**FY 2014 CHIEF OF NAVAL OPERATIONS**
**ENVIRONMENTAL AWARD COMPETITION**
**AWARD CATEGORY:**
**SUSTAINABILITY TEAM**

*Spray Aeration Reduces Trihalomethane Concentrations in Drinking Water*

## Introduction

Naval Base Coronado (NBC) is home to 25,700 active duty military and 5,800 civilian employees. NBC's primary mission is to support the Fleet, Fighter and Family, by providing the highest quality base operating support and quality of life services to U.S. Navy operating forces and other assigned and visiting activities. We seek to provide the right support, at the right time, in the right amount, enabling operating forces to produce the right level of combat readiness.

The NBC Installation Commanding Officer (ICO) is responsible for eight geographically separate installations including Naval Air Station North Island (NASNI), Naval Amphibious Base Coronado (NAB), Silver Strand Training Complex (SSTC), Naval Outlying Landing Field Imperial Beach (NOLFIB), Remote Training Site Warner Springs (RTSWS), Mountain Warfare Training Camp Michael Monsoor (CMM), Camp Morena, and Naval Auxiliary Landing Field, San Clemente Island (SCI).

SCI is the cornerstone of the tactical training ranges supporting the Southern California Operations Area (SOCAL OPAREA). SOCAL supports the largest concentration of naval forces in the world. The SCI land, air, and sea ranges provide the U.S. Navy, U.S. Marine Corps, and other military services space and facilities which they use to conduct readiness training and test and evaluation activities.

## Background

SCI is approximately 67 miles from San Diego and Coronado Ca., the home of Naval Base Coronado. The majority of logistical supplies are shipped from San Diego via commercial barge. Potable water supplied to customers at SCI is also shipped via a barge from Naval Base San Diego (NBSD) to Wilson Cove on SCI. The water supplied to the barge is a blend of water from Sweetwater Authority (SWA) and City of San Diego (SDW). Figure 1 shows the locations of SWA and SDW meters and sampling points at NBSD.

