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**POLLUTION PREVENTION OPPORTUNITY ASSESSMENT  
UNITED STATES NAVAL BASE NORFOLK  
NAVAL AIR STATION**

by

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## FOREWORD

The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

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E. Timothy Oppelt, Director  
National Risk Management Research Laboratory

## ABSTRACT

This report summarizes work conducted at the U.S. Navy's Naval Base Norfolk, Naval Air Station (NAS) located at Sewells Point in Norfolk, Virginia, under the U.S. Environmental Protection Agency's (EPA) Waste Reduction Evaluations at Federal Sites (WREAFS) Program. This project was funded by the EPA and conducted in cooperation with U.S. Navy officials.

The purposes of the WREAFS Program are to identify new technologies and techniques for reducing wastes from process operations and other activities at Federal sites, and to enhance the implementation of pollution prevention/waste minimization through technology transfer. New techniques and technologies for reducing waste generation are identified through waste minimization opportunity assessments and may be evaluated further through joint research, development, and demonstration projects.

Additional support for this Pollution Prevention Opportunity Assessment (PPOA) was provided by the Strategic Environmental Research and Development Program (SERDP), which is a cooperative effort between the DOD, DOE, and EPA to develop environmental solutions to enhance mission readiness.

Under the Chesapeake Bay Agreement, Naval Base Norfolk is a member of the Tidewater Interagency Pollution Prevention Program (TIPPP). At Norfolk, the Navy and the EPA have evaluated techniques and technologies to reduce waste generation from cooling tower operations. A PPOA was conducted at the Norfolk Naval Air Station in June 1994 which identified areas for waste reduction during operation and maintenance of the NAS cooling towers. The study followed procedures outlined in the EPA's Facility Pollution Prevention Guide. Opportunities were identified for reducing the generation of waste from cooling tower water treatment operations. Changes in operational and treatment processes and procedures have been evaluated for their potential to achieve pollution prevention objectives. The options have been studied for technical and economic feasibility, and are summarized in this report.

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## ABBREVIATIONS

AMP	Amino-Tri(methylenephosphonic) Acid
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BTU	British Thermal Unit
Cd	Cadmium
CGC	Coast Guard Cutter
COMNAVBASE	Commander Naval Base (Norfolk)
Cu	Copper
DBNPA	Dibromonitripropionamide
DOD	Department of Defense
DOE	Department of Energy
EDTA	Ethylene Diamine Tetra Acetic Acid
Eh	Electrical Potential
EPA	Environmental Protection Agency
FMD	Facility Maintenance Department
gal	Gallon
GPH	Gallons Per Hour
GPM	Gallons Per Minute
HEDP	1-Hydroxyethylidene-1,1-Diphosphonic Acid
KDF	Kinetic Degradation Flux
Mg	Magnesium
mg/L	Milligrams Per Liter
Mn	Manganese
MSDS	Material Safety Data Sheet
NADEP	Naval Aviation Depot
NAS	Naval Air Station
Ni	Nickel
NPDES	National Pollutant Discharge Elimination System
NRMRL	National Risk Management Research Laboratory
ppm	Parts Per Million
PPOA	Pollution Prevention Opportunity Assessment
pt	Pint
PWC	Public Works Command
qt	Quart
qv	Quaternary Ammonium Compound
RREL	Risk Reduction Engineering Laboratory
SERDP	Strategic Environmental Research and Development Program
SIMA	Shore Intermediate Maintenance Activity
TDS	Total Dissolved Solids
TIPPP	Tidewater Interagency Pollution Prevention Program
UV	Ultraviolet
VOC	Volatile Organic Compound
WET	Water Equipment Technologies
WREAFS	Waste Reduction Evaluation at Federal Sites (program)
Zn	Zinc



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## SECTION 1 INTRODUCTION

### 1.1 PURPOSE

The purpose of this project was to conduct a Pollution Prevention Opportunity Assessment (PPOA) of the United States Naval Air Station (NAS) at the Norfolk Naval Base in Norfolk, Virginia. The assessment was conducted under the Waste Reduction Evaluations at Federal Sites (WREAFS) Program, which is administered by the Pollution Prevention Research Branch in the National Risk Management Research Laboratory (NRMRL) (formerly Risk Reduction Engineering Laboratory (RREL)) of the EPA. The study was conducted in accordance with the EPA manual, Facility Pollution Prevention Guide (EPA/600/R-92/088), which provides a methodology for assessing operations to identify, evaluate, and implement pollution prevention alternatives.

Pollution prevention in environmental management requires the development of a comprehensive program which continually seeks opportunities to implement cost-effective strategies to reduce waste generation. PPOAs provide detailed assessments of waste streams, options for reducing waste generation or preventing pollution, and analyses of alternative operating practices which generate less waste. Appendix A contains PPOA worksheets for the NAS and includes information obtained during conversations with base personnel and a three-day site visit. Figure 1 identifies the key elements of a pollution prevention program showing the interrelationship of the PPOA to the program. The elements of the pollution prevention program are discussed in detail in the Facility Pollution Prevention Guide.

The approach for conducting a PPOA at the Norfolk NAS is described in this section, along with background information about the site. Section 2 provides background information related to cooling tower operations and water treatment processes. Section 3 describes the current cooling tower activities and operations that were observed during the NAS site visit. Possible alternative practices for minimizing these wastes are discussed in Section 4. Recommendations on potential follow-up activities are also included in Section 4. Appendices include PPOA worksheets (Appendix A), National Pollutant Discharge Elimination System (NPDES) discharge limits (Appendix B), discharge data (Appendix C), material safety data sheets (MSDS) (Appendix D), the Hampton Roads Sanitation District Cooling Tower Waste Discharge Policy with Industrial Wastewater Pollutant Limitations and Discharge Requirements (Appendix E), and the MSDS for DIAS-Aid Tower Treatment XP-300 (Appendix F).

### 1.2 GENERAL SITE ACTIVITY DESCRIPTION

Commander, Naval Base (COMNAVBASE) Norfolk is the world's largest naval base, providing and coordinating quality logistic support functions for over 100 ships and 50 aircraft squadrons. Naval Base Norfolk is also the regional coordinator for the Hampton Roads area, which encompasses all Naval activities within a 50-mile radius. The Navy employs approximately 109,000 active duty personnel and about 40,000 civilians in Hampton Roads.

The Naval Base complex is approximately 5,200 acres and is heavily industrialized. Over 55 percent of the base land holdings have been developed for current operations, with an additional 25 percent of the land allocated for aircraft runways. The base is comprised of nine subordinate commands functioning as a consortium of interdependent activities providing core mission and support services to the largest submarine forces in the world. Core mission facilities include 13,000 feet of runways, 14 piers and 7 miles of ship berthing space. The Naval Base houses the Navy's largest Supply Center, a Naval Aviation Depot, and a major Military Airlift Command terminal. In addition, the Naval Base contains the Navy's largest Personnel Support Activity network and the

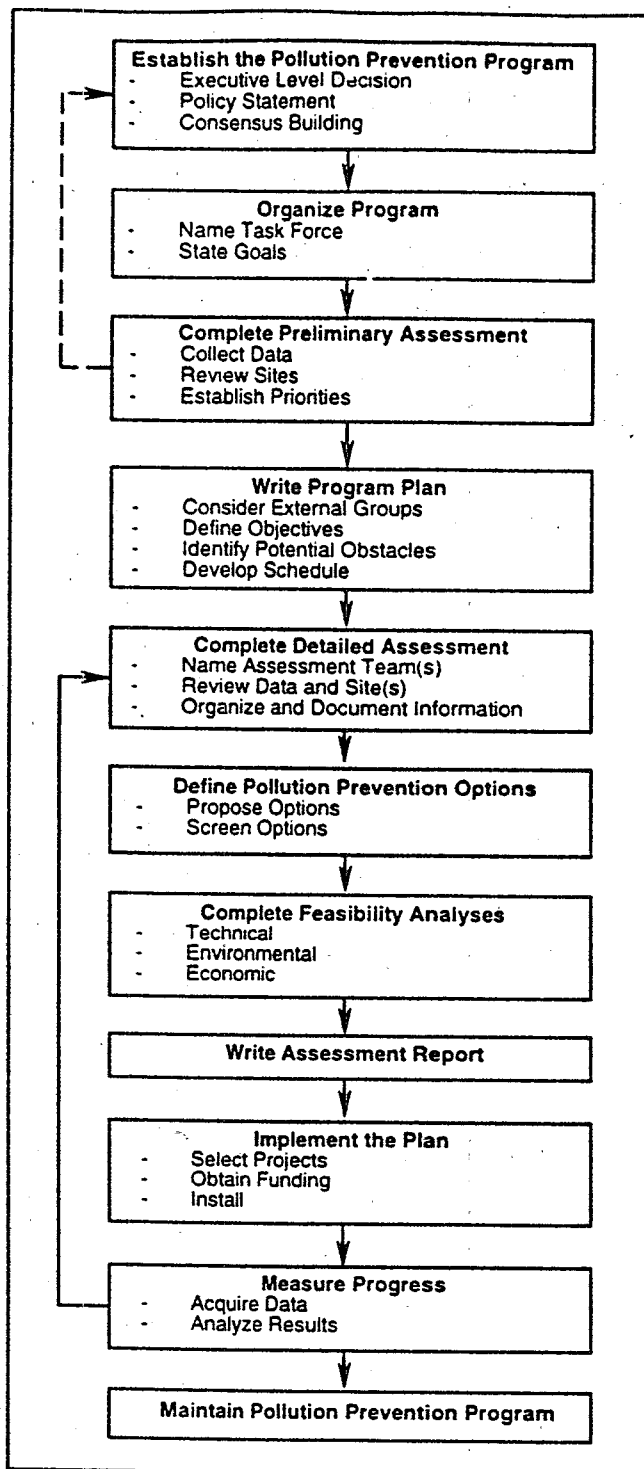


Figure 1. Pollution Prevention Program Overview

largest Navy Family Service Center. Eighty-five Navy Exchange retail outlets at 55 locations generate annual revenues of \$80 million. The installation contains 2,100 permanent buildings valued at \$2.9 billion, 37 Bachelor Enlisted and 9 Bachelor Officer Quarters, 3,300 family housing units, and 160 miles of paved roads.

The NAS functions as a subordinate command to the Naval Base, and is comprised of 598 buildings on 1,266 acres. The NAS employs 10,659 military and 7,685 civilian personnel, who perform operational support activities for aircraft and squadrons on base.

### 1.3 PREVIOUS POLLUTION PREVENTION ACTIVITIES

Under the Chesapeake Bay Agreement, Naval Base Norfolk is a member of the Tidewater Interagency Pollution Prevention Program (TIPPP). The TIPPP is to identify pollution prevention opportunities, as well as develop and implement measures to eliminate pollution at the source. Under the auspices of TIPPP, a Hazardous Waste Minimization Study was completed in 1992 which identified several pollution prevention opportunities at the Naval Aviation Depot (NADEP). After this initial report, the Navy conducted a pollution prevention opportunity assessment for the remaining activities at Naval Base Norfolk, which included the examination and assessment of activities at approximately 140 shops at the base.

Previously completed pollution prevention studies noted several hazardous waste management activities with opportunities for waste reduction and minimization. Implementation of plans generated from these studies have resulted in a decrease in the amount of hazardous waste generated yearly at Naval Base Norfolk, as well as significant

cost savings in decreased waste disposal charges. In addition, the establishment of a recycling program during the mid-1980s has resulted in the recycling of approximately 30 percent of the solid waste generated at the base, as well as an estimated savings of \$3.4 million during fiscal year 1992.

Pollution prevention efforts undertaken at Naval Base Norfolk include the initiation of a hazardous waste minimization program which focuses on training, education, and single point hazardous material issuance. This program was implemented at the Naval Air Supply Station Supply Department, Naval Supply Center, Norfolk Paint Mart, and Reutilization Store. As a result, hazardous waste disposal decreased from 408,000 gallons in fiscal year 1990 to 253,000 gallons in fiscal year 1992.

Additional pollution prevention efforts in the areas of electroplating, painting, and depainting have also reduced the quantity of hazardous wastes generated at the Naval Base. Through the use of commonly available equipment, the quantity and toxicity of wastewaters generated during electroplating operations have been reduced. Furthermore, the quantity of heavy metal sludges, which typically contain chromium, cadmium, silver, and nickel, has also been reduced. The conversion of the painting facilities at the base from wet to dry booths is expected to increase the efficiency of paint use which will result in a reduction of the quantity and toxicity of paint wastes, and will lower volatile organic compound (VOC) emissions. During depainting operations, efforts have been implemented to minimize sand blast grit generation in the paint shops.

In an effort to reduce solvent usage, aqueous parts washers were installed at the Shore Intermediate Maintenance Activity (SIMA) and aboard the *U.S.S. Theodore Roosevelt* at the Naval Base. The parts washers use high-pressure water and water-based cleaners, rather than solvents, to degrease the metal parts. An estimated \$24,000 in annual operating costs for purchasing solvents and disposing of cleaning rags has been saved with the implementation of the aqueous parts washers.

#### 1.4 APPROACH TO THE CURRENT PPOA AT THE NORFOLK NAS

During the PPOA site visit, cooling tower water treatment methodologies and practices at the NAS were observed and assessed in terms of the types and amounts of waste produced. The site visit began and concluded with briefings of the Norfolk NAS staff who showed a strong interest in the goals of the PPOA. During the site visit, operating personnel were interviewed to gain their perspectives on alternative practices which could lead to reduced waste generation. The operating personnel provided important input into the characterization of potential alternatives, expressing an understanding of the importance of minimizing waste while meeting performance needs.

The Navy and the EPA are currently evaluating techniques and technologies to reduce wastes generated from cooling tower operations within the Norfolk NAS. Approximately 28 open-system recirculating cooling towers are currently operated at 19 buildings within the Norfolk NAS. These units range in size from 5 to 300 tons, and are all associated with comfort cooling systems which operate on a seasonal basis (approximately 6 months per year).

Wastes associated with open-system recirculating cooling towers consist mainly of water treatment chemicals. These are discharged to the environment along with the cooling tower water discharge (bleed or blowdown).

Several alternative cooling tower water treatment processes have been identified, consisting of both chemical- and non chemical-based technologies. Section 4 of this report presents these

alternatives, and assesses these treatment options in terms of their technical and economic feasibility as well as their overall effect on the quantities and the constituents of the waste produced by each affected process. Finally, selected treatment options are recommended for further evaluation.

## SECTION 2 BACKGROUND

### 2.1 COOLING TOWER PROCESS DESCRIPTION

A cooling tower is an enclosed device designed for the evaporative cooling of water by direct contact with air. Cooling towers are used in conjunction with air conditioning and industrial process equipment and act as the heat sink for these systems by providing a continuous source of cool water for process operations. Open-system recirculating cooling towers are typically chosen for operation with air conditioning and refrigeration equipment because they are relatively inexpensive and minimize heat rejection costs while still conserving water. All of the cooling towers at the Norfolk NAS identified in this PPOA are of the recirculating, open-system type.

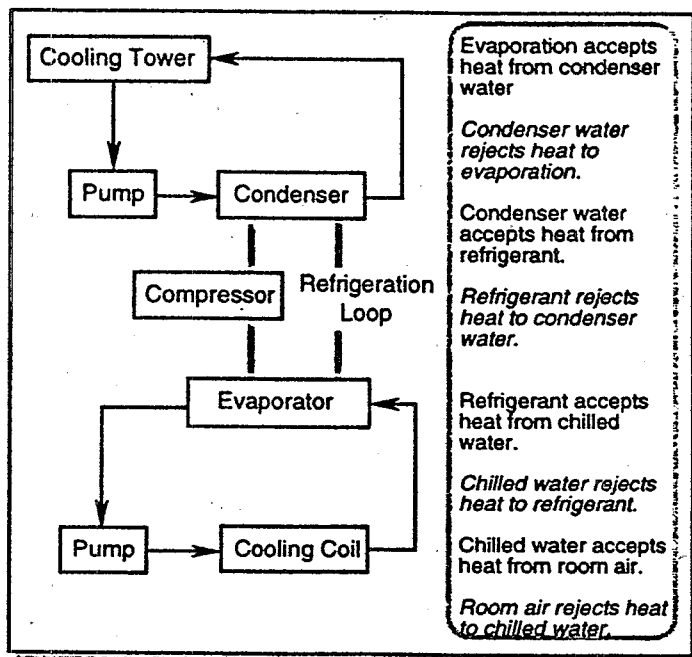
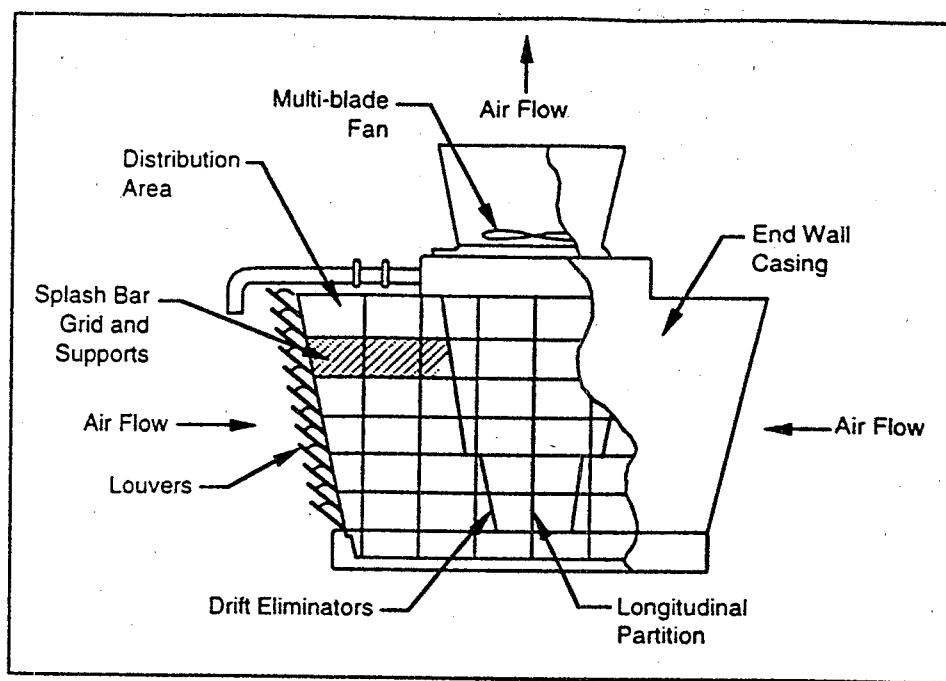


Figure 2. Typical Three-Loop Air Conditioning Refrigeration System

A typical three-loop air conditioning refrigeration system is shown in Figure 2. Air conditioning can be thought of as the addition of refrigeration to the heating and ventilation of a building in order to provide cooling and dehumidification (Gurney and Cotter, 1966). Heat and moisture from the conditioned space are extracted at the air coil where the refrigerant, which is chilled water in this case, conveys this heat away from the conditioned area. The heat is dissipated under low grade conditions (*i.e.*, with a relatively small change in temperature), as the water is re-cooled for reuse by means of the water cooling tower.

