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TR-NAVFAC-EXWC-EV-1903  
SEPTEMBER 2018**

**UNDERSTANDING THE IMPACT OF LOW WATER  
FLOWS ON SEWER SYSTEMS AND WASTEWATER  
TREATMENT PLANTS – NESDI #518**



*Prepared by:*  
Tami Relph, PE  
Daniel Edwards  
Autumn Resto  
Hunter Spence  
*Naval Facilities Engineering & Expeditionary Warfare Center*

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| 14. ABSTRACT<br>This report documents an assesment of the impacts of reductions in drinking water consumption on Navy wastewater collection and treatment systems. Available data on wastewater systems and Clean Water Act compliance Notices of Violation (NOVs) were analyzed at the regional and installation level in an effort to elucidate long term trends and wastewater system vulnerability. EXWC personnel completed site visits to specific Navy installations to assess how utility managers are dealing with the impacts of declining flows in wastewater systems. Key issues were identified and potential solutions provided. The project team found that the issues impacting wastewater infrastructure are mainly linked to aging systems or poorly designed systems and management of these systems, rather than declining flows. While low flow issues can lead to quality issues, the overarching wastewater infrastructure degradation is a combination of factors including: poor system design, lack of maintenance and timely upgrades, personnel and staffing issues, dated and aging infrastructure. Complete findings and recommendations are reported herein. |                  |                                    |                                         |                                                                    |                                                           |
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Navy Environmental Sustainability Development to Integration Program



# UNDERSTANDING THE IMPACT OF LOW WATER FLOWS ON SEWER SYSTEMS AND WASTEWATER TREATMENT PLANTS

#518

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This research was made possible by the Navy Environmental Sustainability Development to Integration (NESDI) Program with resources provided by the Chief of Naval Operations Energy and Environmental Readiness Division (CNO N45). The NESDI program seeks to provide solutions by demonstrating, validating, and integrating innovative technologies, processes, materials, and filling knowledge gaps to minimize operational environmental risks, constraints and costs while ensuring Fleet readiness. For more information, visit the NESDI program website at <https://epl.navfac.navy.mil/nesdi/> or contact the NESDI Program Manager at 805-982-4893.

## EXECUTIVE SUMMARY

This document serves as the Final Report for NESDI Project #518 entitled “Understanding the Impact of Low Water Flows on Sewer Systems and Wastewater Treatment Plants”. The objective of this project was to determine whether there are adverse impacts from low flow devices in Navy operated wastewater collection and treatment systems. NESDI Project #518 identifies problems that may result from low wastewater flows and potential solutions to ensure that wastewater collection systems and treatment plants operate within their design specifications. Our report outlines the scope of the problem, including data collected on water conservation, wastewater collection and treatment systems, and from site visits to different regions. The data is then summarized into the key issues identified along with potential solutions/BMPs outlined.

The Navy Environmental Sustainability Development to Integration (NESDI) need N-1042-15 asserts that the Navy needs to understand, assess, and address the impacts of water conservation measures on installation wastewater infrastructure. Increased use of low flow devices and widespread mandated water conservation measures may have resulted in reduced and concentrated flow through wastewater collection systems. These changes can result in regulatory compliance violations and necessitate increased maintenance.

Over the course of this study the project team analyzed wastewater quality and flow data, performed site visits, interviewed local and regional personnel, and examined wastewater treatment and conveyance systems. The project team did not find sufficient evidence that low flows directly cause compliance issues. Analysis of wastewater quality and flow data showed no specific trends in concentrations either in the influent or effluent that definitively related to low flow conditions. Changes in wastewater quality during periods of flow reduction did not generally result in treatment changes or plant violations of discharge requirements.

Overall, the Navy-wide reduction in water consumption is modest. Some installations showed a significant decrease in water consumption while others did not. The installations that did experience significant reductions were no more likely to have a CWA NOV than those that experienced no reductions in water consumption. The water consumption and compliance data obtained does not show any widespread trends that suggest reductions in water consumption (i.e. low flows) is currently causing increases in exceedance related CWA NOVs at the regional level.

Common wastewater system challenges as identified in this study vary from site to site as result of multiple variables including system design and facility operations. Overall there were multiple issues identified that can be caused or exacerbated by low flows, all of which can lead to NOVs and reduce overall effectiveness of the wastewater infrastructure. While the purpose of this study was to identify problems associated with low flows as a result of conservation efforts, many of the issues identified often had other factors (aside from low flows) that contributed or caused system degradation and NOVs. All of these issues are exacerbated by declining flows, but are endemic to most wastewater systems regardless of flow conditions. These issues include concentrated flows, flow variability, aging infrastructure, increased hydrogen sulfide (H<sub>2</sub>S) and odor problems, excessive nutrients in the inflow and effluent streams, and oil and grease buildup.

The project team found that the issues impacting wastewater infrastructure are mainly linked to aging systems or poorly designed systems and management of these systems, rather than declining flows. While low flow issues can lead to quality issues, the overarching wastewater infrastructure

degradation is a combination of factors including: poor system design, lack of maintenance and timely upgrades, personnel and staffing issues, dated and aging infrastructure. Each these factors contribute significantly more to degradation of wastewater quality than low flow as a result of conservation. By addressing the aging infrastructure problems and implementing effective and appropriate design, operation and maintenance of wastewater treatment and conveyance systems wastewater quality can be assured. An effectively managed and appropriately designed system allows for the mitigation of multiple potential issues typical of wastewater operations including low flow issues.

While the project team initially expected the solutions for managing impacts of low flows in wastewater systems to be technical, nearly all of the common factors for compliant wastewater systems were non-technical. The most important factor was having a sufficient number of staff members with enough long-term personnel familiar enough with the system to foresee and prevent potential issues from occurring. The ability to execute proactive strategies to prevent future problems, rather than operating in reactionary mode, has a major impact on keeping a system in compliance. Other overarching factors that contributed to maintaining compliance were a well-designed wastewater system with equalization tanks and redundancies, a good working relationship between the wastewater system operators and NAVFAC PW/EV staff, and a robust operations and maintenance strategy.

Additional solutions to mitigate risk of CWA NOV's include better characterization of each installation's wastewater system through wastewater monitoring at the facility level, more robust wastewater monitoring at the process level, and maintaining detailed records of operations and maintenance. Consultations and detailed investigations are uniquely effective at evaluating wastewater system vulnerability to CWA compliance violations and providing optimized solutions for site-specific wastewater infrastructure challenges. Technical solutions include odor, nutrient, and oil and grease removal technologies.

Navy installations that have wastewater quality issues should conduct a detailed wastewater conveyance and treatment system review and field analysis to trace the root problem or problems. Each facility has unique challenges based on geographic location, tenant usage, conveyance and treatment system design, and shifting operations. This analysis will provide meaningful insight into the dynamics of the wastewater conveyance and treatment systems and allow for the optimization or retrofit of the system. Wastewater systems should be evaluated by personnel that have appropriate expertise to ensure identification of system issues and to recommend viable and cost-effective solutions including solutions provided in this report for risk mitigation strategies to address water system vulnerability to NOV's. In addition, installations should do their best to develop a long-term proactive strategy and maintain a full staff in order to keep their system in compliance and prevent future problems, rather than operating in a day to day more and reacting to issues as they occur. For example, installations that implement I&I reduction strategies should also consider the subsequent impact on declining flows through the wastewater collection and treatment systems. Future RDT&E recommendations include real-time detection of oil and grease inflows to lift stations, particularly near piers, and plug-in nutrient removal technologies.

## ACRONYMS AND ABBREVIATIONS

|                  |                                              |
|------------------|----------------------------------------------|
| AOC              | Administrative Order of Consent              |
| BMP              | Best Management Practice                     |
| BOD              | Biological Oxygen Demand                     |
| BOWTS            | Bilge and Oily Wastewater Treatment System.  |
| CFA              | Commander Fleet Activities                   |
| CFAC             | CFA Chinhae                                  |
| CFAY             | CFA Yokosuka                                 |
| CWA              | Clean Water Act                              |
| DoD              | Department of Defense                        |
| DUERS            | Defense Utility Engineering Reporting System |
| ECM              | Environmental Compliance Metrics             |
| EDMWeb           | Environmental Data and Metrics Website       |
| EMS              | Environmental Management System              |
| EO               | Executive Order                              |
| EPA              | Environmental Protection Agency              |
| EV               | Environmental                                |
| EXWC             | Engineering & Expeditionary Warfare Center   |
| FOG              | Fats, oils and grease                        |
| FY               | Fiscal Year                                  |
| GPD              | Gallons per Day                              |
| H <sub>2</sub> S | Hydrogen Sulfide                             |
| I&I              | Infiltration and Inflow                      |
| iNFADS           | internet Navy Facilities Asset Data Store    |
| IUDP             | Industrial User Discharge Permit             |
| IWWTP            | Industrial Wastewater Treatment Plant        |
| JAX              | Jacksonville                                 |
| JBPHH            | Joint Base Pearl Harbor Hickam               |
| KEGS             | Korean Environmental Governing Standards     |
| kWh              | kilowatt hours                               |
| MCLB             | Marine Corps Logistics Base                  |
| MFC              | Microbial Fuel Cell                          |
| MFT              | Media Field Team                             |
| MGD              | Million Gallons per Day                      |
| MILCON           | Military Construction                        |
| NAS              | Naval Air Station                            |
| NASNI            | Naval Air Station North Island               |
| NASSIG           | NAS Sigonella                                |
| NAVFAC           | Naval Facilities Engineering Command         |
| NAVMAG           | Naval Magazine                               |
| NAVSTA           | Naval Station                                |
| NB               | Naval Base                                   |
| NBK              | Naval Base Kitsap                            |
| NBVC             | Naval Base Ventura County                    |

|       |                                                              |
|-------|--------------------------------------------------------------|
| NESDI | Navy Environmental Sustainability Development to Integration |
| NOV   | Notice of Violation                                          |
| NPDES | National Pollutant Discharge and Elimination System          |
| O&M   | Operations & Maintenance                                     |
| PH    | Port Hueneme                                                 |
| PM    | Point Mugu                                                   |
| POAM  | Plan of Action and Milestones                                |
| POTW  | Publicly Owned Treatment Works                               |
| PW    | Public Works                                                 |
| RDT&E | Research, Development, Test & Evaluation                     |
| ROK   | Republic of Korea                                            |
| SBR   | Sequential Batch Reactors                                    |
| SCADA | Supervisory Control and Data Acquisition                     |
| SDWA  | Safe Drinking Water Act                                      |
| SNI   | San Nicholas Island                                          |
| SOP   | Standard Operating Procedure                                 |
| TDS   | Total Dissolved Solids                                       |
| TN    | Total Nitrogen                                               |
| TP    | Total Phosphorus                                             |
| TSS   | Total Suspended Solids                                       |
| UFC   | Unified Facilities Criteria                                  |
| USEPA | United States Environmental Protection Agency                |
| UV    | Ultraviolet                                                  |
| WWTP  | Wastewater Treatment Plant                                   |

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## **1.0 INTRODUCTION**

Most Navy wastewater systems worldwide were originally designed and constructed for higher flow rates. Increased use of low flow devices (toilets, showers, etc.) and widespread mandated water conservation measures have resulted in reduced and concentrated flow through wastewater collection systems. As technology improves and water conservation requirements tighten in the future, flow rates will be even further reduced. Currently, little is known about the impact of low wastewater flow on Navy installation collection and distribution systems which were designed for much higher flow rates. Potential problems could arise such as increased corrosion in lines, elevated levels of hydrogen sulfide (a threat to sanitation workers in confined spaces), more frequent blockages, and increased concentrations of unhealthy contaminants. Impacts are already being felt: Naval Air Station North Island has received 18 Notices of Violation (NOV) for hydrogen sulfide exceedances in the past year.

Poor performance and failures of treatment and collections systems can lead to water quality violations service interruptions, and costly emergency repairs. Service interruptions can impact mission essential services which impact operations. Problems associated with wastewater collection and treatment systems can affect overall mission readiness and quality of life at shore facilities. The Navy has identified the need for further understanding of the implication and impacts from water conservation on wastewater systems. An assessment of impacts and an evaluation of measures and alternative technologies for addressing the problems resulting from low flows, stagnation, and increased biofilms is needed.

The Navy Environmental Sustainability Development to Integration (NESDI) need N-1042-15 asserts that the Navy needs to understand, assess, and address the impacts of water conservation measures on installation wastewater infrastructure. Increased use of low flow devices and widespread mandated water conservation measures may have resulted in reduced and concentrated flow through wastewater collection systems. These changes can result in regulatory compliance violations and necessitate increased maintenance.

## **2.0 BACKGROUND**

### **2.1 NESDI NEED N-1042-15**

Increased use of low flow devices (i.e. low flush toilets, waterless urinals, low flow faucets and shower heads, water saving sprinkler heads, etc.) and widespread mandated water conservation measures have resulted in increased residence time in potable water distribution networks, and reduced and concentrated flow through wastewater collection systems. The effects on water and wastewater infrastructure are can result in regulatory compliance violations with operating permits and the integrity of the infrastructure.

Congress has passed numerous federal regulatory drivers since 1992 to reduce water consumption, but most Navy water and wastewater systems worldwide were originally designed and constructed for higher flow rates. As technology improves and water conservation requirements tighten in the future, flow rates will be even further reduced. Currently, little is known about the impact of low wastewater flow on very expensive installation distribution systems, pumps, wastewater treatment

plants, etc. Wastewater compliance problems will likely stem from increased corrosivity in lines, elevated levels of hydrogen sulfide (threat to sanitary sewer workers in confined space), more frequent blockages, and increased concentrations of unhealthy contaminants. Potable water health issues from reduced water flow include: bacteria and pathogen growth, disinfectant decay, disinfectant byproduct formation, sedimentation, taste and odor issues, chemical and metals contamination, corrosion, nitrification, etc.

## 2.2 REGULATORY DRIVERS

Congress and the White House have steadily tightened DoD water conservation policy regulatory drivers over the past 20 years. These include:

- Executive Order (EO) 13123: install cost-effective water conserving fixtures
- EO 13423: reduce water intensity requirements 2 percent per year through FY 2015
- Energy Independence and Security Act of 2007: implement identified water efficiency measures in federal buildings
- EO 13514: extends water use reduction of 2 percent per year through FY 2020, adds requirement to reduce non-potable water consumption by 2 percent per year through FY 2020

The primary drivers for this project are currently Executive Order 13693 and the Clean Water Act (CWA). The CWA sets permitted wastewater effluent concentrations for individual wastewater treatment systems. Executive Order 13693 requires *“reducing agency potable water consumption intensity measured in gallons per square foot by 36 percent by 2025 through reductions of 2 percent annually through fiscal year 2025 relative to a baseline of the agency's water consumption in fiscal year 2007”*. In addition, installations are compelled to require with several state and local mandates in drought-prone areas to further reduce water consumption.

Unified Facilities Criteria (UFC) 1-200-02 “High Performance and Sustainable Building Requirements” requires greater energy and water efficiency measures be implemented (and must be supported by a life-cycle cost analysis). These water efficiency measures include indoor low-flow fixtures, landscaping water reduction, alternative water sourcing, and overall waste usage reduction.

## 2.3 IMPACTS ON WASTEWATER INFRASTRUCTURE

Failing wastewater conveyance systems pose significant risk to human health and the environment. Sewer blockages can lead to sanitary sewage overflows which can cause flooding damage to facilities and the release of untreated sewage into the environment (Feeney, 2009). The relationship between solids content and impacts such as conveyance losses and malodorous gas generation within wastewater collection systems is well documented (Ashley, 2005). Evidently, higher solids content and increased detention times caused by reduced flows lead to more blockages and increased operation and maintenance (O&M) costs (CWA, 2017). Increased solid concentrations also lead to increased concentrations of organics and sulfur compounds that induce greater sewage break down by facultative anaerobes and result in heightened odors and hydrogen sulfide production (CWA, 2017). As a result, wastewater conveyance systems are affected by higher rates

of hydrogen sulfide induced corrosion, higher incidence of failures, and increased odor problems. Conveyance system operators encountering these issues can struggle with managing the increased blockages, odors, and accelerated degradation of infrastructure. While these impacts have been documented in private industry, the extent to which Navy conveyance systems are impacted by reduced flows and increased solids content is not well understood.

In addition to impacts on wastewater conveyance systems, reduced flows also impact wastewater treatment plant (WWTP) operations. WWTP effluent discharges are regulated by individual National Pollutant Discharge Elimination System (NPDES) permits which set limits on certain water quality constituents. Increases in the concentration of such constituents such as ammonia, total dissolved solids (TDS) can impact the performance of WWTPs. Elevated levels of these constituents, especially salinity, can adversely affect treatment operations, push WWTPs beyond design specifications, and increase the risk of NPDES permit violations (CWA, 2017).

In situations where WWTPs produce water for reuse, reduced influent flows and elevated nutrient loading can impact WWTP operations in such a way as to reduce water available for reuse, partly off-setting water reductions by increasing reliance on potable sources. The increased nutrient loading can cause treatment plants to fail to treat influent sewage to a standard suitable for re-use or the reduced flows can change the economics and render reuse uneconomical (Tran, 2017). Therefore, water conservation efforts can have un-anticipated impacts on water use and reuse in absence of a holistic approach to water supply management. It is not known to the extent of which sewage flow reductions have impacted water reuse operations on Navy facilities.

## **2.4 OBJECTIVE**

The objective of this project is to determine whether there are adverse impacts from low flow devices in Navy operated wastewater collection and treatment systems. This project will identify problems that may result from low wastewater flows and identify solutions or best management practices (BMPs) to ensure that wastewater collection systems and treatment plants operate within their design specifications. Implementation of these BMPs may reduce future NOV's for treatment plant discharges or violations of pretreatment standards for municipally operated treatment plants.

The project consists of two main objectives:

- 1.) Data collection and investigation of problems at both Navy operated wastewater treatment and collection systems.
- 2.) Preparation and recommendations of technical solutions or BMPs to address these problems and reduce impacts to systems and wastewater quality.

This project will be considered successful if key issues resulting from reduced flow rates are clearly identified and BMPs are defined to address those issues.

This report outlines the scope of the problem, including data collected on water conservation, wastewater collection and treatment systems, and from site visits to different regions. This data is then summarized into the key issues identified along with potential solutions/BMPs outlined.

### **3.0 PROBLEM SCOPE**

The first phase of this project was to identify the scope of low flow issues at Navy wastewater collection and treatment systems (not including industrial wastewater or bilge and oily wastewater treatment systems). This phase included data collection from a significant portion of Navy operated systems and a select number of similar municipal systems, along with detailed investigations of problem systems.

The team asked for data on flow rates, total suspended solids, nitrogen, Biological Oxygen Demand (BOD) and sulfur concentrations. This data is regularly collected to ensure CWA compliance, but each site location stores and reports this data differently. The project team also collected data on NOV's as well as qualitative information from managers and the Water Media Field Team. This included such data as increased odor, lift station blockages, higher hydraulic detention times, increased grit loads after heavy rain due to low flow periods, etc. Data sources came from data calls, Environmental Compliance Metrics (ECM), Environmental Management System (EMS), internet Navy Facilities Asset Data Store (iNFADS), NOV Web, site visits, and other related EXWC studies.

#### **3.1 WATER CONSERVATION**

Naval facilities continually strive to reduce water usage to ensure maximum conservation efforts. These efforts save money for facilities, and are often necessary due to local and regional drought conditions. There are multiple conservation methods being implemented including smart controllers, efficient sprinkler heads, providing public outreach, and installing low flow fixtures such as toilets and showerheads. Conservation methods can dramatically reduce water consumption and as a result wastewater generated. Naval Base Ventura County (NBVC) has implemented multiple water conservation measures and have reduced water consumption by 45.5 percent since 2007 (NBVC, 2015).

Additional water use reduction occurs when facility operations shift or contract, for example, facilities may terminate housing operations or lose tenant commands, which reduce both water consumption and wastewater generation. Water consumption data was collected from the Defense Utility and Energy Reporting System (DUERS) database. This water consumption data only consists of water consumption at the installation level and is reported on a monthly basis. For this project, water consumption data was collected for years 2007-2014.

NOV data was collected using the Environmental Data and Metrics Website (EDMWeb). Only NOV's that occurred through years 2007-2016 due to water quality exceedances were considered. All NOV's that resulted from administrative or operational errors, as well as equipment or infrastructure failures, were not considered.

Water consumption data sets for specific facilities within Navy installations were not found. There is currently no Navy maintained database which tracks water consumption at the building or facility level, and there is no requirement for Navy installations to report water consumption at the building or facility level. Only installation level data is tracked and reported. Furthermore, it was found that there is no requirement for installations to ensure buildings are metered and it is

common for buildings to lack water meters entirely. As a result, metered data with higher resolution than the installation level is not widely available.

### 3.1.1 Trend Analysis

Overall water consumption was compared to the number of CWA NOVs caused by water exceedances for years 2007-2014 (Figure 3-1). A 12% reduction in total water consumption is observed for years 2007-2014. This reduction in water consumption follows a consistent trend from year to year. The number of exceedance related NOVs over this time period is highly variable and does not correlate with the modest reduction in overall water consumption over the same period.