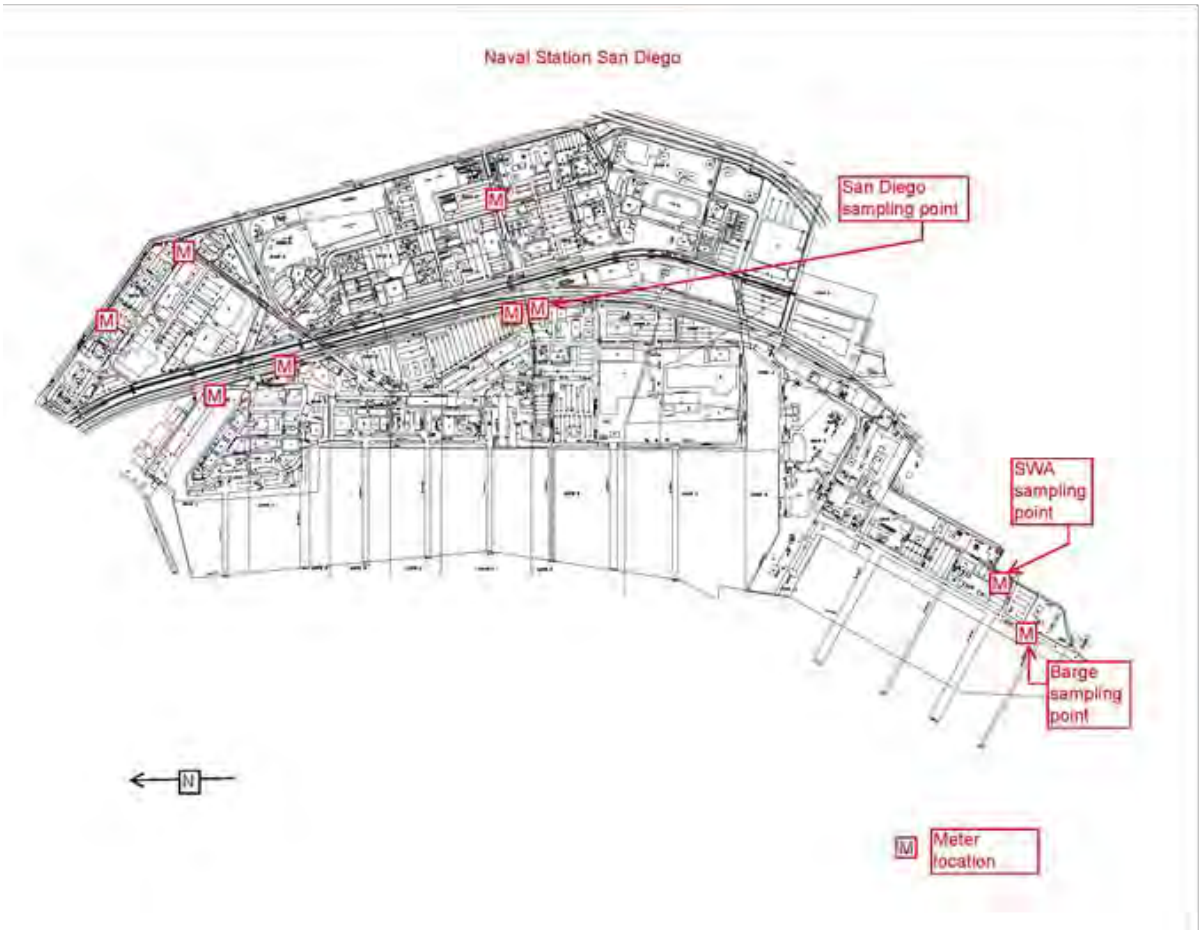



Figure 1: San Diego and SWA meters and sampling points at Naval Station San Diego.

In 2007, NBC received an Administrative Order (AO) from the U.S. Environmental Protection Agency (EPA) requiring the potable water system located at SCI be in compliance with the Disinfection By-Products Rule for Total Trihalomethane (TTHM) by January 1, 2009. This AO was amended on December 31, 2008, allowing the NBC additional time to achieve compliance, and also established a negotiated plan of action with short, medium, and long term solutions.

Trihalomethanes (THMs) are present in the source water for the SCI at levels below the regulatory limit of 80 micrograms per liter (µg/L). When the water is offloaded at SCI, it is placed in the distribution system (storage tanks) where it is breakpoint chlorinated, stored, and then distributed. As a result of the need to store water for emergency and fire protection needs, the water age at SCI varies from 3 days to several months, with an average of about 34 days (1.7 mil/gal). NBC maintains chlorine residual throughout the distribution system by recirculation and bleach injection systems at storage reservoirs on the island. With a long water residence time and a free chlorine residual, THMs continued to form as the chlorine reacts with preexisting precursors present in the water thereby keeping the TTHM levels out of compliance.

The elevated THM levels have been a concern to NBC and to the EPA for quite some time. According to the EPA "Some people who drink water containing total trihalomethanes in excess of the MCL over many years could experience liver, kidney, or central nervous system

problems and increased risk of cancer." Unfortunately, for this small water system, treatment options are limited since everything has to be barged to the island tripling coasts for just about everything as compared to mainland activities.

In order to comply with the EPA AO several short, medium and long term measures were considered and or implemented. While these measures originally decreased THM levels, the reductions could not be sustained due to uncontrolled factors such as weather and fluctuations in THM precursors in the source water. The following short term solution measures were implemented:

1) Installed an orifice plate or throttling valve on the barge fill at NBSD to limit the barge fill to the capacity of the SWA threshold (about 1,000 gpm);

2) Installed larger valves and a meter on the SWA threshold within NBSD;

3) Increased monitoring of SWA and barge fill by conducting total organic carbon (TOC) sampling and analysis every other week and TTHM Formation Potential (TTHMFP) once a month at NBSD;

4) Provided a monthly update to the EPA and California Department of Public Health (CDPH) on the Navy's activities and present TOC, TTHMFP, and SCI TTHM analytical results as well as water meter data; and

5) Conducted monthly TTHM sampling and analysis at the four-stage 1 TTHM monitoring locations at SCI and included the results in monthly status reports.

One midterm solution was implemented that provided the EPA & CDPH a report that evaluated the sampling results and infrastructure changes. Finally, one long term solution was identified as the ultimate solution; funding and installation of a reverse osmosis (RO) facility on SCI. A Military Construction project MILCON 1391 package was submitted for approval but did not receive funding in part due to significant construction and maintenance costs of an RO facility (>21 million dollars).

