APPENDIX S

Disinfection Byproduct Formation Study

Prepared by McGuire Environmental Consultants, November 2004

McGuire Environmental Consultants, Inc.

November 11, 2004

To: **Ms. Josie McKinley**
Poseidon Resources Corporation

From: **Ken Reich**
McGuire Environmental Consultants, Inc.

Subject: **Report of Additional SDS Disinfection Byproduct Testing**

INTRODUCTION

As described in a previous report to Poseidon Resources Corporation, *("Disinfection Byproduct Formation in a Simulated Distribution System: Blending Desalinated Seawater from the Poseidon Resources Corporation Pilot Facility with Local Drinking Water Sources"*, March 2004), McGuire Environmental Consultants, Inc. (MEC) developed a bench scale simulated distribution system (SDS) protocol to ascertain whether disinfection byproducts (DBPs) would form when disinfected, desalinated seawater is blended with local drinking water supplies. MEC obtained desalinated seawater from the Poseidon's reverse osmosis (RO) pilot plant, then disinfected the permeate and blended it with an equal volume of each of three local finished drinking water sources – chloraminated surface water from Metropolitan's Diemer Filtration Plant, chlorinated groundwater from the City of Newport Beach and chloraminated groundwater from Irvine Ranch Water District – for testing in the SDS. Control (100% disinfected RO permeate and 100% disinfected source waters) and blend (50% RO permeate:50% local source water) SDS samples were analyzed for DBPs (total trihalomethanes and haloacetic acids) over the 72-hour SDS.

The most significant conclusion drawn from this study is that blending disinfected, desalinated seawater with local surface and groundwater sources does not result in increased DBP formation of regulated total trihalomethanes (TTHMs) or haloacetic acids (HAAs). Notably, a DBP dilution effect is observed when treated surface water obtained from the Metropolitan's Diemer Filtration Plant or local groundwaters are blended with the disinfected RO permeate.

At the request of the City of Huntington Beach, two more SDS tests were conducted in October, 2004 using blends of RO permeate and 1) ozonated groundwater from Mesa Consolidated Water District's Colored Water Treatment Plant and 2) imported water from the City of Huntington Beach's distribution system. Both of these source waters carry a combined chlorine residual in their respective distribution systems. In addition, the City of Huntington Beach adds fluoride to their imported water supply.

SDS PROTOCAL

One modification was made to the SDS analytical protocol. Bromate, a common disinfection byproduct in ozonated drinking water when bromide is present, was added to the list of DBPs analyzed during tests with Mesa's ozonated groundwater.
In the SDS tests with Mesa water, the 0 Hour and 96 Hour permeate controls were analyzed for DBPs. All five permeate controls (0, 24, 48, 72, and 96 hour samples) were analyzed during the tests with Huntington Beach water.

The only other modification to the original protocol was the extension of the test period from 72 hours to 96 hours.

SOURCE WATER QUALITY

Table 1 shows the general water quality condition of the three source waters. Just prior to initiating the recent round of SDS tests, Poseidon replaced the pilot plant's RO membranes with a new brand of membranes that is more efficient at rejecting salts. Currently, Poseidon's pilot facility is producing permeate with 2 – 3 times less total dissolved solids (TDS) than in permeate used in the original SDS. Because the initial SDS tests were conducted with permeate having approximately 300 mg/l TDS, MEC felt that consistency and comparability with the first tests required a 300 mg/l TDS permeate for this round. Primarily, MEC wanted to achieve similar bromide concentrations. This was achieved through operational changes at the plant that forced a much poorer permeate water quality from the membranes than the plant actually produces under normal operating conditions.

TABLE 1: INITIAL SOURCE WATER QUALITY

Analyte	Units	RO Permeate "300 TDS" 0 HR SDS	Mesa Groundwater 0 HR SDS	Huntington Beach MWDSC Imported 0 HR SDS
Aluminum	ug/L	<25	<25	<25
Alkalinity as $CaCO_3$	mg/l	54	177	72
Bromide	mg/l	0.61	0.55	0.07
Calcium	mg/l	<1.0	12	32
Chloride	mg/l	160	130	92
Copper	ug/L	<2.0	<2.0	2.6
Fluoride	mg/l	<0.050	0.77	0.57
Hardness as $CaCO_3$	mg/l	5.8	33	146
Iron	mg/l	<0.020	0.029	<0.020
pH	units	8.1	7.5	8.1
Magnesium	mg/l	1.4	0.76	16
Manganese	ug/l	<2.0	<2.0	<2.0
Nitrite, Nitrogen	mg/l	<0.50	<0.20	<0.2
Nitrate as N	mg/l	<0.50	<0.20	0.45
Potassium	mg/l	3.5	<1.0	3.4
Sodium	mg/l	120	160	80
Sulfate	mg/l	<4.0	<4.0	97
TDS	mg/l	310	420	380
Total Organic Carbon	mg/l	<0.5	3.8	1.6
Zinc	ug/l	<5.0	<5.0	<5.0

DBP RESULTS

Mesa Consolidated Groundwater

Figures 1 through 4 present the results of the Mesa groundwater DBP SDS:

Figure 1	Total Trihalomethanes
Figure 2	Bromoform
Figure 3	Haloacetic Acids
Figure 4	Bromate

The results are consistent with those obtained in the original SDS tests. The most significant conclusion drawn from the data is that regulated DBPs – TTHMs (Figure 1) and HAAs (Figure 3) - in the blended water are lower than in the Mesa groundwater control at every time interval through 96 hours of the SDS tests. A dilution effect is observed when Mesa groundwater is blended with the disinfected RO permeate. With respect to a full-scale ocean desalination plant at Huntington Beach, no Disinfection /Disinfection Byproduct Rule compliance issues are foreseen for agencies receiving the desalinated ocean water.

As observed in the original SDS, some bromide incorporation does occur. Figure 2 illustrates what appears to be a slight stimulatory blending effect or a DBP "shift" associated with the formation of bromoform. This resulting slight shift toward more highly brominated DBP species is not unexpected due to the fact that both source waters contained bromide in excess of 0.5 mg/l; however, this poses no problem with respect to meeting present or contemplated future drinking water quality regulations. Currently, bromoform is not regulated as an individual DBP and it is not anticipated that it will be regulated as such in the future.

At the Mesa Colored Water Treatment Facility, bromate is formed during ozonation of the colored water. Bromate is subsequently removed to non-detectable levels with further treatment using a special activated carbon supplied by the Calgon Corporation prior to final disinfection and entry into the distribution system. Source water for this SDS was collected just prior to a change out of the carbon by Calgon, which occurs on a regular basis when the carbon's absorption capacity is exhausted and the bromate level in the finished water starts to exceed the maximum allowable limit. Compliance with the standard is based on a running annual average of monthly sample results, so that at times the finished water can legally exceed the standard as long as these higher levels, when averaged with the other monthly compliance samples, results in a running annual average which is below the standard. It is noted that the initial bromate level in the ozonated Mesa groundwater of 24 micrograms per liter exceeded the allowable regulatory level of 10 micrograms per liter in drinking water.

FIGURE 1
TOTAL TRIHALOMETHANES IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, MESA GROUNDWATER AND BLENDED PERMEATE/MESA WATER

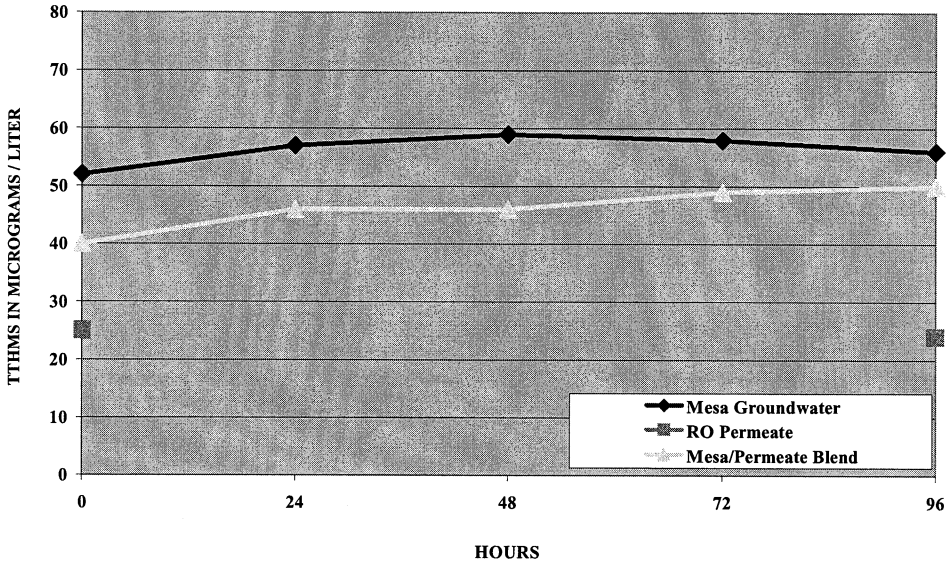


FIGURE 2
BROMOFORM IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, MESA GROUNDWATER AND BLENDED PERMEATE/MESA WATER

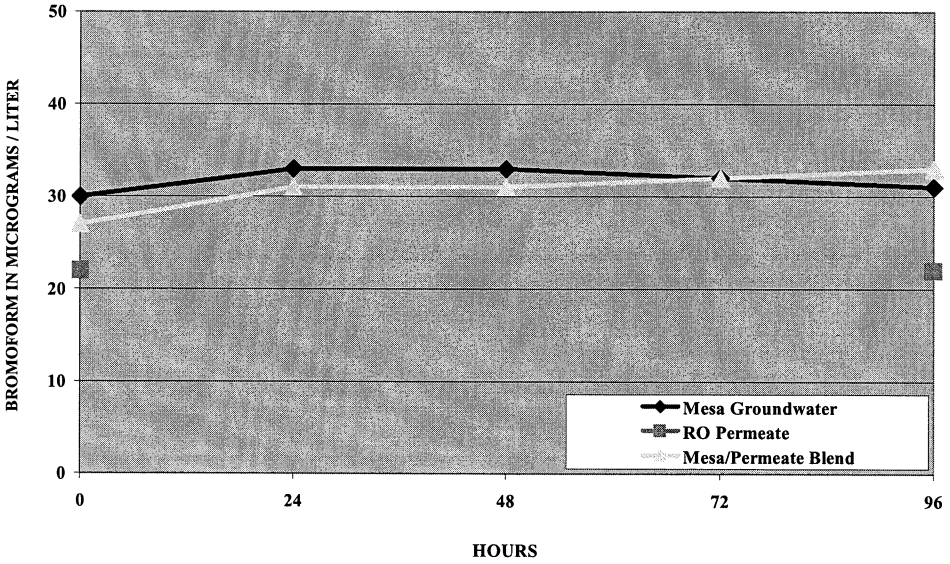


FIGURE 3
HALOACETIC ACIDS IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, MESA GROUNDWATER AND BLENDED PERMEATE/MESA WATER

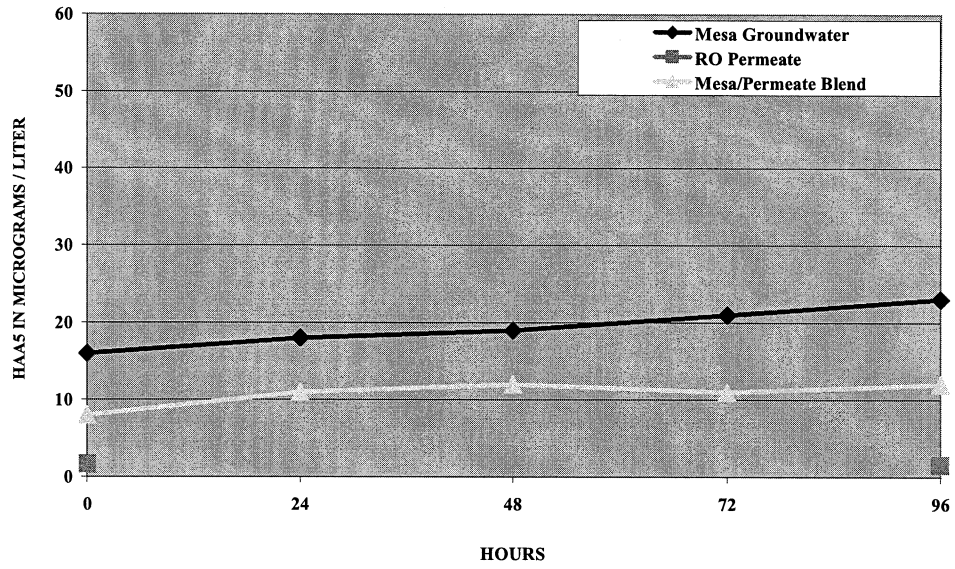
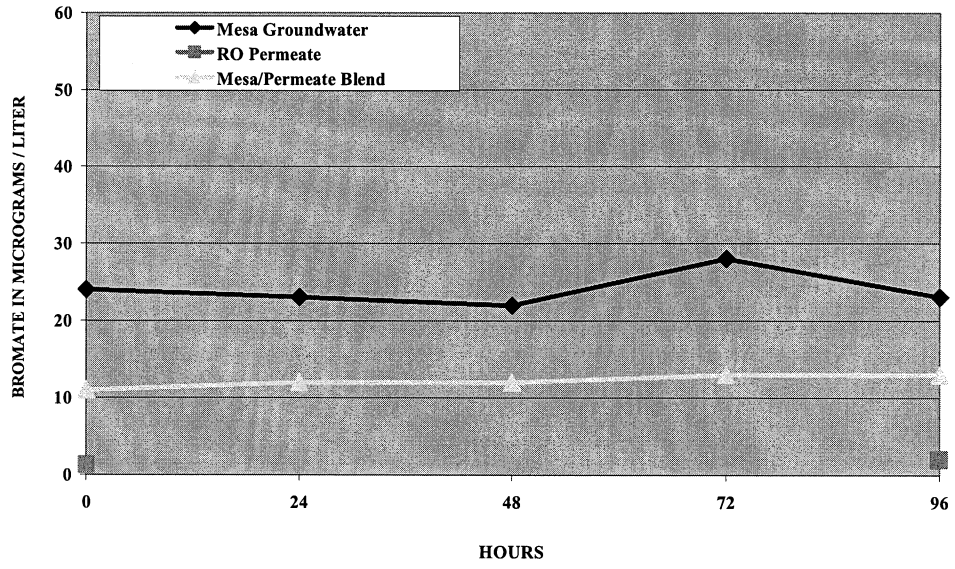


FIGURE 4
BROMATE IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, MESA GROUNDWATER AND BLENDED PERMEATE/MESA WATER



Huntington Beach Imported Water

Figures 5 and 6 present the results of the 96-hour SDS test with imported water collected from the Huntington Beach distribution system. The collection point was downstream of

where the City adds fluoride to their water. Again, the results show no stimulatory effect with respect to DBP formation when imported water is blended with disinfected, desalinated seawater.