Cooling towers operate by passing warm water through cool air, which transfers heat from the water to the air. The warm air is discharged, and the cooled water is then used for air conditioning or other equipment cooling. Water cooling occurs in the tower through both

evaporation and the transfer of heat to the air flowing through the water. To maximize heat transfer and subsequent water cooling, cooling towers are designed to optimize air/water contact. Figure 3 illustrates a typical cooling tower. Water is distributed as evenly as possible across the top of the tower and is allowed to fall through the tower. Simultaneously, air is drawn into the tower and is circulated upwards through the water column, cooling the water as it falls through the tower.



**Figure 3. Schematic of Typical Cooling Tower**

Cooling towers can be classified as natural or mechanical draft systems. Natural draft cooling towers are designed to take advantage of the temperature differences between the hot air inside the tower and the cooler air outside. The cooler air entering the bottom of the tower pushes the warmer air out of the top without the assistance of blowers or fans. Mechanical draft towers, which use fans or blowers to force air through the tower, may be of either the forced- or induced-draft type and are generally used with air conditioning units. Typical forced- and induced-draft cooling towers are shown in Figures 4, 5, and 6. Forced-draft cooling towers have a fan at the air intake, which forces air into and through the tower; in induced-draft towers, both counter flow (5) and cross flow (6) have a fan at the air outlet which draws air through the tower.

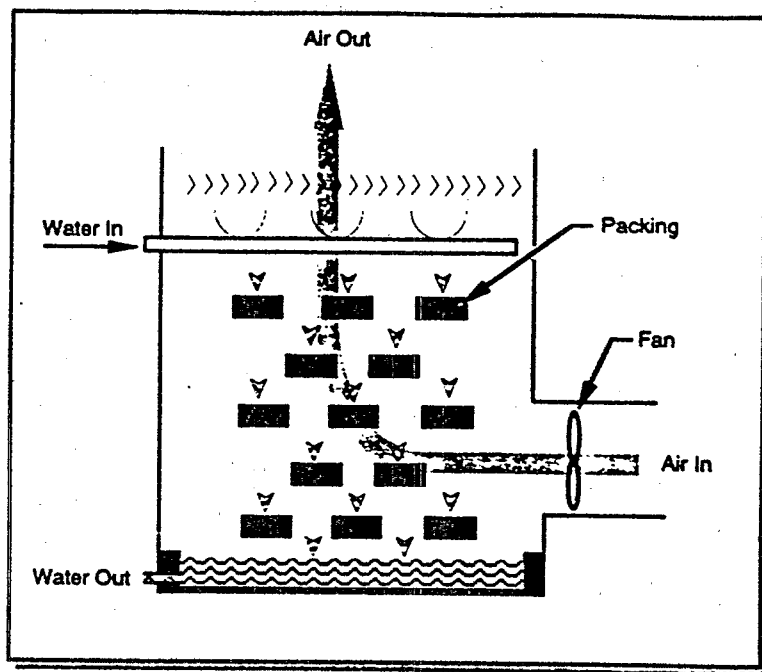


Figure 4. Schematic of Typical Forced-Draft Cooling Tower

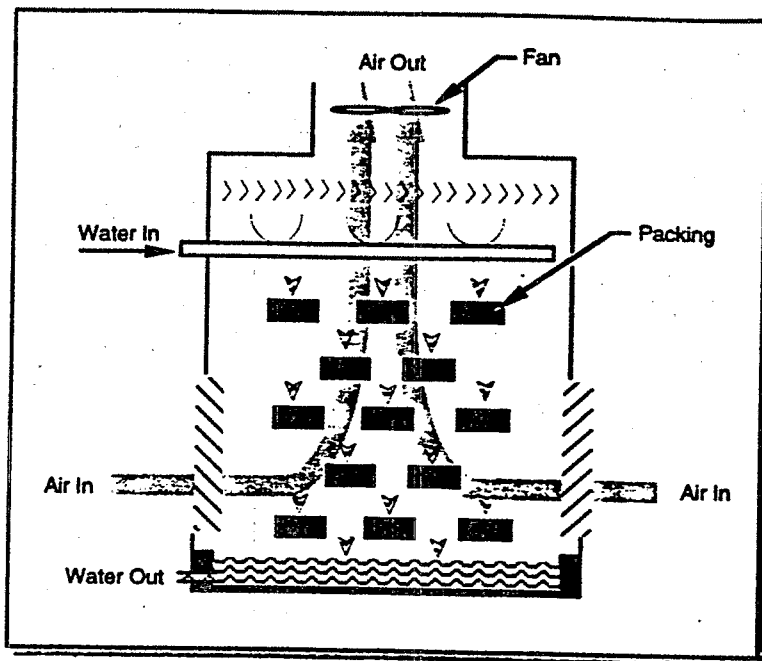
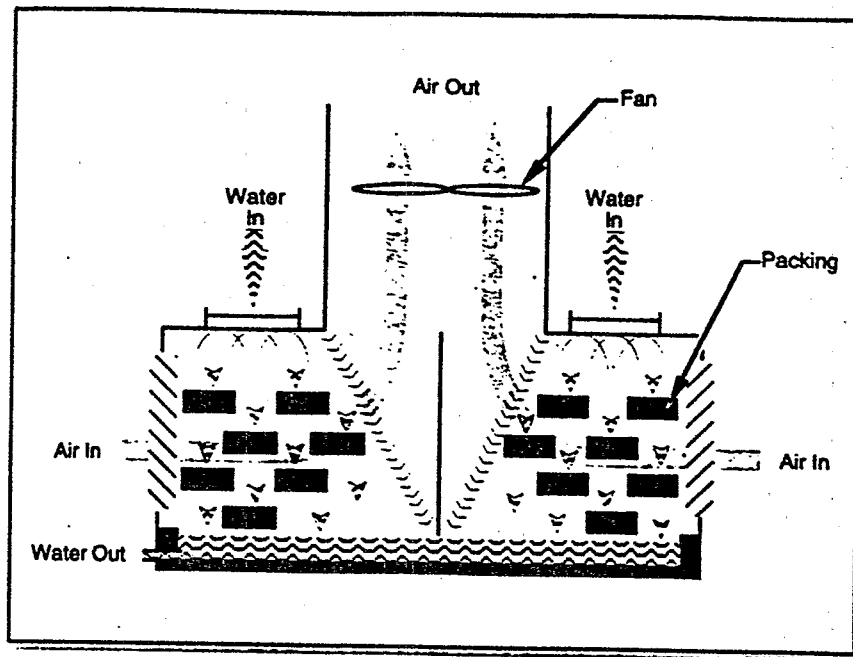


Figure 5. Schematic of Typical Induced-Draft Cooling Tower, Counterflow Method





**Figure 6. Schematic of Typical Induced-Draft Cooling Tower, Cross Flow Method**

Open cooling systems utilizing recirculation have the potential to minimize water consumption because a much of the process water is recirculated through the tower for reuse. A once-through system, in contrast, uses a continuous source of cool water which is pumped through the water jacket of a heat exchanger where it absorbs heat before being discharged. In a recirculating system, a continuous source of makeup water is required to replenish the water which is evaporated in the tower during the heat transfer process. Additional makeup water is required as water is lost from the tower due to tower bleed or blowdown, which is the discharge of system water to control the concentration of suspended solids and impurities, as described below.

## **2.2 COOLING TOWER WATER TREATMENT**

### **2.2.1 Sources of Contamination and Resulting Conditions**

All natural waters contain various amounts of impurities such as dissolved solids, gases, and a variety of suspended matter. Gases such as carbon dioxide, oxygen, and sulfur dioxide are absorbed from the atmosphere and from organic decay to form dilute acids. Dissolved solids, including mineral salts of calcium and magnesium, as well as iron, silica, and carbonates, are absorbed from the earth and are the basis of scale-forming water hardness. Suspended solids,

otherwise known as turbidity, consist of silt, clay, and a variety of organic constituents, including microorganisms, oils, fats, greases, and sewage. In addition, all waters have the potential to developing algal and biofilm growths under favorable conditions including sunlight, warm temperatures, and abundant water with a high concentration of nutrients.

As water evaporates during the cooling process, impurities and minerals which enter the tower in the makeup water are left behind and accumulate in the cooling tower and process equipment. The accumulation of impurities leads to a variety of problems including scale formation, corrosion, and the fouling of surfaces due to biological growth. These conditions in turn cause heat transfer losses, metal deterioration, and blockage which decrease the tower efficiency.

#### **2.2.1.1 Scale--**

One of the most serious problems which can develop in untreated cooling tower water is that caused by scale. Scale formation occurs when the solids in the cooling tower water reach their limits of solubility and precipitate out onto wet surfaces. When the precipitates fall onto mucinous films, they bind to the metal surface and begin to form scale. Scale is commonly caused by the precipitation and binding of magnesium, calcium, sulfate, phosphate, hydroxides, and silicate compounds.

Scaling is related to water characteristics such as dissolved salt concentrations, total dissolved solids, hardness, alkalinity, and temperature. Water hardness is caused by the presence of dissolved calcium and magnesium salts which remain soluble under many environmental conditions but precipitate out of solution as scale when exposed to elevated temperatures or exist in excessive concentrations. As a result, hard water in a cooling system requires extra attention and care to prevent scaling.

The presence of scale deposits on heat transfer surfaces results in a reduced capacity for heat transfer from the water to the air. This in turn results in higher operating temperatures and higher power consumption as the air conditioning unit unsuccessfully tries to cool the water. The decrease in operating efficiency and the increased strain on the cooling tower unit may eventually lead to system degradation and costly system shutdown and repair.

#### **2.2.1.2 Corrosion--**

Corrosion occurs as metal parts deteriorate and revert to their original (ore) state, resulting in the loss of structural integrity. Two types of corrosion, general and pitting, commonly occur in a cooling water system. General corrosion occurs when the corrosion attack is uniform and covers the entire exposed surface area of the metal. Pitting occurs in small localized areas, for example, under scale deposits. As a result, rapid penetration of the metal and subsequent failure occurs.

Corrosion processes generally proceed rapidly under acidic conditions, and more slowly under neutral or slightly alkaline conditions. The presence of high concentrations of dissolved solids can also lead to corrosion. Other factors contributing to corrosion include high temperature, high oxygen concentration, high velocity of liquid (water) on the metal surfaces, and galvanic action of two dissimilar metals.

#### **2.2.1.3 Saturation and Stability Index--**

Corrosive aggression and scaling tendencies are related characteristics, both of which depend to a large extent on the concentration of dissolved solids, temperature, alkalinity, and pH. The tendency of water to deposit scale when it is alkaline or to attack metals corrosively when it is

acidic depends on the balance of various constituents in the water. Water described as "in balance," explained below, exhibits neither corrosive nor scale-forming characteristics.

The Langelier Saturation Index and the Ryznar Stability Index are commonly used to predict scale-forming tendencies or corrosive properties of a cooling water. The Saturation Index represents the difference between the actual measured pH and the calculated pH at saturation with calcium carbonate. A positive number indicates that calcium carbonate scale will form, while a negative number indicates that the water has corrosive tendencies. A stability index of 0 indicates a water which is in balance exhibiting neither corrosive nor scale-forming tendencies. Ryznar's Stability Index was developed to provide a closer correlation between the calculated prediction and the quantitative results in the field. With an optimum value of 6, scale formation can be anticipated at values less than 6, and corrosion at values greater than 6.

#### 2.2.1.4 Fouling--

Fouling problems arise from the deposit of solids and the growth of microorganisms on cooling tower surfaces. Fouling can occur in a cooling tower in a manner similar to scaling. The air passing through the cooling tower contains small amounts of contaminants including silt, dust, organic debris, and other entrained particulates. These particulates can be washed from the air into the cooling water and become suspended or dissolved solids. The subsequent precipitation of these solids onto heat transfer surfaces can leave a silt-like deposit similar to scaling and reduce the efficiency of the cooling unit.

In addition, these silt-like deposits may provide nutrients for various microorganisms including algae and bacteria. Common biological growths found in open recirculating water systems include algae, bacteria, molds, and fungi. The uncontrolled growth of these microorganisms can lead to reduced water flow, plugged pipes, a loss of heat transfer capability, severe corrosion in areas surrounding the growths and deposits, and ultimately, equipment failure.

Algae are the most common microbiological growths found in open recirculating water systems and account for the majority of the problems encountered. Green algae is the type most commonly found in the fresh-water environment. To survive, algae require air, water and sunlight. When they are exposed to light, algae produce oxygen and consume carbon dioxide. Most algae prefer moderate temperatures (60°F to 100°F); however, they can withstand temperatures from below zero to boiling. In addition, algae require elements such as calcium, phosphorus, magnesium, and silicon. As a result, the most abundant algal growths are found in warm, sunny areas, with large amounts of hard water.

Bacteria present a minor problem when compared to algae. The most important types of bacteria are those which react with sulfur and iron. The presence of these types of bacteria may be noted by increased turbidity in the water, as well as a sulfur or "rotten egg" odor in the water. Abundant numbers of bacteria may actually turn the water red, and leave a reddish sludge deposit in water pipes, nozzles, pumps, and other equipment.

Fungi and molds are the most biologically complex of the three types of microbiological organisms found in open recirculating water systems. Fungi and molds have a plant body with many fine, elongated cells that form a fibrous network. They also have a root structure which attaches them to the cooling tower and provides a base for nutrient gathering. Most commonly, fungi and molds tend to grow on wooden surfaces; but they can also grow on cement, metal, or fiberglass. The presence of these microorganisms can result in deterioration of the surfaces to which they are attached.

### **2.2.2 Traditional Methods of Control**

In the past, various water treatment philosophies and their associated devices have avoided the problems related to high concentrations of impurities by increasing the bleed or blowdown of process water from the tower. By increasing the amount of water released from the system, these treatments are increasing the makeup water requirements and operating the system at low concentrations of suspended solids. The amount of blowdown necessary to maintain a particular maximum mineral concentration is related to the operating cycles of concentration, which refers to the number of times the minerals are concentrated in the system. The cycles of concentration are defined as the ratio of chloride concentration in the cooling system to the concentration of chloride in the makeup water. Conductivity or any dissolved compound could be used in calculating cycles of concentration, but chloride is typically chosen because it is soluble and does not form precipitates as do calcium, magnesium, carbonate, phosphate, silicate, and occasionally other ions (Meitz, 1990).

Systems which operate at high cycles of concentration minimize the bleed or blowdown rates and are capable of substantial reductions in makeup water requirements and associated water and sewer costs. However, the risk of severe scale or corrosion problems increases dramatically with higher cycles of concentration. Provisions are necessary to handle high solids and higher concentrations of corrosive ions such as chloride and sulfate, as well as ions that precipitate, particularly those associated with hardness and alkalinity. This is traditionally accomplished by standard water treatment techniques which include the addition of treatment chemicals to the circulating water for scale inhibition, corrosion control, and control of microbial growth.

#### **2.2.2.1 Scale Control--**

The traditional practice for scale control involves the discharge of cooling tower blowdown to the sewer, thereby controlling the concentration of dissolved minerals to levels below the saturation point. However, as the cost of makeup water has increased, this practice has become less attractive. Scale deposits can also be minimized by maintaining a low system operating pH since the solubility of most mineral salts increases under acidic conditions. However, the resulting acidity of the process water will lead to corrosive conditions in the tower. Internal treatment for scale deposits usually involves the addition of dispersion agents or polymeric materials and scale inhibitors under slightly alkaline conditions. If the scale-forming ions can be tied up with complexing agents, their propensity to form precipitates that lead to scaling is reduced.

Among the most widely used dispersants for cooling water treatment are a number of polymers and copolymers, such as polyacrylic acid and its salts, acrylamide-acrylic acid copolymers, polymaleic acid, sulfonated polymers, and many others. In general, dispersants consist of low molecular weight polymers (below about 20,000), while those with molecular weights approaching  $10^6$  and above are used as flocculents. Other commonly used dispersants consist of chemically modified natural products such as tannins, lignosulfonates, and carboxymethyl cellulose. In addition, newly developed polymers are being produced which provide effective dispersion at much lower concentrations and can be tailored for dispersion of specific foulants.

