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Technical Memorandum No. 8

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Subject: Desalination Facility Waste Characterization
MMWD Seawater Desalination Pilot Plant Program
0468029

This Technical Memorandum describes the waste characteristics of the solids and brine waste streams that would be generated by a full-scale, 15 million gallon per day (MGD) desalination facility and a conceptual approach to the disposal or reuse of those waste streams. The solids wastes that would be produced from the desalination process include:

- Strainer Backwash Waste
- Conventional Pretreatment Waste
- MF/UF Pretreatment Waste

The brine wastes that would be produced by the desalination facility include:

- First Pass Reverse Osmosis (RO) Brine Waste
- Second Pass RO Brine

Additional wastes include:

- Clean-in-Place Wastes
- Biological Growth Control Cleaning Waste
- RO Lay-up Solution Waste (from membrane storage during prolonged shutdowns)

During the pilot testing, spent washwater and solids characteristics were analyzed and characterized. The general characteristics presented in the tables below are based on the results of the pilot testing and additional characterization testing conducted to confirm that the wastes can be discharged or disposed of as anticipated.

CONVENTIONAL PRETREATMENT SYSTEM SOLIDS WASTE

The primary wastes from the conventional pretreatment system include spent washwater and suspended solids from filter backwashes (BW) and sludge from the clarification process. Table 1 summarizes the estimated general waste stream characteristics of the conventional system process spent washwater for a 15 MGD facility.

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Table 1: Conventional System Spent Washwater General Characteristics

Process Waste	Constituents	Approx. TDS (mg/l)	Approx. TSS (mg/l)	Approx. Volume (gal/day)	Approx. Frequency	Treatment/ Disposal
Clarifier Sludge	Dissolved Solids; Suspended Solids; Coagulant, Polymer	10,000 to 30,000	17,000	130,000 to 275,000	Periodic Blow-down	- Remove solids - Return supernatant to head of plant
Conventional Filter BW and Filter to Waste	Dissolved Solids; Suspended Solids; Coagulant, Polymer	10,000 to 30,000	50 – 3,100	1,200,000 to 2,000,000	1 every 24 to 48 hrs	- Remove solids - Return supernatant to head of plant

The spent washwater for the conventional system equipment contains solids filtered out from raw water as well as the dissolved solids present in the water. The treatment proposed for this type of waste would be to send it to a Washwater Recovery Basin (WWR Basin) to capture the spent washwater. The majority of the suspended solids would be removed through clarification. The recycled water would be returned to the head of the desalination plant and the solids would be further thickened for disposal to a landfill as described below.

The solids that are removed from the conventional system spent washwater would be thickened, dewatered and sent to Redwood Landfill in Novato, CA for disposal and potential use as cover. Thickening could consist of a gravity sludge thickening process. Dewatering could consist of centrifuges, screw presses or belt filter presses. Bench tests were performed to determine the thickening and dewatering properties of the waste solids.

MF/UF PRETREATMENT SYSTEM SOLIDS WASTE

The primary wastes from the MF/UF pretreatment system include washwater and suspended solids from the strainer and filter backwashes (BW). Cleaning wastes for the MF/UF systems are described later in this memorandum. Table 2 summarizes the estimated general waste stream characteristics of the MF/UF pretreatment process spent washwater for a 15 MGD facility.

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Table 2: MF/UF System Spent Washwater General Characteristics

Process Waste	Constituents	Approx. TDS (mg/l)	Approx. TSS (mg/l)	Approx. Volume (gal/day)	Approx. Frequency	Treatment/ Disposal
Strainer BW	Dissolved Solids; Suspended Solids	10,000 to 30,000	250	90,000	1 every 60 to 120 minutes	- Remove solids - Return to head of plant
MF/UF BW	Dissolved Solids; Suspended Solids	10,000 to 30,000	170 - 370	2,400,000	1 every 22 to 30 minutes	- Remove solids - Return to head of plant

The spent washwater for the MF/UF system equipment contains solids filtered out from raw water as well as the dissolved solids present in the water. The treatment proposed for this type of waste would be to send it to a Washwater Recovery Basin (WWR Basin) to capture the spent washwater. The majority of the suspended solids would be removed through clarification. The recycled water would be returned to the head of the desalination plant and the solids would be further thickened for disposal to a landfill as described below.