FIGURE 5
TOTAL TRIHALOMETHANES IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, HUNTINGTON BEACH SUPPLY AND BLENDED PERMEATE/HUNTINGTON BEACH WATER

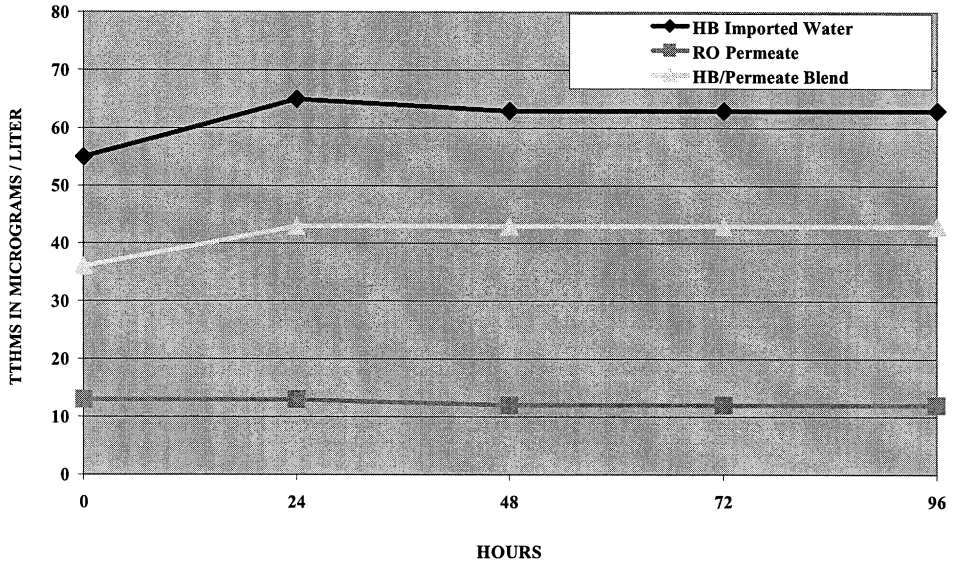
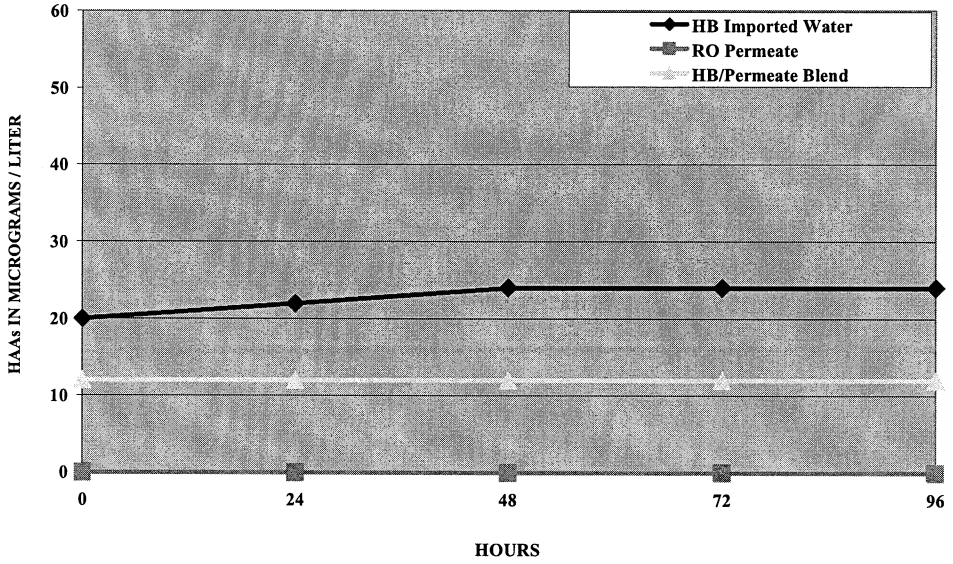


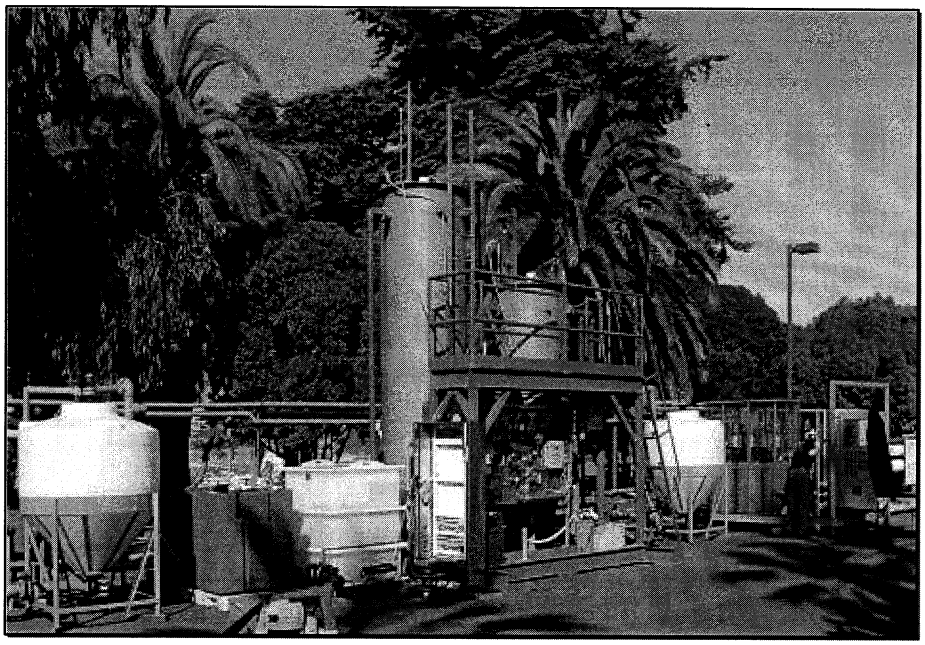
FIGURE 6
HALOACETIC ACIDS IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, HUNTINGTON BEACH SUPPLY AND BLENDED PERMEATE/HUNTINGTON BEACH WATER



FINAL REPORT

DISINFECTION BYPRODUCT FORMATION IN A SIMULATED DISTRIBUTION SYSTEM: BLENDING DESALINATED SEAWATER FROM THE POSEIDON RESOURCES CORPORATION PILOT FACILITY WITH LOCAL DRINKING WATER SOURCES

MARCH 2004



POSEIDON RESOURCES

McGuire Environmental Consultants, Inc.

DISINFECTION BYPRODUCT FORMATION IN A SIMULATED DISTRIBUTION SYSTEM: BLENDING DESALINATED SEAWATER FROM THE POSEIDON RESOURCES CORPORATION PILOT FACILITY WITH LOCAL DRINKING WATER SOURCES

EXECUTIVE CONCLUSIONS

Poseidon Resources Corporation is developing a new source of potable water supply for coastal cities in Orange County. Poseidon is proposing construction of a 50 million gallon per day (mgd) seawater desalination plant to be located on the grounds of the AES power generating facility in Huntington Beach. The desalination plant will take raw seawater from the AES Huntington Beach power plant cooling water system and produce potable drinking water for transmission to the regional water supply system. The principal treatment technology for this plant will be filtration with reverse osmosis (RO) membranes. Desalinated water may blend or mix in the regional distribution system with existing supplies of different water quality. This will necessitate converting the chlorinated, desalinated water to a combined residual disinfectant via addition of ammonia prior to distribution to satisfy compatibility issues, especially when blending would occur with local and/or imported chloraminated water.

A bench scale Simulated Distribution System (SDS) protocol was developed to ascertain the formation of disinfection byproducts (DBPs) when disinfected desalinated seawater is blended with several local drinking water supplies. Three source waters were selected for the SDS – filtered and chloraminated surface water from the Metropolitan Water District's Robert Diemer Filtration Plant, chloraminated groundwater from the Irvine Ranch Water District (IRWD), and chlorinated groundwater from the City of Newport Beach.

Desalinated seawater was obtained from the Poseidon Resources Corp. RO pilot plant located at the Encina power plant in Carlsbad. Currently, the pilot plant does not have final disinfection or alkalinity addition in the treatment process, so all chemical additions (chlorine and ammonia dosing, stabilization of the RO permeate with sodium bicarbonate and pH adjustment) were conducted in the laboratory prior to blending with the three source waters. The disinfection protocol for the desalinated seawater prior to initiating SDS blending scenarios included 4 hours free residual contact at 1 mg/L, boosting the chlorine to 2.5 mg/L, adding ammonia at a 4.5:1 chlorine to ammonia-N ratio to achieve an initial 2.5 mg/L combined residual and adjusting to pH 8. Three local finished drinking water sources – chloraminated surface water, chlorinated groundwater and chloraminated groundwater – were tested in the SDS. Control (100% RO permeate and 100% source waters) and blend (50% RO permeate:50% local source water) SDS samples were periodically analyzed for DBPs (total trihalomethanes and haloacetic acids) and disinfectant residual over the 72-hour SDS.

The most significant conclusion drawn from this study is that blending disinfected, desalinated seawater with local surface and groundwater sources does not result in increased DBP formation of regulated total trihalomethanes (TTHMs) or haloacetic acids (HAAs). Notably, a DBP dilution effect is observed when treated surface water obtained from the Metropolitan Water District of Southern California's Diemer Filtration Plant or local groundwaters are blended with the

disinfected RO permeate. This is due to the low DBP levels in the RO permeate (less than 3.5 ug/L TTHMs and less than 0.5 µg/L HAAs) and the lack of significant bromide incorporation into DBP precursors that may be present in the local source waters. Some bromide incorporation does occur resulting in bromoform and dibromochloromethane levels that are marginally higher in the blends compared to the volumetric average of the 100% RO control and the source water controls. This resulting shift toward more highly brominated DBP species, however, poses no problem with respect to meeting present or contemplated future drinking water quality regulations.

With respect to a full-scale ocean desalination plant at Huntington Beach, no D/DBP Rule compliance issues are anticipated for agencies receiving the desalinated ocean water. Blending of desalinated water with current local sources in the distribution system will reduce or not change the level of regulated DBPs in drinking water currently being served to customers. This is an important public health benefit that should not be overlooked.

One unanticipated finding was the rapid disappearance of combined chlorine residual (chlorine plus ammonia) in the disinfected RO permeate compared to the chloraminated drinking waters in the SDS. The observed residual decay appears to be a result of bromamine formation and an accelerated disproportionation of bromamines. Residual levels were stabilized somewhat by rechlorinating the RO permeate.

BACKGROUND

Poseidon Resources Corporation is developing a new source of potable water supply for coastal cities in Orange County. Poseidon is proposing construction of a 50 million gallon per day (mgd) seawater desalination plant to be located on the grounds of the AES power generating facility in Huntington Beach. The desalination plant will take raw seawater from the AES Huntington Beach power plant cooling water system, produce potable drinking water for transmission to the regional water supply system, and discharge concentrated seawater back into the power plant cooling water lines for dilution and discharge into the ocean. Source water for the desalination plant will be taken from the existing condenser cooling water circulation system from the power plant. The desalination plant intake structure will be located downstream of the steam condensers.

Desalinated water may blend or mix in the regional distribution system with existing supplies of different water quality. This will necessitate converting the chlorinated, desalinated water to a combined residual disinfectant prior to distribution to satisfy compatibility issues, especially when blending would occur with local or imported chloraminated water.