Scale inhibitors function either by altering the crystalline structure of the scale-forming salts, or by coating the particles with a film which prevents coagulation. Polymers such as polyphosphates, phosphonates, and phosphate esters act as inhibitors for inorganic crystalline scales such as calcium carbonate and calcium sulfate, and they stabilize iron and manganese. Polyphosphates retard or delay the rate of precipitation by absorbing onto crystal faces thereby arresting the growth of the crystal. Stabilization depends on the time interval necessary, the operating temperature, and the presence of sufficient quantities to effectively prevent precipitation.

Polyphosphates encourage biological growth and also readily revert to orthophosphates which do not provide effective protection. Organic additives such as lignins, tannins, and ethylene diamine tetra acetic acid (EDTA) are often used in combination with polyphosphate treatment. The organics function by sequestration, reacting with minerals to form insoluble complexes that do not precipitate and are removed with system blowdown.

Although adding chemical dispersants and scale inhibitors will extend the solubility of many elements dissolved or suspended in the water, eventually a saturation point will be reached and precipitation will occur. In addition to chemical inhibitors, an effective chemical treatment program for scale inhibition includes a periodic blowdown of the system to limit the concentrations of dissolved solids.

#### 2.2.2.2 Corrosion Control--

Chromates have historically been the most widely used additive for corrosion control. Typically, an acid feed was administered to maintain the system pH between 6 and 7, thereby reducing scale problems due to the increased solubility of dissolved minerals at a low pH. Chromates were used under these acidic conditions because they are good oxidizing agents in acid and react to maintain a protective film of oxide at the metal surface. As much as 2,000 parts per million (ppm) chromate were typically used in the 1960s (ASHRAE, 1973). The toxic characteristics of chromates provided further protection against microbial growth. Due to environmental concerns, chromates were banned from use in comfort cooling systems in 1990 (EPA, 1990).

Chromates largely have been replaced with non-chromate treatment programs using polyphosphates, orthophosphates, zinc compounds, nitrites, phosphate esters, phosphonates, azoles, molybdates, and silicates. When chromates are omitted, corrosion inhibitors are generally used at higher concentrations to be effective.

Treating cooling water with chemicals to make it less aggressive (e.g., by dispersion of suspended solids), offers some degree of corrosion protection, although effective control is typically achieved by using corrosion inhibitors to form a protective film. Inhibitors may be inorganic or organic. Inorganic inhibitors, in turn, may be further classified according to those that require oxygen, such as sodium phosphates, silicates, and borates, and those that function with or without oxygen, such as chromate and nitrate. Inhibitors may also be classified in terms of their mechanism, that is whether they function by influencing the anodic or cathodic side of the electrochemical cell, although this depends largely on conditions of pH, temperature, and oxygen content. Inorganic inhibitors usually affect the anodic process. In general, chromates, nitrites, silicates, phosphates, ferrocyanides, molybdates, and borates are considered to be anodic inhibitors. Anodic inhibitors function either by forming a film on the metal surface or by chemisorption on metal surfaces. The dosage depends on the temperature, salt content, nature and location of dissimilar metals, and the ratio of metal surface area to volume of solution. Silicates require close pH monitoring, which should be maintained between 6.5 and 7.5. Although they are successful in soft water areas, silicates are not recommended for alkaline waters. High silicate concentrations lead to precipitation of calcium silicates. Nitrites require relatively high concentrations and close pH control (usually 7.0 to 9.0). Nitrites decompose and the result is serious corrosion at a pH of less than 6.5. The nitrites are also subject to conversion to nitrates by nitrobacteria. Although they have a long history of use as single-component inhibitors, nitrites and silicates are not acceptable for cooling tower applications.

Polyphosphates are widely used corrosion inhibitors that have a long history of use. Polyphosphates and phosphonates form a protective iron-orthophosphate film which also helps to prevent carbonate deposition on metal surfaces. However, polyphosphate reverts to orthophosphate

with possible precipitation as complex calcium phosphates, depending on calcium and orthophosphate concentration, pH, temperature, and total solids concentration. Phosphates tie up iron ions and prevent the formation of rust, although the phosphates used for corrosion inhibition lead to the formation of calcium phosphate and resulting scale deposits.

Inhibitors that react with the cathodically generated hydroxide to form an insoluble compound, such as  $Mg^{2+}$ ,  $Cu^{2+}$ ,  $Zn^{2+}$ ,  $Cd^{2+}$ ,  $Mn^{2+}$ , and  $Ni^{2+}$ , are considered to be cathodic. Cathodic inhibitors function by forming insoluble hydroxides at cathodic areas, causing cathodic polarization. None are practical corrosion inhibitors when used alone.

Formulations for corrosion control that contain mixtures of inhibitors generally provide greater protection than individual components. Corrosion control has historically been effective through the widespread use of combinations of polyphosphates, nitrites, chromates, zinc, and silicates. Although zinc is still widely used in treatment formulations, chromate has been omitted. Furthermore, non-heavy metal treatment programs in which zinc has been omitted are receiving increasing attention.

Widely used non-chromate mixtures include zinc with polyphosphate, organic phosphonate, molybdate, or lignin derivatives. Non-heavy metal formulations in which zinc has been omitted include combinations of polyphosphates, amino-tri(methylenephosphonic acid) (AMP), and 1-hydroxyethylidene-1,1-diphosphonic acid (HEDP); mixtures of polyphosphates with phosphonate or silicate; and combinations of phosphates AMP and HEDP with polymers. Most formulations include a polymeric dispersant such as polyacrylate, which maintains sediment, scale, corrosion products, and organic particles in suspension, thereby minimizing the risk of pitting, corrosion under a deposit, and other forms of localized corrosion. Many non-chromate mixtures operate within a relatively narrow pH range of 6.5 to 7.5, to effectively control corrosion or to prevent the precipitation of zinc. Formulations which do not contain zinc function cathodically and are more effective with higher pH values, typically from pH 7.3 to pH 9.5 (Hey and Hollingshad, 1987).

Many organic compounds have been used as corrosion inhibitors. Organic inhibitors function by bonding with the metal surface through forces including electrostatic adsorption, chemisorption, and delocalized electron adsorption. Organic corrosion inhibitors used in cooling tower water treatment applications include amines, amides, pyridines, carboxylic acids, esters, mercaptans, and formulations of alkylthiophosphate, organic phosphate esters, and zinc salts. Organic additives and surface active materials in conjunction with polyphosphates, zincs, or chromates improve the corrosion inhibition efficiency of the inorganic inhibitor. Organic additives interfere with the precipitation of inorganic salts and aid in dispersion of suspended solids.

#### 2.2.2.3 Fouling Control--

Biofouling results from the growth of microorganisms which plug water distribution holes and interfere with droplet formation in the tower thereby reducing heat transfer efficiency. Biological growths historically have been controlled by chemical or mechanical means. Chemical controls involve the addition of oxidizing or nonoxidizing biocides and algicides. Among the oxidizing types are chlorine gas, chlorine dioxide and chlorine donors such as calcium hypochlorite. Although chlorine is inexpensive and widely used, its biocidal properties are pH-dependent. The pH of the water needs to be slightly acidic because the toxicity of chlorine depends to a large extent on the formation of hypochlorous acid. In a pH range of about 4 to 6, chlorine gas hydrolyzes to form hypochlorous acid and small amounts of hydrochloric acid. Chlorine is a relatively poor biocide above a pH of about 7.5. This limits its application to cooling tower water treatment because many corrosion inhibitors operate in the alkaline range. Moreover, chlorine is corrosive and forms toxic organochlorine compounds. Discharge regulations for chlorine are more stringent than for other

biocides because of concerns over its role in the formation of trihalomethanes. Additionally, chlorination has been shown to reduce the effectiveness of the two most commonly used organic phosphates in cooling tower water treatment applications: AMP and HEDP (Tvedt and Wilson, 1985).

Nonoxidizing biocides include the isothiazolins, dibromonitrilopropionamide (DBNPA), quaternary ammonium chlorides, carbamates, and organotin compounds. Quaternary ammonium compounds (qv) are the largest class of nonoxidizing microbiocides used in water systems. These compounds exhibit surfactant properties which tend to loosen and penetrate existing biofilm accumulations thereby facilitating more rapid and effective treatment. Isothiazolin-based microbiocides have been shown to be particularly effective against biofilm organisms (Richardson, 1982). DBNPA is relatively effective at low levels, and decomposes into products that are less toxic than the parent compound. These characteristics make it an attractive additive for discharge purposes. Organic sulfur-containing compounds represent another class of nonoxidizing microbiocides. Most commercially formulated products consist of a mixture of several microbiocides combined with dispersants and surfactants which increase product effectiveness by breaking up accumulated slimes and algae.

Due to the ability of microorganisms to rapidly grow and multiply, they can easily become immune to many biocides. As a result, microbiocides are added intermittently in large doses, to minimize the tendency for microorganisms to become resistant to the chemicals. The likelihood of resistant strains is further ensured by using alternating dosages of two or more different chemical formulations.

Other traditional methods for controlling the growths of microorganisms include pH adjustment and the shielding of wet surfaces from sunlight. Microorganisms need a pH of approximately 6.5 to grow at optimum rates. Therefore, significant changes in the pH levels will reduce the growth of the microorganisms. However, a low pH will noticeably increase corrosion rates and should be avoided. An elevated pH will increase the formation of scale deposits. Therefore, a microorganism control program which increases pH must also increase the bleeding rate to control the formation of scale deposits. Algae need air, water, and sunlight to survive, and effectively removing sunlight from wet areas will control the growth of algae. Sheet metal or marine plywood are usually adequate for this purpose, although inadvertently restricting air circulation through the cooling tower should be carefully avoided.

## SECTION 3 SITE ACTIVITY DESCRIPTION

### 3.1 GENERAL PROCESS DESCRIPTION

Approximately 598 structures are located at the Norfolk NAS. Of these, 18 buildings are equipped with air conditioning systems operating in conjunction with evaporative recirculating cooling towers for a continuous supply of process water. The air conditioning systems provide comfort cooling during warm spring and summer months, largely between April and October. The NAS cooling towers do not operate during the cool season. Table 1 is a master equipment list showing that 28 cooling towers provide process water for the air conditioners which service these 18 buildings. As described in Table 1, these cooling towers are located on roofs, are adjacent to an exterior wall, or are in a courtyard outside of the building. They range in capacity from 5 tons to 300 tons. One cooling tower ton is equivalent to the removal of 15,000 BTU/hour.

Also included in Table 1 is a description of the current treatment status for each NAS cooling tower. As indicated, only 10 of the 28 towers are currently receiving chemical treatments for control of scale, corrosion, and biofouling. The remaining 18 towers are small units that do not receive chemical treatment during the operating season. The chemical addition program is discussed in Sections 3.2 and 3.3.

The last column in Table 1 lists the available system water volume in gallons. The volumes are used to derive some of the alternative treatment costs in Section 4. These system volumes are estimated values which have been obtained from Base personnel. System water volumes depend primarily on unit size, but are also influenced by the cooling tower locations and piping systems.

#### 3.1.1 Cooling Tower Discharge Practices

All cooling towers at the NAS receive makeup water from the City of Norfolk public water supply. Each of the cooling towers observed during the site visit was equipped with a discharge valve which directed the tower blowdown into floor drains located in the vicinity of the heat exchanger and condensed water pump. This equipment was typically situated within the mechanical room of the particular building being serviced by the unit. The observed flowrates of fresh makeup water and tower discharge varied from unit to unit.

Facility Maintenance Department (FMD) personnel interviewed during the site visit expressed confidence that all of the NAS cooling towers (both treated and untreated) drain to the sanitary sewer; however, this has not been confirmed as fact. As illustrated in the NPDES permit information and the listing of effluent sources provided in Appendix B, several of the NPDES permitted outfalls at the NAS are believed to discharge water from areas associated with air conditioning units. For example, tower blowdown from the two cooling tower units on the roof of building V53 is directed to a corner roof drain which discharges to the storm sewer at NPDES permitted outfall no. 112 (previously no. 077).



TABLE 1. MASTER EQUIPMENT LIST - COOLING TOWERS AT NORFOLK NAS

Equipment #	Building	Location	Size (Tons)	Volume (Gallons)
<u>Cooling Towers Receiving Chemical Treatment*</u>				
081275	SP367	East Outside	75	127
--	SP254**	Roof	200	600
--	SP256**	Roof	200	1,000
028197	V53	Roof	150	1,200
028198	V53	Roof	175	1,400
021087	SP29**	West Courtyard	300	3,500
024341	U16**	East Side	300	2,500
081218	SP45	South Side	125	1,250
093171	SP91	Behind Building	100	1,000
093172	SP91	Behind Building	40	400
<u>Cooling Towers Not Receiving Treatment***</u>				
022189	LP13	Roof East Side	25	N/A
080394	LP13	Roof West Side	25	N/A
086933	LP13	Roof West Side	25	N/A
080385	LP2	Roof West Side	25	N/A
080386	LP2	Roof East Side	25	N/A
080387	LP3	Roof West Side	25	N/A
080388	LP3	Roof East Side	25	N/A
022188	LP4	Roof East Side	25	N/A
080389	LP4	Roof West Side	25	N/A
052754	S33	Roof	20	N/A
086998	S33	West Side	5	N/A
093369	SP238	South End	20	N/A
097454	SP64	Outside Building	20	N/A
021751	T26	Roof East Side	20	N/A
085676	T26	Roof West Side	60	N/A
085677	T26	Roof	60	N/A
050597	U48	West Side	7.5	N/A
083286	V82	Roof	45	N/A

\* Refers to status of treatment at the time of report preparation, August 1994.

\*\*Chemical treatment has been instituted at these new units since the site visit in June 1994.

\*\*\*The cooling towers currently not receiving treatment are designed for chemical treatment.

--These two new units have not yet been issued equipment identification numbers.

Appendix C contains monitoring data collected from stormwater outfall no. 077 ( currently 112). As shown in the data reports, the concentrations of zinc and chromium in outfall no. 077 (112) exceeded the NPDES permitted discharge limits on two separate occasions, in the winter of 1993 and in the spring of 1994, respectively. After each exceedance, a sample was collected from the cooling tower drainage at building V53 in an effort to locate the origin of the zinc and chromium discharge. However, on both occasions the samples collected from the cooling tower at building V53 did not show a correspondingly high concentration of the contaminant of concern. Despite these inconsistencies, it is believed that the cooling tower at building V53 discharges to NPDES-permitted stormwater outfall no. 077 (112) (Sean Heaney, Naval Base Norfolk, personal communication, 1994.).

### **3.1.2 Cooling Tower Maintenance Activities**

Maintenance and operation of the cooling towers and air conditioning units are performed by the Public Works Command (PWC), under contract to the NAS. PWC personnel do not currently have a systematic method for managing the NAS cooling towers. As indicated in Table 1 and described in Sections 3.2 and 3.3, 10 of the 28 NAS cooling towers are serviced under a chemical treatment contract to PWC by one of two water treatment specialists. Each of these ten units is maintained by a treatment representative, whose primary responsibility includes cooling tower water testing and treatment. Additional responsibilities of the water treatment contractor vary depending on the details of the contract, but these may include regular cleaning of the tower to remove accumulated sludge and debris.

The remaining towers which are not serviced by a contractor are the responsibility of PWC mechanics. These units receive no chemical treatment during the operating season, aside from the occasional addition of biocide to control excessive fouling. PWC mechanics operate under a "building ownership" system whereby certain mechanics have maintenance duties for certain buildings. Building maintenance includes the servicing of cooling towers and ancillary equipment.

General maintenance activities for the cooling towers not serviced by a water treatment specialist include an annual overhaul of each unit, which is performed during the winter months while the unit is not operating. The annual overhaul consists of external cleaning with brushes and water flushing, and, depending on the general state of the unit, completely disassembling each unit for interior cleaning. Interior heat exchanger tubes are cleaned by a process known as "roddening," in which a rotating brush is inserted into each tube in combination with a water flush. Although this process is typically performed only once a year, heat exchanger tubes may be cleaned at other times if a unit is showing signs of scaling or fouling. Signs of scaling and fouling include a high pressure drop or small change in temperature across the unit. Cooling towers are normally designed to operate with a 10°F temperature drop across the tower.

Following the annual overhaul, PWC maintenance personnel apply an algicide to each of the cooling tower units not serviced by a chemical contractor. A one-gallon container of Calgon algicide is fed by continuous drip to each unit to control biological growth in the system. Some of the towers may occasionally receive additional biocide during the operating season to control excessive biological fouling, although application rates and schedules vary.

## **3.2 CHEMICAL ADDITION PROGRAM**

The chemical treatment program instituted at the Norfolk NAS involves PWC personnel, who purchase the chemicals, and a water treatment contractor, whose responsibilities include testing the tower water, administering chemicals as needed, and adjusting control parameters such as bleed and makeup water flowrates.

Of the 28 cooling towers in operation at the NAS, a total of 10 are currently receiving chemical treatment. These ten cooling towers, identified in Table 1, are serviced under contract by one of two cooling tower water treatment specialists who also service other units on base. As noted in Table 1, four of these units are equipped with chemical pumps and metering systems but they were not included in a chemical treatment contract at the time of the site visit in June 1994. Chemical treatment programs have recently been implemented at these four units. In the future, PWC intends to hire one water treatment specialist to maintain and service all cooling towers at the Naval Base Norfolk. The contractor would be required to inspect each tower on a monthly basis and would chemically treat the towers as needed. Thus, all towers at the NAS will eventually be included in a chemical addition program.

