SECTION 5

Drainage Service Options

5.1 Introduction

Thirty drainage treatment, disposal, and control options were identified in the San Luis Unit Drainage Plan, Preliminary Options Descriptions (Reclamation, 1990a). For this Report, a subset of the options has been identified, which met Reclamation's definition of drainage service and which are deemed to be demonstrated technology. On-farm drainage reduction options are not included as drainage service options at this phase of preliminary alternatives development. The cost, effectiveness, and impacts of all drainage management, treatment, and disposal development activities will be evaluated as part of the detailed plan formulation and analysis in Phase 2.

The selected options were re-evaluated, using the 1991 descriptions as a basis. The re-evaluation focused on two aspects of the drainage service options:

- A description and design of the option and how that may have changed since the 1990 Options Descriptions
- An update of the cost estimates, based on current design parameters (if different from the 1990 descriptions)

Options descriptions were prepared to cover a range of potential drainage volumes and quantities. Two scenarios of drainage volume per acre, 0.5 and 0.3 acre-feet per acre, were used in Section 3 to project drainage volumes and quality for purposes of this Report. A third scenario was also used for cost estimation, representing an assumed sequential reuse process that would reduce drainwater volume by a factor of 10 and increase concentrations by the same factor.

5.2 Options Identified for Re-Evaluation

The twelve options fall into three categories: Drainage Water Treatment and Concentration; Drainage Water and Solids Disposal; and Beneficial Use of Drain Water and Salts. Table 5-1 summarizes the drainage service options updated for this Report. The complete updated descriptions are included in Appendix B.

TABLE 5-1
Summary of Drainage Service Options

Option	Relationship to other options	Effectiveness	Efficiency	Acceptability
Drainage Water Treatment and Concentration				
Desalination	Requires disposal of brine.	Capacity sufficient for SLU volume. Technology available.	RO is $440-680 per acre-foot treated. Very sensitive to energy costs and drainwater quality.	Some concern over brine disposal and energy requirements.
Selenium Removal – Anaerobic	Requires discharge or reuse option for treated water and disposal of biological sludge.	Capacity can be scaled to target high selenium drainage; impractical for entire SLU volume. Technology demonstrated at pilot project scale.	$145-244 per af treated. Sensitive to scale, influent water quality, and target reduction.	Probable concerns about reliability of Se removal, disposal of sludge, exposure to wildlife. Regulation expected to be strict.
Selenium Removal – Microalgal	Requires discharge or reuse option for treated water and disposal of algal sludge.	Capacity can be scaled to target high selenium drainage; impractical for entire SLU volume. Technology demonstrated at pilot project scale.	$104-272 per af treated. Sensitive to scale, influent water quality, and target reduction.	Probable concerns about reliability of Se removal, disposal of sludge, exposure to wildlife. Regulation expected to be strict.
Selenium Removal – Chemical	Requires discharge or reuse option for treated water and disposal of byproduct waste to landfill.	Capacity can be scaled to target high selenium drainage. Technology demonstrated in laboratory and field tests, but further study is required.	$270 per af of drainage water.	Few known concerns except for waste disposal. Regulation expected to be strict.
Integrated Drainage Management	Requires disposal of concentrated drainwater effluent.	Capacity sufficient for SLU volume. Technology demonstrated, but long-term effects still under study.	Approx. $150 per af of influent drainwater. Sensitive to the water use, production cost, and market value of salt-sensitive crops grown.	Acceptability has been good. Concerns about selenium bioaccumulation, localized groundwater degradation. Regulation by RWQCB.

TABLE 5-1
Summary of Drainage Service Options

Option	Relationship to other options	Effectiveness	Efficiency	Acceptability
Evaporation - Solar	Requires disposal of brine or solids.	Capacity sufficient for SLU volume. Technology available.	Costs of up to $6,100 per af, energy benefit could offset a significant portion of the costs.	Acceptable if small in number and wildlife use is prevented. Strict regulation by RWQCB.
Evaporation - Ponds	Requires disposal of brine or solids. May require pre-treatment for selenium.	Capacity sufficient for SLU volume. Technology available.	Capital costs estimated at $2050 per acre of pond.	Acceptable if small in number and wildlife use is prevented. Strict regulation by RWQCB.
Drainage Water and Solids Disposal				
Ocean Discharge	Complete if no treatment is required.	Capacity sufficient for SLU volume. Technology available.	Capital costs estimated at $320 million.	Significant public opposition and regulatory requirements. Potential long-term environmental effects.
San Joaquin Delta Discharge	Complete if no treatment is required.	Capacity sufficient for SLU volume. Technology available.	Capital costs estimated at $370 million.	Significant public opposition and regulatory requirements. Potential long-term environmental effects.
Landfill Disposal	Requires evaporation option to reduce volume before disposal.	Capacity sufficient for SLU volume. Technology available.	$20 per ton tipping fee to Class II landfill. $100 per ton hauling cost.	Generally acceptable for disposal to existing landfills. Permitted landfills already meet regulatory requirements.
Deep Well Injection	Complete if capacity is adequate. Likely to require an evaporation or sequential reuse option to reduce volume before disposal.	Capacity unknown, but unlikely to be sufficient without concentration of drainwater. Technology unproven for this scale and location.	$242-357 per af injected. Very sensitive to injection flow rate, well depth and characteristics.	Some concern about seismic impacts and groundwater degradation. Strict regulatory requirements.