The California Department of Health Services (DHS) responded to Poseidon's Watershed Sanitary Survey for the proposed Huntington Beach Ocean Desalination Plant in a letter to Poseidon dated May 10, 2002. In that letter, DHS requested additional information "to assure that disinfection byproducts (DBPs) that will form as a result of the water supply from this plant do not interact with DBPs of the water systems receiving the water and result in a shift in the make-up of the regulated DBP constituents causing compliance problems for the systems

receiving the water." DHS recommended "that a laboratory analysis be conducted using water from the anticipated receiving utility and a batch of treated ocean water that has been disinfected with pilot treatment membranes." This recommendation was carried out by conducting a bench-scale analysis of DBP levels resulting from blending treated seawater from Poseidon's pilot desalination plant located in Carlsbad with imported water from the Metropolitan Water District of Southern California (MWDSC) Diemer Filtration Plant and two sources of local groundwater – chlorinated groundwater from the City of Newport Beach and chloraminated groundwater from the Irvine Ranch Water District (IRWD).

DBP FORMATION DURING DESALINATION AND POST-RO TREATMENT

At the Huntington Beach desalination plant, DBPs could be formed during two stages in the treatment process: 1) intermittent chlorination at the intake wet well and 2) final chlorine disinfection after reverse osmosis (RO) membrane treatment. After RO treatment, sodium hypochlorite would be added to form a free residual. Approximately four hours of free disinfectant contact time through post-RO stabilization and treated water storage is projected for the full-scale plant. Ammonia will then be added to the product water to form combined a residual entering the Poseidon distribution pipeline.

Formation of DBPs in drinking water is a function of several factors: total organic carbon (TOC), bromide, water temperature and chlorine dose. There is ample data described in the literature and available through other pilot studies (such as Tampa Bay Water) showing only moderate DBP formation when raw seawater is chlorinated (20 - 30 µg/L total trihalomethanes (TTHMs) and haloacetic acids (HAAs)) and that these levels can be substantially reduced (<10 µg/L TTHMs and HAAs) by a combination of volatilization and rejection through the pre-treatment filters and RO membranes, respectively. Since only intermittent pre-chlorination is proposed by Poseidon to control biofouling within the plant, most of the RO permeate will be devoid of DBPs. After RO treatment, the desalinated water would be characterized as containing low DBPs, relatively high bromide (0.5 – 0.8 mg/L) and low TOC (<0.5 mg/L) in comparison to imported MWDSC water produced at the Diemer Filtration Plant having low bromide and high TOC (0.1 mg/L Br^- and 3 mg/L TOC) with DBPs averaging 52 ug/L TTHMs and 17 ug/L HAAs.

Final disinfection of desalinated water could produce brominated DBPs because of the conversion of bromide to hypobromite ion, a brominated DBP precursor, by free chlorine. However, this is anticipated to produce negligible DBPs because the RO process simultaneously removes the organic DBP precursors, which would theoretically react with the hypobromite ions to form the brominated DBPs. As described above, after free chlorine contact, ammonia will be added to the water for distribution, forming a combined chloramine and bromamine residual.

One study conducted in Saudi Arabia (Fayad, J. AWWA, January 1993) investigated TTHM formation in distribution systems receiving only desalinated water from multi-flash distillation, only groundwater, or a blend of desalinated water and groundwater. In the eight water systems which were studied, distribution system residence times ranged from 4 – 16 hours. Disinfection was achieved by chlorine addition at applied doses of 0.4 – 1.0 mg/L. Drinking water in Saudi

Arabia, regardless of source, is characterized as low in TOC (<0.1 – 1.3 mg/L). In the study, TOC in desalinated drinking water was at the lower end of this range and was usually less than 0.2 mg/L.

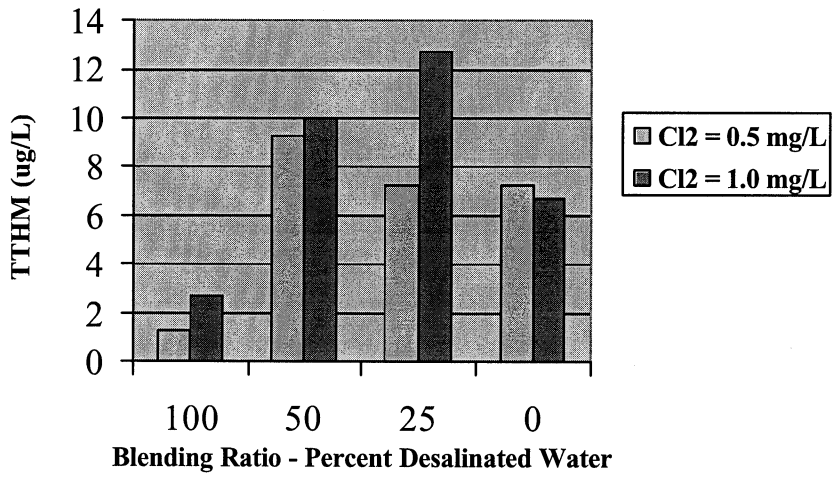
The investigators conducted a preliminary bench-scale experiment simulating different blends of groundwater and desalinated water (0, 25, 50 and 100% desalinated water) at two chlorine doses (0.5 and 1.0 mg/L). Figure 1 presents the author's results.

The experiment showed:

- Minimum TTHM concentrations were formed in the pure desalinated water;
- Maximum concentrations were formed in the blends with 25 and 50 percent desalinated water;
- Bromoform was the dominant TTHM formed; and
- Simulated experiments supported the field results.

In the field studies, TTHMs were lowest in cities that did not blend groundwater and desalinated water, and brominated TTHM species dominated. The TTHM concentrations observed in distribution systems ranged from <0.1 – 42 μg/L.

FIGURE 1
SIMULATED TTHM FORMATION IN BLENDED SAUDI ARABIAN DESALINATED WATER AND GROUNDWATER



In another Saudi study (Dalvi, et. Al., J. Desalination, 2000), the formation of HAAs was investigated in chlorinated seawater, chlorinated multi-flash distillate (disinfected product water with and without lime/CO_2 stabilization), and blended product water at the Al Jubail plant. Plant residual chlorine was 0.25 mg/L with a contact time of 10 – 15 minutes. In all cases, very low HAA concentrations were observed. Total HAAs (sum of bromoactic acid, chloroacetic acid, dichloroacetic acid, trichloroacetic acid, bromochloroacetic acid, and dibromoacetic acid) were estimated as follows:

- Chlorinated Seawater – 7 μg/L
- Product Water – 1.6 μg/L
- Product Water After Lime Stabilization – 1.5 μg/L
- Blended Water – 2.4 μg/L

STUDY OBJECTIVES

It is reasonable then that the DHS concern about DBPs does not reflect on projected DBP levels formed as a result of disinfection of desalinated water, but focuses on what might occur when desalinated water blends with organic DBP precursors in chloraminated MWDSC water or chloraminated/chlorinated groundwaters. The chlorine/bromine organic chemistry in blends of desalinated ocean water and MWDSC water is probably very complex. Existing DBP formation models, more commonly used to predict disinfection outcomes of conventional surface water treatment, are not optimal for use in the type of scenario described above. To this end, a basic bench scale Simulated Distribution System (SDS) protocol was developed to ascertain the formation of DBPs when different treated waters blend in the distribution system.

The SDS is characterized by a single attribute: it is designed to simulate the DBP formation in a particular system on a particular day. This test uses a site-specific chlorine dose, pH, temperature and contact time. The values chosen are either based on an existing system on a particular day; or they are based on a very specific scenario intended to simulate a postulated system. The SDS is used when the most accurate information about compliance and real-world concentrations are needed.

SOURCE WATERS FOR TESTING

Desalinated water was obtained from the Poseidon pilot desalination plant located at the Encina power plant in Carlsbad. Figure 2 is a schematic of the pilot plant. Source waters for blending were obtained from the Metropolitan Water District of Southern California Diemer Filtration Plant (chloraminated surface water), Irvine Ranch Water District (chloraminated groundwater) and the City of Newport Beach (chlorinated groundwater).

FIGURE 2

POSEIDON RESOURCES

DESALINATION DEMONSTRATION FACILITY

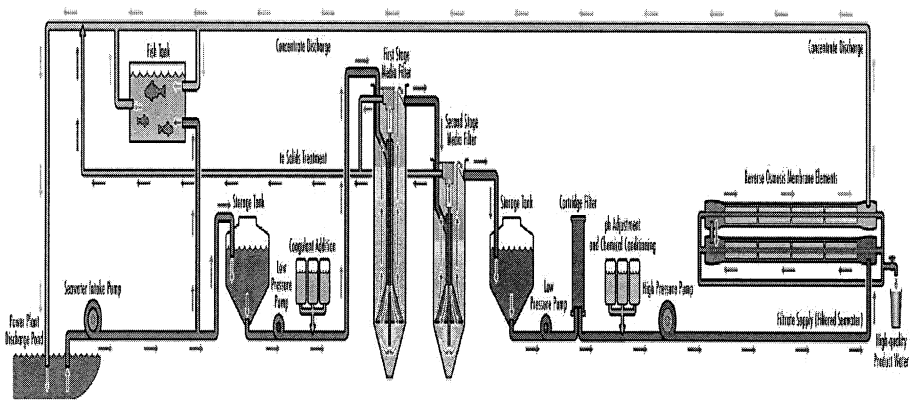


Table 1 presents the actual water quality of the pilot plant intake, RO permeate and the source waters used in the SDS experiments.

TABLE 1
POSEIDON DBP BLENDING STUDY SOURCE WATER QUALITY

	Units	MRL	Seawater Intake March '03 / May '03	RO Permeate March '03 / May '03	MWDSC Finished March '03	IRWD Ground. May '03	Newport Beach Ground. May '03
Total Organic Carbon	mg/L	0.5	ND / 0.5	ND / 0.5	2.8	ND	ND
Haloacetic Acids (HAA5)	ug/L	1.0	ND / ND	ND / ND	31	ND	ND
Total Trihalomethanes	ug/L	0.5	4.9 / ND	ND / ND	56	9.1	6.5
pH	pH units	0.001	7.7 / 7.4	6.5 / 6.7	8.1	8.2	8.0
Conductivity	umhos/cm	4.0	46,500 / 48,900	631 / 610	505	425	670
Alkalinity (as CaCO3)	mg/L	1.0	112 / 113	2.0 / 3.0	75	147	168
Ammonia (as N)	mg/L	0.05	ND / ND	ND / ND	0.4	0.43	ND
Chloride	mg/L	2.0	18,000 / 17,895	180 / 170	76	20	24
Sulfate	mg/L	4.0	2,500 / 2,300	8.1 / 6.7	40	33	45
Bromide	mg/L	0.025	60 / 64	0.73 / 0.72	0.07	0.07	0.04
Turbidity	NTU	0.05	0.45 / 0.20	0.20 / 0.05	0.4	0.1	0.1
Sodium	mg/L	1.0	9,600 / 9,400	110 / 72	53	61	53
Calcium	mg/L	1.0	380 / 390	1.2 / ND	24	24	70
Magnesium	mg/L	0.1	1,200 / 1,300	4.0 / 2.3	12	4.9	12

TEST CONDITIONS

RO permeate with a target TDS of 300 mg/L was obtained from the Poseidon pilot plant. This target was achieved with a product water recovery of 50 percent. The RO permeate was collected

in 1-gallon amber glass jars and maintained in the laboratory at 80°F in a water bath until the start of the experiments. Currently, the pilot plant does not have final disinfection or alkalinity addition in the treatment process, so all chlorine and ammonia dosing, stabilization of the RO permeate with sodium bicarbonate, and pH adjustment were conducted in the laboratory prior to blending with the three source waters. Alkalinity was added to the RO permeate using sodium bicarbonate. The target alkalinity of 50 mg/L as $CaCO_3$ was based on calculations currently being performed to evaluate corrosion control strategies for the Huntington Beach plant.

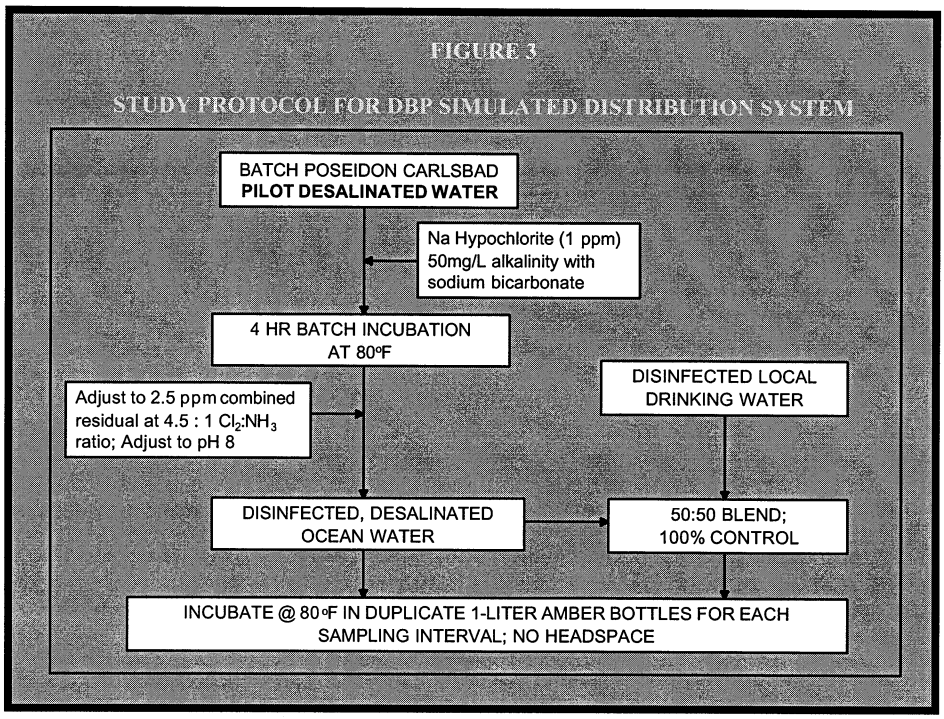
The batch of pre-heated and stabilized desalinated water was dosed with 1 mg/L sodium hypochlorite as Cl_2, measured using the Hach DPD colorimetric method. Free residual after 4 hours incubation at 80°F was also1 mg/L. After the 4-hour incubation period, the stabilized RO permeate was adjusted to a 2.5 mg/L free disinfectant residual with sodium hypochlorite, and ammonia was added at a 4.5:1 Cl_2 to NH_3-N ratio. The resulting total residual (mg/L as Cl_2, measured using the Hach DPD colorimetric method) was substantially the same as the free residual measured prior to ammonia addition. After adding chlorine and ammonia, pH was adjusted to pH 8.0 with hydrochloric acid. This water was used to blend with the other three source waters. Trial dosing runs were conducted prior to the actual experimental runs to ascertain appropriate chemical additions based on disinfectant demand and alkalinity/pH stabilization.