### **3.2.1 General Procedure for Chemical Procurement**

The procedure for procurement and administration of water treatment chemicals involves a cooperative effort between the appropriate PWC personnel and the water treatment or chemical contractor responsible for the unit. Each cooling tower under contract to a water treatment specialist is inspected periodically to ensure that the tower is operating properly and is receiving adequate chemical treatment. Operating malfunctions are corrected by the contractor. If the contractor determines that additional chemicals must be purchased, PWC is notified. PWC personnel order the appropriate materials for delivery to the specific building at the specific zone on base. PWC orders all cooling tower chemicals in an effort to minimize the purchase of excess materials. After the chemicals arrive on site, the contractor returns to administer the treatments.

PWC personnel who were interviewed during the site visit stated that under no circumstances do PWC maintenance personnel administer chemicals to the NAS cooling towers, regardless of whether or not the towers are maintained under contract by a water treatment specialist. At the time of the site visit, however, two towers were observed that were not currently under contract by a water treatment specialist but that were connected to a chemical holding tank and an engaged metering pump. Based on these observations, the actual chemical administration procedures as practiced remain somewhat uncertain.

A chemical exchange program exists within each zone on base. Most chemicals are stored in the mechanical room of the building in which they are used. As more chemicals are needed by a particular building, PWC will first verify that excess chemicals do not exist in storage at another building before ordering a new supply. This procedure avoids excess stockpiling of chemicals. Although PWC is in charge of ordering all cooling tower chemicals, no purchase records are maintained at PWC. Purchase records are maintained in the Base Supply, building X275. MSDS files are maintained in the Safety Department, building Z140.

### **3.2.2 Chemical Descriptions and Usage Data**

The chemicals used for cooling tower water treatment at the NAS are presented in Table 2 along with their primary ingredients, type of control, application rate, and frequency of use. Appendix D contains the MSDS for each of the chemicals used. These chemicals are applied by the two water treatment specialists currently under contract to service the NAS cooling towers. Purchase data for these chemicals were unavailable from PWC. However, typical application rates for each chemical, shown in Table 2, have been combined with cost information to estimate annual usage rates and associated costs. Usage rates are based on a six month operating season and assume that all towers operate with 4 cycles of concentration at 100 percent capacity for 12 hours per day. A summary of the annual usage rates and costs for each treatment chemical are presented in Table 3. As described above, the chemicals applied to each of the NAS cooling towers, which total approximately 814 gallons, are ultimately discharged to the environment through tower bleed.

The total annual chemical costs for the NAS cooling towers currently receiving chemical treatment are estimated to be approximately \$13,876.

### **3.3 COOLING TOWER DESCRIPTIONS**

Seven of the cooling towers listed in Table 1 were observed during the site visit, including towers at buildings SP367, V53, SP254, SP256, SP29, and U16. The observed cooling towers are among the largest units and, although all were equipped with automated valves and chemical metering pumps, the four units at buildings SP254, SP256, SP29, and U16 were not yet under contract for chemical addition. Chemical addition programs have been instituted at each of these towers since the time of the site visit.

The remaining NAS cooling towers which are not chemically treated consist primarily of small units, ranging in size from 5 to 60 tons, with most being 25 tons or less. These towers were not observed during the site visit because they were not being chemically treated. However, the size and operation of these additional towers will be considered in the overall assessment of cooling tower activities and treatment options, since they will be included in any treatment program which encompasses all NAS cooling towers.

#### **3.3.1 Building SP367**

The cooling tower at Building SP367 is a 75-ton unit located on the east side of the building. This unit was observed to be continuously bleeding a large amount of water directly into a sump which, according to base personnel, apparently discharges to the sanitary sewer. The discharge problem was apparently due to a manual bleed valve which was locked in the open position. The bleed flowrate is unknown; however, the measured total dissolved solids (TDS) in the tower were approximately 200 ppm. This rate is identical to that of the makeup water from the city of Norfolk. This level of TDS indicates that the tower was not effectively recycling water but was operating instead as a once-through system. Chemicals used regularly in this tower include an algicide and a scale and corrosion inhibitor, both are fed by a continuous drip. A dispersant used once or twice per year during startup and shutdown procedures.

#### **3.3.2 Buildings SP254 and SP256**

The cooling towers located at Buildings SP254 and SP256 are new, 200-ton units located on the roof of each building. These units have automated controls in place to measure conductivity which is an indicator of TDS. The controls automatically open the tower bleed valve when TDS measures are greater than approximately 600 ppm. Automatic metering pumps are in place for continuous chemical addition. Although the controls were observed at the time of the site visit, chemicals were not being dispensed to these units. A chemical addition program has been implemented at these cooling towers since that time. Chemicals used regularly in these towers include an algicide and a scale and corrosion inhibitor. Both are fed by an automated drip system, and a dispersant is used once or twice per year during startup and shutdown.

#### **3.3.3 Building V53**

The two cooling towers at Building V53 are 150- and 175-ton units located on the roof of the building. These cooling towers are relatively new and are constructed of a plastic material. The chemical contractor servicing these units expressed dissatisfaction over the performance of the new material, indicating that the units are not capable of achieving a sufficient temperature drop in cooling water. Maximum temperature drops achieved across the units were reportedly in the range of 8°F, not the 10°F temperature drop desired.

TABLE 2. TREATMENT CHEMICALS CURRENTLY USED AT NORFOLK NAS COOLING TOWERS

Trade Name	Principal Ingredients	Type of Control	Application Rate	Use Frequency
Chemicals Used in Cooling Towers for Buildings SP367, SP254, and SP258				
Formula 1100*	Poly [Oxyethylene- (Dimethyliminio) Ethylene- (Dimethyliminio) Ethylene Dichloride]	Biocide	2 qt/week/300 ton 1/2 qt/week/100 ton	1/week 1/week
Formula 1109*	Sodium Ethylene Bisdithiocarbamate Sodium Dimethyldithiocarbamate Ethylene Thiourea	Biocide	2 qt/week/300 ton 1/2 qt/week/100 ton	1/week 1/week
Formula 2055	Sodium Hydroxide Methylene Phosphonic Acid	Scale/Corrosion Inhibitor	1 qt/100 ton/day	Continuous
Formula 7200	Potassium Hydroxide 1-Hydroxyethylidene-1, 1-Diisophosphonic Acid	Dispersant/ Antifoulant	approximately 30 gallons/year	At start-up and shutdown
Chemicals Used in Cooling Towers for Buildings SP45, SP91, V53, SP29 and U16				
Dicaton	Sodium Hydroxide	Non-Acid Descaler	2.5 gal/1,000 gal system water	At start-up or periodic cleanup
GAX-16*	Poly [Oxyethylene- (Dimethyliminio) Ethylene- (Dimethyliminio) Ethylene Dichloride]	Biocide	1/4 to 1/2 pt/1,000 gal makeup water**	1/every other week
GAX-20*	2,2-Dibromo-3 Nitropropionamide	Biocide	1/4 to 1/2 pt/1,000 gal makeup water**	1/every other week
GAX-28	5-Chlor-2 Methyl-4-Isothiazolin-3-One 2-Methyl-4-Isothiazolin-3-One	Biocide	1/2 gal/1,000 gal system water	At start-up and shutdown
GCO-10-LM	Sodium Molybdate Poly [Oxyethylene- (Dimethyliminio) Ethylene- (Dimethyliminio) Ethylene Dichloride]	Scale/Corrosion Inhibitor w/ Biocide	1/2 to 1 pt/1,000 gal makeup water**	Continuous
GCO-10	Poly [Oxyethylene- (Dimethyliminio) Ethylene- (Dimethyliminio) Ethylene Dichloride]	Scale/Corrosion Inhibitor w/Biocide	1/2 to 1 pt/1,000 gal makeup water**	Continuous
Penetrex	Not Available***	Dispersant/ Antifoulant	1/2 pt/1,000 gal system water	At start-up and shutdown

\*Biocides are generally alternated on a weekly basis, to increase the effectiveness of treatment.

\*\*Dosage varies depending on system load.

\*\*\*Principal ingredients are listed as proprietary information and are not available.

**TABLE 3. CURRENT ANNUAL CHEMICAL PURCHASES AND COSTS**

Chemical	Annual Usage (gallons)	Annual Cost (\$/yr)
Biocide	34	\$660
Scale/Corrosion Inhibitor	608	\$9,909
Dispersant	144	\$1,971
Descaler	28	\$1,336
<b>TOTALS</b>	<b>814</b>	<b>\$13,876</b>

These units have automatic controls in place to measure conductivity, and they automatically open the tower bleed valve when TDS measures greater than approximately 600 ppm. Chemicals are administered by an automatic metering pump. The pump is designed to remain closed while the tower bleed valve is open to minimize shortcircuiting of chemicals through the system. The bleed water from both towers at building V53 is directed to a corner roof drain which is believed to discharge through stormwater outfall no. 077 (previously no. 112; see Appendices B and C). Chemicals used continuously in these towers include a biocide and a scale and corrosion inhibitor with biocide. A dispersant and descaler are both used once or twice per year during startup and shutdown or for periodic cleanup.

#### **3.3.4 Buildings SP29 and U16**

The cooling towers at buildings SP29 (one 300-ton unit in the west courtyard), and U16 (one 300-ton unit on the east side) were not reportedly maintained under a service contract at the time of the site visit, although these units were observed to be connected to chemical tanks and engaged metering pumps. Information obtained since the time of the site visit indicates that chemical treatment programs have recently been instituted at these two new units. Each of the units discharges to a floor drain located in the mechanical buildings where the condenser and heat exchanger equipment are located. The chemical treatment programs at buildings SP29 and U16 are similar to that described above for the towers at V53. Chemicals used continuously in these towers include a biocide and a scale and corrosion inhibitor with biocide. A dispersant and descaler are both used once or twice per year during startup and shutdown or for periodic cleanup.

#### **3.3.5 Buildings SP45 and SP91**

The cooling towers located at Buildings SP45 (one 125 ton unit on the south side) and SP91 (one 100 ton unit and one 40 ton unit, both behind the building) were not observed during the site visit. However, these towers are serviced by a chemical contractor in a manner similar to the method described for the towers at building V53. Cooling tower blowdown is believed to be discharged to the sanitary sewer from each of these cooling towers. Chemicals used continuously in these towers include a biocide and a scale and corrosion inhibitor with biocide. A dispersant and descaler are both used once or twice per year during startup and shutdown or for periodic cleanup.

## SECTION 4 OPPORTUNITY ASSESSMENT

### 4.1 SURVEY AND DESCRIPTION OF AVAILABLE OPTIONS

Three alternatives for cooling tower water management and treatment have been identified during this PPOA: no treatment, chemical treatment, and non-chemical treatment. Table 4 provides a brief description of methods available for the control of scale, corrosion, and biofouling, including traditional and more innovative treatment technologies. In the subsections that follow, ten treatment options are presented, as they apply to these alternatives.

#### 4.1.1 Non-treatment Alternatives

Although non-treatment alternatives may eliminate the application and subsequent discharge of cooling tower water treatment chemicals, the result may be an increased water usage rate to control the accumulation of suspended solids in the system. In addition, improper treatment and management of cooling tower water may result in an excessive buildup of scale deposits and biological fouling that will ultimately result in system failure.

##### 4.1.1.1 Option 1. No Treatment--

Many of the NAS cooling towers currently have no formal chemical treatment program. One option for pollution prevention is to extend this practice to all 28 NAS cooling towers. Under this scenario, the towers would receive annual maintenance as described in Section 3. During the off-season, the units would be externally cleaned with wire or nylon brushes, the heat exchanger end plates would be removed, and the tubes would be roddened with a round wire brush to remove scale deposits as needed. Approximately one gallon of algicide would be added to each unit by means of a drip feed.

Refraining from chemical treatment would result in the annual consumption of approximately 28 gallons of algicide at a cost of approximately 15 dollars each, for a total of \$420.00 per year. This represents a savings of approximately \$13,300 dollars annually in chemical costs, and a substantial reduction in the discharge of cooling tower water treatment chemicals to the environment. However, failure to properly maintain the towers during the operating season results in the buildup of scale deposits and significant algal growth. This will lead to operational down-time for the repair work and mid-season cleaning. This is costly in terms of employee man-hours. In addition, the operational lifetime of a unit, typically in the range of 15 to 20 years, is significantly reduced by improper maintenance and also by failure to provide adequate corrosion protection. Systems clogged by excessive scale deposits often require acid dosing to clear blocked passageways. This is an aggressive treatment procedure and can be harmful to the materials of construction, especially where corrosion has already exposed oxidized portions of the metallic surface. Thus, while a no-treatment option appears to be cost effective in terms of operating expenses, ultimately, the excess capital expense of new equipment purchases due to system failure makes this option less attractive.

TABLE 4. GENERAL ALTERNATIVES FOR COOLING TOWER WATER TREATMENT

Nature of Problem and Factors Related to Occurrence	Treatment Methods	Comments
Scaling <ul style="list-style-type: none"> <li>-concentrated salts</li> <li>-calcium</li> <li>-hardness</li> <li>-alkalinity</li> <li>-total dissolved solids</li> <li>-high pH</li> <li>-high temperature</li> </ul>	<p>Water softening to remove calcium, magnesium, iron</p> <p>Softening soda lime</p> <p>Softening Zeolite or base exchange and ion exchange</p> <p>Demineralization</p> <p>De-alkalization</p>	<p>Water softening methods may lead to corrosive conditions.</p>
	<p>pH adjustment with acid (sulfuric hydrochloric, nitric, sulphamic acids, sodium bisulfate)</p>	<p>Must be accompanied by corrosion inhibitors and close monitoring of pH. Adjustment of pH is based on a set of conditions at one point in the system. As the water passes through the system and reaches another point, the environmental conditions may have changed and scale or corrosion can take place.</p>
	<p>Addition of inorganic chromate salts, inorganic and organic phosphates and polyphosphates, chromate and phosphate combination treatment, organic chromates, silicates, filming amines</p>	<p>Function by either altering the crystal structure of the scale-forming salts, or by coating the particles with a film which prevents their coagulation. Most also form a protective film of molecular thickness on metal surface. Polyphosphates retard or delay the rate of precipitation. Stabilization depends upon the presence of sufficient quantities to effectively prevent precipitation, the time interval necessary and the temperature involved.</p>
	<p>Organics addition (tannins, lignins, EDTA)</p>	<p>Polyphosphates encourage biological growth and also revert to orthophosphates which do not provide good protection; chromate is toxic; silicates are successful in soft water but ineffective in alkaline water; certain filming amines may be dangerous. Organic additives such as EDTA function by sequestration; reacting with minerals to form insoluble complexes that do not precipitate. They are used in combination with polyphosphates, lignin, or tannins.</p>
	<p>Sequestering agents</p>	<p>Polyphosphates are normally added at 3 to 5 ppm to control scaling tendencies. At higher concentrations, between 100 and 1000 ppm, they exhibit a sequestering action in that the calcium and magnesium compounds react with the polyphosphates to form soluble complex salts that do not precipitate.</p>



TABLE 4 (continued)

Nature of Problem and Factors Related to Occurrence	Treatment Methods	Comments
Poly-electrolyte anti-coagulants		Successful for muddy waters. Material contains highly charged particles which attract mud, causing flocculence. The mud is carried through rather than adhering to surfaces in the system.
Bleed-off or blowdown		Dissolved solids concentration maintained at required level by continuously bleeding off a portion of the recirculating water. Some forms of treatment require a greater bleed-off than others. Harder water requires a lower concentration factor; higher values are accepted with certain types of treatment, notably those with a filming action. Concentration values of about 3 to 7 are enough to cause some salts to precipitate out as scale.
Corrosion - dissolved oxygen - dissolved CO <sub>2</sub> - other gases (SO <sub>2</sub> , SO <sub>3</sub> ) - scale inhibitors - low pH - temperature	Inorganic anodic inhibitors: sodium and potassium chromates and dichromates, polyphosphates, silicates, nitrites, ferrocyanides, molybdates.	Anodic inhibitors function either by forming a film on the metal surfaces or by chemisorption on to metal surfaces. Chromates are used most frequently but they are toxic. Chromates form a thin passivating film directly on the anodes. Dosage depends on nature and location of dissimilar metals temperature, salt content and the ratio of metal surface area to volume of solution. High concentrations are necessary when chromates are used alone. Polyphosphates form a protective iron-orthophosphate film which also helps to prevent carbonate deposition on metal surfaces. Polyphosphate reverts to an orthophosphate with possible precipitation as complex calcium phosphates, depending on calcium and orthophosphate concentration temperature, pH and total solids concentration. Silicates require close pH control, which should be maintained between 6.5 and 7.5. High concentration lead to precipitation of calcium silicates. Nitrites require high concentrations (200 to 500 ppm) and close pH control (7.0 to 9.0). Nitrites decompose and results in serious corrosion at pH less than 6.5 and are subject to conversion to (ineffective) nitrates by nitrobacteria.
Inorganic cathodic inhibitors: salts of zinc, nickel, manganese, trivalent chromium		Form adhering, insoluble hydroxides at cathodic areas and cause cathodic polarization. None are practical corrosion inhibitors when used alone.
Combinations of chromate, phosphate, zinc, silicates, nitrites		Chromate component is effective but toxic. When omitted, higher dosages are required.