## Summary of Accomplishments

### *TTHM Compliance can be complex, costly, and time-consuming*

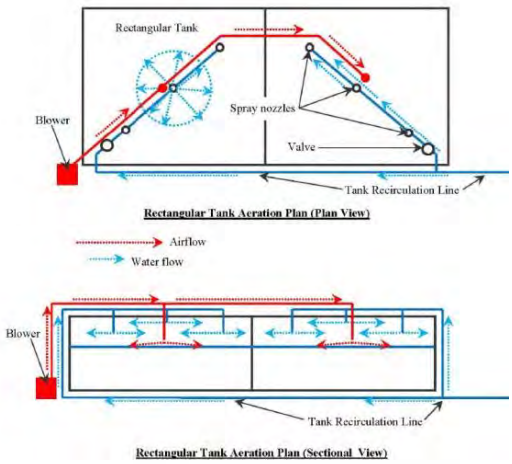
Soon after receiving the first violation from CDPH and EPA, NBC considered using granular activated carbon (GAC), which was considered the best technology available to reduce THMs at that time. Unfortunately costs to install GAC at SCI were over $3 million and no space was available at San Diego bases and at SCI for a GAC treatment facility. Producing drinking water from the ocean surrounding SCI using desalination technologies such as reverse osmosis were also considered but proved to be cost prohibitive at approximately $21 million and would require 5 to 6 years (best case) to construct. Additionally, RO would require complex and expensive environmental permitting for the brine ocean discharge, biological entrainment and entrapments with the ocean intake.

In 2012, the THM "Perfect Storm" hit the SCI Water system. The barge was scheduled for regular maintenance, therefore SCI took on additional water, thereby increasing the amount of water storage and hold time. Additionally, SWA provided source water with higher THM levels. By April 2012, THM concentrations soared and the SCI drinking water system was out of compliance with the TTHM MCL. High concentrations of THMs occurred in the SCI water system until October 2013. Mr. Len Sinfield and Mr. Thomas Niday who had been working this

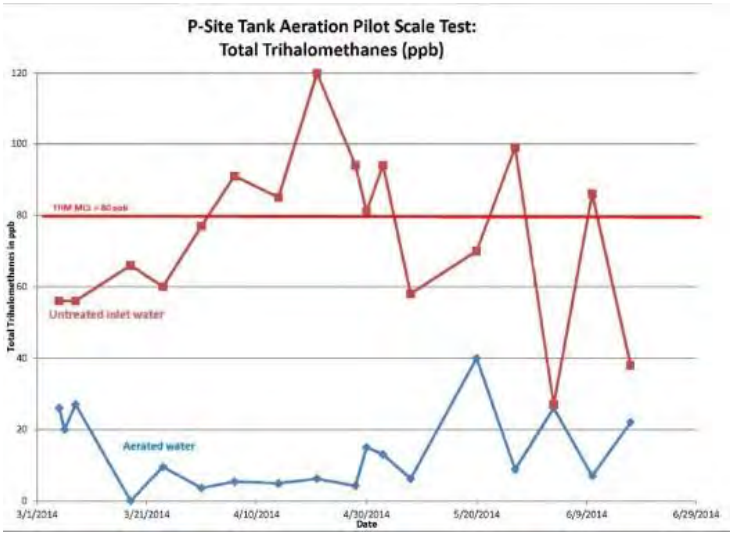
issue since the onset believed there had to be a more cost affordable and effective solution. After lengthy research they determined that spray aeration could be the solution.

## *Spray Aeration; It's simple and may retrofit on existing tank recirculation systems*

Spray aeration is simply the spraying of water into the headspace of a water tank to strip volatile THMs from the water. A positive pressure blower with an air filter is used to push fresh air into the tank headspace to remove the stripped THM gases out the tank air vents. At SCI, the existing tank water recirculation systems were modified for spray aeration by adding additional piping and spray nozzles. The design includes a non-clogging (large diameter particle pass-through) spray nozzles (glorified showerhead) that produces the smallest water droplet size (based upon water flow rate and pressure). The spray angle, based upon tank configuration, is adjusted to achieve the longest droplet travel distance. This differs from bubble aeration where air is bubbled into the bottom of the water tank and rising bubbles strip THMs from the water. Bubble aeration was not selected because it requires a large blower to overcome the water pressure in the tank. Although spray aeration was considered experimental by EPA NBC was able get approval to conduct a Pilot Scale Test in October 2013.