BLENDING SCENARIOS

Equal volumes of batch disinfected desalinated water and local source water were mixed together in 1-L amber glass bottles. Duplicate bottles were filled for each sampling time interval in the experimental protocol, and incubated without headspace in a water bath at 80 °F.
The blending scenarios were:

- 100% Disinfected Desalinated Water
- 50%:50% MWDSC Diemer Finished Water and Disinfected Desalinated Water
- 50%:50% Newport Beach Chlorinated Groundwater and Disinfected Desalinated Water
- 50%:50% IRWD Chloraminated Groundwater and Disinfected Desalinated Water
- 100% Disinfected Local Source Waters – Diemer, Newport Beach, IRWD

Four incubation times were selected: 0, 8, 24 and 72 hours. At each interval, two blend bottles per source water and two bottles of each control were pulled from the water bath, analyzed for disinfectant residual and then decanted into sample bottles for DBP and other chemical analyses. The "0" time blends represent water quality immediately after mixing without any further incubation. The experimental protocol is outlined in Figure 3.



The blend experiment utilizing MWDSC Diemer Plant was initiated on March 17, 2003 and lasted 72 hours. The groundwater experiments began on May 5, 2003 and lasted 72 hours. Fresh RO permeate was collected from the pilot plant prior to each experiment. The local source waters were collected on the morning of the day each was blended with the RO permeate.

CONTROLS

Three sets of controls were included in the experimental design:

- Reagent Control
- Source Water Control
- Desalinated Water Control

The reagent control consisted of distilled water treated in an identical manner as the RO permeate. This type of control demonstrates that the reagents used in the preparation of the RO test water (chlorine, ammonia, sodium bicarbonate and hydrochloric acid) do not themselves contribute DBPs directly into the test system. Distilled water was stabilized, chlorinated, chloraminated, and incubated according to the established test protocol for preparing the RO permeate. TTHMs and HAAs were not detected in the Reagent Control during the experiment.

The Source Water Controls and the Desalinated Water Control consisted of incubating the source waters (Diemer and the two groundwaters) and disinfected desalinated water over the length of

the SDS. These types of controls established the extent of DBP changes in the absence of blending.

Controls were sampled for TTHMs and HAAs at 0, 8, 24, and 72 hours.

ANALYSES

Raw seawater entering the pilot plant, RO permeate, stabilized desalinated water, and each of the three source waters were analyzed at the start of the experiments for the following parameters:

- Conductivity, Temperature, Disinfectant Residual, and pH in the field
- Total Organic Carbon
- Bromide
- HAAs/TTHMs
- Alkalinity
- Turbidity
- Calcium, Magnesium, Sodium
- Chloride, Sulfate
- Total Ammonia

At each SDS time interval, duplicate control and blend bottles were pulled from the water bath. Aliquots from each bottle were tested for total disinfectant residual using the DPD method. Aliquots were gently poured into sample analysis bottles. Samples were submitted to Montgomery Watson Harza (MWH) Laboratories in Pasadena for TTHM and HAA analysis by Methods EPA 551.1 and Standard Methods 6251 B, respectively. Approved drinking water analytical methods were used along with the required sample bottles and preservatives. Designated sample holding times were not exceeded.

DISINFECTANT RESIDUALS

The RO permeate is expected to have higher concentrations of bromide than typical groundwaters and surface waters. When solutions containing bromide are chlorinated, there is rapid inter-conversion from hypochlorous acid to hypobromous acid, which is known to possess stronger disinfection and oxidation potential and is responsible for greater bromine incorporation into DBPs.

$$HOCl + Br^- = HOBr + Cl^-$$

A common practice in drinking water treatment is to add ammonia when chlorinating water to form chloramines, which is weaker oxidant, and reduces DBP formation potential. The nature of bromamine formation is analogous to chloramine formation, excepting differences in speciation due to the differences in the acid-base chemistry of chlorine versus bromine.

$$HOBr + NH_4^+ = NH_2Br + H_2O + H^+$$

The step intended to simulate free chlorine contact time for disinfection of desalinated water was successful and predictable. Chlorine added to pilot plant RO permeate resulted in an initial free residual of 1 mg/L (as Cl_2, using the Hach DPD colorimetric method). An analytical technique using glycine was employed to differentiate the amount of hypochlorous acid and hypobromous acid present in the RO permeate. Each disinfectant species was present in approximately the same amount.

Free residual was also measured at the end of the four hour contact time, where a residual of 1 mg/L was also observed. As expected, the RO permeate only exerted a very slight oxidant demand. Additional chlorine was added to form a projected free disinfectant residual of 2.5 mg/L. Free residual was measured and ammonia was then added with vigorous mixing at a 4.5:1 Cl_2 to NH_3-N ratio to achieve a measured total residual of approximately 2.5 mg/L as Cl_2.

The total residual in SDS bottles that contained 100% RO permeate (RO Product Control) decline rapidly, as shown in Figures 4 through 6. Within 8 hours of initiating SDS incubation, the total residual decreased by 50% from 2.5 mg/L to 1.2 mg/L. Most of this decline occurred during the first two hours of incubation. The observed residual decay appears to be a result of bromamine formation and an accelerated disproportionation (auto-catalyzed decay into higher bromamines or chloramines and nitrogen species without reaction with organic matter) of bromamines. It is known that, at least in the chloramines system, higher chloramines (di- and trichloramine) are very unstable and their formation is a function of pH and chlorine:ammonia ratio.

Blending disinfected desalinated water with the two chloraminated source waters (MWDSC and IRWD), resulted in total residual decline over the 72 hour test period, but not as much as the 100% RO Product Control (Figures 4 and 5). The disinfectant residual in the blends at each sampling interval were nearly the volumetric average of the two controls – 100% RO Product Control and 100% Source Water Control.

City of Newport Beach groundwater exhibited a completely different residual decay curve when blended with RO permeate, as shown in Figure 6 (total residual) and Figure 7 (free residual). Newport Beach groundwater is chlorinated with sodium hypochlorite. Newport Beach does not practice conversion to chloramines. Blending caused the rapid decay of the measured total residual to a point where the total residual after 24 hours was 50% less than the corresponding residual in the RO Product Control.

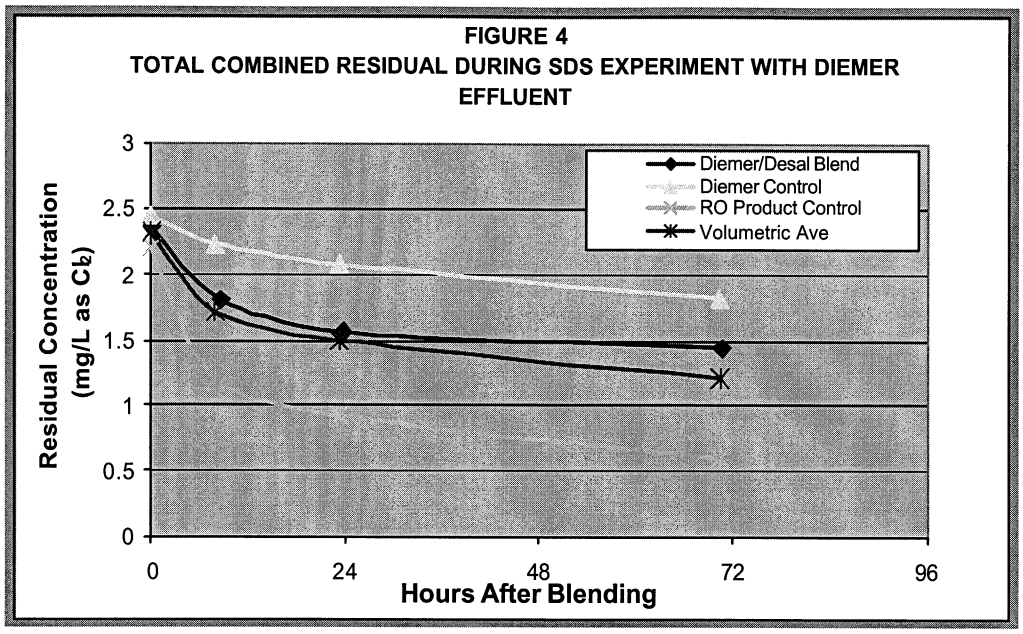


FIGURE 4
TOTAL COMBINED RESIDUAL DURING SDS EXPERIMENT WITH DIEMER EFFLUENT
Residual Concentration (mg/L as Cl2)
3
2.5
2
1.5
1
0.5
0
0
24
48
72
96
Hours After Blending
Diemer/Desal Blend
Diemer Control
RO Product Control
Volumetric Ave

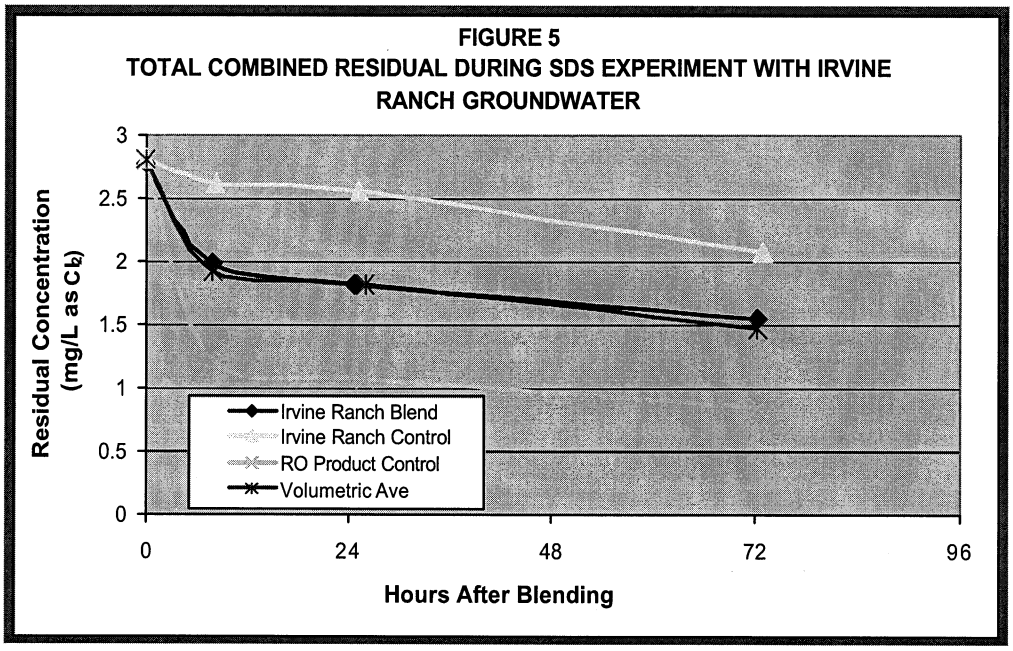


FIGURE 5
TOTAL COMBINED RESIDUAL DURING SDS EXPERIMENT WITH IRVINE RANCH GROUNDWATER
Residual Concentration (mg/L as Cl2)
3
2.5
2
1.5
1
0.5
0
0
24
48
72
96
Hours After Blending
Irvine Ranch Blend
Irvine Ranch Control
RO Product Control
Volumetric Ave