TABLE 4 (continued)

Nature of Problem and Factors Related to Occurrence	Treatment Methods	Comments
Biological Growth - algae - biofilm	Organic inhibitors: amines, amides, pyridines, carboxylic acids, esters, mercaptans	Organic compounds in ionic form are adsorbed and form protective films which inhibit corrosion by cathodic polarization. Organic additives and surface active materials in conjunction with polyphosphates or chromates improve the corrosion inhibition efficiency of the inorganic inhibitor. Organics interfere with the precipitation of inorganic salts and aid in the dispersion of suspended solids.
	Nontoxic inhibitors: proprietary combinations of phosphate and zinc	Some formulations are available which contain neither chromate nor phosphates. Usually used at higher dosages and lower pH levels than is customary to be used with chromates, they are often formulated for a particular type of system and operating range.
	pH adjustment (pH 8) combined with polyphosphates addition	Corrosivity is reduced; reversion to orthophosphate reduced; scale-inhibiting properties of polyphosphate are used to control high scaling potential. Combinations with zinc introduce a problem in the stabilization of this ion in soluble form at high pH.
	Controlled scale	Maintaining slight scaling conditions will inhibit corrosion.
	Cathodic protection	See anodic and cathodic inhibitors. Cathodic inhibitors are not effective when used alone.
	Chlorine (hypochlorite and chlorinated phenols	Water should be regularly checked by pH monitoring. Effective under slightly acidic conditions only.
	Quaternary ammonium copper complexes	Used intermittently.
	Bactericides	Some corrosion inhibitors contain a mild bactericide.
	UV sterilization	Economical for small quantities only. Water undergoes no chemical change. Overdose is impossible.
	Ozonation	May cause odor.
	Slipstream filters	Bleed off a portion of recirculating water for filtration then return. Filtration rates, normally up to 10 percent of recirculation rate. Centrifugal separators are also used in a similar manner for treating up to 10 percent of the recirculation rate.

TABLE 4. (CONTINUED)

Innovative treatment ideas Water Treatment Technology	Comments
Plastic cooling towers and components	<p>Industrial-grade plastics have been used since about 1970 in prepackaged factory-assembly cooling tower units. Plastics are non-corrosive, have a seamless, leakproof one-piece shell. They are non brittle, non-porous/one-piece when wet. They are lighter, require less maintenance and give longer service. These materials are impervious to industrial smoke, chemical fumes, salt heavy dust and alkaline, chlorinated or acid water and they resist algae growth. One chemical contractor on base has stated that these types of equipment do not provide effective performance, the plastic cooling towers did not achieve significant temperature drops across the cooling towers.</p> <p>Causes hardness to precipitate as a flocculent sludge, which can be removed by blowdown. Does not inhibit corrosion.</p> <p>This device when clamped to pipe, creates a positive magnetic field. Electron polarization and spin excitation of the water manipulated by the positive field is caused by hydration; the magnetic field amplifies the electromotive force potential in the water and dissolves hardwater mineral salts (scale) back into the solution. When used in conjunction with an exchange resin, the material field extends the lifetime of the bed indefinitely. This generally does not inhibit corrosion.</p>
Electrical scale preventive device	
Magnetic scale preventive device	
DIAS-Aid Tower Treatment XP-300	<p>A newly developed chemical formulation which strongly bonds high concentrations of material salts and maintains unprecedented high concentrations in solution. These systems operate with low chemical dosage rates and extremely high cycles of concentration. Many systems operate with zero bleed throughout an entire operating season (six months). This treatment controls scale formation and corrosion. Intermittent biocide addition may be necessary but infrequent.</p>
KDF system (zinc/copper alloy in the form of granules, filament or wool, wire or brush and powder)	<p>Calcium carbonate precipitation and scaling are controlled by an undetermined mechanism that reduces the ability of calcium carbonate to link together. Electrochemical reactions interfere with the crystalline structure of limescale and a powdery rather than vitreous scale formation is seen when the water dries in the splash areas of the cooling tower. No scale is noted on the heat transfer surfaces, and no chemical formula has been developed to explain this phenomenon.</p> <p>Biofilm accumulation and bacterial growth are controlled by the formation of hydroxyls. Some of the water reacts with zinc and that liberates a small portion of the hydrogen ion from the water molecules causing hydroxyls to form (<math>Zn + 2H_2O - Zn(OH)_2 + H_2</math>). It is believed that these OH radicals, along with a redox shock (a change in the electrical potential, Eh, interfere with normal cellular activity of bacteria and algae, thus reducing biofilm formation. Different types of bacteria and algae can only grow within a particular range of redox potential. The passage of water through KDF causes a cascade of subsequent damage to the cell walls of single-cell organisms.</p>

continued

TABLE 4. (CONTINUED)

Innovative treatment ideas  
Water Treatment Technology

Comments

Corrosion inhibition is achieved by cathodic protection provided by the less noble metal zinc. Zinc ions in solution are available to react chemically or cathodically. The effectiveness of this method for corrosion inhibition is questionable.

Spent KDF is a common alloy and can be recycled through local scrap dealers.

This describes corrosion detection using nondestructive test methods including hydrogen evaluation or corrosion probes. Hydrogen is a by-product of most aqueous corrosion processes. Hydrogen evaluation cannot locate corrosion but can predict approximate corrosion rates. Corrosion probes detect and measure corrosion at a given point, can estimate total amount of corrosion and type of corrosion anticipated.

The saturation index (Langlier equation) is the difference between the actual measure pH and the calculated pH at saturation with calcium carbonate ( $>0$ , scaling;  $<0$ , corrosive;  $=0$  balanced). The stability index (Ryznar equation), has an optimum value of 6.6 (6.5, scaling; 7.0, corrosive; 6.5 to 7.0 ideal). It was developed to provide a closer correlation between the calculated prediction and the quantitative results obtained in the field.

As with pH adjustments techniques, characteristics at one particular point in the system may not accurately reflect conditions at a point further downstream.

Test water for scaling tendencies and corrosive properties before instituting program

Notes

The dissolved mineral matter in most natural waters consists mainly of calcium and magnesium in the form of bicarbonate or temporary hardness, and chlorides and sulfates as permanent hardness. Temporary hardness can be eliminated by boiling the water to transform bicarbonate into insoluble carbonate. Permanent hardness is the calcium and magnesium residue in the water after boiling. Temporary hardness does not take into account the presence of carbonate which is only soluble. Permanent hardness also measures the carbonate remaining in the solution.

The tendency of the water to deposit scale when made alkaline by heating, or to attack metals corrosively, depends on the balance of the various constituents present in the water. Scale formed under moderate temperatures is usually due to temporary (bicarbonate) hardness being converted into calcium carbonate. This occurs upon heating or with an increase in alkalinity sufficient to result in calcium carbonate saturation. The solubility of calcium carbonate also affects corrosion since the alkalinity of dissolved carbon dioxide in water is greatly reduced as the saturation equilibrium is approached. Ideally, at equilibrium, the various forms of carbon dioxide (free  $\text{CO}_2$ , bicarbonate, and carbonate) are so balanced that they cause neither scale nor corrosion.

#### 4.1.1.2 Option 2. Continuous Bleed-off or Blowdown--

The purpose in using recirculating cooling systems is to conserve makeup water. Systems using higher cycles of concentration use less water. Achievable cycles of concentration depend on the concentration of ions such as calcium and silica in the makeup water, since these ions and dissolved solids accumulate throughout evaporative losses which take place in the cooling tower. The risk of severe scale or corrosion problems increases dramatically with higher cycles of concentration. Solids and impurities will continue to accumulate until the system water is removed through bleed-off or blowdown. Dissolved oxygen increases in a recirculating system because the water is aerated during each passage through the cooling tower. In normal practice, a portion of the recirculating water is removed through system blowdown in order to maintain the concentration of dissolved solids and gases at a required level, thereby preventing scale deposits and corrosion.

The maximum concentration factors are defined for open cooling water systems according to the hardness of the water and the type of treatment applied. Systems receiving makeup water of relatively low hardness or those which receive effective scale-inhibiting treatment may operate at high concentration factors, thereby maximizing the portion of recirculating water and minimizing the makeup water requirements. Without treatment, concentration values of about 3 to 7 are enough to cause some salts to precipitate out as scale. Various water treatment approaches and devices have, historically, avoided scale formation by increasing the bleed and makeup water rates rather than controlling calcium carbonate or silicate formation by chemical or mechanical means.

Minimum dissolved solids and mineral concentrations could be maintained by operating the cooling tower with a continuous supply of fresh water and a maximum flow of tower bleed. A once-through system would avoid the buildup of solids, gases and impurities in the process water, thereby limiting the potential for scale deposits and corrosion, and would eliminate the need for administration and discharge of chemicals to the environment through cooling tower blowdown. However, the high operating costs incurred by purchasing large amounts of makeup water make this a fairly unattractive option. Makeup water requirements and associated costs are reduced drastically by operating at higher cycles of concentration.

To illustrate this point, consider a 100-ton cooling tower operating at 100 percent capacity for 12 hours per day. Assuming a 10°F temperature differential across the tower, this tower will circulate approximately 300 gallons of water per minute and approximately 3 gallons per minute would evaporate. Thus, operating at one cycle of concentration, the makeup water requirements would be approximately 18,000 gallons per hour, or 6.5 million gallons per month based on 12 hours per day of operation. At a combined water and sewer cost of \$3.40 per 1000 gallons (based on City of Norfolk 1994 water and sewer rates), this type of operation would incur a monthly operating cost of \$22,000. Operating this same tower at 2 cycles of concentration would substantially reduce the makeup water requirements to 360 gallons per hour, or 130,000 gallons per month, representing a monthly cost of \$443 and a savings of 98 percent. The effect of increasing cycles of concentration on water consumption and associated costs is presented in Table 5.

Although a continuous bleed would help to reduce the buildup of dissolved solids and gases, the potential still exists for algal and bacterial growth. Thus, the system may still malfunction during the operating season if biofouling is allowed to progress. Each cooling tower unit should still receive an annual overhaul and an application of a one-gallon biocide drip, which will increase annual operating costs accordingly.

**TABLE 5. BLEED AND MAKEUP WATER REQUIREMENTS AND ASSOCIATED  
MONTHLY COSTS AT DIFFERENT CYCLES OF CONCENTRATION\***

Cycles of Concentration	2	3	4	5	8	10	16
Evaporation (gpm)	3	3	3	3	3	3	3
Total Bleed Rate (gpm)	3	1.5	1	0.75	0.4	0.33	0.2
Makeup Water (gpm)	6	4.5	4	3.75	3.4	3.33	3.2
Water Cost (\$/month)**	\$443.09	\$335.07	\$297.84	\$279.22	\$253.16	\$247.95	\$238.27

\* Assumes a 100-ton open-system recirculating cooling tower operating at full capacity for 12 hours per day, with a 10°F temperature drop across the tower. Pump circulation rate is 300 gpm.

\*\* Costs are based on a combined water and sewer cost of \$3.40/1000 gallons. Norfolk City water prices are currently \$1.34/1000 gallons, and sewer prices are \$2.06/1000 gallons. Since cooling towers at the Norfolk NAS are generally not provided separate metering systems for drainage, combined rates are charged for makeup water. It is obvious from the above table that as the operating cycles of concentration increase, the volume of bleed discharged to the drain is substantially reduced. Separate metering systems would allow calculation of a credit for makeup water which is not discharged to the drain (e.g., evaporative losses), and would result in substantial savings.

#### **4.1.2 Chemical Treatment Alternatives**

The addition of chemicals to control corrosion, scale deposits and biological fouling represents a traditionally acceptable method for cooling tower water treatment. In an adequately monitored system, chemical dosage rates can be adjusted to maintain proper system operation efficiency. However, the possible storage and handling of large volumes of chemicals represents a potentially dangerous situation for maintenance and operating personnel. In addition, increasingly stringent limitations on the composition of sanitary and storm sewer discharge streams require close monitoring of water treatment chemical constituents. The Hampton Roads Sanitation District's Cooling Tower Waste Discharge Policy and Industrial Wastewater Pollutant Limitations are presented in Appendix E.

##### **4.1.2.1 Option 3. Conventional Chemical Addition Programs--**

Chemical treatment programs have been instituted to enable cooling tower systems to operate at increased cycles of concentration, thereby conserving water use. As discussed in Section 2, most chemical additives for scale control function essentially by increasing the capacity of the process water to carry dissolved solids, allowing higher concentrations of solids to remain in solution rather than depositing out as scale, while corrosion inhibitors function primarily by forming a protective film on the metal surface. Historically, chromates were used to prevent corrosion under acidic conditions because chromates are good oxidizing agents in acid, and react to maintain a film of oxide on the metal surface. With an acid feed to maintain a solution pH between 6 and 7, scaling was not a problem due to the increased solubility of calcium carbonate at low pH.

Environmental concerns led to the ban on applying chromate to comfort cooling towers, implemented in February and May of 1990 (EPA, 1990). Non-chromate programs using phosphates, polyphosphates, phosphonates and zinc have been substituted for corrosion control, and dispersion

agents or polymeric materials are typically added to counter scale formation. Section 2 discusses the chemicals used in cooling water treatment applications.

Although the majority of cooling tower water treatment chemicals in use today have been formulated with environmental safety in mind, almost every chemical used for water treatment can be harmful or environmentally detrimental under certain circumstances. Phosphorus is typically a primary component of commonly used corrosion and scale inhibitors, but it is an environmentally sensitive compound due to its potential effects on ecosystems and its contribution to algal blooms and eutrophication. As shown in Appendix E, the discharge of phosphorus in cooling tower blowdown is subject to a surcharge when the concentration exceeds 6 mg/L.

With increasingly stringent regulations governing the quality of discharges to sanitary and stormwater sewers, the composition and quantity of chemical cooling tower additives have become a primary concern. The chemicals' effects on the operation of the Base's wastewater treatment system and their environmental acceptability in the wastewater discharge should be considered. The ultimate fate of the cooling tower discharges is currently unknown. These drains may lead to the sanitary sewer, or they may drain directly to a stormwater discharge point. These uncertainties exacerbate the need for stringent environmental controls regulating the applied treatment chemicals. Blowdown or tower bleed which flows to aquatic systems and drift to the terrestrial landscape carry applied chemicals to locations where natural biota can be damaged through direct poisoning or where toxins can accumulate to potentially detrimental levels as they are transferred through the food chain.

By their nature, microbiocides used to control biological fouling exhibit toxic and environmentally harmful characteristics. Increasingly stringent regulations regarding the composition of discharge streams draw attention to the proper handling and application of these chemicals. The use of non-toxic or environmentally friendly alternatives, when available, is always preferred.

Depending on the characteristics of the system, mechanical cleaning may represent a viable alternative to chemical treatment for control of biofouling and possibly scale deposits. Either brushes or abrasive-surfaced balls can be forced through piping systems to scour away deposits. Additional non-chemical treatment alternatives may also be applicable, as discussed in Options 6 through 10.

#### 4.1.2.2 Option 4. DIAS-Aid Tower Treatment XP-300 --

The chemical scale and corrosion inhibitors currently applied to treated towers at the NAS generally consist of proprietary mixtures of phosphonates, phosphates and molybdated phosphates, nitrites, and polymers, as shown in Table 2. The tendency of these traditional materials to bond with and hold calcium, magnesium and iron is relatively weak and easily interrupted. If the makeup water hardness increases or the cycles of concentration are increased, control of the metallic constituents is lost and scale deposits form. This can be counteracted by additional chemical dosages or a reduction in the cycles of concentration.

A new generation of water treatment products is available which will reportedly enable cooling tower systems to operate effectively with zero bleedoff throughout an entire operating season. DIAS-AID Tower Treatment XP-300, manufactured by DIAS, Incorporated, is an innovative chemical agent designed to control scale and corrosion under virtually any hardness conditions. The MSDS for this compound is included in Appendix F. XP-300 consists of a proprietary mixture of several environmentally-safe, hydrolytically stable chemical compounds that interact synergistically and selectively with calcium, magnesium, and iron ions in solution. The mechanisms for scale and corrosion control include threshold stabilization, sequestration, and crystal modification. In its

concentrated form, XP-300 is an acid-based material. The acid blend has very little effect on the alkalinity of water; at a dilution of 100 ppm in water, the pH is at 6.0. The recommended dosage for cooling tower water treatment applications is approximately 8 ppm. The use of secondary acid is not required for an alkalinity adjustment since the pH level of the treated water has no effect on product performance.

The effectiveness of XP-300 relies on the fact that scale and corrosion are both related to changes in the molecular bonding of heavy metals. In the normal cycle of change which takes place within process equipment, calcium, magnesium and iron ions bond with other elements to form new compounds. XP-300 is stable in water and has a stronger affinity to heavy metals than the other elements these metals normally bond with, resulting in the formation of a strong chemical bond between the molecules of XP-300 and the ions which are otherwise likely to precipitate out as scale. In contrast to the traditional, weaker bonding materials which bond with dissolved minerals at a ratio approaching one to ten, one molecule of XP-300 will bond with over 3,000 molecules of dissolved hardness ions such as calcium, magnesium, and iron. This high bonding ratio allows the system to concentrate minerals to any level and remain clean without requiring the addition of fresh makeup water. In fact, DIAS, Inc. claims that systems treated with XP-300 can operate continuously with zero bleedoff.

The DIAS XP-300 water treatment chemical does not contain a pesticide and no claims are made for the control of existing biological contamination. However, experimentation and extensive field testing performed by DIAS, Inc. have shown that when proper treatment levels are maintained, biological growth does not occur in a clean system. Problems may arise as existing scale deposits are removed from interior surfaces while they are cleaned by XP-300 treatment, exposing trapped algal and microbial spores. Spores existing under these circumstances are usually mature; when exposed to nutrients in the process water, algal spores will create a bloom, and bacteria, fungi, and viral cells will enter a reproductive phase. This process could continue until the system is free of all existing deposits. Once growth is present in a system, it cannot be controlled by adding more XP-300; rather, a biological control substance must be used to correct the situation. Oxidizing agents such as chlorine are normally added for a period of 24 hours to sterilize the system. XP-300 will decompose in the presence of strong oxidizing agents and must be replaced after microbicidal treatment.