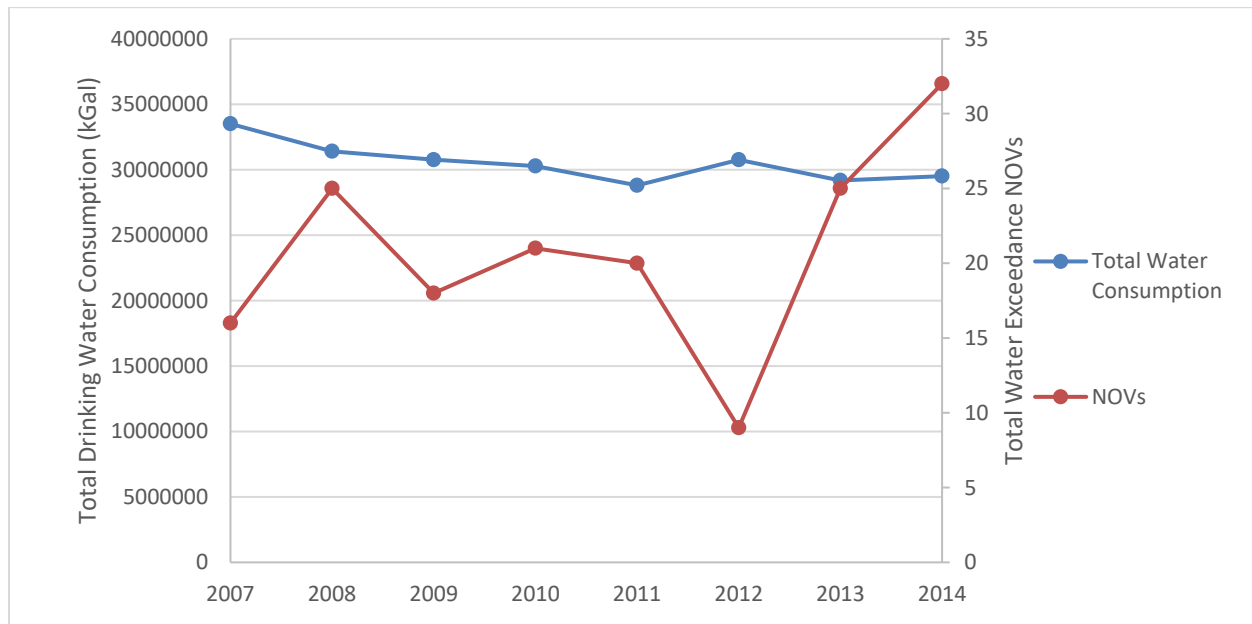


**Figure 3-1: Total Drinking Water Consumption and NOVs for all Domestic Navy Installations**

The incidence of exceedance related NOVs within installations that experienced water consumption reductions was compared to the rate of exceedance related NOVs within installations that experienced no water consumption reductions over the 2007 to 2014 timeframe (Figure 3-2). The rate of exceedance related NOVs among installations with observed water use reductions and without was 38% and 46%, respectively. The total number of installations that did not experience water use reductions was higher than those that did while the proportion of installations that received an exceedance related NOV was lower for those that experienced water consumption reductions.

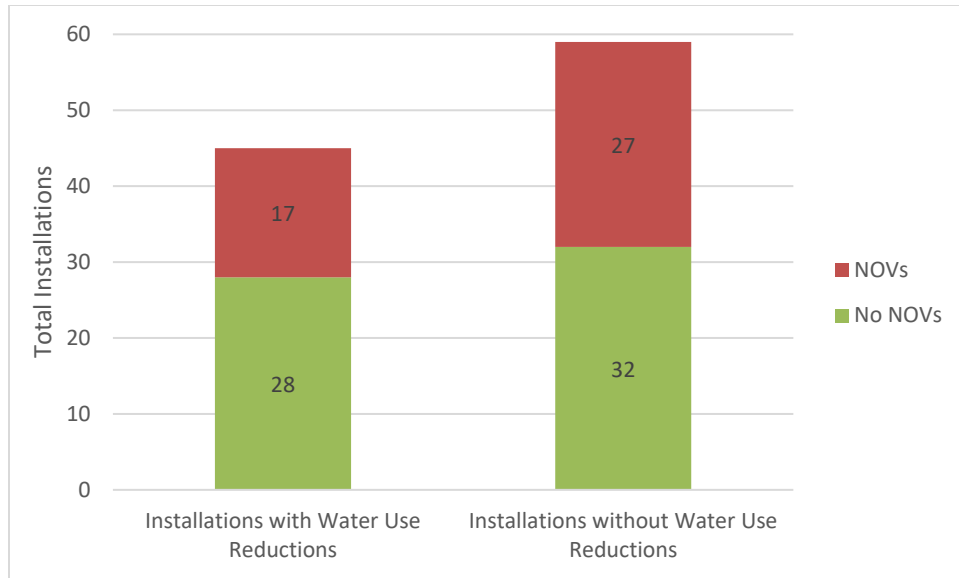


**Figure 3-2: Distribution of Installations that have and have not received NOVs across installations that have or have not reduced water consumption.**

The total number of exceedance related NOV's that occurred at installations which had observed water use reductions and compared with the total number of exceedance related NOV's which occurred at installations which did not have water use reductions over the years 2007-2016 (Figure 3-3). There is no apparent correlation between the rate of exceedance related NOV's and water consumption reductions on an annual basis. The incidence of NOV's on an annual basis seems to be highly variable from year to year with no apparent long-term trends in either group.

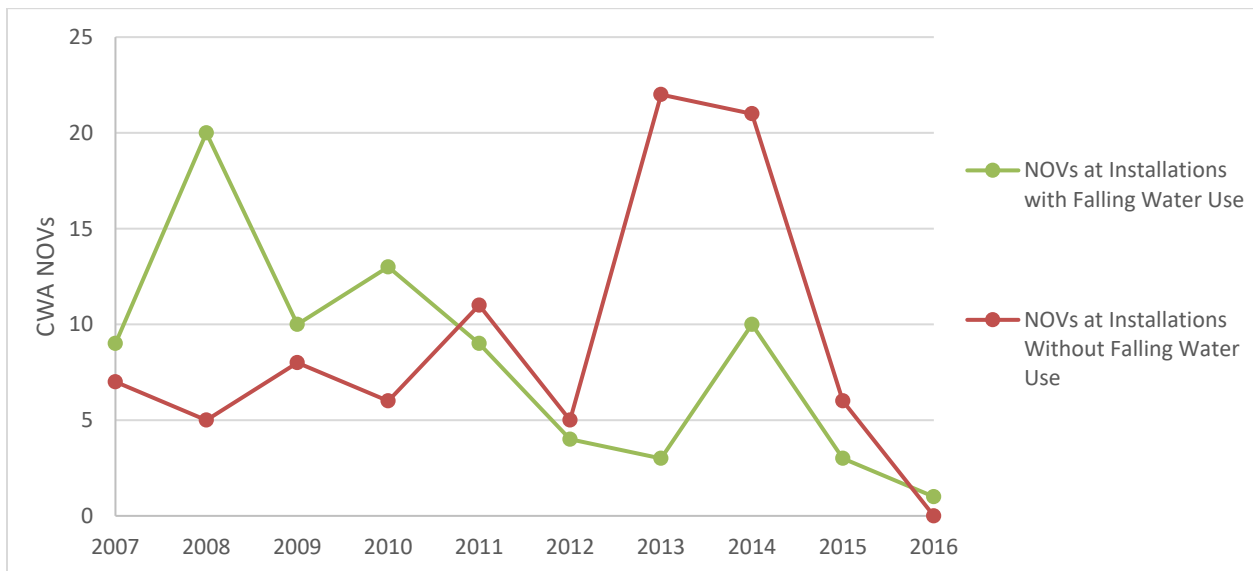


**Figure 3-3: NOV data for Navy installations with and without falling water usage.**

Water consumption and NOV data was compared by region (Figure 3-4 to Figure 3-7). Navy regions Mid-Atlantic and Naval district Washington were combined as both regions are within the

northeast continental united states. There remained no apparent trends that correlate NOVs to reduced water consumption at the regional level.

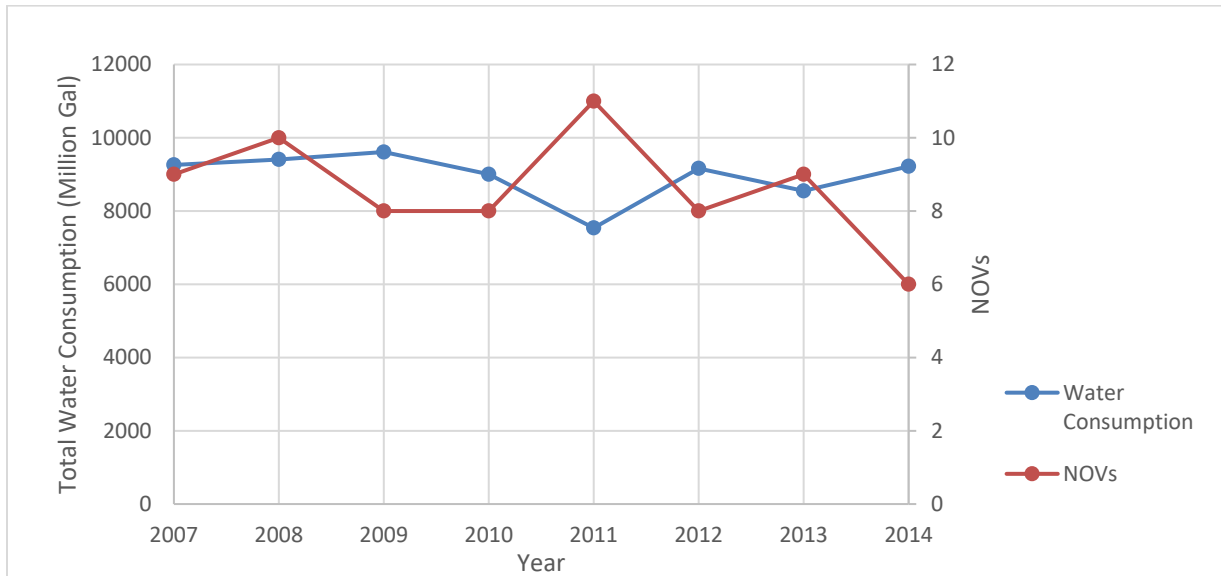


**Figure 3-4: Combined Mid-Atlantic and Naval District Washington water consumption and NOV data.**

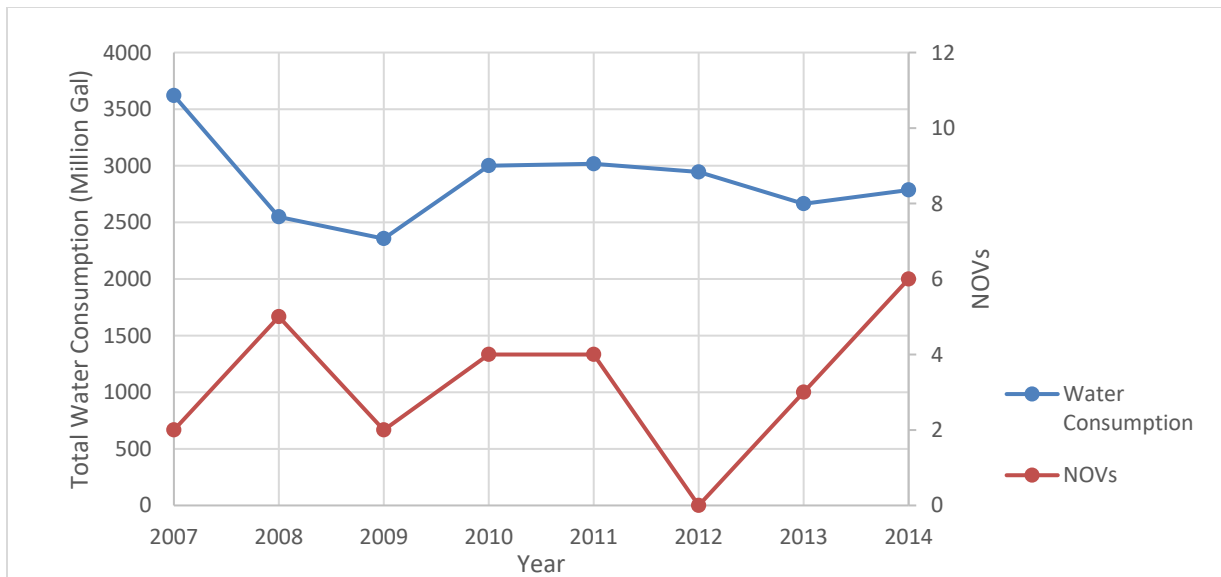


**Figure 3-5: Navy region Southeast water consumption and NOV data.**

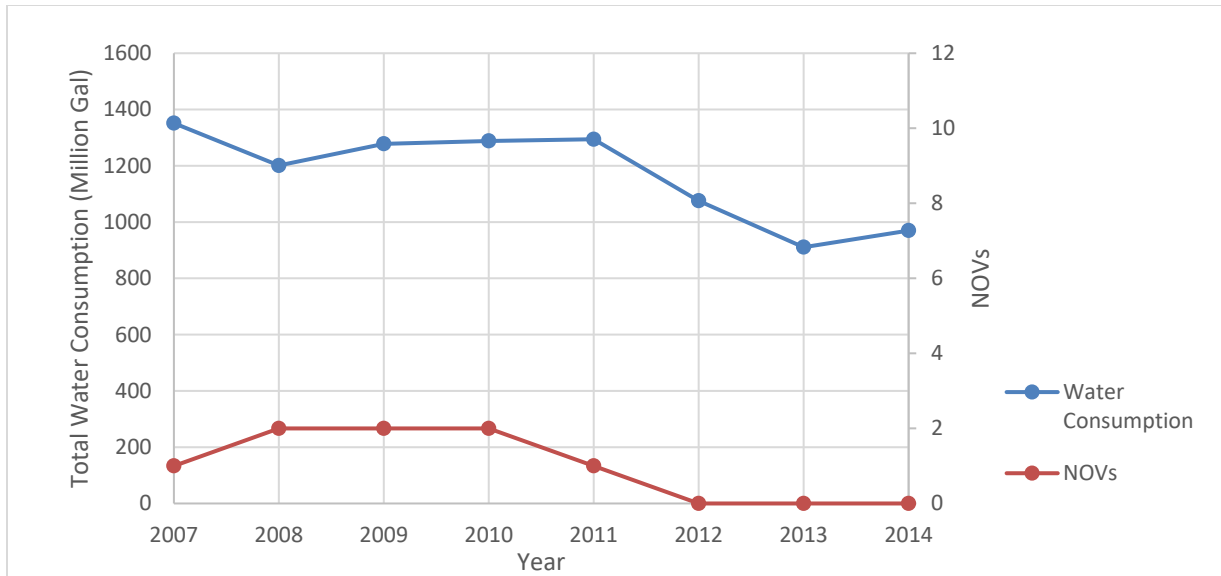


**Figure 3-6: Navy region Northwest water consumption and NOV data.**

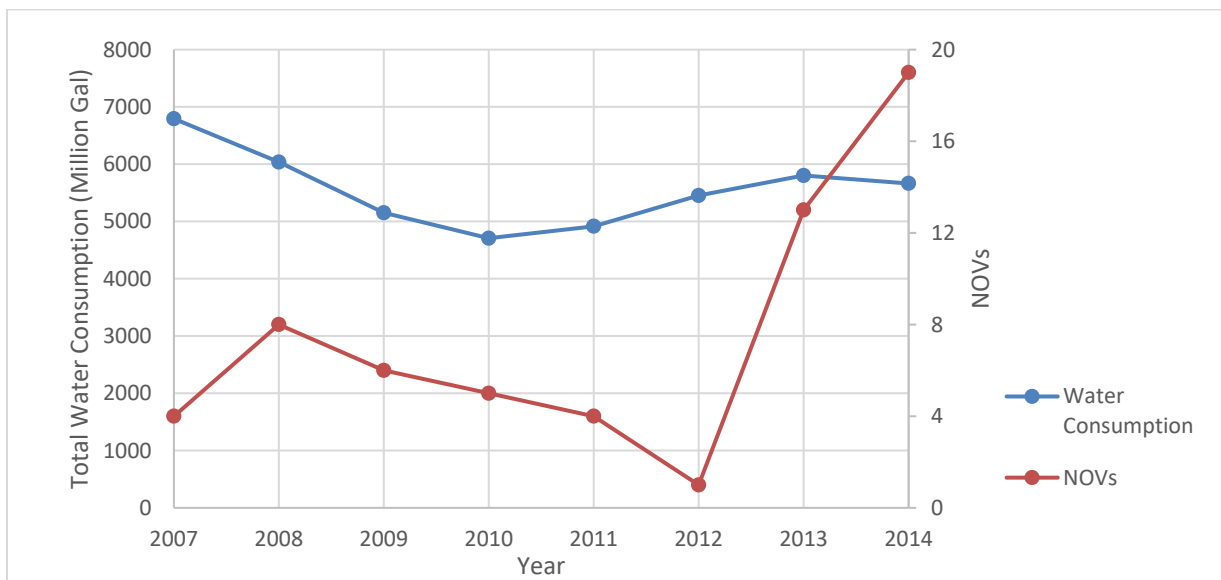


**Figure 3-7: Navy region Southwest water consumption and NOV data.**

### 3.1.2 Impacts of Water Conservation

Navy water consumption data was analyzed by installation going back to 2007, and less than 10% of installations have been consistently reducing their water consumption over the last decade. After interviewing personnel at several installations, common themes on conservation efforts began to emerge. The majority of water conservation was due to cutting back or ceasing irrigation activities on the installations. In one case, NAS Jacksonville had enough rain each year to reduce water used for irrigation. In another case, NAS Lemoore had drought conditions that resulted in restrictions on irrigation, and they were forced to cut back on water consumption. Regardless of the cause for reduction, irrigation activities had the most prominent effect on total water

consumption at the installations. Other activities that had an impact were maintenance related, such as fixing a major leak in the distribution system, and on base operations, such as the deployment of a large number of personnel. Active forms of water consumption reduction, e.g. installing low flow fixtures, were minor in comparison and did not have a noticeable effect on the consumption trends.

The water consumption and compliance data obtained does not show any widespread trends that suggest reductions in water consumption is currently causing increases in exceedance related CWA NOVs at the regional level. Overall, the Navy-wide reduction in water consumption is modest. Some installations showed a significant decrease in water consumption while others did not. The installations that did experience significant reductions were no more likely to have a water quality related NOV than those that experienced no reductions in water consumption. Whatever challenges an installation might be experiencing that are related to water age due to water conservation are masked at this level of analysis.

### 3.2 WASTEWATER TREATMENT AND COLLECTION SYSTEMS

Navy wastewater treatment systems process and handle multiple streams of wastewater including residential, commercial, industrial and ship discharge wastes. Due to the wide range of waste streams, Navy wastewater systems are often subject to varying conditions in wastewater flows as well as strengths and because of these Navy systems consist of multiple types of treatment processes. For the purposes of this report, Navy wastewater systems are grouped into two main categories: onsite wastewater treatment plants (WWTP) and pass through systems. The sections below provide additional details into these categories.

#### 3.2.1 Onsite Treatment

Navy sites in this category and maintains their own collection systems as well as WWTP and discharge to receiving waters. Sites in this category may also have additional treatment capacities including Bilge and oily wastewater treatment systems (BOWTS) and industrial wastewater treatment plants (IWWTP).

**Table 3-1. DoD Owned or Combination DoD/Commercial Wastewater Treatment Systems**

| Installation                                 | Region      | Wastewater Treatment         |
|----------------------------------------------|-------------|------------------------------|
| NAVAL BASE GUAM                              | CJRM        | Combination DOD & Commercial |
| CAMP LEMONNIER, DJIBOUTI                     | CNREURAFSWA | DOD Owned                    |
| NAVAL AIR STATION SIGONELLA                  | CNREURAFSWA | DOD Owned                    |
| NAVAL SUPPORT ACTIVITY BAHRAIN               | CNREURAFSWA | Combination DOD & Commercial |
| NAVAL SUPPORT ACTIVITY SOUDA BAY             | CNREURAFSWA | DOD Owned                    |
| PACIFIC MISSILE RANGE FACILITY BARKING SANDS | CNRH        | DOD Owned                    |
| JOINT BASE PEARL HARBOR-HICHAM               | CNRH        | DOD Owned                    |
| COMMANDER FLEET ACTIVITIES YOKOSUKA          | CNRJ        | DOD Owned                    |

|                                                           |        |                              |
|-----------------------------------------------------------|--------|------------------------------|
| COMMANDER FLEET ACTIVITIES OKINAWA                        | CNRJ   | DOD Owned                    |
| NAVAL AIR FACILITY ATSUGI                                 | CNRJ   | DOD Owned                    |
| COMMANDER FLEET ACTIVITIES SASEBO                         | CNRJ   | Combination DOD & Commercial |
| NAVAL AIR FACILITY MISAWA                                 | CNRJ   | DOD Owned                    |
| NAVAL SUPPORT FACILITY DIEGO GARCIA                       | CNRJ   | DOD Owned                    |
| NAVAL SUPPORT ACTIVITY CRANE                              | CNRMA  | Combination DOD & Commercial |
| NAVAL WEAPONS STATION EARLE                               | CNRMA  | DOD Owned                    |
| NAVAL INFORMATION OPERATIONS<br>COMMAND SUGAR GROVE       | CNRMA  | DOD Owned                    |
| NAVAL SUPPORT ACTIVITY ANNAPOLIS                          | CNRNDW | Combination DOD & Commercial |
| NAVAL AIR STATION PATUXENT RIVER -<br>WEBSTER FIELD       | CNRNDW | DOD Owned                    |
| NAVAL SUPPORT ACTIVITY SOUTH<br>POTOMAC - NSF DAHLGREN    | CNRNDW | DOD Owned                    |
| NAVAL SUPPORT ACTIVITY SOUTH<br>POTOMAC - NSF INDIAN HEAD | CNRNDW | DOD Owned                    |
| NAVAL SUPPORT FACILITY THURMONT                           | CNRNDW | DOD Owned                    |
| NAVAL AIR STATION WHIDBEY ISLAND                          | CNRNW  | DOD Owned                    |
| NAVAL MAGAZINE INDIAN ISLAND                              | CNRNW  | DOD Owned                    |
| NAVAL BASE KITSAP                                         | CNRNW  | DOD Owned                    |
| NAVAL STATION EVERETT                                     | CNRNW  | DOD Owned                    |
| NAVAL AIR STATION JACKSONVILLE                            | CNRSE  | DOD Owned                    |
| NAVAL AIR STATION KEY WEST                                | CNRSE  | Combination DOD & Commercial |
| NAVAL AIR STATION CORPUS CHRISTI                          | CNRSE  | DOD Owned                    |
| NAVAL STATION MAYPORT                                     | CNRSE  | DOD Owned                    |
| NAVAL STATION GUANTANAMO BAY                              | CNRSE  | DOD Owned*                   |
| NAVAL AIR WEAPONS STATION CHINA<br>LAKE                   | CNRSW  | DOD Owned                    |
| NAVAL AIR FACILITY EL CENTRO                              | CNRSW  | DOD Owned                    |
| NAVAL AIR STATION FALLON                                  | CNRSW  | DOD Owned                    |
| NAVAL AIR STATION LEMOORE                                 | CNRSW  | DOD Owned                    |
| NAVAL BASE VENTURA COUNTY                                 | CNRSW  | DOD Owned                    |

*\*Temporary facility that has been in use for 16 years*

### 3.2.2 Pass Through Systems

Navy sites classified as pass-through systems are simply collection systems generally consisting of gravity sewer lines, force mains, manholes, and lift stations. These collection systems pass on the collected wastewater to a municipally operated WWTP and do not treat wastewater onsite. Some pass-through systems do operate BOWTS and/or IWWTP however the effluent from these treatment processes is then sent on to a municipal WWTP facility. The majority of DoD installations have commercially provided wastewater treatment rather than DoD owned and operated onsite treatment. Wastewater collection systems are almost always DoD owned and managed.