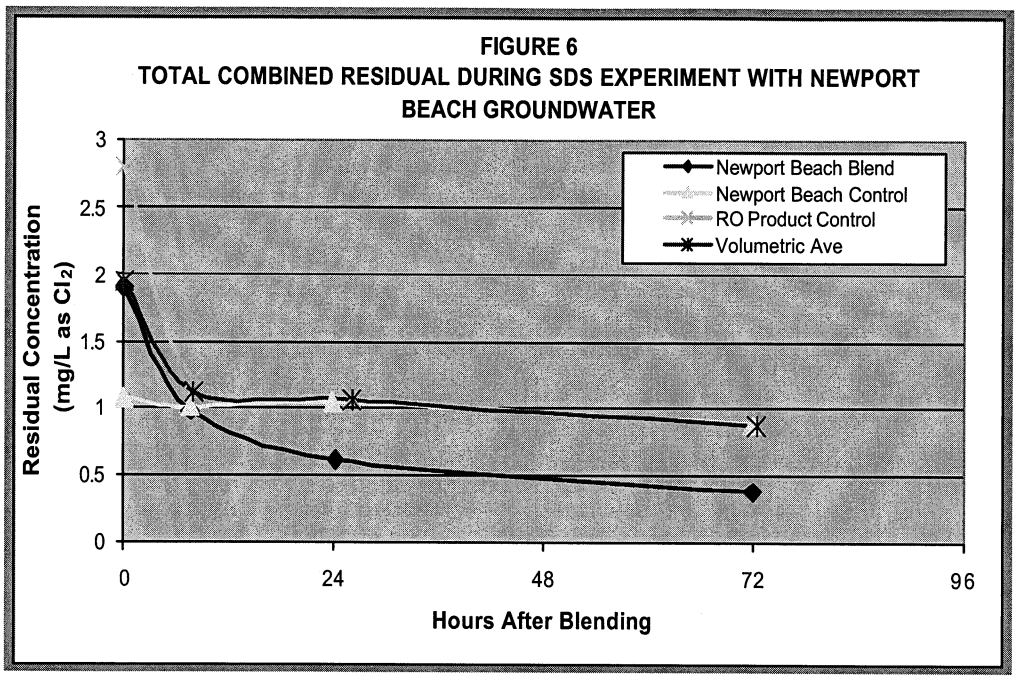


FIGURE 6
TOTAL COMBINED RESIDUAL DURING SDS EXPERIMENT WITH NEWPORT BEACH GROUNDWATER
Residual Concentration (mg/L as Cl2)
3
2.5
2
1.5
1
0.5
0
0
24
48
72
96
Hours After Blending
Newport Beach Blend
Newport Beach Control
RO Product Control
Volumetric Ave

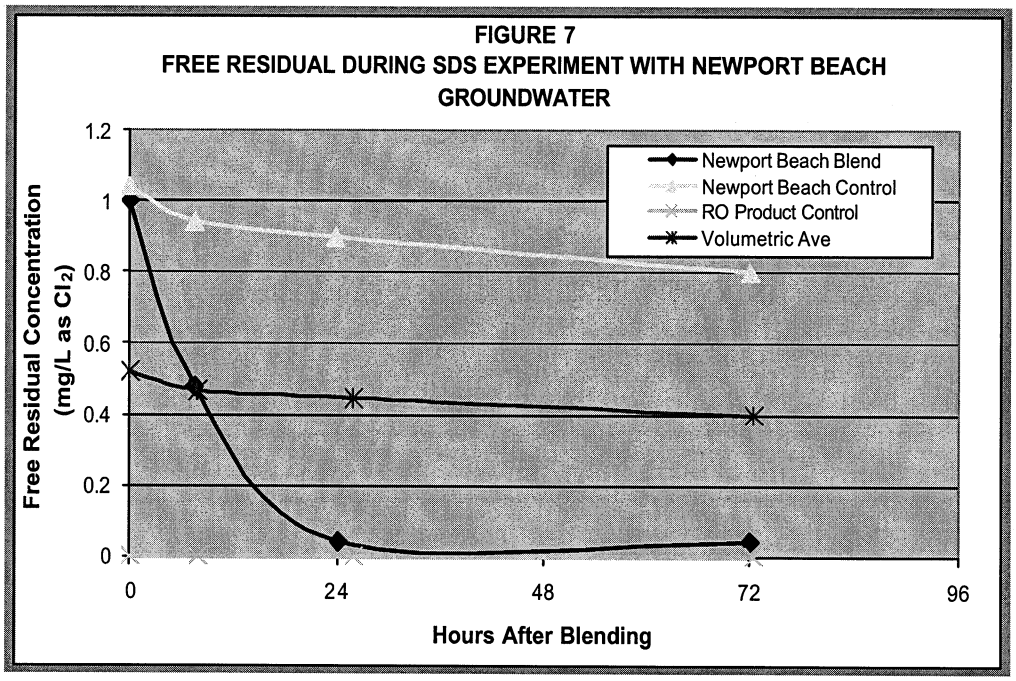


FIGURE 7
FREE RESIDUAL DURING SDS EXPERIMENT WITH NEWPORT BEACH GROUNDWATER
Free Residual Concentration (mg/L as Cl2)
1.2
1
0.8
0.6
0.4
0.2
0
0
24
48
72
96
Hours After Blending
Newport Beach Blend
Newport Beach Control
RO Product Control
Volumetric Ave

DISINFECTION BYPRODUCT FORMATION

DBP data generated during the series of SDS blending experiments are presented in Figure 8 (summary), Table 2 (Diemer/RO Blend) and Table 3 (Groundwaters/RO Blends). Interpretation of the data is discussed for blending scenarios with chloraminated surface water (MWDSC), chloraminated groundwater (Irvine Ranch) and chlorinated groundwater (Newport Beach).

Summary

The most significant conclusion drawn from the data is that regulated DBPs – TTHMs and HAAs - in the blended waters are lower or the same as in the three local source water controls at every time interval through 72 hours of the SDS tests. A dilution effect is observed when MWDSC Diemer water or Newport Beach groundwater is blended with the disinfected RO permeate. DBP levels in the IRWD groundwater blended with RO permeate are about the same as in the IRWD Control.

With respect to a full-scale ocean desalination plant at Huntington Beach, no Disinfection /Disinfection Byproduct Rule compliance issues are foreseen for agencies receiving the desalinated ocean water. Maximum levels of TTHMs and HAAs observed during the 72 hour SDS are compared in Table 4 for each type of source water, blended and unblended.

Blending of desalinated water and current local supplies in the distribution system will reduce or not change the level of DBPs being served to customers. This is an important public health benefit that should not be overlooked.

Figure 8

Maximum DBP Levels in SDS Controls and Blends (maximum levels during 72 hr. test period)

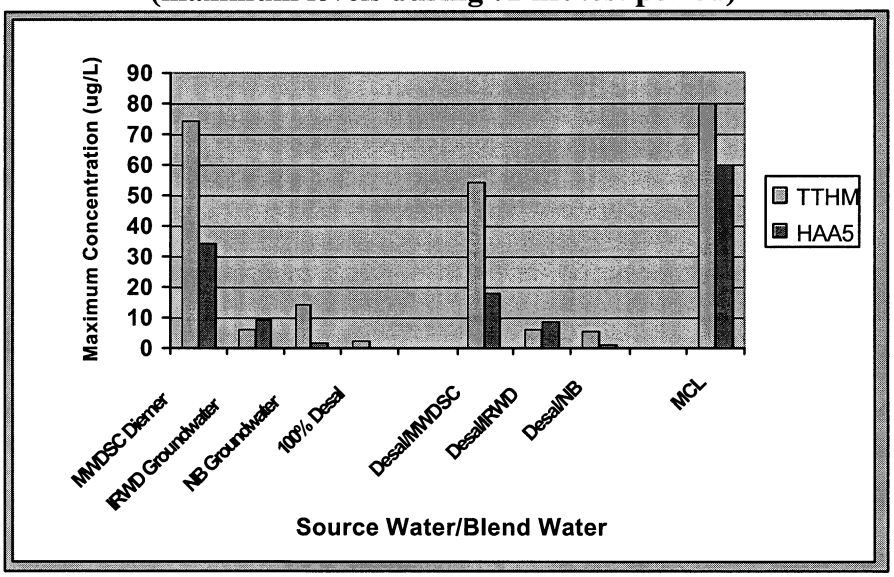


TABLE 2
DBP BLENDING STUDY DATA - MARCH 2003
POSEIDON RESOURCES PILOT PLANT DESALINATED SEAWATER AND MWDSC DIEMER WATER

	MRL (ug/L)	Seawater Intake	RO Permeate	RO Product 0 Hours	RO Product 8 Hours	RO Product 24 Hours	RO Product 72 Hours
HAA5	1	ND	ND	ND	ND	ND	ND
Bromoacetic Acid	1	ND	ND	ND	ND	ND	ND
Dibromoacetic Acid	1	ND	ND	ND	ND	ND	ND
Chloroacetic Acid	2	ND	ND	ND	ND	ND	ND
Dichloroacetic Acid	1	ND	ND	ND	ND	ND	ND
Trichloroacetic Acid	1	ND	ND	ND	ND	ND	ND
Chlorodibromoacetic Acid	2	ND	ND	ND	ND	ND	ND
Dichlorobromoacetic Acid	1	NA	NA	ND	ND	ND	ND
Tribromoacetic Acid	4	ND	ND	ND	ND	ND	ND
Bromochloroacetic Acid	1	ND	ND	ND	ND	ND	ND
Not included in HAA5 calculation							
TTHMs	0.5	4.9	ND	1.6	1.6	3.3	2.4
Bromodichloromethane	0.5	0.7	ND	ND	ND	ND	ND
Dibromochloromethane	0.5	ND	ND	ND	ND	0.5	ND
Bromoform	0.5	4.2	ND	1.6	1.6	2.8	2.4
Chloroform	0.5	ND	ND	ND	ND	ND	ND
	MRL (ug/L)			**Diemer Control 0 Hours**	**Diemer Control 8 Hours**	**Diemer Control 24 Hours**	**Diemer Control 72 Hours**
HAA5	1			31	32	30	34
Bromoacetic Acid	1			ND	ND	ND	1.0
Dibromoacetic Acid	1			4.7	4.6	5.0	4.7
Chloroacetic Acid	2			ND	ND	ND	ND
Dichloroacetic Acid	1			13	13	13	15
Trichloroacetic Acid	1			13	14	12	13
Chlorodibromoacetic Acid	2			6.4	6.1	6.8	NA
Dichlorobromoacetic Acid	1			NA	NA	13	NA
Tribromoacetic Acid	4			ND	ND	ND	NA
Bromochloroacetic Acid	1			12	12	9.8	13
Not included in HAA5 calculation							
TTHMs	0.5			56	62	62	74
Bromodichloromethane	0.5			19	21	24	26
Dibromochloromethane	0.5			17	17	18	24
Bromoform	0.5			6.5	6.0	4.2	5.5
Chloroform	0.5			13	18	16	18
	MRL (ug/L)			**Diemer Blend 0 Hours**	**Diemer Blend 8 Hours**	**Diemer Blend 24 Hours**	**Diemer Blend 72 Hours**
HAA5	1			17	17	17	18
Bromoacetic Acid	1			ND	ND	ND	ND
Dibromoacetic Acid	1			4.1	4.4	4.8	5.1
Chloroacetic Acid	2			ND	ND	ND	ND
Dichloroacetic Acid	1			6.5	6.3	6.5	6.5
Trichloroacetic Acid	1			6.7	6.4	6.2	6.7
Chlorodibromoacetic Acid	2			3.7	3.4	3.9	NA
Dichlorobromoacetic Acid	1			NA	NA	7.5	NA
Tribromoacetic Acid	4			5.7	5.2	4.4	NA
Bromochloroacetic Acid	1			7.3	7.2	5.6	8.0
Not included in HAA5 calculation							
TTHMs	0.5			31	39	46	54
Bromodichloromethane	0.5			10	11	13	16
Dibromochloromethane	0.5			9.5	10	13	14
Bromoform	0.5			7.3	10	12	16
Chloroform	0.5			4.5	8.4	7.6	8.2

NA = Not analyzed
ND = Not Detected at the Method Reporting Limit (MRL)

TABLE 3
DBP BLENDING STUDY DATA - MAY 2003
POSEIDON RESOURCES PILOT PLANT DESALINATED SEAWATER AND LOCAL GROUNDWATER SOURCES

	MRL (ug/L)	IRWD Blend 0 Hours	IRWD Blend 8 Hours	IRWD Blend 24 Hours	IRWD Blend 72 Hours
HAA5	1	1.3	5.8	1.9	1.6
Bromoacetic Acid	1	ND	ND	ND	ND
Dibromoacetic Acid	1	1.3	1.2	1.9	1.6
Chloroacetic Acid	2	ND	4.6	ND	ND
Dichloroacetic Acid	1	ND	ND	ND	ND
Trichloroacetic Acid	1	ND	ND	ND	ND
Chlorodibromoacetic Acid*	2	ND	NA	NA	NA
Dichlorobromoacetic Acid*	1	ND	NA	NA	NA
Tribromoacetic Acid*	4	ND	NA	NA	NA
Bromochloroacetic Acid*	1	ND	ND	ND	ND
*Not included in HAA5 calculation					
TTHMs	0.5	7.0	8.5	6.8	8.6
Bromodichloromethane	0.5	1.3	1.3	0.5	1.2
Dibromochloromethane	0.5	2.1	2.2	2.2	2.7
Bromoform	0.5	3.6	5.0	4.1	4.7
Chloroform	0.5	ND	ND	ND	ND
	MRL (ug/L)	**NB Blend 0 Hours**	**NB Blend 8 Hours**	**NB Blend 24 Hours**	**NB Blend 72 Hours**
HAA5	1	ND	ND	1.1	ND
Bromoacetic Acid	1	ND	ND	1.1	ND
Dibromoacetic Acid	1	ND	ND	ND	ND
Chloroacetic Acid	2	ND	ND	ND	ND
Dichloroacetic Acid	1	ND	ND	ND	ND
Trichloroacetic Acid	1	ND	ND	ND	ND
Chlorodibromoacetic Acid*	2	ND	NA	NA	NA
Dichlorobromoacetic Acid*	1	ND	NA	NA	NA
Tribromoacetic Acid*	4	ND	NA	NA	NA
Bromochloroacetic Acid*	1	ND	ND	ND	ND
*Not included in HAA5 calculation					
TTHMs	0.5	5.6	5.7	5.7	5.0
Bromodichloromethane	0.5	0.7	0.7	0.7	ND
Dibromochloromethane	0.5	1.0	1.1	1.1	1.3
Bromoform	0.5	3.9	3.9	3.9	3.7
Chloroform	0.5	ND	ND	ND	ND