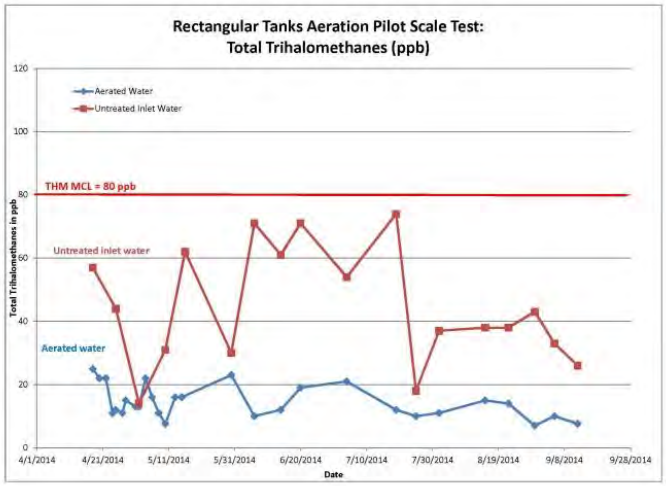



## *Initial* Spray Aeration Test at SCI; A Fancy Showerhead and an air blower



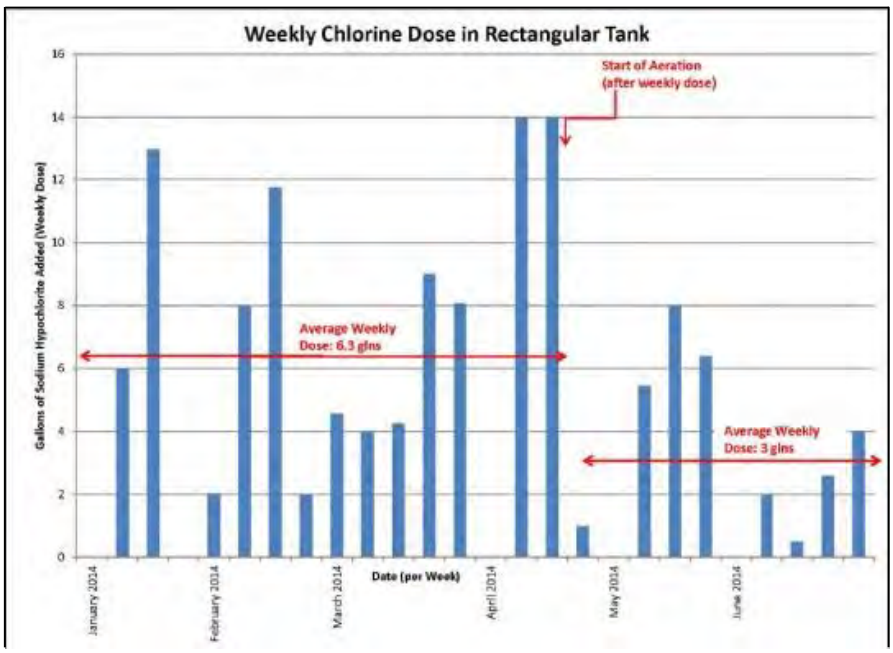

An initial spray aeration pilot test was conducted in October on the P-site tank, a small 10,000-gallon tank at a remote location at SCI. P-site was a desirable site due to its long water age and high concentrations of THMs. This initial pilot test was installed at minimal material cost of less than $5,000. NAVFAC water system operators under the direction of Mr. Niday, installed a BETE™ spray nozzle rated at 20 gallons per minute (gpm) on the existing water recirculation and booster chlorination system. An electrical blower rated for 30:1 air to water ratio and associated plumbing were installed to exchange air in the tank headspace. Within ten days, approximately 90 % of the THM were removed from the water at P-site. Overall, this modification removed on average 76% the THMs. Additionally, this resulted in TTHM concentrations below 80µg/l at downstream monitoring locations.

## Expansion of Spray Aeration System at SCI; More fancy showerheads and blowers




The initial success was reported to the California Department of Public Health (CDPH) and EPA in January 2014. NBC proposed upgrading the P-site aeration system and expanding the spray aeration system to all the tank systems at SCI. The CDPH and EPA immediately accepted the proposed system upgrades and expansion. The upgrades and additional tank aeration systems were installed and became operational throughout the first and second quarters of 2014. Total material and installation costs for the spray aeration system for the whole SCI water system were less than $75,000. It is estimated that spray aeration removed from 56% to 86% of the THMs in the rectangular tank water, averaging 67% removal efficiency overall.

While CDPH and EPA were pleased with the TTHM levels, concerns were expressed about spray aeration and whether the chlorine disinfectant was going to be stripped from the water. Mr. Sinfield and Mr. Niday reviewed chlorine dosing data from before and during aeration, and provided the following chart that showed that chlorine was not stripped. In fact **chlorine dosing rates were shown to be lower**. Results showed that overall chlorine dosing rates were half that of non-aeration rates.