### 3.2.3 Trend Analysis

The team analyzed information collected from several installations including flow rates, total suspended solids, nitrogen, BOD, and other influent/effluent parameters that were available. Extensive data analysis of several sites showed no apparent trends that could be attributed to low wastewater flows. Most of the key issues from low wastewater flows were determined from site visits and discussion with operations and maintenance personnel.

## 4.0 **SITE VISITS AND INSTALLATION ASSESSMENTS**

This section describes specific issues at naval installations and includes data from reporting databases, regulatory reports and non-compliance events as well as from site visits and interviews conducted by project personnel. Site visits, facility tours, and meetings with local facilities personnel were conducted to gather information about facility wastewater treatment and collection systems as well as water conservation efforts in place. Prior to during and after site visits information, records and details were collected from onsite personnel.

### 4.1 **SOUTHWEST REGION**

#### 4.1.1 Naval Air Station North Island

Naval Air Station North Island (NASNI) is part of Naval Base Coronado in Southern California. NAS North Island is a homeport for multiple aircraft carriers as well as fixed wing and rotary wing aircraft squadrons. NAS North Island discharges pretreated industrial wastewater and domestic sewage to the City of San Diego's sewer system under Industrial User Discharge Permit (IUDP) (#08-0018), which then passes through the collected wastewater system to San Diego Municipal treatment plant. NASNI also has an onsite BOWTS system oily water treatment prior to pass through to the municipal WWTP.

Naval Air Station (NAS) North Island has received 18 CWA NOV's for hydrogen sulfide exceedances in several years. The City of San Diego added a dissolved sulfides limit of 1 mg/L to the permit about 5 years ago. The IUDP for Naval Amphibious Base (#08-0490) will also have a dissolved sulfides limit by 2019. The violations note potential root causes of the exceedances as infrastructure deficiencies, specifically that the current design of sewer system is resulting in stagnation of sewage that is creating anaerobic conditions and leading to the excess generation of

sulfides. An ongoing NESDI project, NESDI 548, is testing dissolved oxygen injection as a potential solution to eliminate the sewer gas. NASNI also has aging infrastructure issues.

#### 4.1.2 Naval Base Ventura County (NBVC)

NBVC is a naval installation composed of three operating facilities: Point Mugu (PM), Port Hueneme (PH) and San Nicolas Island (SNI). NBVC supports approximately 80 tenant commands with a base population of more than 19,000 personnel. Both Point Mugu and Port Hueneme have pass through systems, San Nicholas Island has an on-site wastewater treatment facility. NBVC PH occupies 1600 acres with a population of 9700 military, civilian, and contractor employees and 2000 residents. NBVC PM encompasses 4490 acres and provides support services for Naval Air Warfare Center Weapons Division and other tenants. Naval Base Ventura County (NBVC) has implemented multiple water conservation measures and have reduced water consumption by 45.5 percent since 2007 (NBVC, 2015).

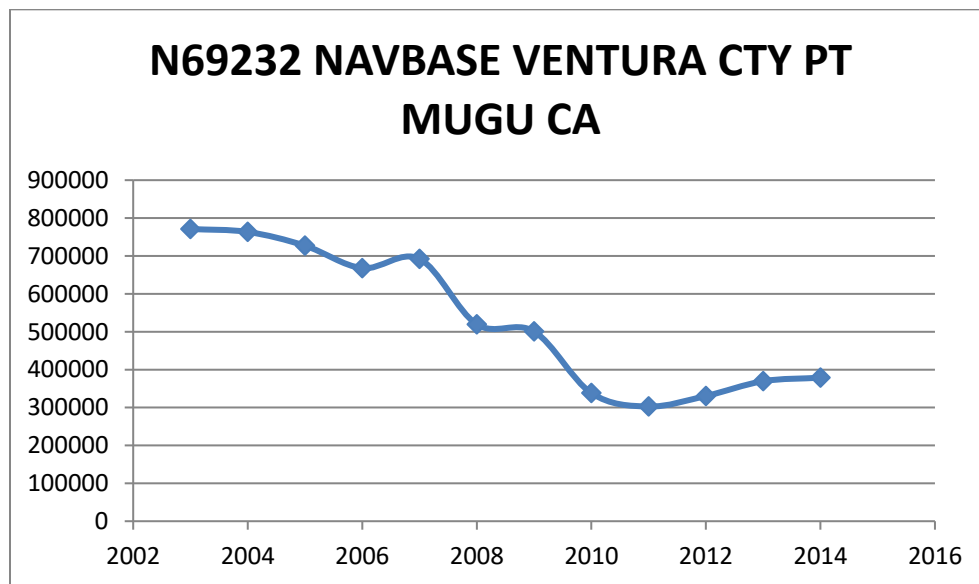


**Figure 4-1. Reduced Water Consumption at NBVC Point Mugu**

NBVC SNI is located approximately 65 nautical miles southwest of Point Mugu and is the most remote of California's Channel Islands, with an average population of around 250 persons. SNI has two primary functions: a launch platform for short and medium missile testing and an observation facility for missile testing. Due to the geographical remoteness of San Nicolas Island, the operation and treatment of domestic wastewater on SNI is owned and operated by the Navy and managed by NAVFAC SW. The wastewater treatment plant (WWTP) on SNI is located in Building N27 and has a design capacity of 40,000 gallons per day (GPD). Its operating system is comprised of three clay lined soil oxidation and evaporation ponds with a chlorination contact system. The WWTP system allows operators to direct flows of wastewater between the three ponds, control the chlorination process, collect and log samples for reporting and compliance requirements, and spray irrigate excess wastewater to designated irrigation fields when necessary. With the wide disbursement of buildings and limited population on SNI, the WWTP does not serve the entire population and the piping network is not extensive. Therefore, SNI utilizes other

wastewater technologies to assist in the managing of the island's wastewater needs. SNI's total wastewater infrastructure consists of zero oil/water separators and 2 sewage holding tanks, 26 active septic tanks and leach fields, and 3 grease traps. The ponds, sewage holding tanks, grease traps, and septic tanks are serviced on an as needed basis. All sludge generated is barged off the island and disposed to the Ventura County Regional Sanitation District's Toland Road Landfill in Santa Paula, California. The biosolids are further treated onsite at the landfill's Biosolids Drying and Renewable Power Generation Facility.

None of NBVC's installations have had any domestic wastewater related NOV's in the past decade related to low flow issues.

#### 4.1.3 Naval Air Station Fallon

NAS Fallon serves as the Navy's premier tactical air warfare training center. NAS Fallon is the only naval facility where an entire carrier air wing can conduct comprehensive training and is home to the longest runway in the Navy. Typical population when no carrier air wing is onsite is 3,000 mostly civilian daytime sewage loads. This population increases over 65% when a carrier air wing is onsite (to approx. 5,000), this also changes the sewage generation profile as additional housing loads are generated. Current onsite plant is designed to handle 750,000 gallons per day. Several years ago, flows were 425,000 gallons per day. Since then a large effort to curb infiltration and inflow (I&I) was undertaken and actual flows to the plant presently are approximately 200,000 gallons per day.

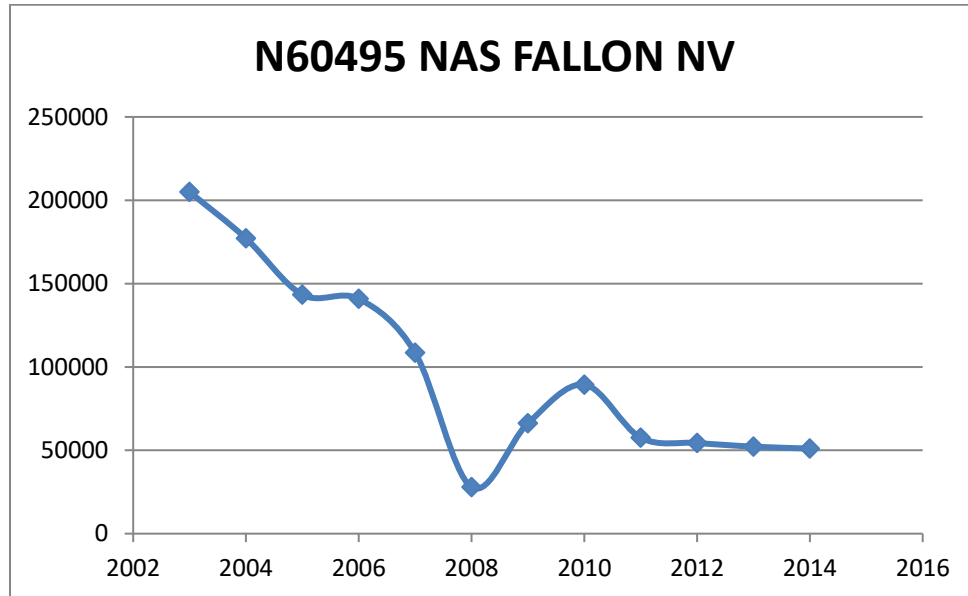


**Figure 4-2. Reduced drinking water consumption at Fallon**

NAS Fallon had multiple exceedances for nutrients, specifically nitrogen. The WWTP installed Sequential Batch Reactors (SBR) in 1995, which do not treat for nutrients, as this was not a requirement for discharge at the time. Beginning in 2008 nutrient limits was included in the facilities discharge permit, which were then exceeded.

The reported root cause is an aging WWTP that was not designed for efficient Total Nitrogen removal. SBRs were installed in 1995 and the permit at the time did not have a limit for Total Nitrogen. Total Nitrogen limit of 10 mg/L was first required in the permit issued in 2007. October 2013: The WWTP is currently in design and the expected completion date is March 2014. This is ahead of the Administrative Order of Consent (AOC) required date of February 2015. New WWTP is expected to be up and running in November 2015. After demonstrating, that the WWTP will achieve compliance the AOC is expected to be closed out in 2016. UPDATE: December 2015: The WWTP design went through some major changes and modifications. The new design completion date is March, 2016, with construction not expected to be complete until December 2018. The AOC is being revised to reflect new dates.

A new WWTP is being designed and will be installed at NAS Fallon. The new plant construction is not yet underway as of the EXWC team site visit on March 2018. The new plant will allow for nutrient reduction and conformance with the AOC.

Infiltration and inflow (I&I) have been drastically reduced base wide. The reduction of I&I has led to an unexpected ancillary effect, the strength of the wastewater has increased as a result of the eliminated I&I, this coupled with the spikes in strength resulting from transient population source generates very concentrated or high-strength wastewater which leads to multiple site issues. One major issue as a result of these concentrated wastewater plugs occurs at the main pump station referred to as the Four Corners Pump Station. The Four Corners Pump Station is located approximately 10,000ft from the WWTP and is plumbed with large diameter pipe, this pump station collects concentrated wastewater with high solids content which leads to large plugs in the conveyance system. These plugs of solids and high strength wastewater are leading to excess wear on the pumping system at four corners, reducing pump capacity and capability over time. In addition, both the environmental (EV) and public works (PW) departments and the wastewater operator noted that when the carrier air group is on base, the wastewater strength “doubles” while flow only marginally increases (not at a seemingly similar rate).

In order to resolve these low flow issues, the base regularly requests on-site construction to dump excess water into the pump stations. Occasionally when this occurs, there will be a total suspended solids (TSS) spike due to settling in the main and the slug finally being pushed through to the WWTP. The incoming pipes and lift stations appear to be sized for much higher flows than actually receiving. The new WWTP was not designed for the reduced flows and will likely also be oversized and have corresponding low flow issues.

There are no Hydrogen Sulfide (H<sub>2</sub>S) or odor issues that have been reported at the installation. Phosphorus removal is an upcoming issue, but so far, the WWTP has not had to deal with it. Neither the current or new version of the WWTP will be able to remove phosphorus to the proposed effluent levels if mandated.

#### 4.1.4 NAS Lemoore

NAS Lemoore is located in central California and is the Navy’s newest and largest jet base. In 1998, NAS Lemoore was selected as the West Coast site for the Navy’s newest strike-fighter

aircraft, the F/A-18 E/F Super Hornet. In 2017, the F-35 Lightning II was received onboard NAS Lemoore, establishing the first F-35 Pacific training squadron. NAS Lemoore shows a significant reduction in water consumption over the past decade (Figure 4-3). The reduction in water consumption at this installation is due to drought conditions requiring specific water reduction policies, zero-scaping (using less irrigation water), and better water consumption awareness (for instance, turning off water when not actively washing components on airplanes).

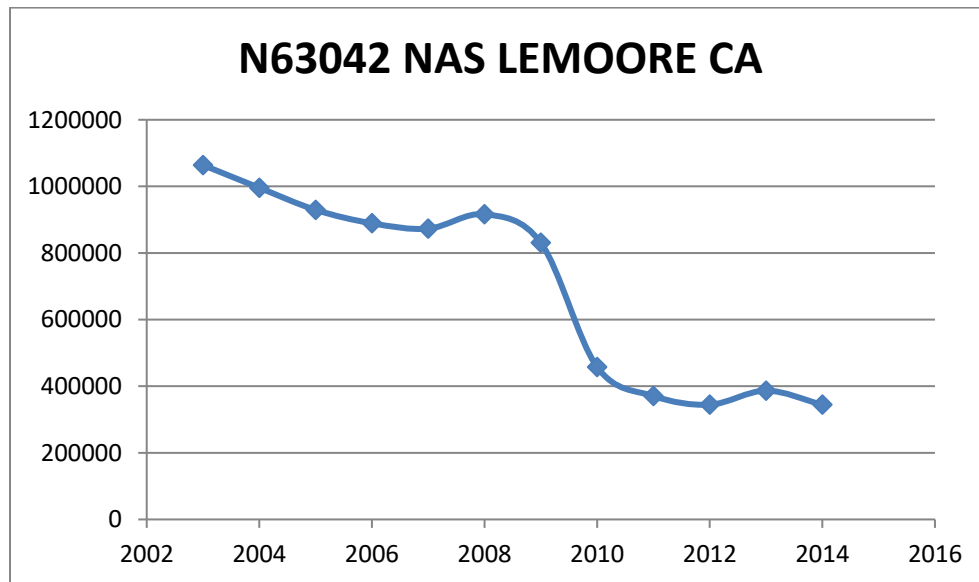


**Figure 4-3. Reduced water consumption NAS Lemoore**

NAS Lemoore's wastewater treatment consists of industrial pretreatment for the operations area that is then combined with the domestic sewage. The wastewater then leaves the base and is treated using facultative and evaporation ponds. Industrial wastewater (with pretreatment), stormwater, and domestic wastewater are all comingled. This treatment system was designed for 2 MGD, but typically receives less than 1 MGD. These low flows have caused odor and dust nuisance near the installation when there is not enough water flowing into the ponds. The resultant dust has been known to cause traffic issues. Overall, the wastewater system, although simple, is not properly designed, maintained, or operated.

## **4.2 NORTHWEST REGION**

### **4.2.1 Naval Magazine (NAVMAG) Indian Island**

NAVMAG Indian Island functions as the ordnance management center for fleet and shore stations in the Pacific Northwest Region and comprises the entirety of the 2,716-acre Indian Island located on the northeast corner of Washington State's Olympic Peninsula. Drinking water usage at NAVMAG Indian Island reduced approximately 20% between 2003 and 2014 (Figure 4-6).

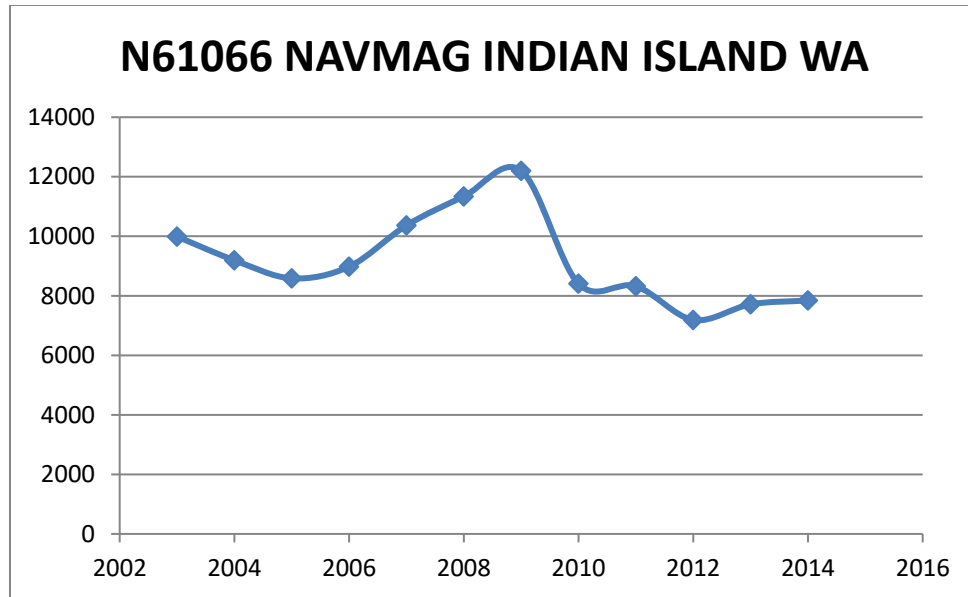


**Figure 4-4. Reduced drinking water consumption at NAVMAG Indian Island**

NAVMAG Indian Island previously had on-base housing, which has been removed, reducing overall wastewater generation. This facility also occasionally accommodates vessels, which will discharge wastewater to the onsite wastewater treatment while in port at the installation. The onsite WWTP is a pre-WWII era facility that typically processes volumes between 2,000 gallons per day and 30,000 gallons per day, volume is highly dependent on vessel discharge, as the shore facility does not generate large volumes of wastewater on a daily basis. There are only 180 employees on the island during the weekdays and less than eight employees on evenings and weekends.

Wastewater sources include:

- Ship sanitary wastewater and seawater flushed through a ship's sanitary wastewater system is identified by NAVFAC as Collection, Holding, and Transfer. These sources are discharged into the Pier Treatment Facility for holding and treatment in the Twin Lakes lagoons.
- Domestic sewage from the base operational areas is discharged into the Main plant, along with stormwater from various sources. NAVFAC has identified known facility stormwater sources that drain to the sanitary sewer system as: Building 185 Government Fuel Station/Vehicle Storage Area (11,800 sf), Building 69 Roof Drains (9640 sf), Building 84 Roof Drains (7488 sf), and anticipated groundwater infiltration. Additionally, NAVFAC has identified steam boilers at Buildings 64, 69, 77, 132, 189, and 836. All buildings discharge to sanitary sewers for the Main Treatment facilities influent.

The WWTP at NAVMAG Indian Island consists of headworks which utilizes two equalization lagoons, an intermittent sand filter, and a UV disinfection system.

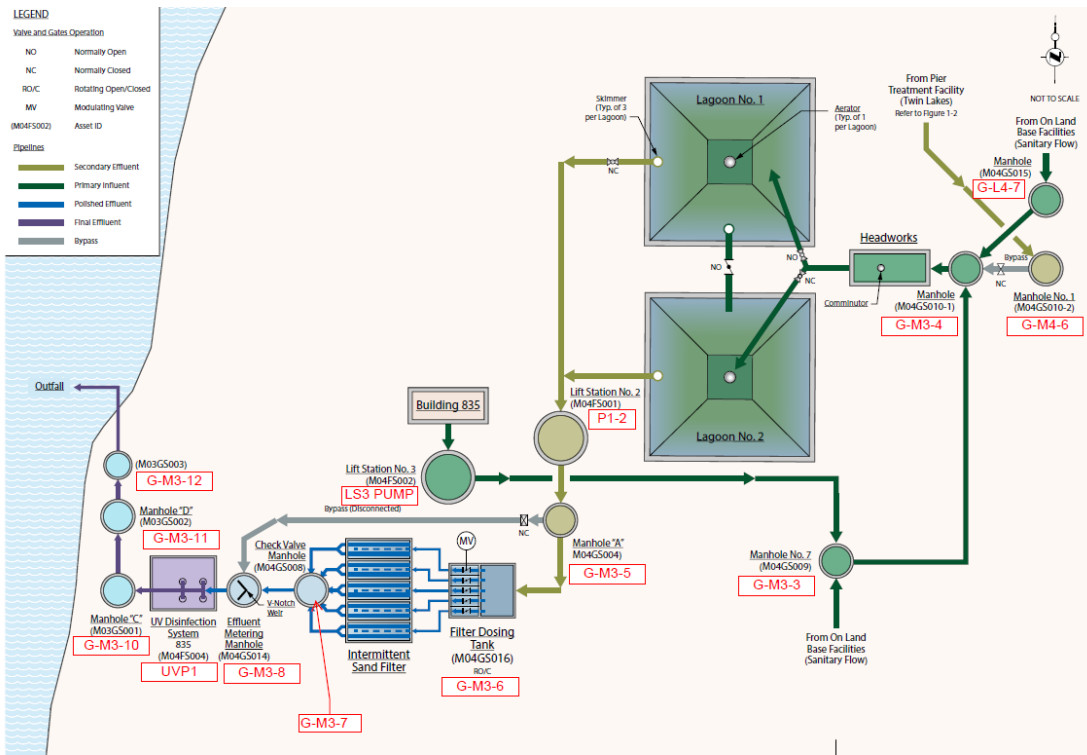


Figure 1-3: Main Wastewater Treatment Plant Process Flow Schematic

1-6

CDM  
Smith

The plant was originally designed to treat a monthly average influent of 36,000 gpd and has a peak capacity of 43,000 gpd. A CDM Smith study of the WWTP completed in 2017 reported an average 1,200 gpd annual influent flow, which is significantly lower than the design flows. As combination of the low-flows and high strength of wastewater onsite, the WWTP is impacted with high-strength wastewater (high nutrient loading) that causes algae blooms and reduces the effectiveness of the oversized lagoons, see Figure 4-5. This growth of algae and duck weed in the lagoons is also due to inadequate mixing/aeration and solar exposure.