NA = Not analyzed
ND = Not Detected at the Method Reporting Limit (MRL)

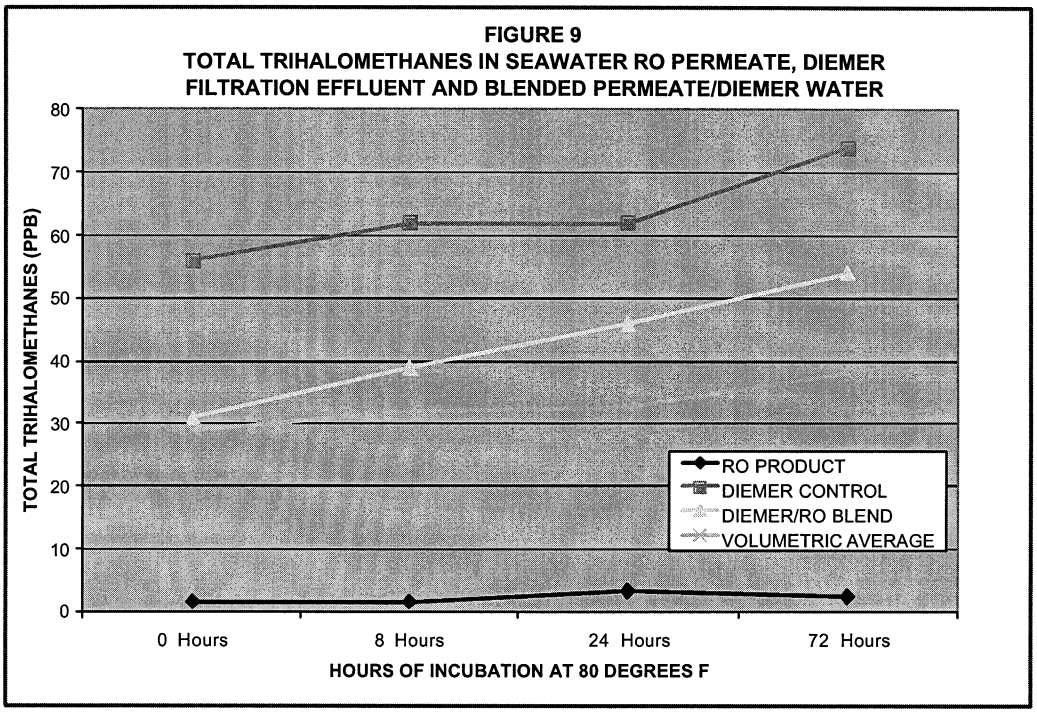
TABLE 4
MAXIMUM DBP LEVELS OBSERVED IN THE SDS CONTROLS AND BLENDS

	Maximum Level of TTHMs Observed During SDS (ug/L)			Maximum Level of HAA5 Observed During SDS (ug/L)		
Source Waters	**Control**	**Blend**	**MCL**	**Control**	**Blend**	**MCL**
MWDSC Diemer Effluent	74	54	80	34	18	60
IRWD Groundwater	6.1	5.8	80	9.1	8.6	60
Newport Beach Groundwater	14	5.7	80	1.7	1.1	60

MCL is Maximum Contaminant Level
Controls are 100% source waters, Blends are 50% ocean desalinated water with 50% source water

Blending with Chloraminated Surface Water – MWDSC Diemer Effluent

At the end of the 72 hour test period, both the RO Permeate/Diemer Blend and the Diemer Control exhibited a 20 – 25 ug/L increase in TTHMs (Figure 9) compared to the initial "0" time levels, whereas the RO Permeate Control did not form any appreciable amount of DBPs (TTHMs or HAAs) over the length of the experiment. Notably, a DBP dilution effect is observed when chloraminated surface water from MWDSC's Diemer Filtration Plant is blended with the disinfected RO permeate from the Poseidon Resources Corp. desalination pilot plant. This is due to the low DBP levels in the RO permeate (less than 3.5 µg/L TTHMs and less than 1.0 µg/L HAAs) and the lack of significant bromide incorporation into DBP precursors that may be present in the Diemer source water.



The theoretical volumetric TTHM average is shown as the light blue line in Figure 9. This value is simply the average of Diemer Control and the RO Product Control TTHMs measured at each sampling interval. The volumetric average of the Diemer Control and the RO Product Control TTHMs at each sampling time is lower than the actual TTHM levels measured in the blend of the two source waters. A small marginal increase of 12 µg/L was observed in the RO Permeate/Diemer blend after 72 hours when compared to the theoretical volumetric average. However, the TTHM concentration in the blend is always substantially less than the Diemer Control, so no problem associated with TTHM compliance would be anticipated from blending the two source waters. As shown in Figure 10, almost no "stimulatory" effect from blending is evident for HAAs.

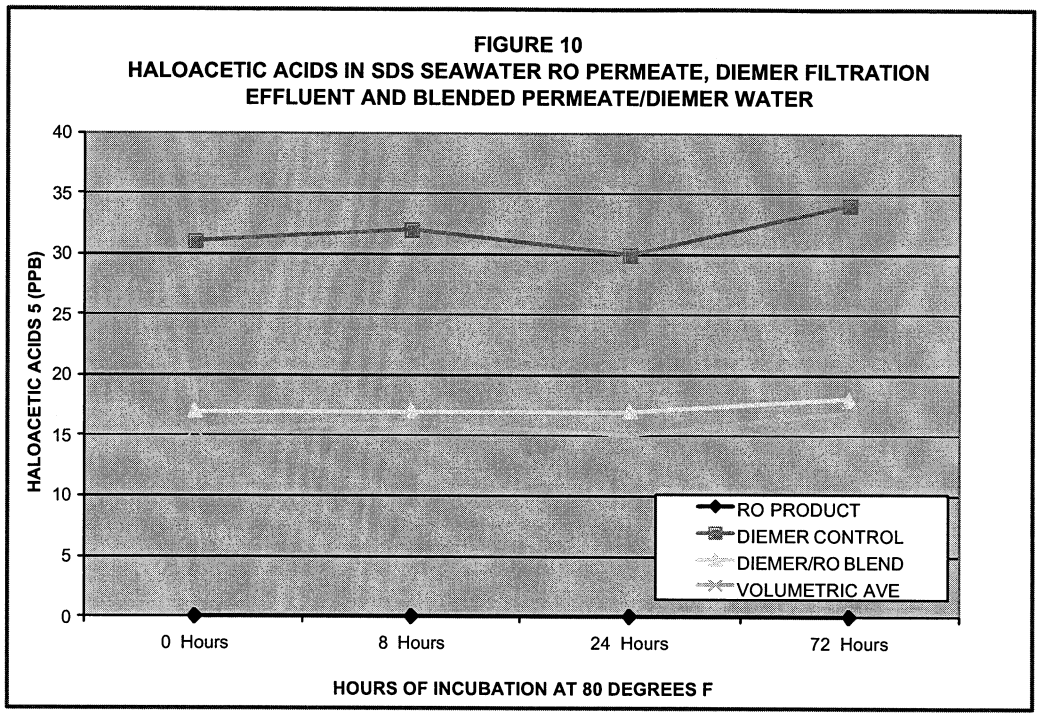


Figure 11 illustrates the maximum levels of individual DBPs observed in the RO Permeate/Diemer Blend and Diemer Control during the SDS experiment. As shown in Figure 11, none of the individual DBPs exceeded 20 µg/L in the RO Permeate/Diemer blend over the 72 hours of the SDS. With the exception of bromoform, the level of the each individual DBP is always lower in the blend than in the Diemer Control. With respect to bromoform, the maximum level observed in the blend is approximately three times higher than the maximum level measured in the Diemer Control.

Figures 12 – 14 illustrate what appears to be a slight stimulatory blending effect or a DBP "shift" associated with the formation of bromoform, and to a lesser degree for bromodichloromethane (BDCM) and dibromochloromethane (DBCM). The extent of the bromoform shift is 12 ug/L greater than the volumetric average of the two control sources after 72 hours (Figure 13). The shift associated with BDCM (Figure 12) and DBCM (Figure 14) is only in the range of 3 – 5 µg/L greater than the volumetric average after 72 hours.

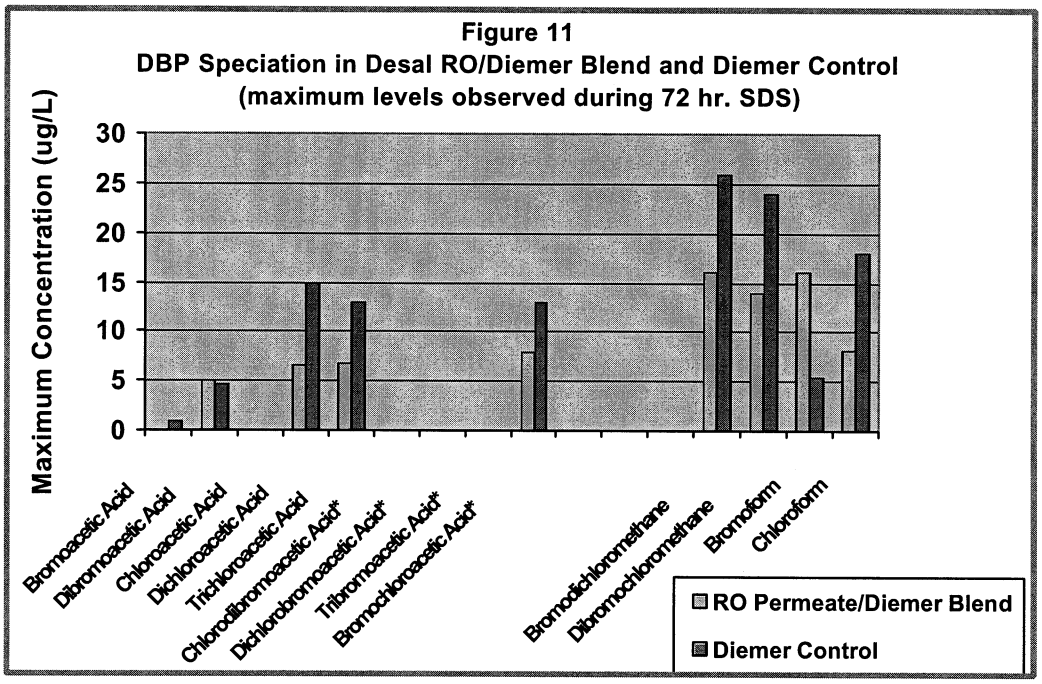


Figure 11
DBP Speciation in Desal RO/Diemer Blend and Diemer Control
(maximum levels observed during 72 hr. SDS)
Maximum Concentration (ug/L)
30
25
20
15
10
5
0
Bromoacetic Acid
Dibromoacetic Acid
Chloroacetic Acid
Dichloroacetic Acid
Trichloroacetic Acid
Chlorodibromoacetic Acid*
Dichlorobromoacetic Acid*
Tribromoacetic Acid*
Bromochloroacetic Acid*
Bromodichloromethane
Dibromochloromethane
Bromoform
Chloroform
RO Permeate/Diemer Blend
Diemer Control

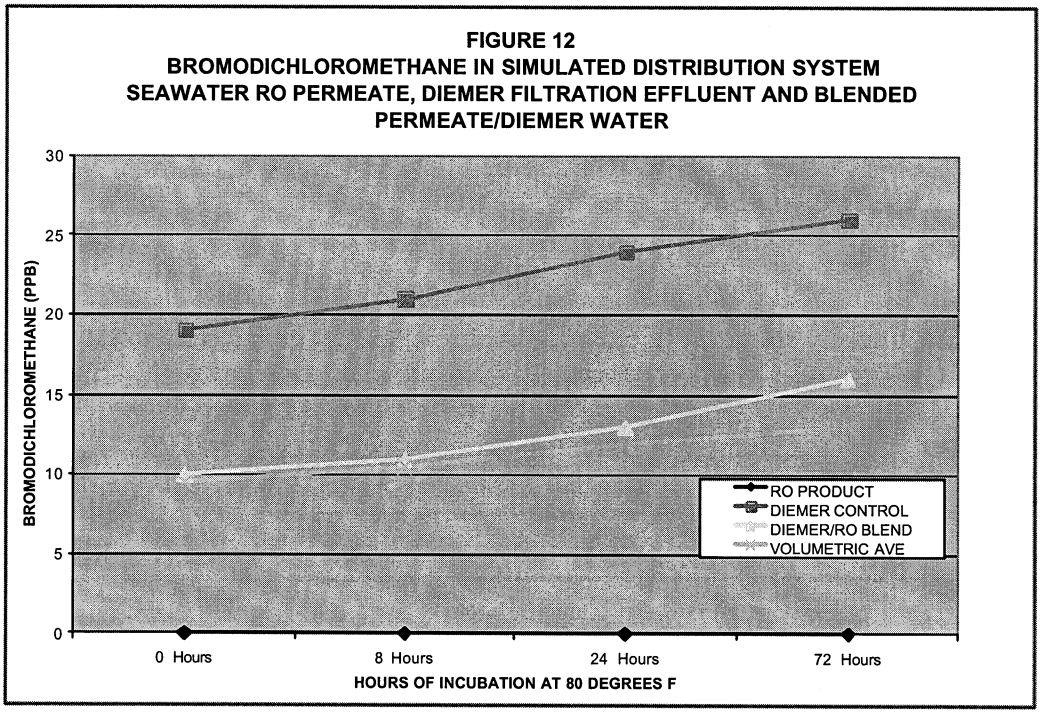


FIGURE 12
BROMODICHLOROMETHANE IN SIMULATED DISTRIBUTION SYSTEM
SEAWATER RO PERMEATE, DIEMER FILTRATION EFFLUENT AND BLENDED
PERMEATE/DIEMER WATER
BROMODICHLOROMETHANE (PPB)
30
25
20
15
10
5
0
RO PRODUCT
DIEMER CONTROL
DIEMER/RO BLEND
VOLUMETRIC AVE
0 Hours
8 Hours
24 Hours
72 Hours
HOURS OF INCUBATION AT 80 DEGREES F