An additional problem may arise during the initial phases of treatment with XP-300. Large pieces of scale deposits may break loose from the interior surfaces and plug dispersion holes or spray nozzles. Strainers may require close monitoring during the initial cleanup process if scale deposits are expected to be present in the system.

DIAS, Inc. developed the DIAS-AID formulation several years ago for use in large tower systems. Field and laboratory studies investigating the possibility of operating a system without bleed-off have led to the use of DIAS-AID in small cooling systems. The treatment is poured in at the beginning of the cooling season, the bleed-off is shut down and the system operates with no bleed for the entire season. This procedure is reported to protect the cooling system from corrosion and scale without any continued maintenance, provided the chemical remains at the desired concentration in the system and that biological growth does not develop, as described above. Approximate monthly addition rates can be calculated based on tower size and existing total hardness of the water supply. The desired concentration is approximately 8 ppm.

Based on the relatively low operating concentrations and the minimum or zero bleed rates achievable with DIAS-AID Tower Treatment XP-300, this cooling tower water treatment alternative represents a fairly attractive option for pollution prevention. Although the ingredients are listed as proprietary information, the material is reportedly safe for discharge to the sanitary sewer. However,



as with all cooling tower water treatment chemicals, tower blowdown containing XP-300 should not be discharged directly to the storm sewer. Given the uncertainties surrounding the constituents of XP-300, and the increasingly stringent limitations for contaminants discharged to both sanitary and storm sewer outfalls, this chemical should be administered following the same precautionary guidelines which are applicable to any of the cooling tower water treatment chemicals discussed above, in Sections 2 and 4.1.2.

DIAS tower treatment chemicals are currently used by a number of facilities to treat cooling towers ranging in size from 50 to over 500 tons. The treatment program appears to be operationally and cost effective. Most of the contacted facilities that use this method of treatment reported substantial savings in chemical costs, some by as much as 50 percent (Mr. Robert Johnson, Four Seasons, Provo, UT School Systems, personal communication, 1994.). In addition, makeup water and tower bleed were substantially reduced, in most cases to a "slow drip" and in one instance, at an older tower (1967 vintage), to zero bleed for the entire 5- to 6-month operating season (Mr. Safet Hatic, Hatic Heating, Cincinnati, OH, personal communication, 1994.). Most of the contacted facilities maintained seasonally operated cooling towers associated with comfort cooling systems, and had used DIAS chemicals for periods ranging from 2 to 6 years.

While most facilities reported that they had no problems with microbiological growth as long as the towers were protected from sunlight, one maintenance facility which uses DIAS chemicals on a number of towers ranging in size from less than 50 tons to over 300 tons implied that they have experienced occasional down-time due to fouling. The problems described had been infrequent and were easily overcome with a one-time application of biocide. This particular maintenance facility, in fact, recommended the DIAS chemicals for application on towers which receive little or no attention throughout the operating season (Mr. Peter Gruener, York International Corp., Troy, MI, personal communication, 1994.). A separate facility which operates an older tower reported using a small in-line filter to remove debris which had entered the system's water from a nearby construction site (Mr. Safet Hatic, Hatic Heating, Cincinnati, OH, personal communication, 1994.).

#### 4.1.2.3 Option 5. pH Adjustment--

The problems of scaling and corrosion are related phenomena, both being influenced by the properties of calcium hardness, alkalinity, total dissolved solids, pH, and temperature. Theoretically, these conditions can be controlled so that the water is in equilibrium and neither corrosion nor scaling result. As demonstrated by the Langelier Index, a high pH encourages calcium carbonate scaling, while low pH facilitates corrosion. Adjusting the pH of the water to provide a Stability Index or Langelier Index which is neither scale-forming nor corrosive is one method for stabilization.

Adjustment of pH is generally accomplished by adding acid, typically sulfuric, hydrochloric, or nitric, to sufficiently depress the pH in order to prevent any scaling conditions from developing. Problems associated with this method of scale control are related to the resulting increased corrosivity of the water. Hydrochloric acid tends to increase the corrosion rate more than sulfuric acid, although both hydrochloric and nitric acid allow high salt concentrations in the water because of the greater solubility of chlorides and nitrates. Sulfuric acid is commonly used for pH adjustment. Injection of sulfuric acid converts calcium and magnesium carbonates (carbonate hardness) into the more soluble sulfates, but acid dosages must be monitored to ensure that the concentration of calcium sulfate remains below the saturation level to avoid precipitation and consequently, scale formation. The prevention of scale formation also requires limiting the concentration of total dissolved solids in the system water. This is accomplished by maintaining a controlled continuous bleed or intermittent blowdown of a small portion of the circulating water. Acid requirements can be calculated based on a simple equation which accounts for the composition of the makeup water (including total sulfate concentration, alkalinity, temperature, and operating cycles of concentration).

The acid is usually injected as near as possible to the makeup water intake, and is controlled by an electric motor connected to a pH analyzer installed to the cooling water supply header.

Adjustments in pH must be made based on a given set of environmental conditions at one point in the system, most typically following the makeup water intake point. As the water passes through the system, the environmental conditions may change to some degree and the water may become corrosive or scale forming. Frequent testing should accompany any acid dosing program because the amount of acid used must be limited to maintain some residual alkalinity in the system. Reducing the pH below 7.0 would result in accelerated corrosion. In addition, the essentially soluble compounds of calcium and magnesium formed from acid dosing cause a corrosive condition, requiring close system monitoring. Corrosion inhibitors are often used in conjunction with pH adjustment to stabilize the water. A typical pH adjustment program involves adding sulfuric acid to lower the system pH thereby reducing scaling tendencies. This program should be accompanied by an inorganic or organic/inorganic corrosion inhibitor.

Adjustments in pH can also be made to prevent corrosive tendencies, while being supplemented with chemical additives for scale control. Maintaining a pH of 8 in combination with the addition of polyphosphate for scale control reduces corrosivity and inhibits the conversion of polyphosphate to the relatively ineffective orthophosphate form. Combinations with zinc introduce a problem with respect to the stabilization of the zinc ion in soluble form at high pH.

One environmentally attractive option involves adjusting the pH and composition of the water to deposit an eggshell layer of calcium carbonate, which would protect the underlying metal from corrosion without interfering excessively with heat transfer or water flow. Temperature variations in the system result in variable composition of the water, however, preventing uniform protection of the metal and allowing some sections to be subjected to heavy scale deposits. Additionally, surface and water conditions often lead to the deposition of a porous layer of calcium carbonate, instead of the desirable eggshell film. The porous layer significantly reduces heat transfer and promotes localized corrosion (Encyclopedia of Chemical Technology, Volume 24, 1984). For these reasons, this method of treatment has generally been unsuccessful.

In theory, cooling tower water treatment through pH adjustment represents a fairly attractive alternative, since this method of treatment avoids the addition of organic and inorganic contaminants potentially present in conventional water treatment chemicals. The tower blowdown should neither be high in acidity (corrosive) nor alkalinity (scale-forming), and should be safe for discharge. In practice, however, this method requires a high degree of system monitoring to maintain the pH within a relatively narrow, ideal range for proper operation. The potential for inadequate treatment is significant, due to the narrow range of acceptable operating parameters and variations at different points within the system. As discussed above, a typical pH adjustment scheme involves the addition of supplemental chemicals for control of scale deposits and corrosion.

#### 4.1.3 Non-Chemical Treatment Alternatives

Non-chemical methods for cooling tower water treatment typically involve the application of physical mechanisms to control corrosion, scale deposits, and biological fouling. The treatment technologies described below vary widely in terms of cost effectiveness and reliability. In addition, some of the treatment technologies may primarily apply to only a certain type of problem, either scale, corrosion, or biofouling, and may not represent a comprehensive treatment program. However, all of the non-chemical treatment alternatives minimize the generation and discharge of contaminants since the addition of chemicals is avoided.

#### 4.1.3.1 Option 6. Zeolite or Base Exchange and Ion Exchange Processes--

Non-chemical methods of water softening can be used to control scale deposits by removing dissolved mineral components while simultaneously avoiding some of the undesirable consequences associated with chemical softening techniques such as high salt concentrations and increased corrosivity. Zeolite or base exchange and ion exchange processes are based on the exchange of harmful constituents in the water for less harmful components. A softening plant of this type requires careful consideration of the quality of water entering the softener because the bed of exchange material will be adversely affected by the presence of suspended and dissolved solids which may precipitate from solution. Also, depending on the characteristics of the intake water, the soft water produced may be somewhat corrosive in nature and the system may require additional corrosion protection. High bicarbonate concentrations in the makeup water will cause a rapid increase in alkalinity subsequent to passage through the exchange bed.

Although they eliminate the discharge of treatment chemicals, zeolite and ion exchange processes are generally quite expensive and require a significant power source for operation. Additionally, these units are used for scale control only and may increase the risk of corrosion.

#### 4.1.3.2 Option 7. KDF Process--

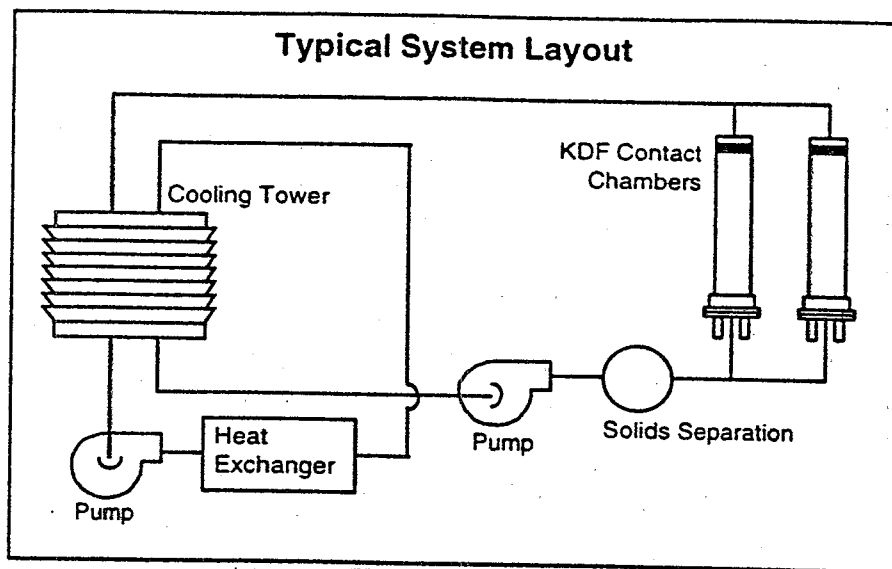
As part of an innovative, non-chemical approach to cooling tower water treatment, Water Equipment Technologies (WET) has developed a process which utilizes a metallic alloy for the control of corrosion, scaling, and biological fouling (Stenger and Dobbs, 1993). The alloy consists of a special formulation of copper and zinc, and is referred to as "KDF" (kinetic degradation flux). The KDF process takes advantage of the difference in electrical potential (Eh) between zinc and copper. The Eh for zinc is -0.76 millivolts, and the Eh for copper is +0.34 millivolts. When sufficient surface area of the alloy is exposed to water, a redox reaction occurs between the dissimilar metals, with zinc acting as the anode and copper acting as the cathode. The resulting electro-chemical reactions and the rise in pH supposedly provide a water treatment process which controls the formation of hardness scale, biofilm development, chlorine removal, and ionic heavy metal reductions.

Chlorine is removed through its conversion to zinc chloride. Heavy metals are removed by plating out onto the copper sites. Corrosion inhibition is achieved because zinc ions in solution are available and react with corrosive ions. Biofilm accumulation and bacterial growth are controlled by the formation of hydroxyls, or OH radicals, formed when some of the water reacts with zinc ( $\text{Zn} + 2\text{H}_2\text{O} = \text{Zn}(\text{OH})_2 + \text{H}_2$ ). These hydroxyls, along with redox shock occurring as a result of the electrochemical reactions between the metallic copper and zinc ions, are believed to interfere with the normal cellular activity of bacteria and algae. Microorganisms are generally limited to survival within a relatively small range of redox potential. The passage of water through KDF causes a rapid and reversible reduction in Eh of about 500 millivolts, which results in a disruption of electron transport mechanisms, possibly causing subsequent damage to the microbial cell walls.

The scale reduction phenomena associated with the redox process media is a function of the source water quality, pH, total dissolved solids, bactericidal properties of the media, and the change in redox potential between the untreated source and the redox-media treated water. It is possible that a shift to a reducing environment disrupts the formation of the crystalline structure of the mineral constituents. Previously deposited insoluble calcium and magnesium salts are gradually removed by continuous contact with redox-treated water. The electrochemical reactions interfere with the crystalline structure of limescale, resulting in the formation of a powdery scale when the water dries in the splash areas of cooling towers, and no scale deposits on the heat transfer surfaces. Additionally, the KDF media controls scale formation by inhibiting biofilm formation, since

biofilm formations provide the mucilage that allows mineral precipitates to adhere to surfaces and thus accelerates the formation of scale deposits.

KDF is manufactured with varying proportions of pure copper and zinc, depending on the application, in several forms including granules, filament or wool, wire or brush, and powder. The KDF wool, where the refined alloy is formed into strands or filament, is used in recirculating loops and lends itself to cooling tower applications. KDF wool cooling tower treatment equipment is available in two types of configurations, depending on the requirements of the cooling tower. One configuration uses plastic modules that contain the KDF wool. The modules float in the splash area of the tower, providing economical treatment by utilizing the hydraulics of the system. A second design uses KDF wool contact chambers in an external side stream loop to recirculate the tower water through the KDF wool. Figure 7 shows a typical system layout for the KDF treatment system.



**Figure 7. Typical System Layout for the KDF Water Treatment System**

A separator is recommended to filter the hard scale and solids removed from the tower and piping system by the KDF wool. Pre-filtration in the 50 micron range is strongly recommended to reduce sediment loading of the KDF wool media. Recirculating cooling tower water passes first through a prefilter for solids removal, and then through a KDF wool contact chamber placed next to and outside the cooling tower water basin, before flowing back into the basin of the cooling tower. Contact chambers are constructed of corrosion resistant Schedule 80 PVC material, secured by victaulic coupling, and supported by heavy duty aluminum support legs. The chambers hold replaceable KDF wool cartridges. Contact chambers can be manifolded for obtaining flow rates of up to 300 gpm. Each chamber has a maximum flow rate of 15 gpm. Each contact chamber measures 13.5" x 13.5" x 58", and weighs 78 pounds.

The following factors affect performance of KDF wool systems:

- Increased contact time improves performance.
- Water should not exceed pH 8.5.
- Warmer water temperatures result in more reactive performance; cool temperatures reduce performance.
- Higher total dissolved salt concentrations result in better performance.
- Sequestering agents for preventing corrosion or scale should not be used in front of the KDF media.
- KDF Redox Wool can be cleaned and restored to active life by rinsing in low pH water. The media should be rinsed with normal fresh water after it has been restored.
- KDF Redox media should not be allowed to dry out after becoming wet.

The performance life of KDF wool will vary, depending on characteristics of the system and the fresh makeup water, but it typically lasts a year or longer provided that the water coming in contact with the media is under a pH of 8.5. Based on studies conducted at 12 Florida test sites, the average performance life of KDF wool, when applied to systems using Florida water, is approximately 6 months. Exposure to air significantly shortens KDF performance life, as will sediment buildup. Spent material may be recycled through local scrap dealers for metals recovery.

The KDF system has been developed to eliminate the use of cooling tower chemicals, and requires approximately half as many labor hours as a chemical treatment system for operation, monitoring, and maintenance. This is largely because the system is self-regulated by changes in pH. Treatment activity increases when in contact with the lower pH makeup water. The increase in activity serves to raise pH, which tends to stabilize the process until it is exposed to additional makeup water at a lower pH. A rise in the pH to neutral or alkaline conditions helps to protect operating equipment against corrosion. The cost of using KDF on a normal basis for cooling tower treatment is comparable to chemical treatment costs. The normal application rate is approximately 5 pounds of wool for a flowrate of 10 gallons per minute.

A demonstration project was conducted on two existing circular, fiberglass Protec comfort cooling towers located at a mid-sized hotel in Fort Lauderdale, Florida (Stenger and Dobbs, 1993). The two towers were rated at 700 and 225 tons, and were regularly receiving chemical treatment prior to the demonstration project. During the demonstration, the larger tower continued to be chemically treated by a service contractor, while the smaller tower was treated with KDF wool. The KDF and chemically treated cooling towers were then compared for corrosion rates, bacterial growth, and scaling tendencies. Results are somewhat variable, due in large part to mechanical difficulties, vandalism, and severe weather (hurricane) which disrupted system performance. In general, the two towers operated at similar cycles of concentration (approximately 4.5 to 5) and exhibited comparable biofilm development. The KDF system demonstrated slightly enhanced scale control and corrosion inhibition as compared with the chemically treated system.

In 1993 there were approximately 20 cooling systems in operation using this technology. The sites were located in south Florida, Michigan, California, Oklahoma, Sweden, Japan, and mainland China. KDF systems promote pollution prevention through the potential elimination of treatment chemicals which are ultimately discharged to the environment. The primary waste consists of a spent metallic alloy, which may be sold as metal scrap for recycling. However, the KDF systems have had occasional difficulty in providing adequate control of biological fouling. As a result, additional biocide applications may be necessary. These biocides would ultimately be discharged to the environment.

