lined ponds with leak detection systems are frequently required. Liners are often the largest individual cost component of this concentrate management method (Mickley 2006).

- **Miscellaneous costs**. Miscellaneous costs can constitute a significant percentage of the total cost of evaporation pond installation. These costs vary by site, depending upon the needs of the specific installation. Possible costs include (Mickley 2006):
  - Fencing
  - Maintenance roadways
  - Disposal
  - Seepage monitoring
  - Contaminated ground cleanup

- **O&M.** Once it has been constructed, the pond operates essentially maintenance free. Periodic maintenance is required only for the repair of the dike or liner, pipe, flow control devices, etc. Operating costs also include security and damage inspection. The annual operating costs are estimated to amount to about 0.5% of the total installation costs (Mickley 2006).

- **Comparison of costs for inland concentrate disposal methods.** Figure 1 illustrates the relative capital costs (neglecting conveyance costs) of the different concentrate management options and reflects economy of scale factors as well as general (relative)

level of cost (Xu et. al. 2009 from Mickley 2005). As shown, evaporation ponds are generally the most expensive method of disposal for all but the smallest plants. Figure 1 provides an idea of relative costs for generic desal facilities, but should be interpreted with caution as the costs associated with concentrate disposal alternatives are very site specific and highly variable.

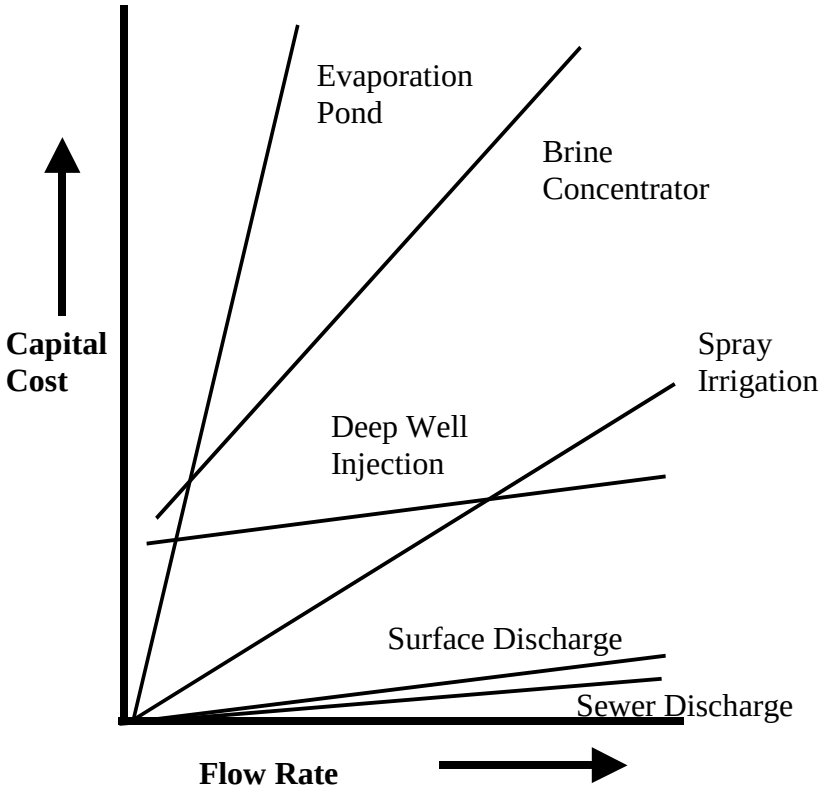

Figure 1. Relative capital cost of different disposal options
Source: Xu et. al. (2009), adapted from Mickley (2005).

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STRATEGIES

- Evaporation ponds are seldom used for concentrate management in the US. However, this strategy can be cost-effective under certain conditions. For example, if a small-capacity desal plant is located in a hot, arid area with a high net evaporation rate and an abundance of low-cost, available land, the use of evaporation ponds could potentially be the most

feasible option. These criteria apply predominantly in the western half of the United States—in particular, the southwestern portion (Mickley 2006).

- While evaporation ponds are typically designed to accommodate concentrate for the projected life of the desal facility, precipitation of salts is expected and must be incorporated into the depth requirements of the pond or provisions must be made for periodic removal and disposal or beneficial use of precipitated salts or for retirement of the ponds and construction of new ponds.

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BENEFITS & COSTS

Benefits

- Evaporation ponds are relatively easy and straightforward to construct.
- Properly constructed evaporation ponds are low maintenance and require little operator attention compared to mechanical equipment.
- For smaller volume flows, evaporation ponds can be a low cost means of disposal, especially in areas with high evaporation rates and low land costs.

Costs

- This disposal method has high capital costs due primarily to land acquisition costs and the costs of protective liners.
- There is little economy of scale for this land-intensive disposal option. Disposal costs can be large for all but small-sized membrane plants.
- Seepage from poorly constructed evaporation ponds can contaminate underlying potable water aquifers. Clean-up costs can be substantial.

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KEY UNCERTAINTIES

Although sizing of an evaporation pond is a relatively straightforward procedure (once appropriate net evaporation data are available), the costs associated with pond construction are highly site specific and quite variable. Therefore, generic cost estimating of evaporation ponds from typical handbook-type data is very difficult and subject to a wide range of accuracy.

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ADDITIONAL RESOURCES

Mickley, M.C., R. Hamilton, L. Gallegos, and J. Truesdall, 1993. *Membrane Concentrate Disposal*. AwwaRF and AWWA. Denver, Colorado.

Mickley, M. 2004. Included in: The Future of Desalination in Texas – Volume II; Report 363 by Texas Water Development Board, December 2004. Available: <http://texaswater.tamu.edu/readings/desal/concentratedisposal.pdf>

Mickley, M. 2005. Membrane Concentrate Management - State of the Science Report No.3. In the *Proceedings of Water Innovation Symposium*. October 17-21, 2005. San Diego, CA. Joint Water Reuse and Desalination Task Force.

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NRC (National Research Council). 2008. *Desalination: A National Perspective*. Washington, D.C.: National Academy Press. Available: <http://www.nap.edu/catalog/12184.html>.

Xu, P., Cath, T, Wang, G., Drewes, J.E. and Dolnicar, S. 2009. *Critical assessment of implementing desalination technology*. AwwaRF Project 4006. Published by American Water Works Association Research Foundation, Denver, CO.

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