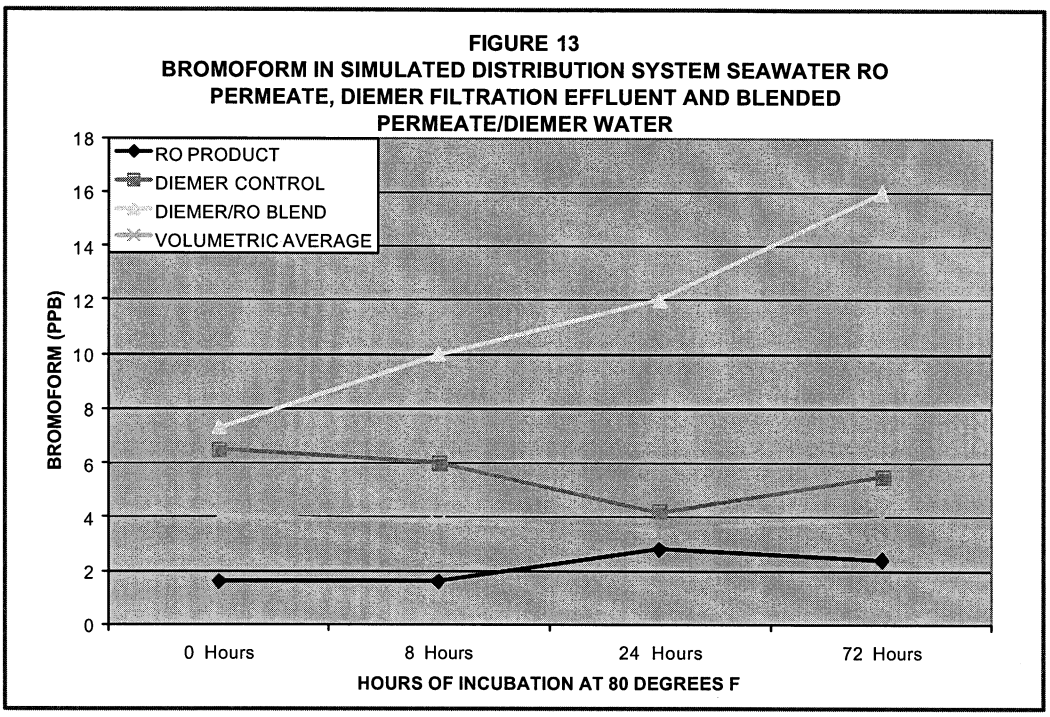


FIGURE 13
BROMOFORM IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, DIEMER FILTRATION EFFLUENT AND BLENDED PERMEATE/DIEMER WATER
RO PRODUCT
DIEMER CONTROL
DIEMER/RO BLEND
VOLUMETRIC AVERAGE
BROMOFORM (PPB)
0
2
4
6
8
10
12
14
16
18
0 Hours
8 Hours
24 Hours
72 Hours
HOURS OF INCUBATION AT 80 DEGREES F

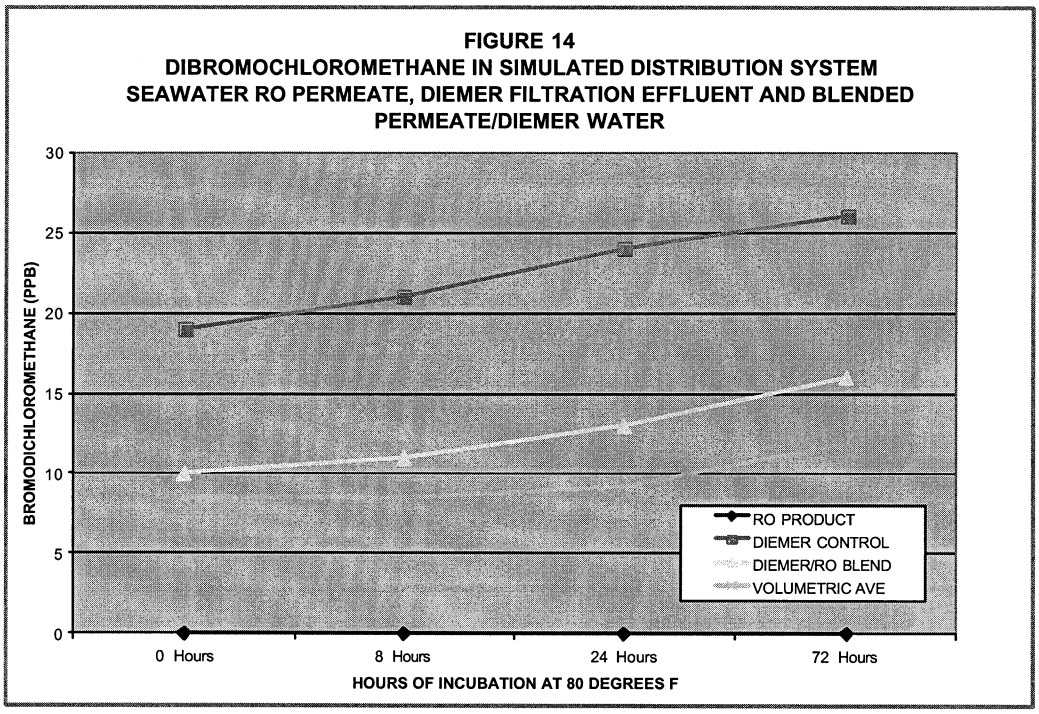


FIGURE 14
DIBROMOCHLOROMETHANE IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, DIEMER FILTRATION EFFLUENT AND BLENDED PERMEATE/DIEMER WATER
BROMODICHLOROMETHANE (PPB)
0
5
10
15
20
25
30
RO PRODUCT
DIEMER CONTROL
DIEMER/RO BLEND
VOLUMETRIC AVE
0 Hours
8 Hours
24 Hours
72 Hours
HOURS OF INCUBATION AT 80 DEGREES F

Groundwater Blends

DBP levels were very low, as expected, in both control and blend samples regardless of the groundwater source, as shown in following figures:

- Figure 15 – Newport Beach groundwater TTHMs
- Figure 16 – IRWD groundwater TTHMS
- Figure 17 – Newport Beach groundwater Bromoform
- Figure 18 – IRWD groundwater Bromoform

The highest TTHM levels were observed in the Newport Beach groundwater control (Figure 15). Similar to the MWDSC Diemer results, blending desalinated seawater with Newport Beach groundwater reduces DBP levels compared to the groundwater control. On the other hand, there is no dilution effect observed as a result of blending IRWD groundwater and RO permeate, as shown in Figure 16. This means some stimulatory effect, but only as little as 3 μg/L, is caused by the blending. This is not enough to form TTHMs in excess of the IRWD Control or anywhere near a regulatory level. Figures 17 and 18 show bromoform levels observed during the SDS. The marginal stimulatory effect of the RO Permeate/IRWD groundwater blend is due primarily to the slight shift seen in Figure 18 with bromoform.

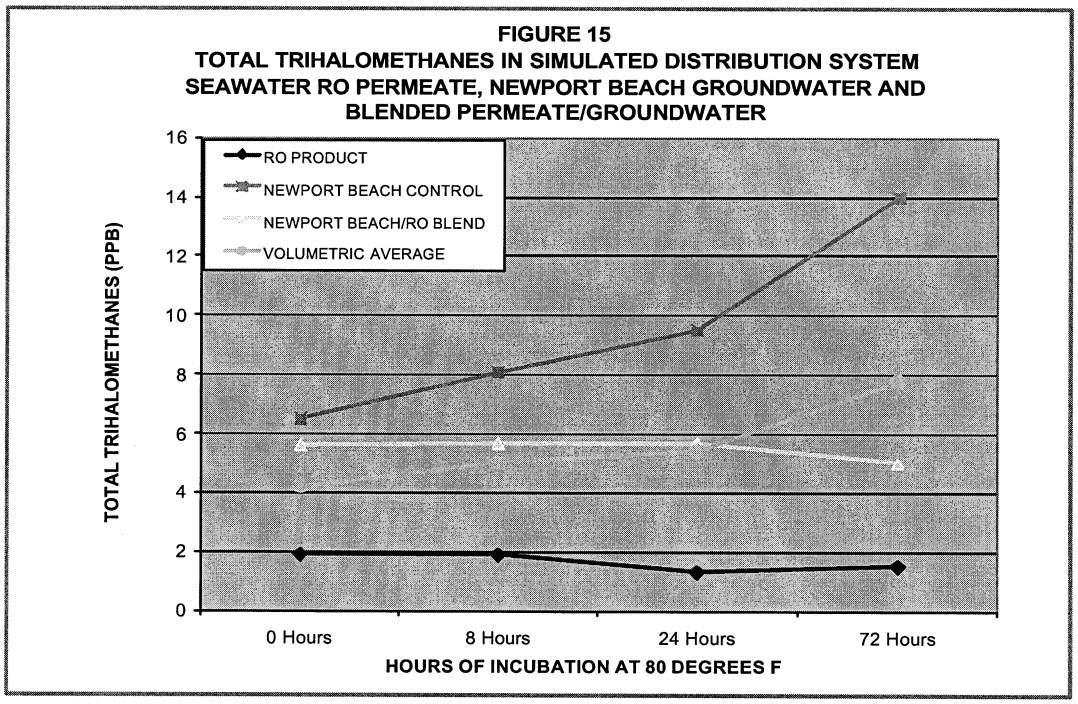


FIGURE 16
TOTAL TRIHALOMETHANES IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, IRWD GROUNDWATER AND BLENDED PERMEATE/GROUNDWATER