PRETREATMENT SYSTEM SOLIDS WASTE CHARACTERIZATION

The solids residuals from the conventional and MF/UF pretreatment systems are made up of the following constituents:

- Inorganic silt and clay particles from the Bay source water
- Organic particles from the Bay source water
- Coagulant and polymer chemicals used for filtration (conventional pretreatment) and settling and thickening of the solids residuals (conventional and MF/UF pretreatment)

Analytical testing of the dewatered pretreatment solids was conducted to confirm that the pretreatment system solids can be disposed of as non-hazardous wastes at the Redwood Landfill. Redwood Landfill requires a Schedule 1 (Waste Acceptance) and Schedule 2 (Title 22 Toxicity Characteristics) analysis be performed. Tables 3 and 4 summarize the pretreatment system's solids analysis results.

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Table 3: Pretreatment System Solids Waste Acceptance Analysis Results (Schedule 1)

Inorganics (WET)¹			
	Redwood Landfill Acceptance Limit (mg/l)	Result 1² (mg/l)	Result 2² (mg/l)
Aluminum	10	2.4	9.9
Arsenic	0.25	0.49 ⁴	ND ⁵
Barium	50	0.18	0.25
Beryllium	0.05	ND	ND
Cadmium	0.25	ND	ND
Chloride	12,500	1300	540
Chromium, VI	2.5	ND	ND
Cobalt	2.5	0.028	0.095
Copper	10	0.27	0.27
Lead	0.75	0.18	0.17
Manganese	2.5	2.2	6.3 ⁴
Mercury	0.0006	ND	ND
Molybdenum	0.5	0.13	ND
Nickel	5	0.069	0.17
Nitrate	500	1.02	0.45
Nitrite	50	0.034	ND
Selenium	0.5	0.17	0.15
Silver	2.5	ND	ND
Sulfate	12,500	210	83
Thallium	0.1	ND	ND
Vanadium	1	0.91	0.78
Zinc	100	ND	0.33
Organics (TCLP)³			
	Redwood Landfill Acceptance Limit (mg/l)	Result 1² (mg/l)	Result 2² (mg/l)
Benzene	0.015	ND	ND
Dichloromethane (Methylene Chloride)	0.075	ND	ND
Diesel (TPH)	0.15	ND	ND
Ethylbenzene	0.45	ND	ND
2-Butone (MEK)	3	ND	ND
PCB's	0.0075	ND	ND
Tetrachlorethylene (PCE)	0.075	ND	ND
Phenol	0.075	ND	ND

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Styrene	0.15	ND	ND
Toluene	0.6	ND	ND
Trichloroethylene	0.075	ND	ND
Vinyl Chloride	0.03	ND	ND
Xylenes	0.3	ND	ND

¹ Waste Extraction Test (WET) per 22 CCR 66700 r.² If results exceed Redwood Landfill's Acceptance Limit, re-run WET using deionized water.³ Toxicity Characteristic Leaching Procedures per EPC Method 1311.⁴ Results exceed Redwood Landfill's Acceptance Limit, but laboratory did not re-run WET using deionized water per note 2.⁵ Initial results exceed Redwood Landfill's Acceptance Limit, laboratory re-ran WET using deionized water and result was ND.