TABLE 5-1
Summary of Drainage Service Options

Option	Relationship to other options	Effectiveness	Efficiency	Acceptability
Beneficial Uses of Drain Water and Salts				
Salt and Water Reuse	Requires treatment options to separate constituents. May require disposal of by-products.	Capacity for salt utilization is uncertain. Market for salts or constituents is undeveloped. Market for treated water is sufficient to take all product water.	Costs of separating,harvesting and marketing salts are not well known. Value of water is up to $150/af for irrigation potentiallly higher for urban use.	Consumer acceptance of salt products unknown. Acceptance of reuse of treated water likely to be good.

5.2.1 Drainage Water Treatment and Concentration

These options are:

- **Desalination by reverse osmosis**, which forces drain water through membranes to separate constituents, results in an outflow stream of very good quality water and a highly concentrated brine waste that requires disposal.
- Three methods of **selenium treatment** are re-evaluated. One method uses holding ponds to allow an anaerobic bacterial process to remove selenium. Selenium would accumulate in a biological sludge on the bottom of the beds, requiring removal and disposal. The microalgal treatment process is somewhat similar in physical features, using treatment ponds to allow the algae to chemically reduce selenium. The resultant biological sludge would require removal and disposal. Chemical treatment uses ferrous hydroxide to reduce selenium to elemental form, which then drops to the bottom of the reaction container for removal and disposal.
- **Integrated Drainage Management** is a process of using drain water to irrigate salt-tolerant crops. Several rounds of reuse can be used to irrigate a series of increasingly tolerant crops. The process can reduce the initial drain water volume by a factor of 10. Variations of this option are also known as Agroforestry or Integrated On-Farm Drainage Management (IFDM).
- **Evaporation Ponds** are used by spreading drain water into large, shallow ponds for evaporation by sun and wind. Solar ponds make use of a salinity gradient to generate energy in the process. Traditional ponds simply allow the water to evaporate. Both variations require ultimate removal of salts, probably to a landfill.

5.2.2 Drainage Water and Solids Disposal

These options are:

- **Ocean Discharge** requires pipeline conveyance of drain water directly to the Pacific Ocean for off-shore discharge.
- **San Joaquin Delta Discharge** involves conveyance of drain water by canal or pipeline to the Delta for underwater discharge. This was the original plan for the partially completed SLU (described in Section 2).
- **Landfills** Would be used for the long-term disposal of salts, brine, and treatment sludge. Landfills fall into different classifications based on design; the classification determines the kind of materials that can be accepted.
- **Deep Well Injection** uses a set of wells to inject drainwater or brine into deep geologic formations.
- **Beneficial Uses of Drain Water and Salts** would be used only in combination with another treatment option and would focus on reusing (selling or giving away) the water and separated constituents for some commercial use.

5.2.3 Evaluation of Options

Each option description includes the conceptual, physical, and operational features, including likely locations and configurations (if appropriate). Standard evaluation criteria applied to each option include:

- **Relationship to Other Options.** An assessment of how dependent an option is on other options for achieving drainage service. An option is complete if it can fully provide drainage service for the SLU. It is partially complete if it can provide complete drainage service to a portion of the SLU.
- **Effectiveness.** Primarily an assessment of an option's capacity but also of the reliability with which the option can provide its designed level of service.
- **Efficiency.** The extent to which an option is cost-effective. Costs per unit of drainage service and the sensitivity of cost to uncertainties in drainage volume and quality are the key measures of efficiency.
- **Acceptability.** Assesses how state and local agencies and the public will judge the option based on environmental and other concerns. Compatibility with existing laws, institutions, and regulations also affect acceptability.