Several facilities in south Florida with the KDF system were contacted and have reported variable results. All of the contacted facilities operate their cooling towers year-round and use them for air conditioning as well as for process cooling operations. Tower sizes range from 100 to 500 tons. Most facilities have used the KDF treatment system for approximately 2 years. None reported the addition of supplemental chemicals, although several facilities have had numerous problems with microbiological fouling. One facility, which operates two 300-ton cooling towers for comfort cooling systems, was reportedly happy with the system but was forced to discontinue use because of excessive fouling. Service contractors had agreed to administer a periodic acid shock to control biological growth. The treatments were never administered and growth continued to clog the system until finally the KDF was removed and traditional chemical treatment resumed (Mr. Richard Conway, Oceantree Condominiums, Singer Island, FL, personal communication, 1994.).

Other facilities reported discontinued use because of excessive growth in the system (Ms. May Ellen, Abe Schwartz Air Conditioning and Refrigeration, West Palm Beach, FL, personal communication, 1994.). However, several of the contacted facilities reported satisfactory results with the system and would recommend this treatment methodology to others (Mr. Don Murray, Capital Bank Property Management Division, North Bay Village, FL; Mr. Richard Needle, Symbiosis Corp., Miami, FL; Mr. Steve Burgroff, Hollywood, Inc., Hollywood, FL, personal communications, 1994.). It is unclear what factors may have contributed to these differences in operating experience. The variability may be due to localized conditions in the water supply. As described above, a makeup water with a pH below 8.5 is necessary for the KDF media to function properly.

Most of the facilities which experienced satisfactory results reported operating costs which were comparable to those associated with traditional chemical treatment programs. In cases where the KDF costs were slightly higher, however, most maintained that they were willing to pay the added costs to avoid the handling and storage problems associated with treatment chemicals.

#### 4.1.3.3 Option 8. Magnetic Applications--

Magnetic devices are currently used for scale and corrosion control at approximately nine hot water boilers and two steam boilers at Naval Base Norfolk. The devices provide effective protection in the absence of chemical treatment, and supposedly provide permanent protection which will minimize maintenance demands and extend the life expectancy of process equipment by reducing scale and corrosion rates. Magnetic boiler feedwater treatment has been in prototype testing aboard the U.S. Coast Guard Cutter (CGC) Mellon since August, 1989, and has functioned effectively in place of boiler water treatment chemicals. In addition to environmental benefits, the need for periodic acid and manual cleaning is eliminated. Once installed, the units are virtually maintenance free and retain their strength indefinitely. Magnetic treatment systems are passive instruments in that they do not require a source of electrical power.

Magnetic water conditioning units consist of magnetic devices which are permanently installed onto the outside of process equipment through which the water travels. When applied to recirculating open-system cooling towers, the units are installed on the makeup water line, the cooling tower return line, and the condenser inlet. Additional units can be installed on the chill water loop for additional protection. The principle on which this treatment technology is that water, which is a natural conductor, will generate electric current when moving through a magnetic field. Many compounds, especially conductive mineral compounds, will dissolve and break down into a smaller particle mass when passing through the magnetic field, and will remain in solution. In addition, the polarity of some molecules will be reversed by passing through the magnetic field. The applied field technology modifies the crystalline structure of the concentrating minerals (calcium carbonate) in the water. The result is similar to that achieved by the chemical crystal-modifier, polymaleic acid. The calcium in this cycled-up system changes into a structurally weak calcite

flake and aragonite form, a talc-like non-adherent powder, which can be removed using bleed-off and separation techniques.

When magnetic water conditioners are installed on an earth-grounded steel pipe, they hold the pipe as the generator's negative field or stator. Liquid flowing through the pipe becomes the positive pole, supplying the electric energy. Not only do the units create a substantial magnetic field, they also generate a measurable flow of electrons into the water as the pipe becomes negatively charged. This flow of electrons results in a continuous, cathodically protected system through which positively charged water flows.

Water is an excellent electrical conductor, and the presence of minerals enhances this characteristic. As groundwater flows by limestone rock, which form the basis for water hardness, the water carries a positive electromagnetic potential with respect to the rock. The difference in potential between water and rock causes mineral salts to dissolve into solution. The water's positive potential increases the saturation capacity for mineral salts, resulting in high levels of dissolved minerals in the form of orthorhombic crystals, creating the characteristics of a hard water.

The difference in potential between water and process equipment is the reverse of that between water and limestone rock. When mineral-rich water enters a piping system, it loses its positive electromagnetic potential as frictional electricity generated by the flow of water through the pipe and causes electrons to be transferred from the water to the pipe. Dissolved minerals precipitate out onto process equipment in the form of rhombic crystals known as scale.

Applying magnetic treatment to water imitates the phenomenon which occurs in the earth when limestone dissolves. When water containing mineral salts flows through a pipe which is equipped with a magnetic water conditioner, the molecules interrupt the lines of force generated by the magnet and create a positive electric current and a positive static charge on the water. The magnetic field amplifies the potential in the water to the point where the potential of the water is greater than that of the process equipment, causing the precipitated minerals to redissolve and remain in solution. Additionally, as the minerals in the water (calcium, iron, magnesium, etc.) pass through the magnetic field and generate a minor electrostatic charge, charged iron particles become a nucleation point for calcium and precipitate out of solution into suspension. This provides a form of corrosion control because the system is able to operate with a higher level of solids and pH and has the natural buffering tendencies associated with this mode of operation.

Additional advantages of magnetic treatment include the lower surface tension of the magnetized water, caused by the polarized water molecules. The performance characteristics of this water are enhanced such that the water performs like soft water without soft water's typical corrosive tendencies and turbidity. The lower surface tension is accompanied by an increased flowrate, resulting in reduced energy consumption and operating costs for the pumping equipment. The magnetically conditioned water will support unprecedented concentrations of dissolved solids, enabling cooling tower systems to operate with higher soluble mineral content and higher cycles of concentration. This results in overall water savings. When combined with filtration and ion exchange processes, magnetized water results in enhanced filtering capabilities because the associations clustering around the suspended particles are broken up as the polarized molecules become aligned. This creates more solvent fluid flow which impregnates the membrane or filter medium more efficiently. The higher impregnation efficiency results in higher filtration efficiency which, when combined with the dissolved scaling properties of the water, maintains filter longevity free of mineral buildup and thereby reduces replacement and maintenance costs.

The following effects are noted by the manufacturer of one type of magnetic water conditioning system which is used at the Naval Base Norfolk:

- The pipe and the water become statically charged. The pipe becomes negative, the water positive.
- The negative pipe receives cathodic protection.
- The water molecule is dipolar with two hydrogen atoms that are positive static charges and an oxygen atom that has a negative static charge.
- Positive hydrogen is attracted to the negative pipe and dissolves any scale or corrosion; hydrogen cannot react with a clean pipe.
- Negative oxygen atoms are repelled by, and cannot corrode, a negative pipe.
- Negative carbonate ions (scale) are also repelled by the negative pipe.
- The ionization action weakens the hydrogen bonding of water molecules, thereby reducing surface tension.
- The ionization action also produces hydroxyl ions.
- The dominant mineral in hard water is calcium carbonate, which forms calcite that interlocks to form hard scale in pipes. Magnetic water conditioners change the morphology of calcium carbonate to aragonite—a fragile, non-scaling, heat-transparent, needle-like form of calcium which does not adhere to piping.
- Aragonite particles are kept in solution. Previously existing corrosion and scale accumulations will be gradually dissolved by the newly formed hydroxyl ions, which clean the pipe walls.
- Magnetic water conditioners repel scale and attract hydrogen which dissolves scale and then forms a hydrogen film, thus protecting the clean pipe against corrosion.
- Positively charged water kills iron algae and other cathodic molds and algae that grow in showers, swimming pools, fountains, lakes, cooling towers, and petroleum fuels.
- Magnetic water conditioners precipitate suspended solids and compress dissolved solids, thereby producing clear water without chemicals or filters and make softening unnecessary.
- When scale and corrosion phenomena are no longer present, there are three significant changes in the system:
  - pH stabilizes, usually in the range of 7.4 to 8.0, due to the reduction of hydrogen;
  - the available oxygen (aerobic activity) increases noticeably; and
  - energy savings occur, because fewer BTUs are required per degree of temperature change due to more effective heat transfer through clean pipes and equipment.

Magnetic water treatment systems eliminate the application and subsequent discharge of water treatment chemicals, representing an attractive alternative for pollution prevention. However,



although some of the literature suggests that magnetic water conditioners will provide complete water treatment for cooling tower applications, in practice they have been ineffective or marginally effective at controlling biological fouling, algae, and biofilm growths (M. Hegy, Water Treatment Technologies, Inc., Naperville, IL, personal communication, 1994.). Mechanisms used for scale and corrosion control are apparently ineffective for controlling biological growth. As a result, the magnetic systems, like other corrosion- and scale-control systems, typically require a supplemental treatment program for controlling biological growth. If a traditional chemical biocide program is instituted, the reduced surface tension of the magnetized water results in substantial reductions in biocide requirements; 20 to 25 percent of the original biocide dosages have been reported as adequate when applied in conjunction with a magnetic water conditioner (M. Hegy, Water Treatment Technologies, Inc., Naperville, IL, personal communication, 1994.). Other possible control techniques include sidestream solids removal, ozone disinfection, and the application of bromine or chlorine in a solid tablet form which is delivered by an automated dispenser.

Magnetic water treatment systems have been successfully applied for control of scale and corrosion at several open-system recirculating cooling towers. More specifically, these units have been used at over 40 installations in the midwestern U.S. as the primary component in an integrated technologies program combining magnetic systems with additional technologies for solids removal and biofouling control. The magnetically treated systems typically operate at cycles of concentration 25 to 50 percent greater than other systems, and they are accompanied by a 75 to 90 percent reduction in the original biocide application rates where traditional biocides are used.

A magnetic treatment system was tested during a demonstration project performed during the 1993 cooling season on three 400-ton recirculating open-system cooling towers located at retail outlets in Illinois and Wisconsin. No chemical additives were applied to any of the three towers, and no additional treatment was provided to control biofouling. All three systems performed effectively, meeting or exceeding the goals of the performance demonstration. Bleed rates were reduced by 50 percent at one location while still operating the system at much higher levels of dissolved solids and conserving makeup water substantially.

Typically, additional equipment will be installed to operate in parallel with the magnetic systems to control biological growth and fouling. Successful treatment has been obtained using centrifugal separators mounted next to the system, through which approximately ten percent of the system flow is passed for solids removal. In areas where microbial growth is particularly problematic, for example in warmer, humid climates, the additional protection is provided by a bromine, chlorine, or iodine float which administers biocide continually at low concentrations on a self-regulating basis. These units are reportedly simple to operate and cost effective.

#### **4.1.3.4 Option 9. Alternative Sterilization Techniques: Ultraviolet Light Treatment, Ozonation--**

Ultraviolet (UV) sterilization lamps provide a non-chemical alternative for control of microbial growth. UV systems are generally uneconomical for large quantities of water, but may represent an attractive option for smaller units. The advantages of UV treatment are that the water undergoes no chemical change, chemical interaction between the water and pipes is not encouraged as in many scale-control techniques, an overdose is impossible, no chemical odor is produced, and the discharge of treatment chemicals to the environment is eliminated. UV treatment is generally more expensive in terms of capital and operating costs than chemical treatment (Gurney and Cotter, 1966), and is reportedly not a very reliable method of treatment (M. Hegy, Water Treatment Technologies, Inc., Naperville, IL, personal communication, 1994.).

Two types of UV lamps are available, including one unit that is contained within a horizontal cylinder which fits into the water pipe, and another that is mounted within an air space and

irradiates its surroundings. The first type of lamp is recommended for cooling tower water treatment applications because the second application may not directly expose all of the water to UV rays and allow some of the water to remain untreated. The lamp contained within a cylinder through which makeup water is passed ensures treatment of all water entering the system. Precautions for operation include regular cleaning of the lamp and adequate removal of suspended solids from the makeup water since organisms protected from UV exposure by suspended matter will not be affected.

Ozone treatment is a relatively new technology that is finding increasing applications in the water treatment industry. Ozone ( $O_3$ ) is an allotropic form of oxygen. It is the second most powerful oxidizing agent known and is several times stronger as an oxidizing agent than chlorine (Echols and Mayne, 1990). In a cooling tower, ozone reacts with the organic debris and microbes to form oxidation products. The oxidation products formed then react with other microbes, fouled surfaces, and scale. Theoretically, ozone controls scale by removing the organic mucinous deposits on which scale forms. Furthermore, the carboxylic and dicarboxylic acids formed from the oxidation of fatty acids in cell membranes react to form scum and chelated complexes which prevent further scaling and assist in removing scale deposits. Corrosion protection is achieved because ozone, like chromate, is a strong oxidizing agent under acidic conditions. Metals react with ozone to form a protective oxide film on the metal surfaces.

For maximum effectiveness, ozone is injected in a loop that is external to the tower and carries the full volume of circulating water. The amount of ozone necessary for treatment is typically on the order of 2 to 3 grams per 100 tons of cooling tower capacity per hour (Echols and Mayne, 1990). Although some studies have demonstrated complete, effective treatment of cooling tower water using ozone alone, the effectiveness of ozone in preventing corrosion and scale formation may be questionable. Ozone has, however, exhibited excellent microbiological control in pilot cooling tower investigations as well as in case studies (Strittmater, et al., 1993). As with UV sterilization, ozone probably does not represent an effective stand-alone cooling water treatment program. Ozone treatment is costly and is recommended primarily for larger cooling tower applications, typically greater than 500 tons. Thus, although the use of ozone minimizes the discharge of water treatment chemicals to the environment, the size limitation alone may eliminate ozone from consideration at the Norfolk NAS since the largest NAS cooling towers are 300-ton units and most of the units are quite small (less than 100 tons).

#### 4.1.3.5 Option 10. Sidestream Treatment--

The primary goal of any cooling tower water treatment program is to minimize the total amount of blowdown and fresh water makeup necessary by operating the tower at the maximum possible cycles of concentration. The practice of sidestream treatment involves the constant treatment of a fraction of the recirculating water to remove dissolved salts and suspended matter. Conventional practice sets the average cycles of concentration at four to six cycles for average water quality. If designed and performed efficiently, sidestream treatment can increase the cycles of concentration to 15 or more, and may even enable the system to operate with zero bleed or blowdown, depending on the scaling tendencies of the makeup water (Spear and Matson, 1984). Sidestream treatment can be cost effective, depending on the fresh makeup water composition and cost. Alternative techniques which may be applied through sidestream treatment are reverse osmosis, ion exchange, softening, electrodialysis, filtration, and centrifuge treatment. As with other non-chemical approaches to cooling tower water treatment, sidestream treatment potentially minimizes the addition and subsequent discharge of cooling tower water treatment chemicals.

Sidestream treatment for solids control is an effective mechanism for controlling suspended solids concentrations and the resultant microbiological fouling, and may eliminate many problems

associated with scale deposits in open recirculating cooling water systems. This technology may be used alone or in conjunction with other types of treatment, depending on the characteristics of the makeup water and the desired operating conditions. Sidestream filters have been used for a number of years for the removal of suspended solids in cooling water. A sidestream filter is a unit which continuously diverts a very small portion of the recirculating water, typically 1 to 10 percent; filters it for particulate removal; and then returns it to the system. Systems are available which automatically back-wash for ease of operation. Commonly used media include sand, anthracite, and combinations of both. A sidestream centrifuge represents a more recent technological development. It operates in a similar manner, except that a centrifuge unit replaces the filter for solids removal. While filtration is capable of removing light-weight particles from the system water, centrifugal separation removes denser particles. These two processes can be performed simultaneously with a combined filtration/centrifuge device known as a "hurricane filter," which has operated successfully to eliminate clogged strainers and fouled condenser coils at a facility in Washington, D.C. Sidestream filtration and centrifuge separation both represent economical methods to effectively reduce suspended solids to a minimum and to control deposits from foulants. Filter or centrifuge flowrates can be calculated with a simple equation that takes into account existing and desired suspended solids concentrations, and water losses due to system blowdown and evaporation.

Sidestream solids removal techniques are often recommended in conjunction with additional scale and corrosion treatment applications, as described above. For example, the KDF process (Option 7) uses a filter for suspended solids removal to enhance the effectiveness of the metallic media. Sidestream solids removal systems are also recommended for use in conjunction with magnetic water conditioners; primarily for control of suspended solids and bacterial growth.

#### **4.1.4 Summary of Options**

Table 6 provides a summary of the 10 options for cooling tower water treatment discussed above. Advantages and disadvantages related to each option are presented.

### **4.2 ANALYSIS OF FEASIBLE ALTERNATIVES**

The treatment alternatives presented in this section have been selected for further analysis based on their potential applications at the cooling towers operating at the NAS. The selections are based on a combination of cost effectiveness, size limitations, reliability and ease of implementation, and concerns over the amount and composition of wastes discharged to the environment through cooling tower blowdown. Four of the options discussed above have been analyzed, including (1) conventional chemical treatment, (2) DIAS-AID tower treatment XP-300, (3) KDF process treatment, and (4) magnetic applications integrated with solids and biofouling control.