Table 4: Pretreatment System Title 22 Toxicity Characteristics – Organic Substance Results (Schedule 2)

Analyte	TTLIC Limit (mg/kg)	Result 1 (mg/kg)	Result 2 (mg/kg)
Aldrin	1.4	ND	ND
Chlordane	2.5	ND	ND
DDT, DDE, DDD	1.0	ND	ND
2,4-Dichlorophoxy-acetic acid	100	ND	ND
Dieldrin	8.0	ND	ND
Dioxin (2,3,7,8-TCDD)	0.01	ND	ND
Endrin	0.2	ND	ND
Heptachlor	4.7	ND	ND
Kepone	21	ND	ND
Lead, Organic	13	2.7	3.6
Lindane	4.0	ND	ND
Methoxychlor	100	ND	ND
Mirex	21	ND	ND
Pentachloro-Phenol	17	ND	ND
Polychlorinated Biphenyls	50	ND	ND
Toxaphene	5	ND	ND
Trichloroethylene	2,040	ND	ND
2,4,5-Trichloro-Phenoxy Propionic Acid	10	ND	ND

Since Total Threshold Limit Concentration (TTLIC) analysis values were also less than the STLC limits, Soluble Threshold Limit Concentration (STLC) analysis was not required.

Two sample analyses were conducted of dewatered pretreatment residuals from the MMWD SWRO pilot plant, one corresponding to dry season source water characteristics and one corresponding to wet season source water characteristics. The results of the analyses show that the dewatered pretreatment system solids are suitable for disposal as a non-hazardous material in the local Redwood Landfill. Although, the arsenic levels in the Schedule 1 analysis

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initially exceeded the landfill acceptance criteria, the test was re-run using de-ionized water, in accordance with Redwood Landfill procedures, and was acceptable.

FIRST PASS SWRO AND SECOND PASS RO BRINE WASTE

The primary wastes from the first pass SWRO and second pass RO systems include brine wastes that contain concentrated dissolved solids from the source water and a small amount of anti-scalant and sodium bisulfite. Cleaning wastes for the RO systems are described later in this memorandum.

The brine from the first pass SWRO would be discharged by mixing the concentrated salt water with the relatively low TDS effluent discharged into the S.F. Bay from the current wastewater treatment facility owned and operated by the Central Marin Sanitation Agency (CMSA). The second pass RO brine is less concentrated and can therefore be recycled to the feed of the SWRO process.

Table 5 summarizes the general waste stream characteristics of the SWRO and second pass RO brine waste water for a 15 MGD facility.

Table 5: RO Brine Waste General Characteristics

Brine	Constituents	Approx. TDS (mg/l)	Approx. Volume (gal/day)	Frequency	Treatment/ Disposal
First Pass SWRO Brine	Dissolved Solids, Antiscalant, Bisulfite	30,000 to 60,000	15,000,000	Continuous	-Blend with CMSA effluent and discharge through outfall
Second Pass RO Brine	Dissolved Solids, Antiscalant, Bisulfite	1000	1,000,000	Continuous	-Recycle to the feed for the First Pass SWRO

Table 6 presents a more extensive waste characterization analysis of the first pass SWRO brine. The SWRO system was operating at a flux rate of 8 gallons per square foot per day (gfd) and a recovery of 40-percent during the sampling. The results are as expected for a concentration of the source water by 40-percent. Analysis of the brine for constituents from the California Toxicity Rule (CTR) and acute and chronic bioassay testing of the brine and CMSA effluent was also conducted and the results are reported in a separate memorandum.

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Table 6: SWRO Brine Waste Mineral Characteristics (40% SWRO Recovery)