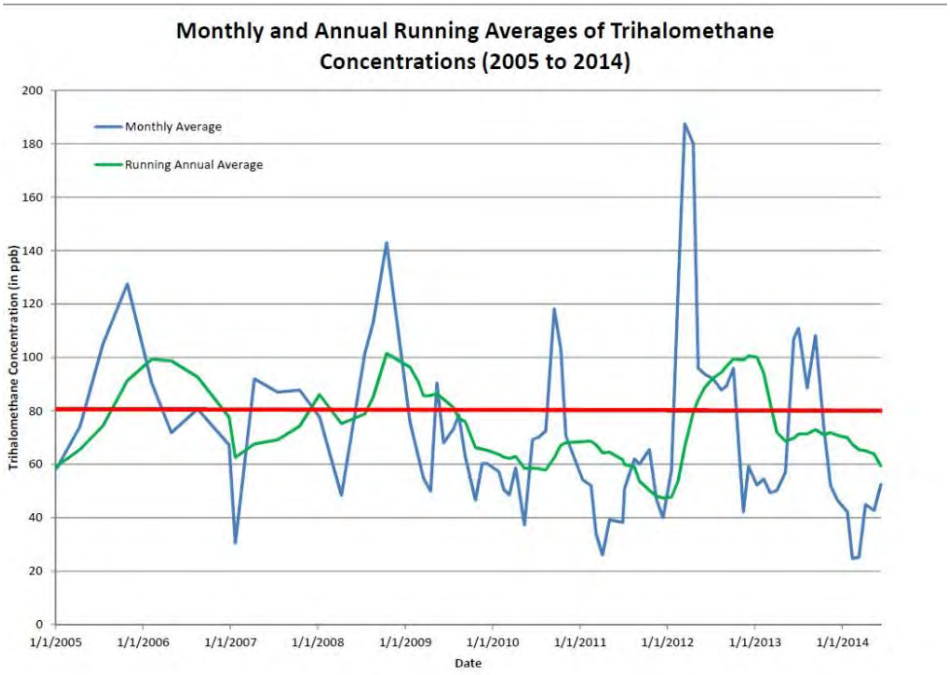


## Spray Aeration Results; SCI is now back in compliance with the THM MCL

**SCI is now in compliance with the EPA TTHM Maximum Contamination Level (MCL)**. While spray aeration was successful in reducing THMs, it seems it was actually the final key to the puzzle. Overall THMs were reduced in the water reservoirs and at the compliance monitoring points at SCI due to a combination of efforts including:

- Switching to SWA source water with low TOC concentrations;
- Relatively low water age (currently 26.9 days);
- Better water mixing in tanks (from both PAX™ mixers and aeration); and
- Stripping of THMs using spray aeration.

**Implementation of these measures resulted in an agreement with CDPH and EPA to close the AO once a final treatment permit is issued (expected spring 2015)**.




## Recommendations for Navy Water Systems; Spray aeration is simple and cost effective

During this process Mr. Sinfield and Mr. Niday considered several options and while spray aeration worked at SIC it may not be the solution for all systems. When evaluating Navy drinking water systems they recommend the following be considered.

- *EPA Best Available Technology (BATs)* for consecutive systems may work in some water systems with short average water ages, but as the SCI example shows, for water systems with long water ages, these BATS may only work in the short term;
- *Hydraulic control measures* such looping water distribution lines can be accomplished for some water systems to reduce water age and associated THMs within the distribution system, but may not be accomplished in others with long pipelines due to high costs;

- *Unidirectional flushing of water distribution piping* is very effective for reducing chlorine demand and THM formation within the distribution system, but this process wastes water and increases costs;

- *A combination of internal tank mixers combined with spray aeration* worked where the source water quality can change and water age is high; and

- *Spray aeration* stabilizes chlorine levels in the tanks and distribution system, reducing the amount of chlorine dosed in the system. In some cases, a small tank with a spray aeration system and a chlorine booster may reduce THMs significantly for dead-end and/or remote areas at the end of long pipelines of a distribution system.

### Sometimes small things with the right people can make a huge difference

It is very clear that for SCI and similar systems this low-cost modification can produce huge returns in better drinking water quality, lower chlorine costs, and greater consumer confidence. While ultimately it was a fairly low cost solution to a large problem, this solution would not have occurred if not for the years of technical experience and dedication to the Navy showed by Mr. Len Sinfield and Mr. Thomas Niday.