**Figure 4-5: Algae Bloom NAVMAG Indian Island**

Aging infrastructure is also an issue at NAVMAG Indian Island, with a poorly-functioning sand filter that is regularly overgrown with duckweed and doesn't function properly. The wrong kind of sand was purchased for these filters and it has been depositing fine particulates into the UV system causing damage.



**Figure 4-6: Aging Sand Filters at NAVMAG Indian Island**

Data analysis of NAVMAG Indian Island flow rates against influent BOD (lb/d and mg/L) and solids (lb/d and mg/L) from July 2006 to December 2015 showed no firm correlations (Figure 4-7). A deeper dive into influent and effluent BOD and solids versus flow rates at the plant, along with plant events, such as algae blooms, faulty BOD readings, and NOV's also revealed no useful trends.

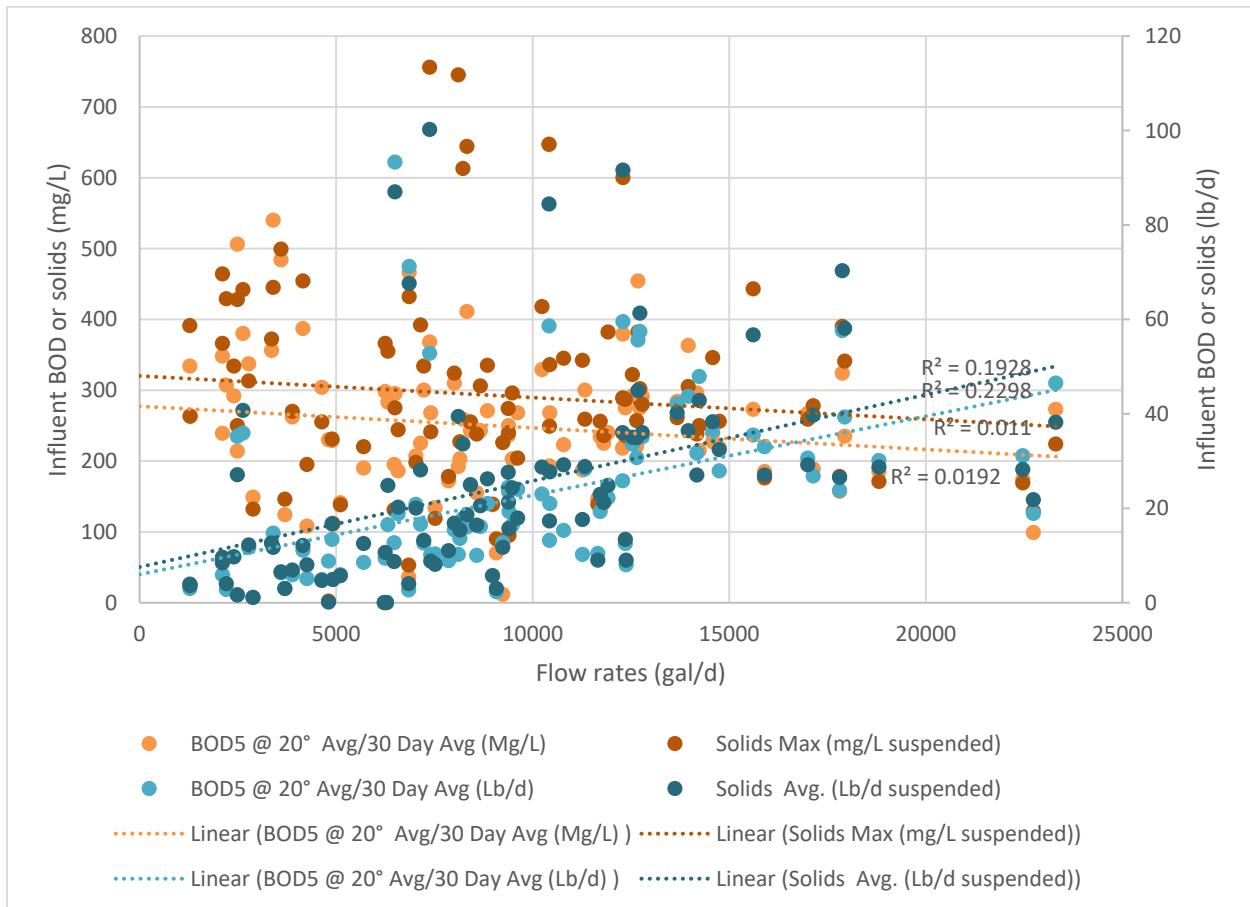


**Figure 4-7. NAVMAG Indian Island flow rates vs influent wastewater quality**

#### 4.2.2 Naval Base Kitsap

**NBK Keyport, Bangor, and Bremerton** are components of the greater Naval Base Kitsap in Washington State. All of these facilities have wastewater collection systems, which then pass through to local municipal treatment facilities. Hydrogen sulfide generation is becoming a problem at these installations, with several odor complaints registered, and they're looking into potential solutions. These installations also have stormwater and seawater intrusion into the sewer system as well, so there's likely some cross-connection issues that will need to be resolved.

#### 4.2.3 Naval Station Everett

Naval Station Everett (NAVSTA Everett) is a military installation located in Everett, Washington, north of Seattle. This facility has an onsite wastewater treatment plant that is just beginning to

notice issues potentially related to low flows. Corrosion problems are having an impact on the infrastructure and odor complaints have risen. Ferric dosing was added to a couple locations with odor issues after 1999, but recently only one location is being dosed since it may be contributing to corrosion issues.

### 4.3 SOUTHEAST REGION

#### 4.3.1 Naval Air Station Jacksonville (NAS JAX)

NAS JAX hosts eight active P-8A/P-3C squadrons, three reserve squadrons and four helicopter squadrons. Additional major tenants include Commander, Navy Region Southeast; Fleet Readiness Center Southeast; Naval Hospital Jacksonville; Naval Facilities Engineering Command Southeast; Fleet Logistics Center Jacksonville and Commander, Patrol and Reconnaissance Wing Eleven. NAS Jacksonville supports approximately 33,000 personnel on base and has an onsite WWTP. The WWTP was initially designed in the 1970's and was planned to accommodate for flows up to 3 MGD, yet current permitting only has approval to discharge 2 MGD. However, current actual flows at the WWTP are typically a mere 0.55 MGD on average. Therefore, NAVSTA Mayport uses most of the permitted discharge allotment to the St. Johns River. There are 42 lift stations, an energy efficient sludge treatment system, approximately 540 manholes, and several feet of newly replaced or re-lined sewer pipes. A smoke test was used in the late 1990s to correct all cross-connection issues with the drinking water system. Drinking water usage at NAS Jacksonville reduced approximately 65% between 2003 and 2014 (Figure 4-8). NAS JAX produces 95% of its own drinking water from wells on base and the rest of the 5% comes from the city. NAS Jacksonville has greatly reduced its water usage over the past ten years by implementing low flow fixture and conservation measures. Initial the reduction in flows caused metal spikes in the system, but WWTP operations were adjusted to correct the issue. NAS Jacksonville also re-uses treated wastewater onsite and provides recycled water to a nearby private golf course as part of a public/private partnership.

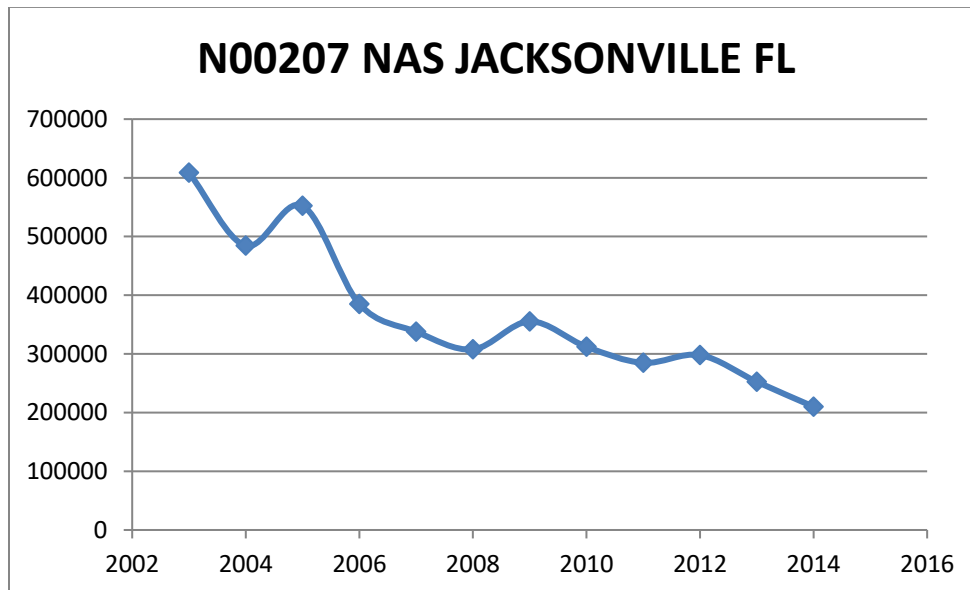


**Figure 4-8. Reduced drinking water consumption at NAS JAX**

NAVSTA Mayport and NAS Jacksonville share discharge limitations of nitrogen for combined discharge of 24k lbs to a shared receiving water the St. Johns River. NAVSTA Mayport is the significant source of the nitrogen as NAS Jacksonville reuses the majority of its water and does not discharge a significant volume or nutrients as compared to NAVSTA Mayport. NAVSTA Mayport received an NOV and subsequent consent decree due to the exceedance of nitrogen limits in 2014.

#### 4.3.2 Naval Station Mayport



**Figure 4-9 NAVSTA Mayport Wastewater Treatment Facility 2017.**

NAVSTA Mayport is one of three major Navy installations in the Jacksonville area. Mayport is home to a busy seaport as well as an air facility. The Navy at Mayport covers 3,409 acres and is the third largest Naval Facility in the continental United States. The WWTP onsite was designed for typical flows of 2 million gallons per day (MGD) while actual wastewater flows at the onsite WWTP are typically much less at 0.6 to 0.7 MGD. There is also a separate waste oil treatment facility onsite to treat oily wastewater. Drinking water usage at Mayport reduced approximately 56% between 2003 and 2014(Figure 4-10).

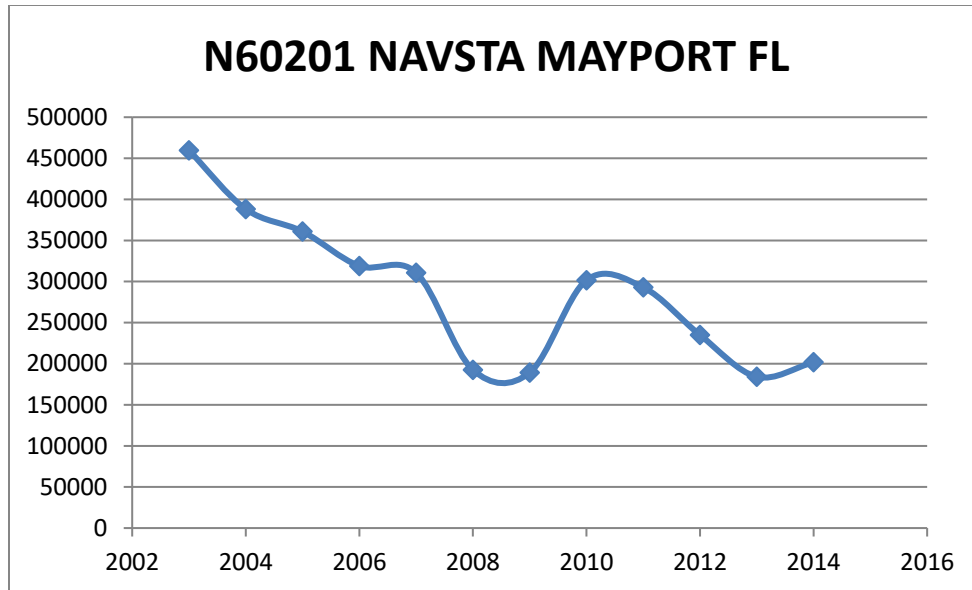


**Figure 4-10. Reduced drinking water consumption at Mayport**

NAVSTA Mayport has elevated H<sub>2</sub>S levels present at the lift stations and wet wells, which has caused degradation of system components and equipment including lift stations, piping, and WWTP tanks, and equipment. The H<sub>2</sub>S has also corroded and decayed system components and structural elements (concrete and rebar) at the WWTP.

There are current MILCON plans to replace the aged WWTP at Mayport and accommodate the new lower flows with a decreased capacity. Planned completion was originally anticipated for FY20.

#### 4.3.3 NAS Corpus Christi

NAS Corpus Christi is a naval aviator flight training facility for Training Air Wing Four, using which utilizes Truax Field and outlying airfields. NAS Corpus Christi is also home to the Corpus Christi Army Depot and serves as the primary aviation depot maintenance for Department of Defense rotary wing aircraft. NAS Corpus Christi has two treatment plants with a combined treatment capacity of 3.75 MGD: a 2.0 MGD IWWTP which serves the industrial operations and a 1.75 MGD domestic WWTP which serves facility operations and housing. Conservation, shifting base operations, and reduction of activity in tenant commands have led to a large reduction in flow. The typical current treatment flow is about 1.7 MGD in total.

The two wastewater treatment facilities only join at the ocean outfall, where the treated effluent is discharged. There are two primary and two secondary clarifiers that alternate operation. There is not a Supervisory Control and Data Acquisition (SCADA) system, so all operations are manual. There is a central lift station that is integral to the wastewater treatment operations. If it backs up and cannot operate, the base will have to be evacuated and there will be a stop in mission operations due to the health hazard. All wastewater flows are determined from the system gauges. Actual

flows through the plant are much lower than the design capacity as the WWTP at NAS Corpus Christie is an older plant designed in the early 1940's. Originally there was greater demand for industrial wastewater treatment, but as industrial operations have reduced over the years, there is significantly more domestic wastewater treated than industrial wastewater.

The domestic wastewater plant uses significantly aged equipment that often lacks replacement parts. For example, the combinatory blade had to be custom casted at a shipyard when a replacement was needed. There are no reliable tie-ins and the system lacks sufficient gravity flow due to the flat elevation of the terrain and high-water table. The plant also experiences periodically high ammonia concentration spikes, especially during storm events, and some nitrate and nitrite issues. The holding tanks sometimes overflow during storm events as well. One potential cause of the ammonia spikes is the use of low flow devices on the domestic side, which often will not allow enough adequate flow for dilution and system movement. There have also been some periodic H<sub>2</sub>S gas spikes in the wastewater system. The operators have experienced some potential industrial waste cross-connections, which could use further investigation.

There were plans for a MILCON to upgrade and replace the wastewater treatment facility operations for a smaller treatment capacity at NAS Corpus Christi, with a planned start date of FY19, but hurricane destruction in the area in 2017 delayed plans.

#### **4.4 MID-ATLANTIC REGION**

##### **4.4.1 Naval Station Norfolk**

NAVSTA Norfolk is geographically located in the Southeastern corner of the Commonwealth of Virginia and is the largest naval complex in the world. NAVSTA Norfolk is home to Commander, Naval Air Force, US Atlantic Fleet, Commander, Navy Region Mid-Atlantic as well as the Defense Department's largest supply center. Multiple aircraft carriers, destroyers, cruisers, and submarines homeport at Norfolk. NAVSTA Norfolk has two distinctly segregated wastewater collection systems, a sanitary sewer system and an oily wastewater (OWWO) system, which then passes through the collected wastewater system to a Municipal treatment plant. Drinking water usage at Norfolk reduced approximately 40% between 2003 and 2014 (Figure 4-11). NAVSTA Norfolk operates the collection and conveyance portions of the wastewater infrastructure; NAVSTA Norfolk does not operate an onsite wastewater treatment plant. All collected wastewater is conveyed to the Hampton Roads treatment plant offsite.

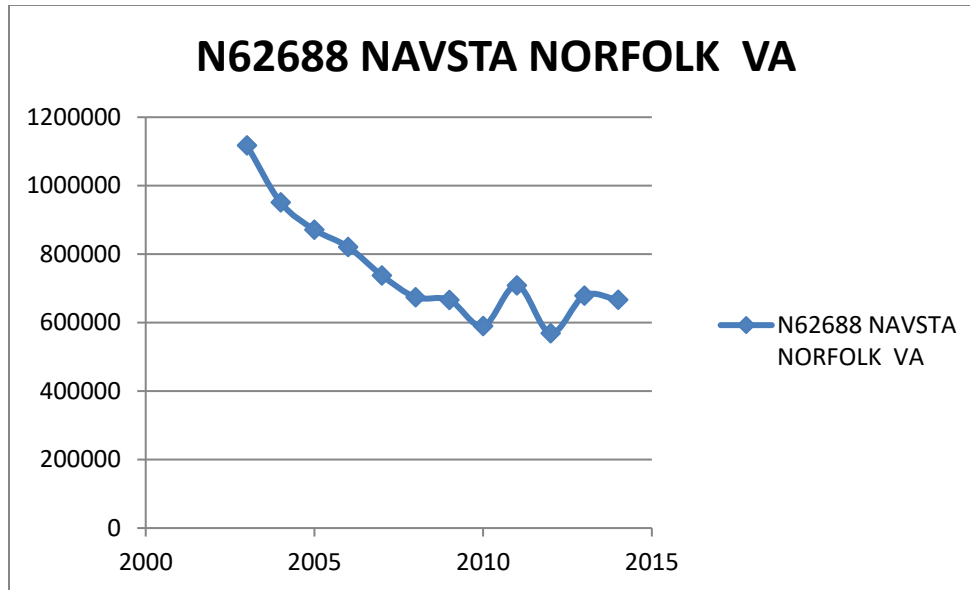


**Figure 4-11. Reduced Water Consumption at Norfolk**

Issues identified in the wastewater collection system include oil and grease wastes entering the conveyance system, which can lead to non-compliance and treatment plant disruption. Portions of the collection system have been repaired/lined by cured in place rehabilitation in an attempt to reduce potential I&I from a region with hydrocarbon impaction. Yet the attempt has not been successful and cross-connections still occur between the oily waste collection system and the sanitary sewer wastewater collection system. The cause of these cross-connections have not been definitively identified and requires further investigation. There have also been some hydrogen sulfide issues in the force mains causing odor and corrosion issues.

## 4.5 OCONUS SITES

### 4.5.1 Commander Fleet Activities Yokosuka (CFA Yokosuka)

CFAY Yokosuka is a 620-acre activity located about 43 miles south of Tokyo and approximately 18 miles south of Yokohama at the entrance of Tokyo Bay. Since 1945, the U.S Navy has occupied the base. Currently, portions of the base are in joint use with the Japanese Maritime Self Defense Forces. Yokosuka Main Base is the most highly populated of the activities comprising CFA Yokosuka, serving as the installation's headquarters and conducting a range of activities including administration, housing, community support, education, and industrial and commercial activities including acting as a port for naval vessels.

CFA Yokosuka had elevated H<sub>2</sub>S problems in a particular portion of their collection system adjacent to the shipyard and maintenance facilities. The shipyard and maintenance area experiences concentrated wastewater flows, ship waste discharges, and long holding times as a result of the location, variable flows, and tenant uses (industrial and ship waste with minimal domestic water to act as dilution for the concentrated wastes). The combination of high-strength wastewater and long holding times lead to the generation of excess H<sub>2</sub>S. To rectify this CFA

Yokosuka installed a H<sub>2</sub>S treatment system at the lift station downstream of the shipyard and maintenance facilities. The treatment system utilizes generated ozone to reduce sewer gas H<sub>2</sub>S levels from around 60 parts per million down to under 10 parts per million. This system is a dry-type ozone deodorization which captures the sewer gas and uses ozone to break down the H<sub>2</sub>S. The system also includes air emissions treatment elements including a scrubber, deodorizer, and absorbent unit for exhaust filtration. The system effectively meets the need of H<sub>2</sub>S reduction however there is an issue with the operating costs. One concern of note is that this dry type system utilizes expensive catalyst coated filters in the emissions processing unit, and these filters are expensive at a cost of \$100,000 to \$200,000 per year. There are alternate options for treatment and given the high operating cost from the filter replacement this is something that should be further examined.

#### 4.5.2 Commander Fleet Activities Chinhae (CFAC)

Commander Fleet Activities Chinhae (CFAC) is a United States Navy installation in the Republic of Korea (ROK). It is located in the district of Jinhae, which was a municipality until July 2010 when it was merged with the cities of Masan and Changwon into the new municipality of Changwon. CFAC's mission is to provide service and operational support to the fleet and strengthen the US-ROK alliance. CFAC provides Command, Control, Communications, Computers and Intelligence (C4I), logistics, and personnel support through joint and combined armistice, exercise and contingency operations.