Analyte	Units	Minimum	Average	Maximum
Inorganic Constituents				
Total Dissolved Solids	mg/l	34,000	41,200	45,000
Conductivity	umho/cm	61,000	71,000	75,000
Hardness, Calcium	mg/l as CaCO ₃	800	800	800
pH	pH units	7.5	7.5	7.5
Alkalinity, Bicarbonate	mg/l as CaCO ₃	130	143.33	150
Alkalinity, Total	mg/l as CaCO ₃	130	142.5	150
Sodium	mg/L	9,300	11,150	13,000
Potassium	mg/L	390	455	520
Calcium	mg/L	320	335	350
Magnesium	mg/L	360	986.67	1,500
Chloride	mg/L	18,000	21,333.33	23,000
Sulfate	mg/L	2,300	2,800	3,100
Iron	mg/L	ND	ND	ND
Manganese	ug/L	8.1	3.37	8.1
Boron	ug/L	4,000	4,433.33	4,800
Silica, Total	mg/L	5.7	7.55	9.4
Silica, Dissolved	mg/L	2.7	1.85	2.8
Aluminum	ug/L	2.9	1.63	2.9
Barium	ug/L	ND	ND	ND
Strontium	ug/L	7,300	8,500	9,700
Fluoride	mg/L	0.93	1.0	1.1
Nitrogen, Ammonia	ug/L	ND	ND	ND
Beryllium	ug/L	ND	ND	ND
Cadmium	ug/L	ND	ND	ND
Chromium	ug/L	ND	ND	ND
Copper	ug/L	ND	ND	ND
Lead	ug/L	ND	ND	ND
Mercury	ug/L	0.3	0.3	0.3
Nickel	ug/L	60	70	80
Nitrate	mg/L	0.28	0.32	0.34
Nitrite	mg/L	0.021	0.021	0.021
Selenium	ug/L	ND	ND	ND
Silver	ug/L	ND	ND	ND
Thallium	ug/L	ND	ND	ND
Zinc	ug/L	ND	ND	ND

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CHEMICAL CLEANING WASTE

Chemical cleaning is necessary to minimize biogrowth and control fouling on the MF/UF pretreatment filters and to minimize scaling and fouling on the RO membranes. The chemical cleaning of the MF/UF filters would consist of automatic daily maintenance wash operations and then periodic semi-automatic clean-in-place (CIP) operations. Table 7 summarizes the general waste stream characteristics of the chemical cleaning waste water for a 15-MGD facility.

Table 7: Chemical Cleaning Waste General Characteristics

Process Cleaning	Chemicals / Source Water	Approx. TDS (mg/l)	Approx. TSS (mg/l)	Approx. Volume (gal/event)	Approx. Frequency	Treatment/ Disposal
MF/UF Maintenance Wash	50 to 200 mg/l Chlorine/ filtered seawater	10,000 to 30,000	~0	5,000	Daily	-Send to WWR Basin
MF/UF CIP	2% Acid, Chlorine/ Fresh Water	2,000	~0	10,000	1 per 45 days	- Neutralized and sent to sewer
First Pass SWRO CIP	2% Acid, Caustic/ Fresh Water	2,000	~0	5,000	1 per 4 to 6 months	-Neutralized and sent to sewer
Second Pass RO CIP	2% Acid, Caustic/ Fresh Water	2,000	~0	5,000	1 per year	-Neutralized and sent to sewer

Technical Memorandum No. 9 provides a detailed discussion of the chemical cleaning wastes from the MF/UF and SWRO systems in a full-scale desalination facility.

The MF/UF maintenance wash wastes could be sent to the Washwater Recovery Basins for treatment and returned to the head of the plant. The relatively high chlorine residual in the wastewater would be diluted by the larger volume in the WWR Basin and reduced through interaction with solids in the process. The strainers and pretreatment system are resistant to chlorine and the RO systems would be protected from residual chlorine by sodium bisulfite feed.

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The CIP cleaning wastes from the MF/UF system and from the RO systems would be neutralized and then should be sent to the sanitary sewer. The waste CIP solutions can be high in dissolved organics and it is not recommended to add these into the main process flow. Because RO Permeate would be used to create the CIP cleaning solutions, the TDS of the spent CIP solutions would be moderately low compared to the source water to the plant and the TDS would consist primarily of the neutralized cleaning chemical and dissolved salts and organics.