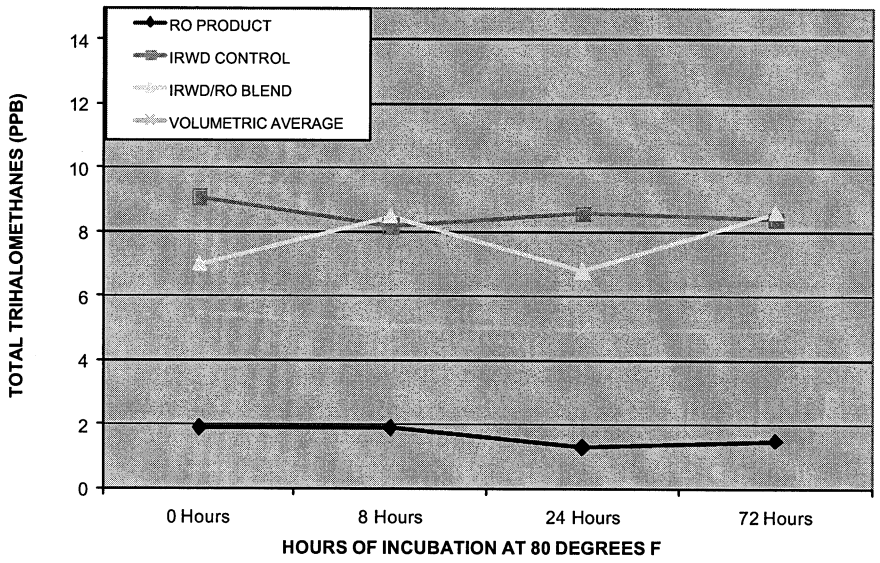
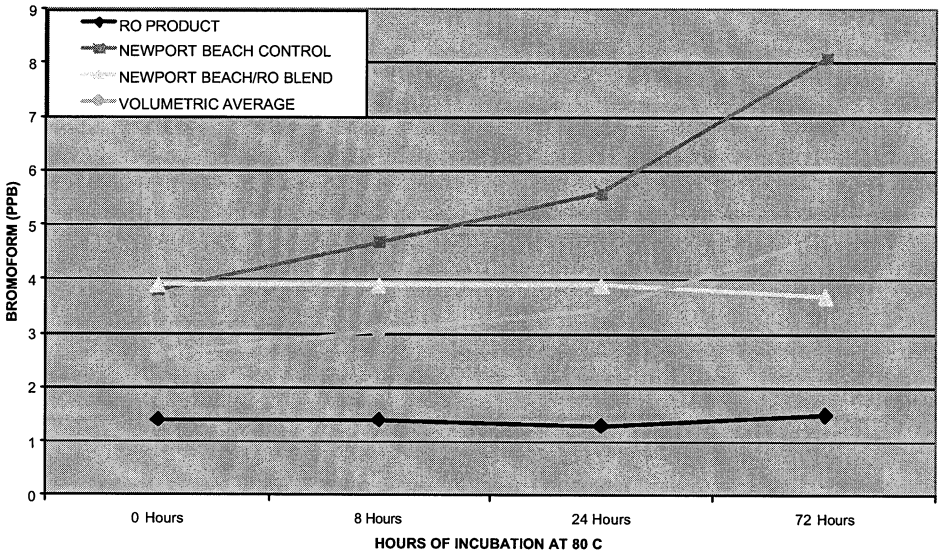
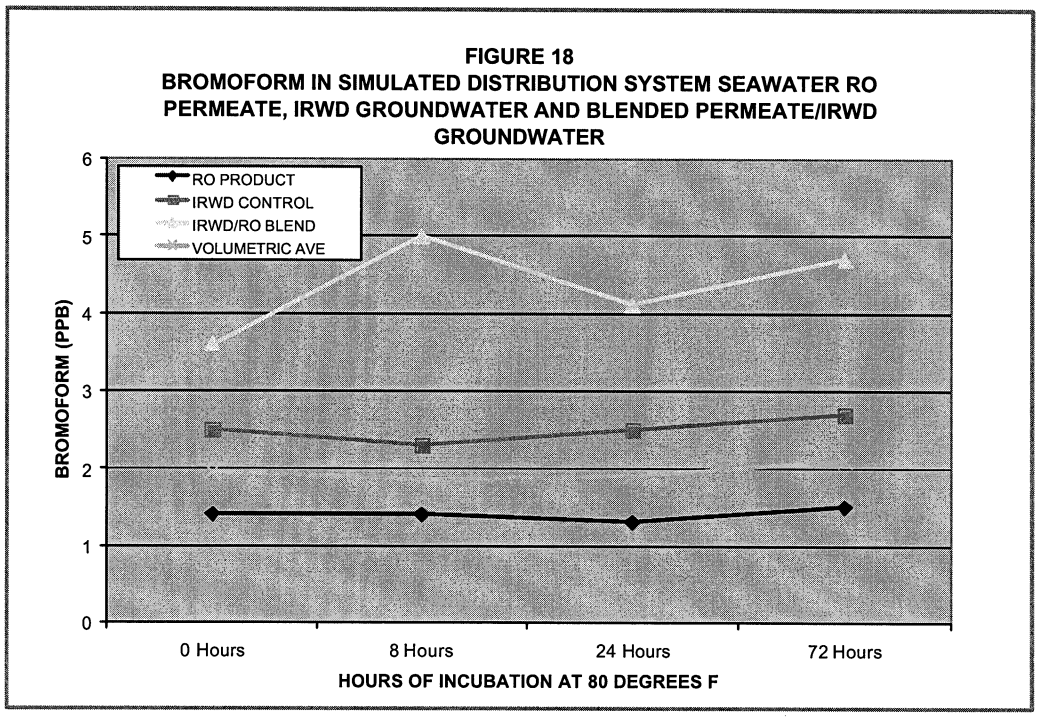


FIGURE 17
BROMOFORM IN SIMULATED DISTRIBUTION SYSTEM SEAWATER RO PERMEATE, NEWPORT BEACH GROUNDWATER AND BLENDED PERMEATE/GROUNDWATER



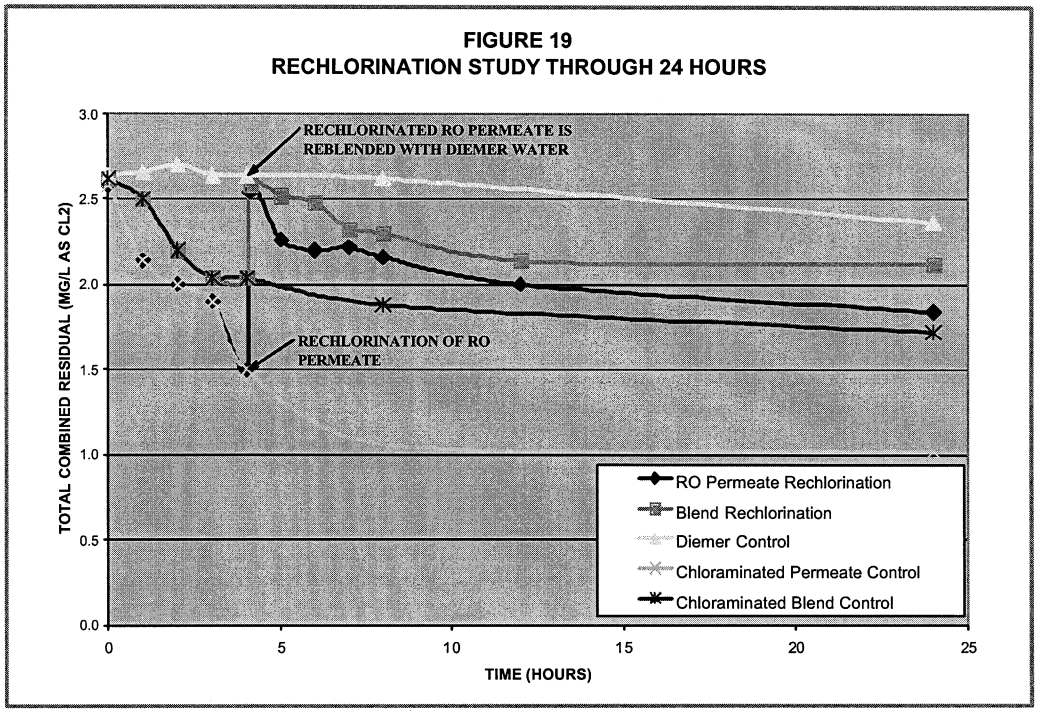


RECHLORINATION OF RO PERMEATE

The accelerated residual decay observed in the RO permeate during the SDS was investigated by rechlorinating the RO permeate after several hours of contact time in an attempt to stabilize the residual level. Chlorine and ammonia were introduced into the RO permeate in the same manner as conducted during the SDS. The combined residual decayed from 2.6 mg/L to 1.5 mg/L after only four hours (Figure 19). At that point, sodium hypochlorite was added to boost the RO permeate residual back up to the initial starting point of 2.6 mg/L. Then, another SDS was initiated with MWDSC Diemer water to determine whether the rechlorination step would impact DBP formation. Immediately after chlorine addition, the rechlorinated RO permeate was blended equally with Diemer water, and along with a non-rechlorinated blend control, 100% rechlorinated RO permeate control and Diemer control, allowed to incubate according to the SDS protocol already described.

Rechlorinating the RO permeate made a dramatic improvement on the rate of residual decay, i.e., stabilizing the residual. The residual in the rechlorinated RO permeate decayed at only one-half the rate of the non-rechlorinated permeate after the equivalent four hours of contact time – a 1.1 mg/L decrease in the non-rechlorinated permeate residual compared to a 0.5 mg/L decrease in the rechlorinated permeate residual (Figure 19). An improvement in residual stability was also observed in the Diemer/RO permeate blend using rechlorinated permeate. The blend using rechlorinated permeate had a stabilized residual that was 0.5 mg/L higher than the blend that utilized non-rechlorinated permeate. Figure 19 illustrates residual stabilization of the rechlorinated RO permeate and the blend of rechlorinated permeate with Diemer water through

20 hours. The test proceeded for 72 hours during which only a minimal amount of incremental decay on the order of 0.2 – 0.4 mg/L occurred.



Stability of an initial 4.5 mg/L combined residual was tested in seawater RO permeate ("superchloramination") over a 24 hour period. As shown in Figure 20, after 20 hours of incubation, the residual disinfectant concentration of 2.0 mg/L is practically the same as the residual measured in the rechlorinated permeate (Figure 19) after the same amount of contact time.

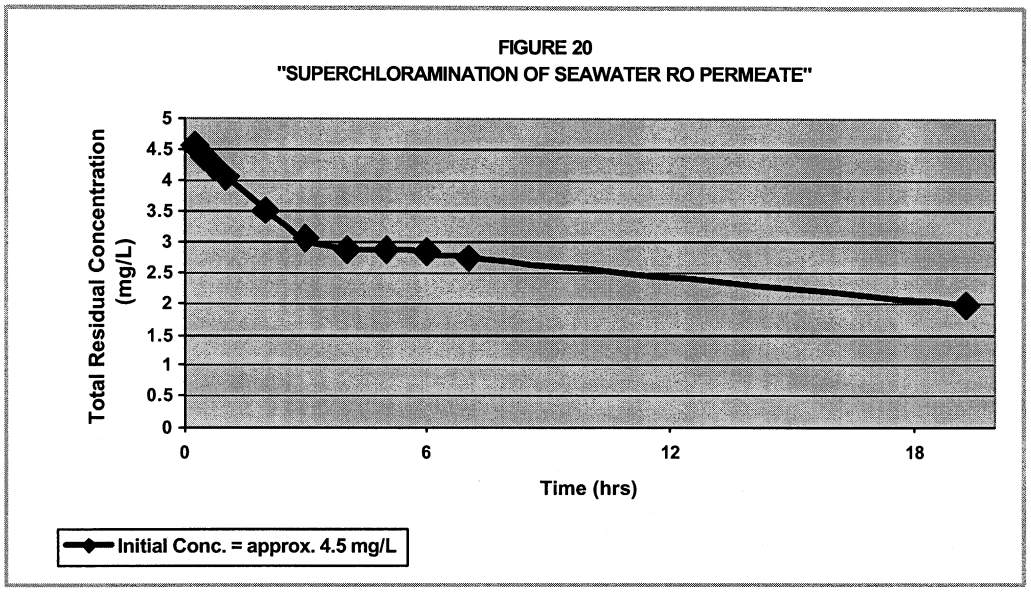


Table 5 compares the DBP levels in the Diemer Control and both types of Diemer/RO Product water blends – made with rechlorinated RO permeate and non-rechlorinated RO permeate. There is no difference between the DBP levels in the two types of blends. Rechlorinating the RO permeate and subsequent blending does not increase the DBP levels compared to a blend utilizing the non-rechlorinated RO permeate.

TABLE 5
RECHLORINATION BLENDING STUDY DATA - OCTOBER 2003
POSEIDON RESOURCES PILOT PLANT DESALINATED SEAWATER AND MWDSC DIEMER WATER

	MRL (ug/L)	Diemer/RO Blend (non-rechlorinated) 24 Hours	Diemer/RO Blend (non-rechlorinated) 48 Hours	Diemer/RO Blend (non-rechlorinated) 72 Hours
HAA5	1	13	14	14
Bromoacetic Acid	1	ND	ND	ND
Dibromoacetic Acid	1	5.6	5.9	6.2
Chloroacetic Acid	2	ND	ND	ND
Dichloroacetic Acid	1	4.8	4.9	5.1
Trichloroacetic Acid	1	2.9	2.9	3.1
TTHMs	0.5	36	35	38
Bromodichloromethane	0.5	9.1	8.4	9.3
Dibromochloromethane	0.5	12	12	13
Bromoform	0.5	11	11.0	11
Chloroform	0.5	4.2	3.8	4.5
	MRL (ug/L)	**Diemer/Rechlorinated RO Blend 24 Hours**	**Diemer/Rechlorinated RO Blend 48 Hours**	**Diemer/Rechlorinated RO Blend 72 Hours**
HAA5	1	13	13	12
Bromoacetic Acid	1	ND	ND	ND
Dibromoacetic Acid	1	5	5.3	5.2
Chloroacetic Acid	2	ND	ND	ND
Dichloroacetic Acid	1	4.8	5.1	4.5
Trichloroacetic Acid	1	2.9	3	2.8
TTHMs	0.5	33	34	34
Bromodichloromethane	0.5	8.8	9.2	9.2
Dibromochloromethane	0.5	12	12	12
Bromoform	0.5	7.7	8.1	8.4
Chloroform	0.5	4.6	4.6	4.6

Disinfection regulations governing approved surface water treatment establish the following three performance standards:

- Water delivered to the distribution system shall not contain a residual of less than 0.2 mg/L for more than four hours in any 24 hour period,
- Residual disinfectant concentrations of samples collected form the distribution system shall be detectable in at least 95 percent of the samples taken each month, during each and every two consecutive months that the system serves water to the public, and
- At any sampling point in the distribution system, the presence of heterotrophic plate count at levels less than 500 colony forming units per milliliter shall be considered equivalent to a detectable disinfectant residual.

In no event will the treated seawater contain a combined residual of less than 0.2 mg/L entering the distribution system. A target of 2.0 – 2.5 mg/L entering the distribution system from the Poseidon facility is realistic given the success of residual stabilization through rechlorination or providing an initial combined residual of 4.0 - 4.5 mg/L.

Rechlorination also will provide a more stabile residual in the distribution system. Detectable residual levels should not be a problem in any of the water systems receiving the desalinated water supply, except possibly those that have not yet converted their groundwater supply to chloramines, but continue to use hypochlorite as their residual disinfectant. Potential residual loss due to mixing of chlorinated groundwater and "chloraminated" desalinated water in the distribution system is no different than the current situation these systems face when the chloraminated MWDSC supply mixes with their chlorinated groundwater.