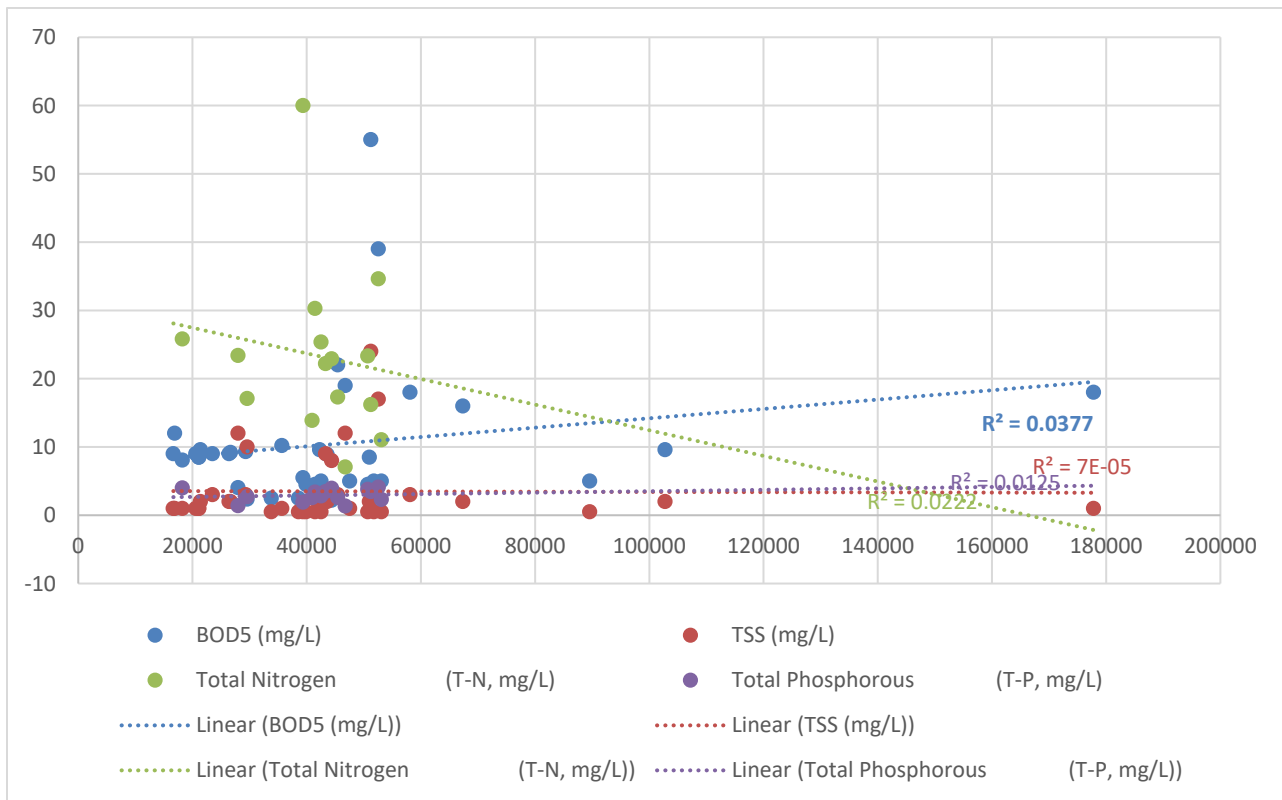
Situated adjacent to the ROK naval base, CFAC occupies 88 acres on a steep hillside. The land use at CFAC consists mainly of communications, administration, medical, public works, housing, storage, personnel support, utility, and recreation facilities. Unlike other naval bases, CFAC does not have a waterfront or air support infrastructure for ships or aircraft, except for electrical distribution systems on ROK-US Navy-owned piers 11 and 22 in Jinhae.

CFAC operates a packaged wastewater treatment plant (Figure 4-13) designed to operate in the extended aeration mode. The WWTP treats mostly domestic sewage for less than 500 residents and non-resident workforce. The WWTP provides secondary (biological) treatment prior to discharging its effluent into the local stormwater conveyance system, which eventually leads to Jinhae Bay. The plant is designed for a minimum flow of 21,000 gallons per day (GPD), an average daily flow of 107,000 GPD, and a peak wet weather flow of 428,000 GPD. During an emergency or significant storm events, the WWTP influent is diverted to a 35,000 gallon holding tank (or septic tank) adjacent to the softball field. When used during significant storm events, minor settling occurs. Table 4-1 shows actual average and peak flows from October 2007 through January 2015. There have been several occasions when the WWTP has diverted peak flows to the septic tank at the softball field, which discharges into a combined sewer line.

**Table 4-1: CFAC WWTP Average, Peak, and Low Flows, Oct 2007 – Jan 2015.**

| Parameter               | Flow (GPD) | Peaking Factor | Incremental Flow (GPD) | Comment           |
|-------------------------|------------|----------------|------------------------|-------------------|
| Average Day             | 47,053     | N/A            | N/A                    | Oct 2007-Jan 2015 |
| Peak Month, Average Day | 135,167    | 3.0            | 90,787                 | July 2009         |
| Peak Day                | 499,339    | 11             | 454,959                | July 8, 2009      |
| Low Month, Average Day  | 13,721     | N/A            | N/A                    | December 2014     |
| Lowest Flow Day         | 264        | N/A            | N/A                    | January 16, 2011  |

While peak flows are also a concern, there have been several months where the average flow has been at or lower than the minimum flow, typically during the winter, and many days where the flow fell below the minimum design flow at the WWTP. However, comparing data for TSS, BOD, TN, and TP with the total daily flow rates showed no correlations (Figure 4-12).

**Figure 4-12. CFAC Flow rates vs. Effluent Water Quality**

The CFAC WWTP was installed in 1998 and upgraded in 2009 and 2014. The 2009 upgrades include replacing all air blower pumps, replacing the influent flow meter, removing the odor control adsorber and replacing with the GAC (Granular Activated Carbon) Odor Control System. In addition, the lift stations were modified and the pumps at all 3 lift stations were removed and replaced.

On 18 June 2012, the USFK issued a new Korea Environmental Governing Standards (KEGS) with new wastewater effluent criteria that went into effect on 1 January 2013. Table 4-2 shows the 2004 and 2012 KEGS limits and the CFAC WWTP effluent water quality since September 2009. The existing wastewater treatment system at CFAC is not capable of producing an effluent that will reliably comply with the 2012 KEGS limits, particularly for BOD, TN, and TP.

**Table 4-2: KEGS Effluent Water Quality Limits for CFAC WWTP in 2004 and 2012.**

| <b>Parameter</b> | <b>2004 KEGS</b> | <b>2012 KEGS</b> | <b>SEP 2009 – JAN 2014 CFAC<br/>Average WWTP Results<br/>Summary</b> |
|------------------|------------------|------------------|----------------------------------------------------------------------|
| BOD              | 20 mg/L          | 10 mg/L          | 10.34 ± 10.02                                                        |
| TSS              | 20 mg/L          | 10 mg/L          | 3.05 ± 5.05                                                          |
| pH               | 6.0-9.0          | 6.0-9.0          | 7.37 ± 0.84                                                          |
| TN               | 60 mg/L          | 20 mg/L          | 22.39 ± 12.06                                                        |
| TP               | 8 mg/L           | 2 mg/L           | 2.84 ± 0.87                                                          |
| Coliforms        | N/A              | 3,000 CFU/mL     | 1291 ± 1392                                                          |

In 2014, NAVFAC EXWC conducted several tests to improve WWTP performance and meet environmental compliance standards. After completing all of the testing at the CFAC WWTP, alum addition was recommended to improve TP and TN removal in the effluent and incorporated into the standard operating procedure (SOP). An optimum alum dose of 50 mg/L was determined, but a constant 10kg/day quantity was recommended because of operator concerns and a typically regular flow rate.

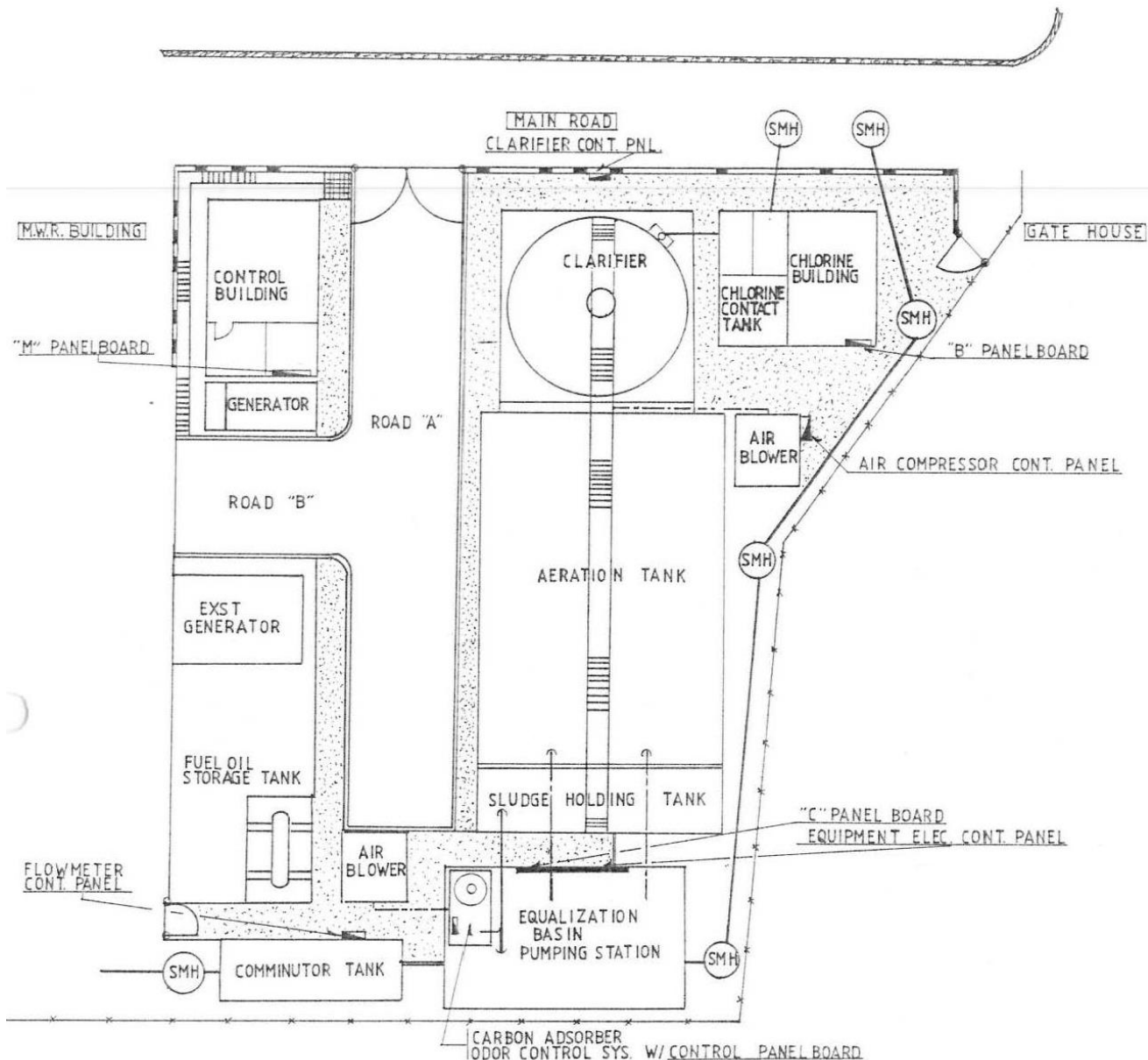


**Figure 4-13. CFAC Utility Plan.**

CFAC has aging infrastructure issues, some H<sub>2</sub>S odor issues at the headworks during low flow periods, and increasingly stringent effluent standards that have been challenging to meet.

#### 4.5.3 Joint Base Pearl Harbor-Hickam (JBPHH)

The Joint Base Pearl Harbor-Hickam (JBPHH) WWTP treats an average of 5.5 million gallons of wastewater per day (MGD) with a design capacity of 13 MGD. Wastewater influent includes both domestic (household) and industrial wastewater. Influent data from 2003-2008 and then from 2006-2014, including BOD, TSS, TP, and TN was plotted against influent flow rates to determine if there was any quantifiable correlation between flow rates and influent characteristics. In all cases there was no quantifiable correlation between flow rates and influent characteristics. While

sometimes low flow cases may have higher TSS, BOD, or nutrients that can be more difficult for the plant to treat during low flow conditions, there are too many variables affecting the influent wastewater to solely attribute these influent characteristics to low flow conditions (see Figure 4-14, Figure 4-15, and Figure 4-16).

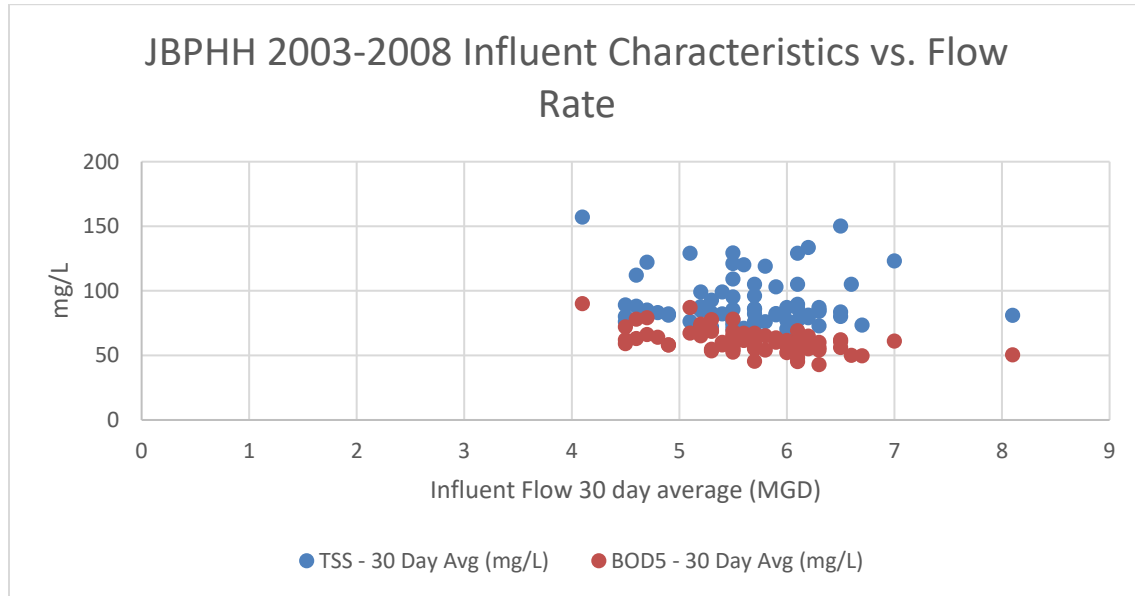


**Figure 4-14. JBPHH 2003-2008 Influent Characteristics vs. Flow Rate (TSS & BOD)**

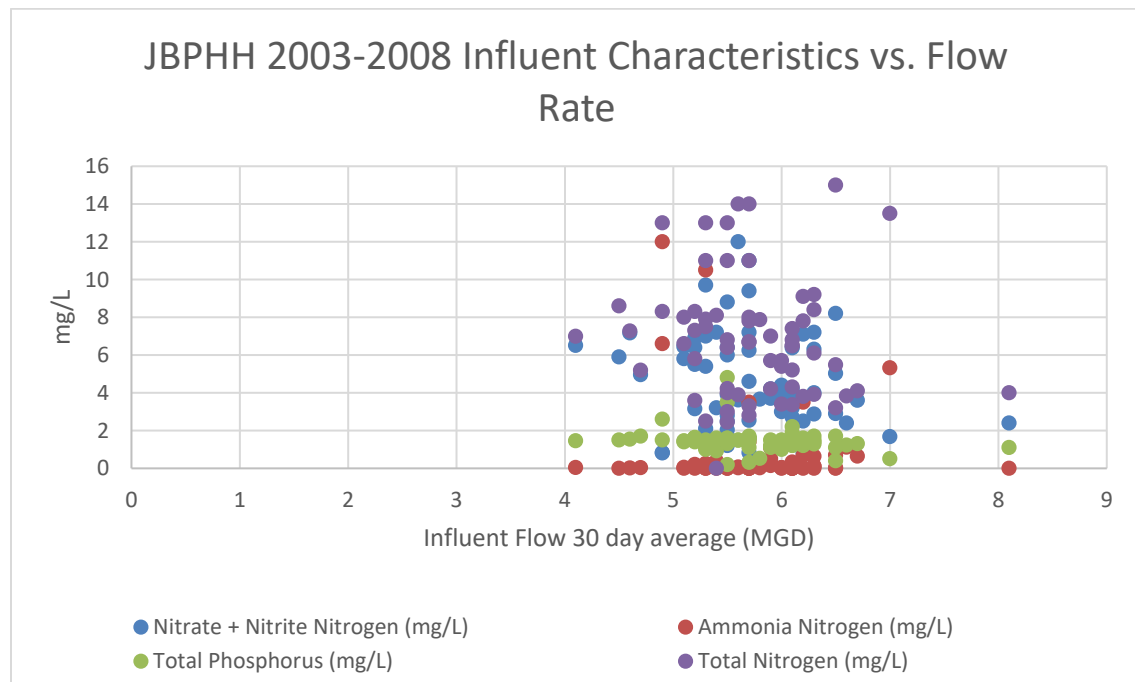


**Figure 4-15. JBPHH 2003-2008 Influent Characteristics vs. Flow Rate (Nutrients)**

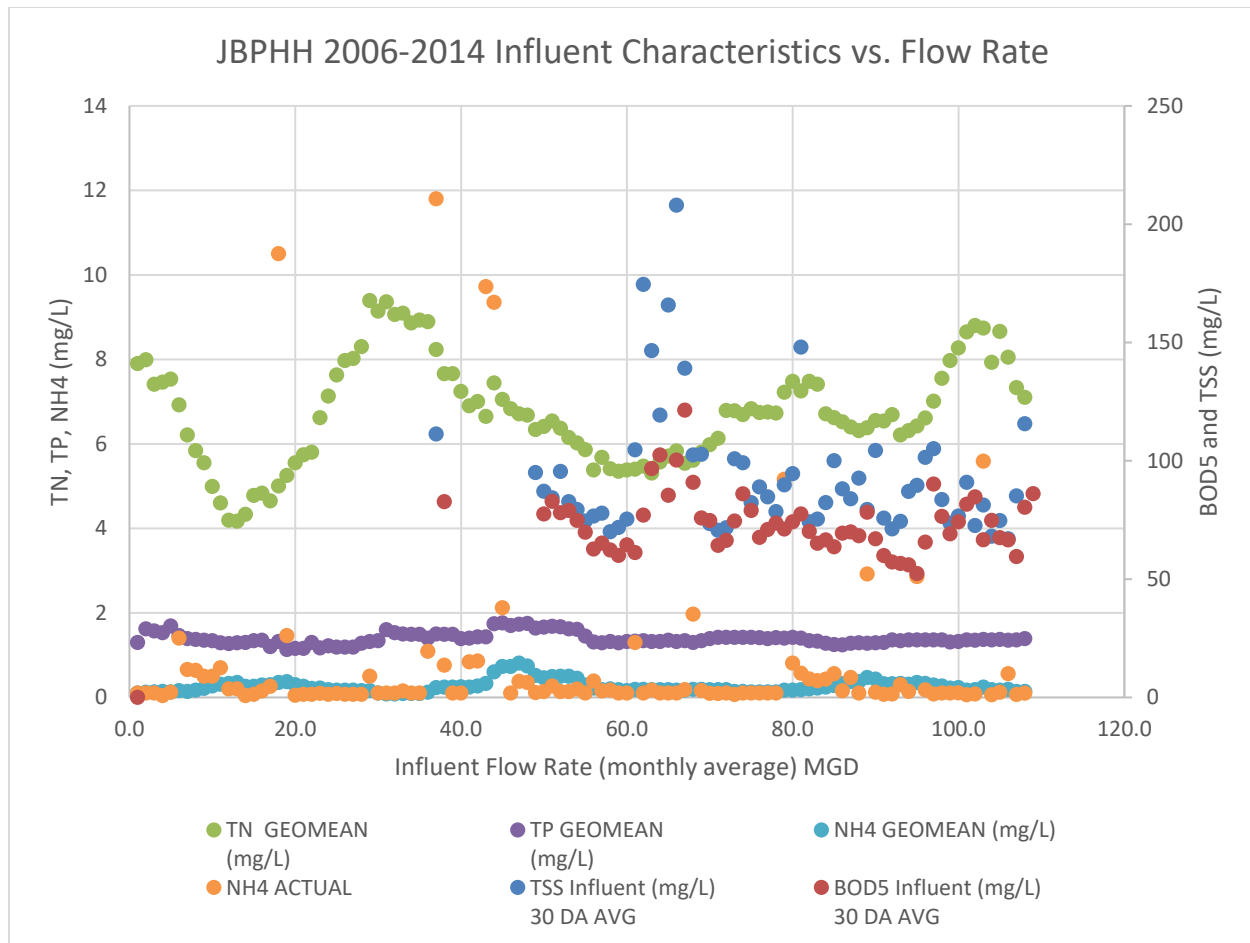


**Figure 4-16. JBPHH 2006-2014 Influent Characteristics vs. Flow Rate**

Low flow conditions can stress the treatment plant and make it more challenging for the plant to treat any spikes in the influent wastewater to appropriate effluent limitations. For example, JBPHH received an NOV for total ammonia nitrogen discharge at an outfall in 2014 that could have been related to a lower influent flow rate at that time. In addition, Navy Region Hawaii has had several spills and sewer line clogging that could also be partially attributed to low flow rates.

Another recurring issue at JBPHH is spikes of oil and grease entering the wastewater collection system and treatment plant. Lower flow rates exacerbate this issue and the oil and grease can seriously disrupt the treatment process, potentially destroying the biological treatment stages and shutting down the wastewater treatment plant.

#### 4.5.4 Naval Base Guam

Naval Base Guam's Apra Harbor WWTP serves the Apra Harbor Naval complex on the island of Guam. The EPA issued NPDES Permit number GU0110019, establishing operational and effluent limitation pursuant to satisfying the CWA and Guam Water Quality Standards for allowable discharges into the Tiplao Bay Outfall. The treatment plant schematic is shown below in Figure 4-17.