BIOLOGICAL CONTROL WASTES

The control of biological growth in the intake and treatment processes is an important aspect of desalination plant operations. Biological growth control will generate periodic wastes that would need to be handled similar to the more typical process wastes described above. These wastes are described in Table 14 below:

Table 14: Biological Control Wastes General Characteristics

Process Cleaning	Constituents	Approx. TDS (mg/l)	Approx. TSS	Volume (gal/event)	Frequency	Treatment/ Disposal
Intake Screen Cleaning Wastes	Solids	Low	high	TBD	Quarterly	- Cleaning Station - Solids Settling - WWR Basin
Intake Pipeline Shock Chlor.	Chlorine, Raw Water, TSS (low)	10,000 to 30,000	Low	TBD	Monthly to Quarterly	-WWR Basin -Return to Head of Plant
Intake Pipeline Pigging Wastes	Raw Water, TSS (High), TDS	10,000 to 30,000	High	TBD	Annually or As Needed	- Receiving Station - Solids Settling - WWR Basin
Strainer Freshwater Shock	Freshwater	Low	Low	TBD	weekly	-WWR Basin -Return to Head of Plant
Process Shock Chlor. Tanks /Piping	Chlorine, Raw Water, TSS	10,000 to 30,000	Low	Varies	Quarterly	-WWR Basin -Return to Head of Plant
RO Lay-up Solution Waste	1% Sodium Bisulfite	1,000	~0	2,000	2 per year	Neutralized and sent to sewer or WWR Basin

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Intake Screen Cleaning Wastes

The intake screen would have an automatic air-burst cleaning system to regularly remove built up debris on the screen. However, organisms such as barnacles and plant life will grow on the stainless steel components of the screen and to a much lesser degree on the copper-nickel components as well. The plant life can grow on the inside of the screen making air-bursting less effective. The intake screen will require periodic physical cleaning to remove these organisms and plant life. An approach could be to clean the screen in-place with divers or to physically remove an individual screen and take it to a designated cleaning station where the screen would be power washed with fresh water. The solids and washwater would be captured at the cleaning station. The solids could be directed to the thickening and dewatering systems and the washwater sent to the WWR Basins for recovery.

Intake Pipeline Shock Chlorination Wastes

The intake pipeline would be periodically shocked with chlorine to help prevent marine organisms and plants from growing and clogging the intake pipeline. The shock chlorination could be done with the pipeline shutdown and isolated or in operation and therefore the waste could just go through the plant. The chlorine residual would be reduced with bisulfite.

The chlorine could also be left to sit in the pipe for a period and then the wastes could either be processed directly through the plant or sent to the WWR Basin and recovered through that process.

Intake Pipeline Pigging Wastes

The intake pipeline could likely also require pigging on a less frequent basis to remove growth in the pipeline. An approach could be to have a pigging waste receiving station where the solids and washwater would be captured. The solids could be directed to the thickening and dewatering systems and the washwater sent to the WWR Basins for recovery.

Strainer Chlorine/Freshwater Shock Waste

The intake strainer could be periodically shocked with chlorine or just with freshwater. Freshwater shocks have been shown to be effective in controlling biogrowth in the strainers and the small volume of the strainer housings limits the amount of water required. With either approach, the solids and washwater would be captured in the WWR Basins for treatment and recovery.

Process Piping/Tank Chlorine Shock Waste

The process piping and tanks within the desalination facility would be periodically shocked with chlorine to control biogrowth in the system. The chlorinated water and any bio-solids would be sent to and captured in the WWR Basins for treatment and recovery.

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RO Lay-up Solution Waste

During shutdowns longer than about 3 to 5 days, membrane manufacturers recommend that membranes be stored in a solution containing sodium metabisulfite (1.0 weight percent) or glutaraldehyde (0.5 to 1.0 weight percent) to prevent organism growth. This solution would be neutralized and sent to the sanitary sewer or possibly, in the case of bisulfite solution, to the washwater recovery system and recycled back to the head of the plant.

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