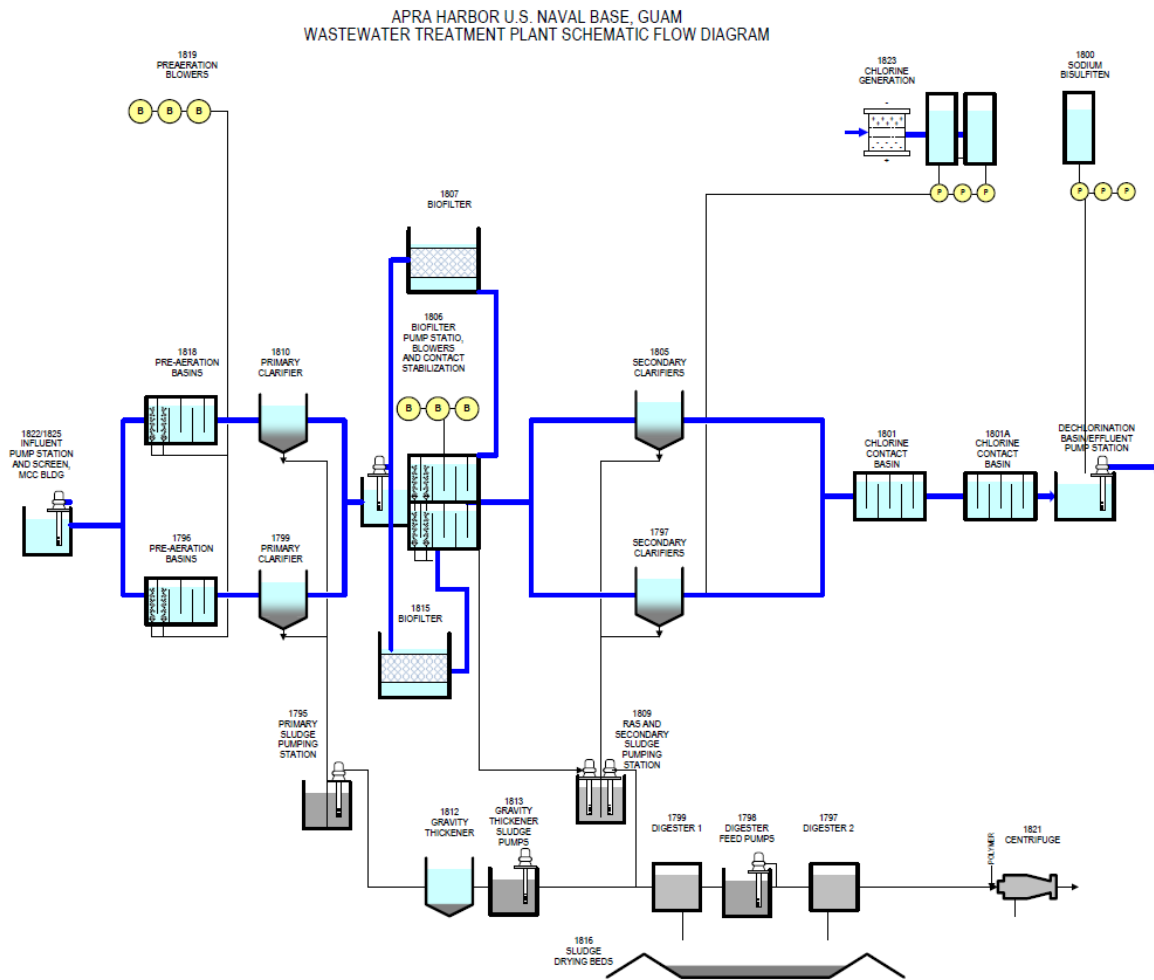
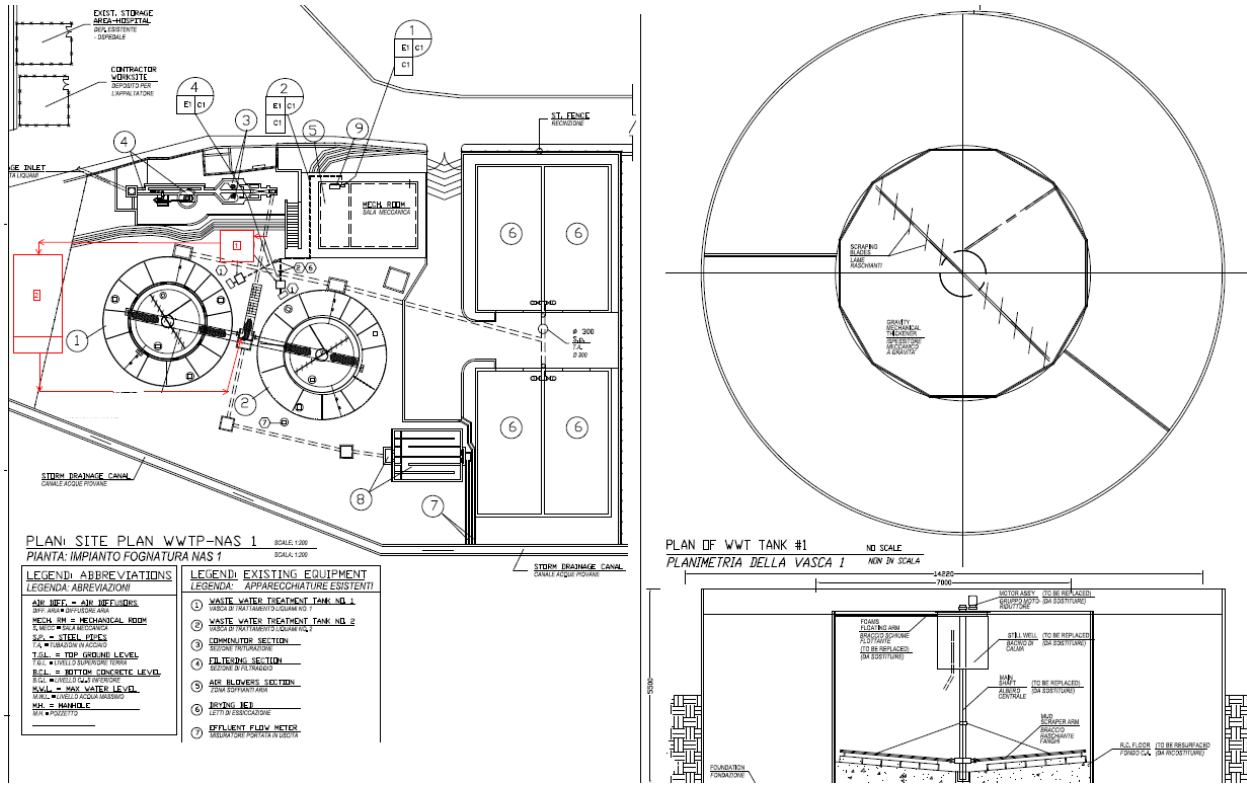


**Figure 4-17. Apra Harbor WWTP Schematic**

While Guam has had several violations of its effluent limitations, including Aluminum, Copper, Nickel, Enterococci bacteria, Total Residual Chlorine, BOD, and TSS, these were resolved by improving the headworks facilities, repairing BOWTS, enforcing stormwater BMPs, and working on preventing illegal dumping. There are still isolated (one-time) oil and grease hits during sampling events, particularly near the piers, that has caused issues in the wastewater collection and treatment systems.

#### 4.5.5 Naval Air Station Sigonella (NASSIG) - NAS I WWTP

In the 1980s, the Naval Air Station Sigonella (NASSIG) or NAS I WWTP using biological treatment was constructed with a designed treatment capacity of 250,000 gallons per day (GPD). Currently the plant treats 140,000 GPD. Base population is approximately 1800 people with an average drinking water demand of 273,245 GPD (per 2014 Sanitary Survey). Plant technology and equipment are outdated and difficult to maintain.



### Figure 4-18. NAS I WWTP Diagram

In 2012, Province of Catania became aware of exceedances during Navy sampling in support of the permit reapplication, including three Letters of Warning for exceeding Total Nitrogen and Total Phosphorus permit limits. In November 2015, the Province of Catania issued an exceedance letter and a 3,015 Euro fine (approximately \$3300 USD) to the installation CO for the 2012 permit violation. NAS I WWTP has not been able to consistently meet permit and GFS limits for Total Nitrogen, Total Phosphorus, Boron, Total Phenols and Surfactants. A Source Tracking Study to identify the source of boron, phenols, and surfactants began February 2016 and should have concluded October 2016. Based on that study, steps will be taken to substitute products or modify processes to eliminate/reduce pollutant(s) and tenants will be educated on what is and is not permitted down the drains and sinks.

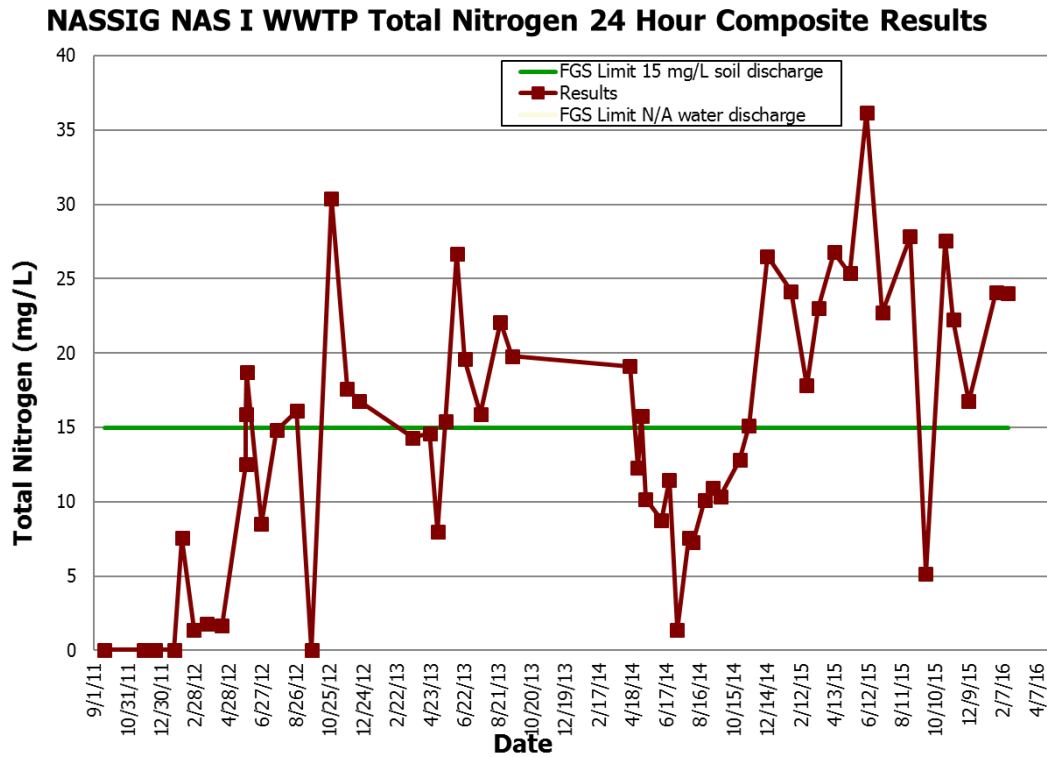


Figure 4-19. NASSIG NAS I WWTP Nitrogen Exceedances

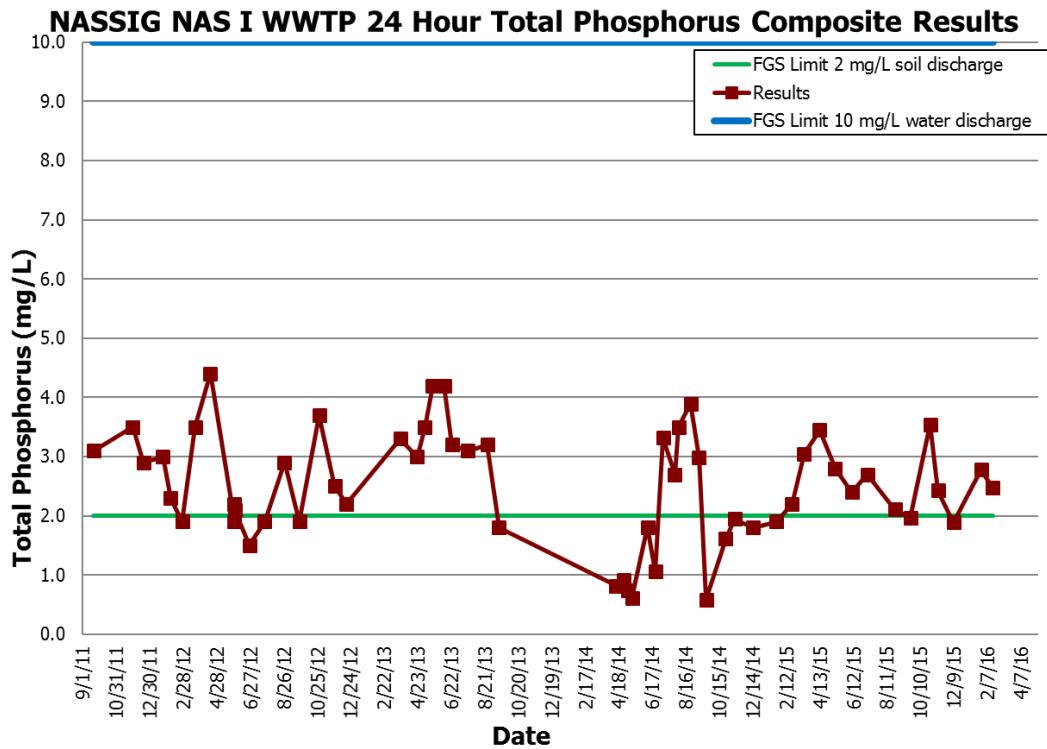


Figure 4-20. NASSIG NAS I WWTP Phosphorus Exceedances

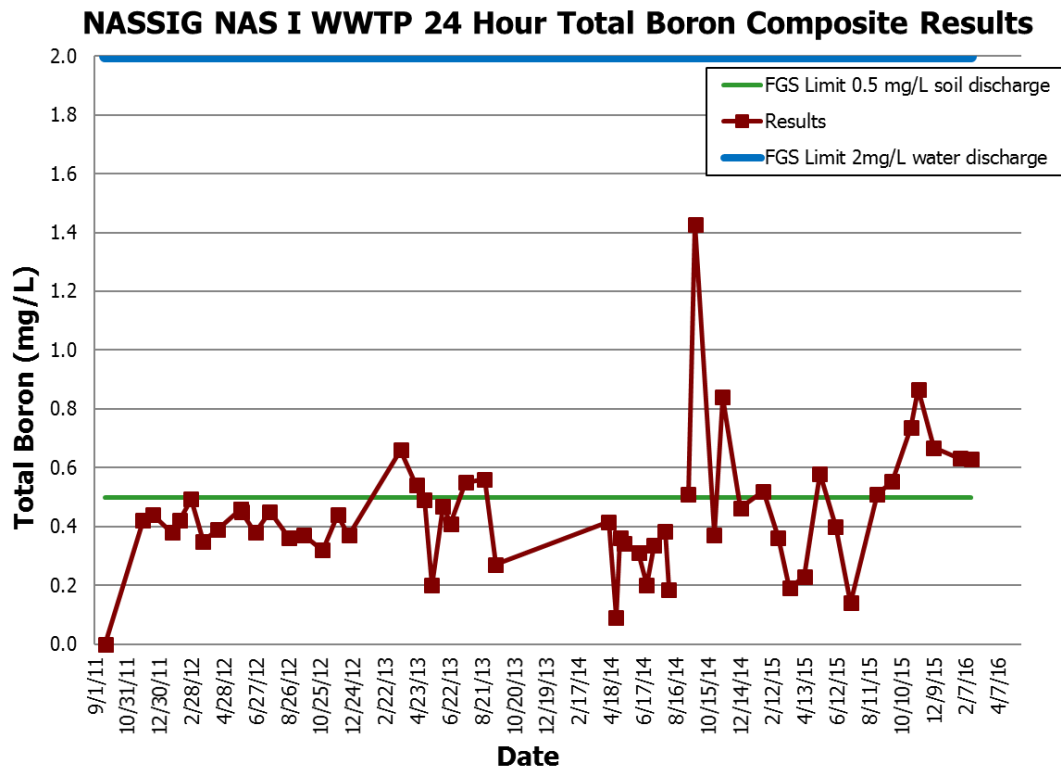


Figure 4-21. NASSIG NAS I WWTP Boron Exceedances

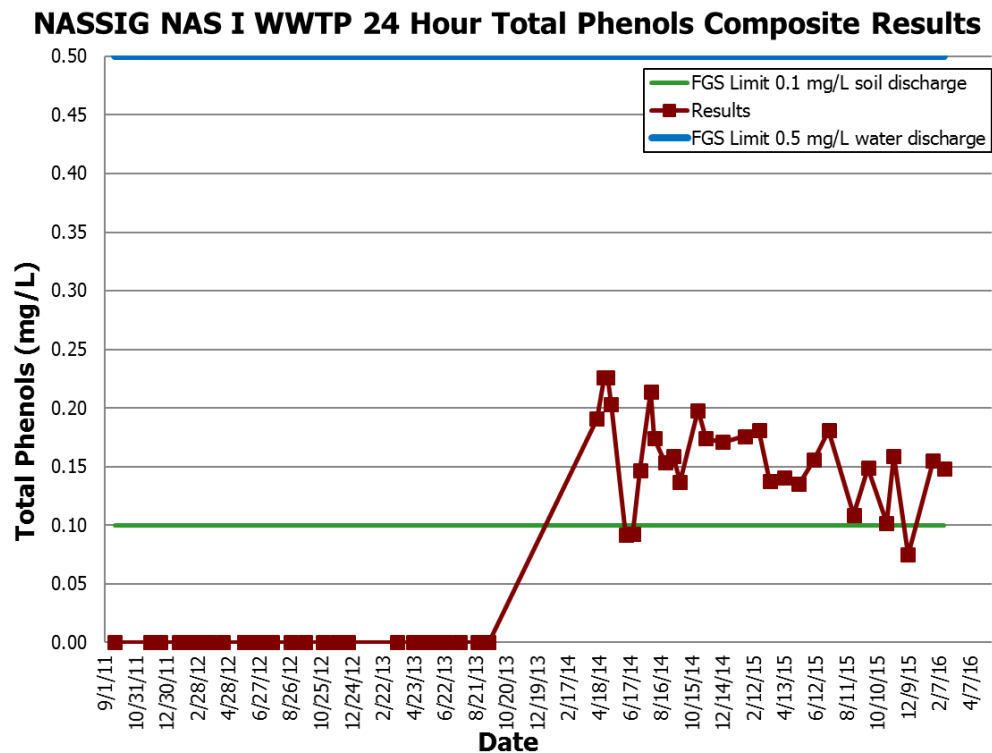


Figure 4-22. NASSIG NAS I WWTP Phenol Exceedances

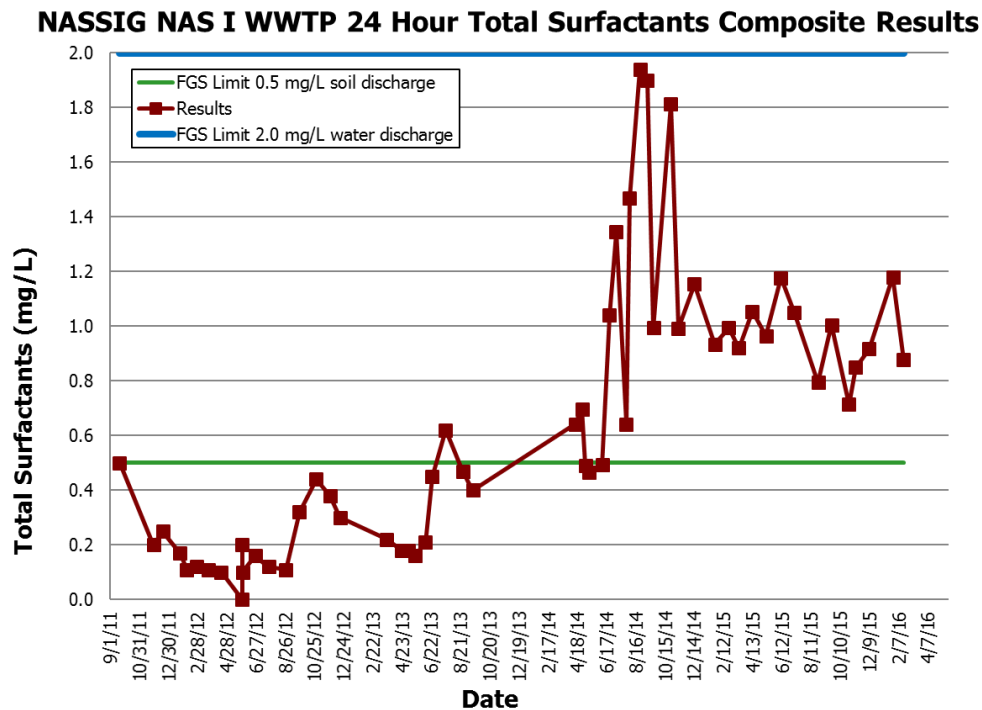


**Figure 4-23. NASSIG NAS I WWTP Surfactant Exceedances**

| Project Title                                                                           | Cost               | Estimated Completion Date | Additional Notes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------------------------------------------------------------|--------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Source Tracking Study                                                                   | \$65,000           | Apr-16                    | Sampling wastewater discharges at strategic locations throughout the collection system to identify tenant operations contributing to exceedances.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Phosphorus Sedimentation Injection by Dosage Skid                                       | \$10,000           | Apr-16                    | In-house project/ Estimated cost - \$10k plus reoccurring chemical costs (~\$500/month); Proposing an Aluminum Sulfate or Aluminum Polymeric Solution for phosphorus sedimentation injected by a dosage skid which included redundant pump and chemical storage tank. The chemical will be injected in the oxidation basin.                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Install New Membrane Bioreactor                                                         | \$1,300,000        | FY19                      | This project will repair and modernize the existing Waste Water Treatment Plants (WWTP) at NAS 1 (Building 229) at NAS Sigonella. This project will replace the existing old treatment technology with modern wastewater treatment plant technology (Membrane Bioreactors) or MBRs.                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| CIP-16-S-02 Install Equalization Basin at B229 WWTP NAS I                               | \$625,000          | FY17                      | The basin will equalize the incoming flow to the WWTP and allow more consistent treatment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| MMR-16-S-02 - Repair SCADA at Wastewater Treatment Plants (WWTP) at NAS I and II (FY16) | \$325,000          | Nov-16                    | Replace SCADA system software and provide all necessary hardware required to run and operate new software. Remove and replace all electronic controls/sensors/meters to insure compatibility with new SCADA system. Salvage and return to government all functional controls/sensors/meters. Hardwire connect all lift stations in NAS 1 to building control system to allow for remote operation and monitoring of lift station pump facilities from building 229. Include SCADA system connections for chlorine pumps and electric motor for the scraper used in the clarifier. Upon completion of system upgrade, test to confirm that all sensors and controls for NAS 1 can be monitored and operated from the control center in building. |
| <b>Total Cost</b>                                                                       | <b>\$2,260,000</b> |                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

**Figure 4-24. NASSIG NAS I WWTP POAM**

## 4.6 MARINE CORPS

### 4.6.1 Marine Corps Logistics Base Barstow

MCLB Barstow provided NAVFAC EXWC findings from their study of the Yermo Annex Wastewater Treatment Facility. The purpose of this study, completed in August 2015, was to determine the condition of the existing treatment plant equipment and provide recommendations for repair:

The original WWTP was completed in 1975 and operated as a primary wastewater treatment plant. In 2002, the facility was upgraded to a secondary wastewater treatment plant with advanced treatment to produce effluent confirming to new requirements.

Between 1975 and 2002, the design flows into the plant decreased from 200,000 to 61,550 gpd (approximately 70 percent). Between 2002 and the present (September 2015), flows have further decreased to approximately 18,000 gpd (70 percent). This decrease in flow affects how the plant can be operated compared to the original intent as defined in 1975 and 2002. Units affected are the influent pumps, grit washer, aerobic digester, anoxic basin, aeration basin, mixed liquor return pumps, clarifiers and RAS/WAS pumps. More importantly is the flow variability throughout the day. An increase in flow consistency will improve the operation within the facility. Also, should the flow from Nebo be conveyed to this facility, the operational and maintenance costs should decrease overall.

MCLB Barstow is an example of a wastewater treatment plant with significantly reduced flows and the potential solution is modification to the plant design, including adding an equalization tank and controls to manage low flow conditions, combined with conveying additional flows from another site.

## 5.0 KEY ISSUES IDENTIFIED

Problems found from both data review and site visits are included in this section.

### 5.1 CONCENTRATED FLOWS AND HIGH-STRENGTH WASTEWATER

Navy sites can experience plugs of high-strength wastewater based operational discharges, which can greatly affect treatment plant operations. High-strength wastewater is wastewater that contains greater amounts, as compared to typical residential wastewater, of wastewater components including fats, oils, and greases (FOG), organic components, suspended solids, and chemicals. High-strength wastewater and strength variability can interfere with the normal biological processes in WWTPs and they can have a major impact on how a system performs. (National Small Flows Clearing House, 2003).

Naval facilities, which commonly service naval vessels, have high solids plug flows when vessels discharge sewage, as ships are conservative with water usage leading to these highly concentrated solids flows. These concentrated flows can also contain elevated nutrient levels, which can lead to

algae blooms. Facilities that have reported high-strength wastewater during site visits include NAVSTA Mayport and NAVMAG Indian Island.

NAVMAG Indian Island generates a relatively small volume of wastewater from onsite personnel. There are minimal sources of wastewater as there is no longer any on base housing or occupancy and overall water usage has dropped. When vessels are at the island, they discharge their onboard sewage tanks leading to plugs of high-strength wastewater entering the collection and treatment systems. As combination of the low-flows and high strength of wastewater onsite, the WWTP is impacted with high-strength wastewater that causes algae blooms and reduces the effectiveness of the WWTP.



**Figure 5-1: Algae Bloom NAVMAG Indian Island**

NAS Fallon also has high strength wastewater events from a combination of factors. NAS Fallon has drastically reduced I&I (as discussed in Section 3.1.2) base wide, which has caused unexpected ancillary effect, the strength of the wastewater has increased as a result of the eliminated I&I which was acting as a dilute strength water source. This reduced dilute water source from I&I coupled with the spikes in strength resulting from a transient population source generates high-strength wastewater which leads to multiple site issues. One major issue as a result of these concentrated wastewater plugs occurs at the main pump station referred to as the “four corners” pump station. The four corners pump station is located approximately 10,000ft from the WWTP and is plumbed with large diameter pipe, this pump station collects concentrated wastewater with high solids content which leads to large plugs in the conveyance system. These plugs of solids and high strength wastewater are causing excess wear on the pumping system at four corners, reducing pump capacity, capability, and integrity over time.

## 5.2 FLOW VARIABILITY

Flow variability as it is referenced in this report can be split into two categories, short-term flow variability and long-term flow variability, each of which have their own challenges. Flow variability as a result of a temporary or short-term surge or decline in operations, transient occupancy, or other short-term anthropomorphic effects can lead to multiple system issues if the system and operators are not equipped to manage the fluctuations. Examples of these short-term flow variation scenarios include when one or more carriers are in port, or if a CAG is temporarily stationed at a facility for several weeks, or during seasonal or holiday personnel fluctuations. The short-term flow variations can be a contributor to the concentrated flows and nutrient issues discussed in Sections 5.2 and 5.4 above however, in this context the impact of volume changes independent of the strength have their own difficulties. Depending on system design, which varies from facility to facility, sharp increases in flows can create treatment challenges as throughput of a designed plant may struggle to meet the demand, conversely is sharp decline in wastewater generation occurs there may not be sufficient loads to properly run the WWTP.

Long term flow variability is more in the context of major flow deviations over a longer period. Long term flow variability may include base water usage increase or reduction and typically leads to issues associated with undersized or oversized conveyance and treatment systems. On site observations suggest more facilities experience issues associated with reduction of wastewater flows due to wastewater systems having been designed to accommodate growth and not reductions in water consumption. When a significant reduction of flow scenario occurs systems can develop longer holding times, which can lead to H<sub>2</sub>S issues as described in Section 5.3. This change in flow over long term periods does tie-in with aging infrastructure which is discussed in Section 5.7 however, these flow shifts are not exclusive to old WWTP's. Several facilities including NAS Corpus Christi are slated to get new WWTPs where designers are anticipating much higher flows in the future and, as such, are being designed for these flows. The issue in oversizing a WWTP without adequate flexibility to handle lower flows is that the system will not run efficiently and problems associated with a relatively low actual flow to design flow can arise. In this instance the new NAS Corpus Christi plant will be designed to operate in a sufficiently wide flow range which should minimize potential issues.

Flux in the flow regimes of facilities, both long and short-term, can lead to decreased performance and increased likelihood of violations especially when the conveyance and treatment systems are not designed to accommodate these fluctuations. Systems need to be designed to be adaptable and ensure there are equalization basins or other modular or flexible components to allow for both short- and long-term flow deviations.

## 5.3 AGING INFRASTRUCTURE

Wastewater system infrastructure is aging as the majority wastewater collection and treatment systems at Navy shore facilities were installed many decades ago. Aging collection and treatment systems and reduction in throughput because of water conservation and shifting operations lead to multiple systemic issues at Navy shore facilities including equipment failure, pipe leaks and breaks. System, which were designed for significantly larger wastewater flows and volumes than currently generated experience greater challenges in wastewater quality due to longer stagnation/holding times in piping, lift stations, and wet wells and equalization basins (which are

needed to normalize flow through treatment plants). Longer collection and holding times can lead to generation of  $H_2S$  as result of the anaerobic conditions and stagnation.

Given the age and design of some plants, replacement equipment can be extremely costly and difficult to procure. The breakdown of treatment and collections systems can lead to treatment difficulties, water quality violations, and costly emergency repairs. Service interruptions can impact mission essential services which impact operations.

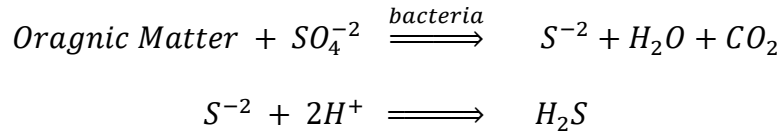
Problems associated with aging infrastructure can negatively impact overall mission readiness and quality of life at shore facilities. The older wastewater collection and treatment systems become the higher the likelihood compliance problems and mission impacts will occur and at increased severity. Compounding these issues, budgeting and available funding make upgrades, full-scale replacements, and even some proactive retrofits for many systems difficult to attain.



**Figure 5-2: Aging Sand Filters at NAVMAG Indian Island**

## **5.4 HYDROGEN SULFIDE**

Hydrogen sulfide ( $H_2S$ ) forms in wastewater systems based on system flows, design, and sewage nutrient levels within the collection and treatment systems.  $H_2S$  is a colorless, flammable, and toxic gas that forms from anaerobic decomposition of organic matter containing sulfur or from reduction of mineral sulfides and sulfates. This byproduct has low solubility in wastewater and a strong, rotten-egg type odor that is the most common in wastewater odor complaints. In addition to increased odor issues, declining flows can accelerate corrosion through increased concentrations of organic material and sulfate, generating corrosive sulfides (i.e.  $H_2S$ ), and through increased residence time enabling the higher organic content to consume oxygen leading to anaerobic conditions. The generalized chemical reactions for the generation of  $H_2S$  are detailed below in Equation 1 (Metcalf and Eddy, 1991).

**Equation 1**

The presence of H<sub>2</sub>S can lead to rapid and extensive damage of concrete and metals used in the construction of wastewater collection and treatment systems. Sewers, pump stations, and treatment facilities, including electrical controls, instrumentation, process equipment, tankage and ventilation systems be affected (EPA, 1991). Equipment used in treatment of wastewater is often subject to hydrogen sulfide corrosion, resulting in equipment malfunctions, poor reliability, increased maintenance, and premature replacement (EPA, 1991).

Multiple Navy sites have a range of issues associated with hydrogen sulfide including system and equipment degradation as well as water quality violations.

NAVSTA Mayport has elevated H<sub>2</sub>S levels present at the lift stations and wet wells, which has caused degradation of system components and equipment including lift stations, piping, and WWTP tanks, and equipment. The H<sub>2</sub>S has also corroded and decayed system components and structural elements (concrete and rebar) at the WWTP.

Naval Air Station (NAS) North Island has received 18 CWA NOV's for hydrogen sulfide exceedances in several years. The City of San Diego added a dissolved sulfides limit of 1 mg/L to the permit about 5 years ago. The IUDP for Naval Amphibious Base (#08-0490) will also have a dissolved sulfides limit by 2019. The violations note potential root causes of the exceedances as infrastructure deficiencies, specifically that the current design of sewer system is resulting in stagnation of sewage that is creating anaerobic conditions and leading to the excess generation of sulfides.

CFA Yokosuka had elevated H<sub>2</sub>S issues for a particular portion of their collection system adjacent to the shipyard and maintenance facility area likely due to concentrated wastewater flows, ship waste discharges, and long holding times. To rectify this CFA Yokosuka installed a H<sub>2</sub>S treatment system to reduce levels prior to conveyance to the WWTP.

The inability to effectively control dissolved sulfides concentrations in the sewer will likely result in continued permit exceedances. This may ultimately result in more restrictions and limitations on wastewater that can be discharged to combined sewer systems (e.g. NASNI discharge to City of San Diego). The Navy would be vulnerable to lawsuits. Elevated dissolved sulfides result in generation of H<sub>2</sub>S gas that creates a health risk to on-site personnel and utility workers, as well as nuisance odors. Other byproducts result in deterioration of piping and sewer infrastructure that necessitate costly repairs and potential interruption of mission operations. Impacts from dissolved sulfides are ongoing and result in costly resampling and mitigation efforts.

## 5.5 NUTRIENTS

Nutrients are common elements in wastewater and can remain in the treated effluent from WWTPs. The primary nutrients of concern in both primary and treated effluent are nitrogen and phosphorous

which can cause a wide array of issues. Total nitrogen in wastewater consists of multiple forms, which include organic nitrogen, ammonia nitrogen, nitrite and nitrate. Phosphorous in wastewater consist of organic phosphate, orthophosphates, and polyphosphates. Nitrogen and phosphorous can accelerate the eutrophication of lakes and reservoirs, stimulate algae growth, deplete dissolved oxygen in receiving waters, exhibit toxicity to aquatic life, and affect chlorine disinfection efficiency (Metcalf and Eddy, 1991). Because of the detrimental effects of nitrogen and phosphorous these nutrients are typically regulated in wastewater discharge permits.

Multiple Navy sites have elevated levels of nutrients that cause degradation of receiving water and discharge violations. NAVSTA Mayport and NAS Jacksonville share discharge limitations for combined discharge to the St. Johns River. NAVSTA Mayport is the source of the majority of nitrogen as NAS Jacksonville reuses its water and does not discharge a significant volume or nutrients as compared to NAVSTA Mayport. NAVSTA Mayport received an NOV and subsequent consent decree due to the exceedance of nitrogen limits in 2014. NAVSTA Pearl Harbor has also received an NOV for total ammonia nitrogen discharge at an outfall in 2014.

NAS Fallon had multiple exceedances for nutrients, specifically nitrogen. The WWTP installed Sequential Batch Reactors (SBR) in 1995, which do not treat for nutrients, as this was not a requirement for discharge at the time. Beginning in 2008 nutrient limits was included in the facilities discharge permit, which were then exceeded.

Reported root cause is an aging WWTP that was not designed for efficient Total Nitrogen removal. Sequential Batch Reactors (SBR) were installed in 1995 and the permit at the time did not have a limit for Total Nitrogen. Total Nitrogen limit of 10 mg/L was first required in the permit issued in 2007. October 2013: The WWTP is currently in design and the expected completion date is March 2014. This is ahead of the AOC required date of February 2015. New WWTP is expected to be up and running in November 2015. After demonstrating, that the WWTP will achieve compliance the AOC is expected to be closed out in 2016. UPDATE: December 2015: The WWTP design went through some major changes and modifications. The new design completion date is March, 2016, with construction not expected to be complete until December 2018. The AOC is being revised to reflect new dates.

A new WWTP is being designed and will be installed at NAS Fallon. The new plant construction is not yet underway as of March 2018. The new plant will allow for nutrient reduction and conformance with the ACOC.

As mentioned earlier, the CFAC WWTP is a packaged activated sludge plant designed to operate in an extended aeration mode. In this mode, the activated sludge system is capable of nitrification—a biological process in which nitrogen, mainly in the form of ammonia ( $\text{NH}_3$ ), is converted to nitrate ( $\text{NO}_3^-$ ). Since nitrate is a component of TN, the TN concentration from treatment in an extended aeration plant is not substantially decreased from typical influent values ranging from 20 to 40 mg/L. For TP, where typical influent values range from 4 to 8 mg/L, phosphorus is not substantially utilized by activated sludge bacteria (and thus eliminated through sludge wasting) in the extended aeration mode. CFAC WWTP submitted a request to USFK in 2013 for an issuance of a temporary waiver from the current KEGS standard since they could not

consistently meet the new effluent standards. Ultimately CFAC plans to connect to the Changwon City sewer collection system and abandon the CFAC WWTP.

The inability to effectively control nutrient concentrations in wastewater effluent will likely result in continued permit exceedances. Elevated nutrient levels in discharged wastewater effluents can lead to eutrophication in receiving waters that can impact sensitive species, habitats, or cause local odor issues around streams, lakes, or lagoons that might affect local communities and impact mission operations. These impacts might also increase exposure to lawsuits or lead to stricter limits on wastewater effluent discharged to combine sewer systems. The increased nutrient concentrations caused by low wastewater flows can necessitate costly upgrades to wastewater treatment plants or affect wastewater treatment operations in such a way that impacts water reuse rates and ultimately increases rates of water consumption at Navy facilities. Such impacts can even lead to the abandonment of Navy owned wastewater treatment facilities altogether and costly increases of discharges to municipal collection systems.

## **5.6 OIL AND GREASE**

Oil and grease can build up in sewer collection systems and form hard solid conglomerates with minerals and other wastewater constituents that can build up and cause blockages. Sewer blockages eat up a significant fraction of O&M budgets and can lead to costly property damages and activity delays. Oil and grease within sewer collection systems can also increase BOD which then contributes to sulfide production, hydrogen sulfide gas evolution, associated malodorous gas generation, as well as sulfide induced corrosion. Oil and grease discharges enter the wastewater collection system and subsequently the corresponding wastewater treatment plant and can disrupt or foul the treatment equipment and process potentially destroying the biological treatment stages. This can shut down the wastewater treatment plant for weeks requiring costly repairs the damaged treatment system and leading to permit violations and causing NOVs. It also poses a health and safety risk if the effluent being discharged is not treated appropriately.

NAVSTA Norfolk as discussed in 4.4.1 operates the collection and conveyance portions of the wastewater infrastructure and has oil entering the conveyance system which can lead to non-compliance and treatment plant disruption at the publicly owned treatment works (POTW) in Hampton Roads. Portions of the collection system have been repaired/lined by cured in place rehabilitation in an attempt to reduce potential Infiltrations and Inflow from a region with hydrocarbon impaction one potential source of oil, however the source has not been fully identified and could be from illicit or improper ship discharge.

Naval Base Guam also has oil and grease issues in wastewater collection and conveyance systems and these elevated constituents can impact the Navy owned WWTP and lead to violations of water quality.

Controlling oil and grease inflows is necessary to preserve the integrity of treatment operations and longevity of wastewater infrastructure. Without suitable controls, sewer collection systems will experience increasingly frequent blockages, equipment failures, and accelerated corrosion. Sewer system failures caused by blockages can lead to unpermitted discharges and NPDES permit violations. Oil and grease can impair wastewater treatment operations and can cause effluent

exceedances NPDES permit violations and impair receiving waters. Without adequate controls for oil and grease, facilities may also experience more issues related to malodorous gases.

## **5.7 ADDITIONAL PROBLEMS**

Additional issues that can occur from declining wastewater flows include impacts on ultraviolet (UV) disinfection, more clogging and pipe blockages, solids settling in sewer lines and lift stations, and impacts on wastewater reuse.

UV treatment provides disinfection at the final stage of the wastewater treatment process. Using ultraviolet radiation to disinfect is rapidly growing in the municipal arena, but was rarely seen at DoD facilities. UV disinfection neutralizes microorganisms as they pass by ultraviolet lamps submerged in wastewater effluent. If wastewater flows are low enough, it's possible for UV bulbs to not be fully submerged and overheat. In this case the UV system should shut down due to high temperatures. This could cause wastewater effluent to be discharged without disinfection.

Lower flow rates through wastewater collection systems can also cause clogging and pipe blockages as debris accumulates that would normally continue to flush downstream into the wastewater treatment plant. Blockages occur normally in sewer systems, but lower flows can exacerbate these blockages in systems that weren't hydraulically designed for lower flows. Settling solids is another contributing factor to debris accumulation and blockages in sewer systems and can also contribute to increased concentrations of sulfate and corrosive sulfides.

Declining wastewater influent also reduces wastewater effluent volumes, which can have a variety of downstream effects. Some municipal installation plants are required to discharge a certain amount of flow to help maintain downstream ecosystems of rivers and streams. While this hasn't yet been an issue for Navy WWTPs, it may become an issue in the future. Another negative impact of reduced wastewater effluent volume is that less recycled water is available for reuse. While few Navy installations currently recycle wastewater for non-potable uses, the need for water reuse is becoming greater in drought-prone and water insecure areas. Many California municipal recycled water projects have noticed the additional strain on production as wastewater effluent volumes have decreased, coupled with concern that further decreases may increase effluent concentrations that could become harder to treat using existing recycled water treatment processes.

## **6.0 SOLUTIONS & BMPs**

This section outlines potential solutions and best management practices for the key issues identified during the data analysis and site visits. It's also worth noting that the easiest, and often most practical, solution to low flow related issues is simply to add additional flow.

Many of the installations the team visited had worked out methods to add additional flow into lift stations or the wastewater treatment plant. At NAS Fallon, they have construction contractors dump their excess water into trouble lift stations to push slugs through. At NAS Jacksonville, the plant is currently working on an agreement with the city to set up a connection that will allow them to divert treated effluent from the city's wastewater treatment into the plant's wastewater treatment to minimize low flow issues. MCLB Barstow also considered adding a pump station at another WWTP to convey the flow from that site to their main WWTP.

Rerouting additional flows into trouble areas or even diverting treated effluent back into the influent tends to be the simplest and most effective solution to handle low flow issues, while still meeting water conservation mandates. This may not always be possible, depending on site specific conditions, therefore this section will outline additional solutions to the key issues identified.

## **6.1 CONCENTRATED FLOWS AND HIGH STRENGTH WASTEWATER**

While this was a key issue at several of the sites visited, the solutions for this depend on the specific impact that occurs due to concentrated flows and high strength wastewater. These are outlined throughout this section. Depending on the concentrations and types of pollutants in the wastewater, potential technology solutions may lay in industrial wastewater treatment processes.

## **6.2 FLOW VARIABILITY**

Flow variability is a given at any Navy WWTP and was seen most dramatically at NAVMAG Indian Island. Solutions for flow variability include sizing the wastewater collection and treatment systems appropriately to accommodate for a wider variety of flows, utilizing proper equalization tanks to minimize flow variability throughout the treatment system, and clear operational guidelines for flow management.

To obtain more steady flow rates, it is recommended that flow equalization be implemented or improved by adding or resizing the flow equalization tanks. Often, unused treatment units, such as aerobic digesters or clarifiers, can be converted into equalization tanks if installing a new structure is cost prohibitive. WWTP system design and retrofitting projects should ensure that the plant modifications or construction allows for flexibility in flow to ensure future operations and their flow variability can be easily accommodated.

## **6.3 AGING INFRASTRUCTURE**

There are some site-specific BMPs, technologies, and optimization techniques that can extend infrastructure lifespan, but only for so long. Installations should have cost estimates ready and be prepared to utilize NOV's or EMS Audit findings to justify infrastructure replacement as necessary. All treatment systems should be designed effectively while optimizing maintenance and operating costs. At many sites, the focus was on the military construction (MILCON) project and turnover, with little to no thought given to operation and maintenance afterwards. This can burden the facility with additional labor needs, excessive energy requirements, high consumables costs, and extreme equipment repair costs.

The only way to adequately mitigate aging infrastructure is repair or replacement which typically requires major maintenance projects or MILCON projects. Important considerations must be included when planning, designing and executing MILCON projects to ensure a worthwhile and long-lasting product. As infrastructure is replaced, it should be sized to accommodate for lower flow conditions (as appropriate). Modifications and replacement of hydraulics should be performed to reduce pump capacities and controls added to accommodate the effects of low flows. Equalization tanks and adequate redundancies allow plants to be better maintained and improve longevity. Modular systems for WWTP with the ability to expand and/or contract are also prudent given the long-term nature of the plants and uncertain flux of operations.

Key to system redesign is utilizing operator knowledge. Many of the operators our team met have been managing the same wastewater systems for decades, yet were not consulted during the design process, resulting in significant issues with newly built replacement plants and infrastructure.

## 6.4 H<sub>2</sub>S REDUCTION AND TREATMENT

H<sub>2</sub>S treatment and odor control can be accomplished via air/oxygen injection, chemical injection, microbial fuel cells, hydroxyl radical fog systems, and require real-time monitoring.

### 6.4.1 Air and Oxygen Injection

Air or oxygen injection increases the dissolved oxygen content of wastewater, increasing available oxygen around the slime layer that allows for biological oxidation of dissolved sulfide. Both air and oxygen injection have advantages and disadvantages:

DO levels above 0.5 mg/L can generally prevent sulfide occurrence (US EPA, 1991). A DO level of 0.2–1.0 mg/L at the terminal point of sewers has been reported when air injection was used to control sulfide emission (Ochi et al., 1998; Tanaka and Takenaka, 1995). Air injection is most commonly applied to force mains and wet wells (Tanaka et al., 2000). Advantages of air injection include a decrease of BOD in sewage and its nontoxicity. A disadvantage of air injection is the limited oxygen transfer (US EPA, 1992). Because pure oxygen is five times more concentrated than air, it is possible to achieve higher DO levels (5–7 mg/L) in sewage by injecting pure oxygen instead of air (DO levels are 3–5 mg/L) (Chen and Leung, 2000; Delgado et al., 1998). Pure oxygen may therefore be a more effective method of sulfide control for cases where the total oxygen requirement exceeds that which can be transferred using air injection. Use of pure oxygen as a sulfide control method is particularly advantageous in a pressurized sewer system, because dissolution of oxygen is greater at higher pressures. The disadvantages are that it is applicable only to the high-pressure force mains and that it represents fire risks (US EPA, 1992). (Zhang, 2008)

Oxygen injection systems are a proven technology that provides good downstream control and low life cycle costs. However, oxygen injection systems require on site oxygen generation which substantially increases the capital costs over air injection systems. Alternatively, oxygen injection must rely on the purchase and handling of liquid oxygen which increases annual costs. Technological innovations have driven the cost of oxygen injection systems down but the large capital costs remain the largest barrier to adoption.

CFA Yokosuka installed a H<sub>2</sub>S treatment system which utilizes generated ozone to reduce sewer gas H<sub>2</sub>S levels from around 60 parts per million down to under 10 parts per million. This system is a dry-type ozone deodorization which captures the sewer gas and uses ozone to break down the H<sub>2</sub>S. The system also includes air emissions treatment elements including a scrubber, deodorizer, and absorbent unit for exhaust filtration. The system effectively meets the need of H<sub>2</sub>S reduction however there is an issue with the operating costs. One concern of note is that this dry type system utilizes expensive catalyst coated filters in the emissions processing unit, and these filters are expensive at a cost of \$100,000 to \$200,000 per year. There are alternate options for treatment and

given the high operating cost from the filter replacement this is something that should be further examined.

#### 6.4.2 Chemical Injection

Many chemical injection methods have been developed in the past. These methods are aimed at preventing the evolution of hydrogen sulfide or by containing hydrogen sulfide *via* chemical means. Caustic shock dosing involves continuous addition of sodium hydroxide to the wastewater stream to elevate and maintain the pH above 12.5 for at least 30 minutes. This caustic shock inactivates and kills sulfate reducing bacteria and can effectively remove all forms of sulfide. Magnesium hydroxide additions raise the pH of wastewater and buffers to a range of 7.5 to 8.6. This pH range causes only low levels of sulfides to exist as H<sub>2</sub>S gas, thereby reducing the rate of H<sub>2</sub>S evolution. Chemical additions of nitrate have been shown to reduce hydrogen sulfide production in sewer collection systems due to the preferential reduction of nitrate over sulfate by microbes. Iron salts have also been shown to reduce H<sub>2</sub>S gas evolution by removing sulfides *via* oxidation or precipitation. There are also oxidative chemical solutions such as hydrogen peroxide, chlorine, or potassium permanganate additions which directly oxidize sulfides and inactivate SRB.

Overall, chemical additions as a means of controlling sulfide production are not cost-effective compared to other solutions. Chemical additions require reliance on constant chemical inputs which come with large recurring annual costs and are often ineffective. Fixed solutions which do not rely on constant chemical inputs are more economical and reliable.

#### 6.4.3 Microbial Fuel Cells

Microbial Fuel Cells (MFC) are an emerging technology being used on some wastewater treatment applications. MFCs use electrodes and anodes to facilitate microbial growth and metabolic processes to passively produce useful electricity. In the context of wastewater treatment, MFCs require no chemical inputs as they rely on the oxidation of wastewater constituents and atmospheric oxygen. Typically, MFCs have been used to produce electricity from the microbial degradation of organic carbon in wastewater. However, MFCs have been shown to effectively convert sulfides to elemental sulfur (Rabaey, 2006). More research is needed to develop an MFC technology for application in wastewater pumping stations and sewer collection systems. If proven effective, MFCs might serve as a highly cost-effective method of sulfide control due to their passive nature, simplicity of design, and low maintenance requirements.

#### 6.4.4 Hydroxyl Radical Fog Systems

Hydroxyl radical fog systems are commercially available as pre-packaged systems. These systems deliver aerosolized water particles containing hydroxyl radicals into the headspace of pump stations. The aerosols capture odor causing compounds and H<sub>2</sub>S which are then degraded by the hydroxyl radicals. These systems are effective at odor control and corrosion prevention at lift stations but provide no downstream treatment.

#### 6.4.5 Real Time Monitoring

Real time H<sub>2</sub>S monitoring systems are required for effective control of H<sub>2</sub>S reduction technologies. Without monitoring, chemical feeds or oxygen injection systems cannot be optimized. Either substantial waste is incurred due to overdosing of chemical inputs or ineffective treatment is achieved. Real time monitoring systems have been successfully deployed by industry in conjunction with various H<sub>2</sub>S controls. There are various commercial systems available that have proven to be cost effective.

### 6.5 NUTRIENT REMOVAL

Several Navy WWTPs have had difficulties meeting their permit requirements for nutrient removal due, in part, to lower flows and higher strength wastewater. Improving nutrient removal requires site specific solutions due to the variation between the types of treatment and permit requirements for each Navy WWTP. The best solution to address nutrient removal issues at a Navy WWTP is to have a team assess the situation through data collection, site visits, and additional sampling to provide an optimized solution for the site.

To address the nutrient concerns at CFAC, EXWC characterized the influent by inspecting laundry and dining facilities, the Base Exchange, and Commissary, and inventorying laundry and dish detergents to search for any additional sources of phosphates being loaded into the WWTP. The lift stations, grease traps, and oil/water separators were also inspected. EXWC also looked at potential improvements for the treatment system to improve the effluent.

Potential solutions for nutrient removal at CFAC included:

- Further reductions to nutrient loading in the influent through implementing a food waste recycling program, providing an outlet to dispose of food waste instead of through garbage disposals/sewer
- Perform sewer inspections to eliminate or reduce infiltration
- Inspect lift stations, grease traps, and oil/water separators for additional maintenance/cleaning requirements
- Trim tree branches overhanging the WWTP to minimize additional organic deposits into the influent
- Modify operation of the aeration basin to optimize nitrogen removal
- Chemical addition (alum) in the aeration basin to optimize phosphorus removal
- Test for orthophosphate and nitrates at least once per week to determine if any alum dosing adjustments are needed
- Additional screening in the headworks to prevent large particulate matter from entering the WWTP
- Scrub the clarifier and chlorine contact chamber as often as needed to prevent algae growth
- Fix the rubber skimmer on the clarifier skimmer arm so that floating scum is more efficiently removed from the clarifier

EXWC conducted a series of tests to determine whether chemical addition (e.g. alum) to the plant would improve phosphorus removal, and whether periodic anoxic operation of the aeration tank

would improve nitrogen removal. This pilot study showed that while periodic anoxic operation of the aeration tank did not significantly improve nitrogen removal, alum addition is recommended to improve both total phosphorus (TP) and total nitrogen (TN) removal in the effluent. Orthophosphate was reduced by 83% in the effluent and nitrates were reduced by 22%. This translates to at least a 50% reduction in TP and a 20% reduction in TN. Based on past data from the CFAC WWTP, this will likely reduce TN permit violations by at least half and TP permit violations by over 90%. Considering the CFAC WWTP was not designed for nutrient removal, these results are a significant improvement.

Enhanced nutrient removal is also on the horizon for many Navy WWTPs as the EPA and other permitting authorities are considering more stringent phosphorus and nitrogen limitations for discharging into several water bodies. EXWC recommends pursuing RDT&E projects for plug-in nutrient removal technologies that would apply to several wastewater treatment plants in order to be prepared for the upcoming, more stringent regulations. These RDT&E projects could examine technologies such as ion exchange, ligand exchange, surface precipitation, resins, adsorbents, or other nutrient recovery technologies that capture nutrients such as phosphorus and nitrogen for reuse rather than disposal.

## **6.6 OIL AND GREASE**

Oil and grease are best removed at the source of input or during pretreatment. Many installations noted that oil and grease has always been an issue, especially with unauthorized connections or illegal dumping, but as flows have decreased the impacts are more significant. Potential solutions include additional oil/grease traps at key locations and particularly oil/grease sensors that identify high concentrations of oils and/or grease that are being input into the wastewater collection and treatment system, in order to divert the high concentrations in time to prevent treatment disruptions. If diversion and separate treatment is not possible, then more stringent pretreatment systems will be necessary at the headworks of the WWTP, such as the BOWTS (Bilge Oily Wastewater Treatment System), adsorption, membrane separation, and electrochemical processes.

Presently there is no complete system capable of identifying high concentrations of oils and/or grease being input into the wastewater system. Specifically, in supporting streamlined assessment, monitoring, and inspection of the wastewater conveyance facilities. Navy wastewater treatment and collection operations need a sensor array for oil and grease detection with real-time or near-real-time notifications. The system also needs to be capable of sounding an alarm in immediate response to high levels of oil and grease entering a pump station before it is received at the wastewater treatment facility. Currently wastewater with high levels of oil and grease aren't noticed until weeks after due to the need to wait for composite sampling and reported lab results. A sensor array capable of detecting high spikes of oil and grease and quickly alarming utility operators in time to prevent damage to the wastewater system is needed to ensure continuity of operations. This sensor array need also applies to detection of potential illicit discharges where base subcontractors or tenants may be dumping chemicals and waste products into the sewer system at undesignated locations, violating the base's discharge permits. This need has been expressed by multiple Navy installations.

## **6.7 CONSULTATION**

Since the majority of solutions are site specific, water utility system managers should seek support from subject matter experts. EXWC has provided such services in the past to interface with utility system managers with the goal of using operational knowledge and demand characteristics to develop a set of optimized solutions. Recently such studies have been conducted at CFAC, Webster Outlying Field, and JBPHH resulting in successful improvements to the plant's treatment and operations. Navy wastewater systems can vary significantly in their design and operation. Consultations or case studies, such as those provided by EXWC, are uniquely effective at evaluating individual installations on a case-by-case basis.

## **6.8 MONITORING & RECORDS KEEPING**

While water consumption may vary little at the installation or regional level, fluctuations in base populations, redistribution of personnel, facility closures, or other changes can lead to changes in flows in the wastewater collection systems and treatment requirements. Without detailed historical data on water consumption at the facility level, it is difficult to pinpoint or rule out reductions in water consumption as a root cause of CWA NOVs or assess future risk. Furthermore, wastewater process monitoring is not performed with the precision and frequency needed to assess long term trends and predict long-term installation wastewater system vulnerability.

Currently, there are broad knowledge gaps due to a lack of monitoring and records keeping that can allow for widespread systemic vulnerability to go unnoticed at the regional level. Monitoring and recording wastewater flow rates, influent and effluent concentrations for key constituents, energy usage for each wastewater process, chemical usage, and O&M requirements would provide meaningful data which might be used to help remedy such knowledge gaps and assess such system vulnerability in the future.

## **6.9 CONTROL AND DETECTION SYSTEMS FOR OPTIMIZATION**

Control systems like Supervisory Control and Data Acquisition (SCADA) allow for tracking and management of wastewater system operations and allow for better control and process management at WWTPs. It is important that SCADA not only be impended at Naval WWTPs, but also effectively used to ensure system optimization. If systems are well managed by using semi-automatic and automatic processes issues related to either low or variable flows can be mitigated to the maximum extent possible for the given system arrangement.

In addition to assisting WWTPs SCADA systems can be sued to support other aspects of wastewater management, like in the application of land application of treated wastewater. NAS Jacksonville has the both the need and capability to land apply, for irrigation purposes, up to 100% of their treated wastewater. A large portion of their treated wastewater is already utilized for golf course irrigation however they are examining automated controllers for land application of the remaining treated wastewater in an undeveloped portion of the base, utilization of automated controls would increase the flexibility and re-use of the treated wastewater while reducing operations and maintenance costs.

In addition to control systems, real-time and near real-time detection systems for constituents which can damage wastewater infrastructure, treatment plants, or even lead to violations are needed to ensure continued compliance and asset protection. One example of a beneficial detection system is a hydrocarbon detection system which could be installed in wet wells or pump stations to alert base personnel to hydrocarbons in the conveyance system prior to discharge to either the POTW or Navy owned WWTP allowing for mitigation measures to be undertaken thereby protecting the WWTP and preventing damage to the equipment and any NOV's.

## **6.10 OPERATIONS AND MAINTENANCE**

Systems need to be operated, managed, and maintained as effectively as possible to reduce and mitigate flow variability, collection and idling time, and infrastructure age-related problems. Many municipal wastewater utilities maintain a hot spot list of areas that staff would routinely check for maintenance. As flows have declined, that list becomes more important, with more sites being added and checked more frequently. Proactive maintenance and monitoring of hot spot locations can prevent the impacts of low flows from becoming severe, including cleaning sewer lines and lift stations more often to remove settled solids.

Operational improvements and increased rehabilitation and maintenance of manholes can also benefit wastewater infrastructure. Proactive pipe patching and lining can also move sewage more effectively, minimizing recurring blockages. Coating manholes in epoxy can combat increased odors and accelerated corrosion rates. The epoxy coating forms a protective layer between the environment and the concrete, providing abrasion and corrosion resistance, allowing for rehabilitation of manholes that don't require significant structural repair.

## **6.11 SLUDGE MANAGEMENT CASE STUDY NAS JACKSONVILLE**

NAS Jacksonville has implemented a new and innovative technology to reduce energy costs, operations costs, and maintenance costs for WWTP sludge treatment. The new sludge treatment system utilized chemical treatment of sludge in lieu of traditional biological or thermal methods. NAS Jacksonville's new sludge treatment system safely generates chlorine dioxide from a combination of sodium chlorite and sulfuric acid. During the treatment process, sludge generated at the NAS Jacksonville's WWTP is pumped to the chlorine dioxide chemistry injection system. The sludge flows through the process control system where it is disinfected and odor-causing compounds are destroyed. The sludge treatment that previously took 4-6 weeks and required thickening and digestions now takes approximately 10 minutes with the new system. Following treatment, the disinfected and odor free product is dewatered a belt press and then collected and transported to a permitted land application site where the nutrient content can be recycled.

Converting the new sludge system has reduced sludge treatment energy consumption from close to one million kilowatt hours (kWh) per year to an estimated 500 kWh per year. This resulted in an energy savings to NAS Jacksonville of around \$75,000 in the first year with anticipated energy savings of over \$100,000 per year for the next 20 years, based on projected energy costs (NAS Jacksonville, 2013). One additional benefit will be the reduction in operation and maintenance costs and recapitalization of aging infrastructure due to the elimination of a primary clarifier, sludge thickener and two aerobic digesters at this facility. These savings, coupled with the energy

savings, result in a simple payback of 6.3 years for the \$700K investment in the new system (NAS Jacksonville, 2013).

This sludge processing system retrofit is an excellent example representing what a group of knowledgeable and pragmatic facility personnel (and contractors) can accomplish by implementing process improvements and striving for cost savings and system performance enhancements. NAS Jacksonville and the site personnel are actively involved in their facility in water and wastewater management and seize every opportunity to improve their operation and resiliency.

## **6.12 DRINKING WATER SYSTEM FLOW CONSIDERATIONS**

Decreased water consumption has also been linked to water quality degradation in drinking water distribution systems that cause issues such as biofilm growth, nitrification, and corrosion. NAVFAC EXWC has conducted a complementary investigation into the effects of low water flows on drinking water systems under NESDI Project 528: Impacts of Water Conservation Measures on Potential Safe Drinking Water Act Violations in Navy Water Supply Systems.

## **6.13 SOLUTIONS COMMON THEMES**

The purpose of the site visits was to identify key issues as a result of lower wastewater flows and to find common themes and lessons learned for addressing these issues in wastewater collection and treatment systems. While the project team initially expected the solutions to be technical, nearly all of the common factors for solving low flow issues were non-technical. The most important factor was having a sufficient number of staff members with enough long-term personnel familiar enough with the system to foresee and prevent potential issues from occurring. This was especially apparent at NAS Jacksonville, where the teams were staffed with several engineers and scientists who had been there for 15 or more years and had a long-term plan for modifications to the system. The ability to execute proactive strategies to prevent future problems, rather than operating in reactionary mode, has a major impact on keeping a system in compliance. Other overarching factors that contributed to maintaining compliance were a well-designed wastewater system with equalization tanks and redundancies, a good working relationship between the wastewater system operators and NAVFAC PW/EV staff, and a robust operations and maintenance strategy.

## **7.0 CONCLUSION**

Overall, the Navy-wide reduction in water consumption is modest. Some installations showed a significant decrease in water consumption while others did not. The installations that did experience significant reductions were no more likely to have a CWA NOV than those that experienced no reductions in water consumption. The water consumption and compliance data obtained does not show any widespread trends that suggest reductions in water consumption is currently causing increases in exceedance related CWA NOVs at the regional level.

Reduction in irrigation activities had the most prominent effect on total water consumption at the installations. Other activities that had an impact were maintenance related, such as fixing a major

leak in the distribution system, and on base operations, such as the deployment of a large number of personnel. Active forms of water consumption reduction, e.g. installing low flow fixtures, were minor in comparison and did not have a noticeable effect on the consumption trends.

Over the course of this study the project team analyzed wastewater quality and flow data, performed site visits, interviewed local and regional personnel, and examined wastewater treatment and conveyance systems. Analysis of wastewater quality and flow data showed no specific trends in concentrations either in the influent or effluent that definitively related to low flow conditions. Changes in wastewater quality during periods of flow reduction did not generally result in treatment changes or plant violations of discharge requirements. Based on results from similar studies, it's likely that O&M costs (including energy and chemical use) was the primary item affected by wastewater flow reduction, but this data is not well monitored for Navy wastewater treatment or collection systems.

Common wastewater system challenges as identified in this study vary from site to site as result of multiple variables including system design and facility operations. Overall there were multiple issues identified that can be caused or exacerbated by low flows, all of which can lead to NOVs and reduce overall effectiveness of the wastewater infrastructure. While the purpose of this study was to identify problems associated with low flows as a result of conservation efforts, many of the issues identified often had other factors (aside from low flows) that contributed or caused system degradation and NOVs. All of these issues are exacerbated by declining flows, but are endemic to most wastewater systems regardless of flow conditions. These issues include concentrated flows, flow variability, aging infrastructure, increased H<sub>2</sub>S and odor problems, excessive nutrients in the inflow and effluent streams, and oil and grease buildup.

The project team found that the issues impacting wastewater infrastructure are mainly linked to aging systems or poorly designed systems and management of these systems. While low flow issues can lead to quality issues, the overarching wastewater infrastructure degradation is a combination of factors including: poor system design, lack of maintenance and timely upgrades, personnel and staffing issues, dated and aging infrastructure. Each these factors contribute significantly more to degradation of wastewater quality than low flow as a result of conservation. By addressing the aging infrastructure problems and implementing effective and appropriate design, operation and maintenance of wastewater treatment and conveyance systems wastewater quality can be assured. An effectively managed and appropriately designed system allows for the mitigation of multiple potential issues typical of wastewater operations including low flow issues.

While the project team initially expected the solutions for managing impacts of low flows in wastewater systems to be technical, nearly all of the common factors for compliant wastewater systems were non-technical. The most important factor was having a sufficient number of staff members with enough long-term personnel familiar enough with the system to foresee and prevent potential issues from occurring. The ability to execute proactive strategies to prevent future problems, rather than operating in reactionary mode, has a major impact on keeping a system in compliance. Other overarching factors that contributed to maintaining compliance were a well-designed wastewater system with equalization tanks and redundancies, a good working relationship between the wastewater system operators and NAVFAC PW/EV staff, and a robust operations and maintenance strategy.

Additional solutions to mitigate risk of CWA NOV include better characterization of each installation's wastewater system through wastewater monitoring at the facility level, more robust wastewater monitoring at the process level, and maintaining detailed records of operations and maintenance. Consultations and detailed investigations are uniquely effective at evaluating wastewater system vulnerability to CWA compliance violations and providing optimized solutions for site-specific wastewater infrastructure challenges. Technical solutions include odor, nutrient, and oil and grease removal technologies.

## **8.0 RECOMMENDATIONS**

Navy installations that have wastewater quality issues should conduct a detailed wastewater conveyance and treatment system review and field analysis to trace the root problem or problems. Each facility has unique challenges based on geographic location, tenant usage, conveyance and treatment system design, and shifting operations. This analysis will provide meaningful insight into the dynamics of the wastewater conveyance and treatment systems and allow for the optimization or retrofit of the system. Wastewater systems should be evaluated by personnel that have appropriate expertise to ensure identification of system issues and to recommend viable and cost-effective solutions including solutions provided in this report for risk mitigation strategies to address water system vulnerability to NOV. In addition, installations should do their best to develop a long-term proactive strategy and maintain a full staff in order to keep their system in compliance and prevent future problems, rather than operating in a day to day mode and reacting to issues as they occur. For example, installations that implement I&I reduction strategies should also consider the subsequent impact on declining flows through the wastewater collection and treatment systems. Future RDT&E recommendations include real-time detection of oil and grease inflows to lift stations, particularly near piers, and plug-in nutrient removal technologies.

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