TABLE 6. SUMMARY OF TREATMENT OPTIONS: ADVANTAGES AND DISADVANTAGES

Treatment Option		Advantages	Disadvantages
1.	No Treatment	<ul style="list-style-type: none"> <li>● Minimal chemical costs</li> <li>● Minimal discharge of chemicals to environment</li> </ul>	<ul style="list-style-type: none"> <li>● High maintenance demands</li> <li>● Poor system operation</li> <li>● Reduced operating lifetime of equipment</li> </ul>
2.	Continuous Bleed	<ul style="list-style-type: none"> <li>● Minimal chemical costs</li> <li>● Minimal discharge of chemicals to environment</li> </ul>	<ul style="list-style-type: none"> <li>● Excessive water consumption and associated costs</li> </ul>
3.	Conventional Chemical Addition	<ul style="list-style-type: none"> <li>● Fairly reliable method</li> <li>● Several chemical options available for customized treatment</li> </ul>	<ul style="list-style-type: none"> <li>● Treatment can be costly in terms of chemicals purchased and required testing and maintenance</li> <li>● Chemicals may be limited in discharge streams</li> </ul>
4.	DIAS-Aid Tower Treatment XP-300	<ul style="list-style-type: none"> <li>● Recent product which has demonstrated effective treatment</li> <li>● Operates with little or no system bleed</li> <li>● Cost effective, in terms of chemical usage and water savings</li> </ul>	<ul style="list-style-type: none"> <li>● Limited operating experience on which to base level of confidence</li> <li>● Additional intermittent treatment may be needed for control of biological growth</li> </ul>
5.	pH Adjustment	<ul style="list-style-type: none"> <li>● Minimal chemical costs; sulfuric acid an economical choice</li> <li>● Minimal discharge of chemical to environment</li> </ul>	<ul style="list-style-type: none"> <li>● Difficult to maintain adequate control</li> <li>● Undesirable dissolved solids may accumulate in system</li> </ul>
6.	Base Exchange and Ion Exchange Processes	<ul style="list-style-type: none"> <li>● Minimal chemical costs</li> <li>● Minimal discharge of chemical to environment</li> <li>● Produces soft, non-scaling water</li> </ul>	<ul style="list-style-type: none"> <li>● Softened water may be corrosive</li> <li>● Generally quite expensive</li> <li>● Provide scale control only</li> </ul>
7.	KDF Process	<ul style="list-style-type: none"> <li>● Minimal chemical costs</li> <li>● Minimal discharge of chemical to environment</li> <li>● Waste product consists of recyclable metallic alloy</li> <li>● System is self-regulating by responding to changes in pH</li> </ul>	<ul style="list-style-type: none"> <li>● Limited operating experience on which to base a level of confidence</li> <li>● Additional filter unit necessary for solids removal</li> <li>● May cost slightly more than conventional chemical treatment</li> <li>● Operating experience shows inadequate control over microbial growth; dosing with blockde or acid may be necessary to maintain a clean system</li> </ul>
8.	Magnetic Applications	<ul style="list-style-type: none"> <li>● Minimal chemical costs</li> <li>● Minimal discharge of chemical to environment</li> <li>● Lifetime warranty</li> <li>● Minimizes maintenance demands</li> <li>● Effective against scale and corrosion</li> </ul>	<ul style="list-style-type: none"> <li>● Limited operating experience on which to base a level of confidence</li> <li>● Additional sidestream treatment usually necessary for solids removal</li> <li>● Additional control may be required for microbial growth</li> </ul>
9.	Ozonation, U.V. Light Treatment	<ul style="list-style-type: none"> <li>● Minimal chemical costs</li> <li>● Minimal discharge of chemical to environment</li> <li>● Effective Sterilization Techniques</li> </ul>	<ul style="list-style-type: none"> <li>● Generally quite expensive</li> <li>● U.V. limited to small size; ozone limited to larger size units</li> <li>● Not effective against scale or corrosion</li> </ul>
10.	Sidestream Treatment	<ul style="list-style-type: none"> <li>● Effective treatment for solids removal and control of fouling</li> <li>● Minimal chemical costs</li> <li>● Minimal discharge of chemical to environment</li> </ul>	<ul style="list-style-type: none"> <li>● Generally used in conjunction with another treatment method to reduce solids and the potential for microbial growth; not an effective stand-alone treatment methodology</li> </ul>

#### 4.2.1 Base Conditions

Due to the variable nature of activities concerning the NAS cooling towers and difficulty in obtaining tower-specific operations data (*i.e.*, chemical volume and cost data), a base condition or set of conditions has been established to enable the analysis of pollution prevention alternatives. The base condition consists of a hypothetical 100-ton cooling tower with 1,000 gallons of system water which operates at 4 cycles of concentration with a 10°F temperature drop across the unit. The tower operates at 100 percent capacity for 12 hours per day, 6 months per year. The pump recirculation rate is 300 gpm. At these operating conditions, the tower will evaporate water at a rate of 3 gpm; tower bleed is equal to 1 gpm. The total makeup water requirements for the tower are 4 gpm, or 86,400 gallons per month. Base conditions for the analysis, including a description of the cooling tower, the makeup water characteristics, maintenance, and cost assumptions, are included in Table 7. Water and sewer costs presented in the table and used in the analysis represent actual rates paid by Naval Base Norfolk to the City of Norfolk public water supply. Makeup water characteristics are based on information provided by contractors servicing some of the NAS cooling towers, and from the City of Norfolk Public Water Supply, from the most recent quarterly grab sample collected at the 37th Street location.

Subsequent to this one-tower description is an extended base condition which assumes that all 28 cooling towers at the Norfolk NAS operate under similar conditions (*e.g.*, 4 cycles of concentration, 10°F temperature drop, 100 percent capacity for 12 hours per day, 6 months per year). The various tower sizes, as listed in the Master Equipment List, Table 1, have been used to calculate application rates and treatment costs for the four treatment options analyzed in the following sections.

Maintenance costs, including maintenance agreements with treatment specialists and costs implemented by PWC maintenance staff, have not been included as part of the following economic analysis. All four of the options analyzed would require a regular service contract to ensure that the towers are receiving adequate water treatment and maintenance. A small degree of variability may exist in the level of service required by the four different treatment options, for example, the DIAS XP-300 treatment option and the magnetic applications option reportedly minimize system maintenance demands, and the KDF system is said to require as little as half as many operating labor hours as a chemical treatment system. However, since these differences are not quantifiable and are expected to be only slight, they have not been considered as differentiating factors in the analysis.

Similarly, portions of operating equipment were not included in the analysis because these pieces of equipment are considered to be necessary for all of the cooling towers, regardless of the method of treatment applied, and would not contribute differentially to any of the four treatment options analyzed. The equipment included in this assumption consists of solenoid valves and conductivity meters used to control tower bleed and blowdown operations.

#### 4.2.2 Summary of Analytical Results

Table 8 includes summaries of annual operating costs and annualized equipment costs for each of the four treatment options included in the analysis, both for treating a 100-ton tower and for treating all 28 cooling towers at the Norfolk NAS. The results indicate that the DIAS water treatment option is the least costly of the four treatment options primarily due to lower water usage and lower equipment costs. Conventional chemical treatment is more costly than any of the other three alternative treatment technologies primarily due to high water consumption and the use of expensive chemicals. However, the variability among all four options is relatively small while the variability among the three alternatives to conventional chemical treatment is smaller.

**TABLE 7. BASIC ASSUMPTIONS FOR COST ANALYSIS**

<b>Cooling Tower Assumptions*</b>	
Tower Size (ton)	100
Temperature Difference (°F)	10
Operating Capacity (%)	100%
Operating Time (months/year)	6
Hours of Operation/day (hrs/day)	12
Approximate System Water Volume (gallons)	1,000

<b>Makeup Water Characteristics**</b>	
Total Hardness (mg/L)	80
Calcium Hardness (mg/L)	46
pH	6.8
Iron (mg/L)	0.053
Chloride (mg/L)	17.5
TDS (mg/L)	200

**Water Consumption Rates**

GPH Evaporated = size of tower (ton) X 1.8

GPH Bleed = GPH Evaporated/(cycles of concentration - 1)

GPH Makeup = GPH Evaporated + GPH Bleed

**Cost Assumptions**

Cooling Tower Life Expectancy (years)	20
Interest Rate (%)	10%
Water and Sewer Cost (\$/1,000 gallons)	\$3.40

**Equipment Assumption**

Cooling towers are assumed to have equipment in place for tower bleed (solenoid valves and conductivity meters). Therefore, no capital recovery cost is attributed to the purchase of this equipment.

**Maintenance Assumption**

Maintenance costs are assumed to be equal for all treatment options, therefore, these costs are not included in this analysis. Maintenance costs may, however, be somewhat lower for the DIAS and Magnetic systems because of the reportedly lower maintenance demands of these systems.

\* Cooling tower assumptions used to generate the costs for all NAS towers are the same as those used for the 100-ton tower.

\*\* Water characteristics based on information provided by water treatment specialists and the City of Norfolk public water supply (37th Street WTP). Prices are based on current combined water and sewer costs at Naval Base Norfolk.

TABLE 8. ANNUAL COST SUMMARY

Annual Cost Element	Treatment Options							
	Conventional		DIAS		KDF		Magnetic	
	100-ton Tower	All NAS Towers	100-ton Tower	All NAS Towers	100-ton Tower	All NAS Towers	100-ton Tower	All NAS Towers
Water Consumption	\$1,787	\$38,378	\$1,340	\$28,782	\$1,675	\$35,978	\$1,675	\$35,978
Chemical Use	\$956	\$20,526	\$632	\$14,606	\$0	\$0	\$85	\$1,184
Equipment Cost	\$210	\$2,044	\$7	\$201	\$754	\$11,587	\$526	\$14,446
Total Annual Cost	\$2,953	\$60,948	\$1,979	\$43,589	\$2,429	\$47,565	\$2,286	\$51,608

It should be noted that although the DIAS chemical treatment option represents the most economically attractive treatment option, chemical wastes generated by the system are ultimately discharged with tower blowdown. Chemical wastes are generally avoided with the KDF and the Magnetic systems; however, as discussed in Section 4.1.3, additional biocides may be necessary with the KDF system to control biological fouling. Biocide costs have not been considered in the analysis of the KDF treatment system because of their sporadic use.

The annualized costs presented in Tables 8 through 12 have been estimated based on a number of qualifying assumptions, as outlined in Table 7 and Section 4.2.1. Additional variability has been introduced between the four options presented due to the inconsistencies in the types of costs associated with each treatment technology. While the costs for chemical treatment options, including conventional chemical application and DIAS-AID Tower Treatment XP-300, consist largely of the annual costs incurred through chemical purchases, the costs associated with the KDF system and the magnetic application technologies consist largely of one-time capital expenditures with minimal annual operating costs. Capital expenditures have been annualized for the purposes of the current analysis, assuming an appropriate life expectancy for the various pieces of equipment. Since the entire analysis is based on a typical cooling tower life expectancy of 20 years, the life expectancy for all associated equipment is also limited to a maximum of 20 years. Salvage value has not been considered in this analysis.

As a result, options which rely heavily on one-time capital expenditures are closely affected by the assumed equipment lifetime expectancy and may appear more expensive as the cooling tower lifetime expectancy shortens. As a case in point, the magnetic pipe protectors discussed in Section 4.2.6 are guaranteed for the lifetime of the cooling tower. Operating a cooling tower beyond its typical 20 years, as is often practiced, would extend the capital costs for the magnetic units over a greater number of years and thereby reduce the annualized costs accordingly.

Costs and assumptions associated with each of the four treatment options included in the analysis are described in the following sections.

#### **4.2.3 Conventional Chemical Treatment**

The annualized application rates and costs associated with conventional chemical treatment are summarized in Table 9. Chemical application rates and costs are based on the method of treatment currently applied to the cooling towers at buildings SP367, SP254, and SP256. The application rates are primarily based on system size, or tonnage, and thus the estimates for all 28 NAS cooling towers have been obtained by scaling up according to the combined tonnage represented by all of the towers.

Equipment costs are not directly proportional to the number of units being treated. While automated metering equipment, including chemical feed pumps, a 7-day clock, and a controller, is standard for the administration of chemicals to the 100-ton tower, chemicals are administered by a simple drip feeder unit to towers which are smaller than 75-ton capacity. As shown in Table 1, 19 of the 28 NAS cooling towers are 60 tons or less.



**TABLE 9. CONVENTIONAL CHEMICAL TREATMENT ANNUAL COSTS**

	100-ton Tower	All NAS Towers
<b>Water Consumption</b>		
Cycles of Concentration	4	4
GPH Evaporated	180	3,866
GPH Bleed	60	1,289
GPH Makeup	240	5,154
Gallons/yr Consumed	525,600	11,287,260
Annual Water Cost	\$1,787	\$38,377
<b>Chemical Use*</b>		
Biocide Use (quart/100 ton/week)	0.5	0.5
Annual Biocide Consumption (gal)	3.3	70
Biocide Unit Cost (\$/gal)	\$15.00	\$15.00
Annual Biocide Cost (\$)	\$49	\$1,047
Scale/Corrosion Inhibitor Use (quart/100 ton/day)	1	1
Annual Scale/Corrosion Inhibitor Consumption (gal)	46	980
Scale/Corrosion Inhibitor Unit Cost (\$/gal)	\$11.00	\$11.00
Annual Scale/Corrosion Inhibitor Cost (\$)	\$502	\$10,780
Dispersant Use (gal/100 ton/yr)	30	30
Annual Dispersant Consumption (gal)	30	644
Dispersant Unit Cost (gal)	\$13.50	\$13.50
Annual Dispersant Cost	\$405	\$8,699
<b>Equipment</b>		
Chemical Feed Pump Unit Cost**	\$320	\$320
Chemical Feed Pump Quantity	2	18
Life Expectancy of Chemical Feed Pump (years)	10	10
Net Present Value - Chemical Feed Pump	\$887	\$7,981
Drip Feeder Unit Cost***	N/A	\$25
Drip Feeder Quantity	N/A	38
Life Expectancy of Drip Feeder (years)	N/A	10
Net Present Value - Drip Feeder	N/A	\$1,316
7-day Clock Unit Cost	\$125	\$125
7-day Clock Quantity	1	9
Life Expectancy of 7-day Clock (years)	10	10
Net Present Value - 7-day Clock	\$173	\$1,559
Controller Unit Cost	\$525	\$525
Controller Quantity	1	9
Life Expectancy of Controller (years)	10	10
Net Present Value - Controller	\$727	\$6,547
Total Annualized Equipment Cost	\$210	\$2,044
<b>Annual Conventional Chemical Treatment Cost</b>	<b>\$2,953</b>	<b>\$60,948</b>

\*Based on chemicals used to treat cooling towers associated with buildings SP367, SP254, and SP256.

\*\*Chemical feed pumps are assumed to be used on cooling tower units equal to or larger than 75 tons.

\*\*\*Drip feeders are assumed to be used on cooling tower units smaller than 75 tons.

The total annual costs of conventional chemical treatment for the 100-ton tower and for all 28 NAS cooling towers are \$2,953 and \$60,954, respectively. In addition to costs, the total annual consumption of biocide, scale and corrosion inhibitor, and dispersant is included in Table 9. Consumption rates for the three types of treatment chemicals when applied to all 28 NAS cooling towers total 70, 140, and 644 gallons per year, respectively. As described above, this treatment option would result in the discharge of these total amounts of chemicals to the environment through the cooling tower blowdown.

#### 4.2.4 DIAS-Aid Tower Treatment XP-300

The annualized application rates and costs associated with DIAS-AID Tower Treatment XP-300 are summarized in Table 10. Application rates are based on recommended dosage rates provided by representatives of DIAS, Incorporated. The general application rate recommended for makeup waters up to 300 ppm hardness is 2 gallons per 100 tons per month; however, based on conditions of the Norfolk NAS makeup water, specifically 80 ppm hardness, the recommended site-specific application rate was actually 0.5 gallons per 100 ton per month. A conservative estimate of 1 gallon per 100 ton cooling tower capacity per month was chosen for use in this analysis. The one-time application of an additional 2 gallons of DIAS-AID XP-300 is recommended for each tower at start-up.

The total chemical consumption rate for DIAS XP-300 treatment of all 28 NAS cooling towers is 185 gallons per year at an annual cost of \$14,606. This represents a substantial savings over the consumption rates and costs associated with conventional chemical treatment, which total approximately 854 gallons per year at an annual cost of \$20,526. Additional savings are realized in water costs. Since the DIAS treatment technology operates with little or no bleed, reductions are achieved in the addition of makeup water. For the purposes of this analysis, makeup water requirements have been estimated to account for tower evaporative losses only. The actual water consumption rates may increase slightly with an increased tower bleed, although representatives of DIAS, Inc., support the assumption that a zero tower bleed can be achieved with XP-300 treatment. It should be noted, in addition, that the installation of a separate metering system which would enable separate billing for water and sewer rates at the NAS cooling towers would result in further savings, since sewer charges would be eliminated from the makeup water costs. Norfolk city water supply prices are currently \$1.34/1000 gallons, while the combined water and sewer price is \$3.40/1000 gallons.

DIAS-AID Tower Treatment XP-300 represents an attractive option for cooling tower water treatment. The technology is economically attractive when compared to conventional chemical treatment, and represents a substantial reduction in the amount of wastes discharged to the environment through cooling tower blowdown. However, although wastes are reduced, this option does generate wastes which are supposedly safe for discharge to the sanitary sewer but whose composition is uncertain because of the proprietary mixture involved. The MSDS for DIAS-AID Tower Treatment XP-300 is included as Appendix F.

**TABLE 10. DIAS-AID TOWER TREATMENT XP-300 ANNUAL COSTS**

	100-ton Tower	All NAS Towers
<b>Water Consumption</b>		
Cycles of Concentration*	N/A	N/A
GPH Evaporated	180	3,866
GPH Bleed	Negligible—All DIAS users contacted stated that they operate with zero or minimal bleed off.	
GPH Makeup	180	3,866
Gallons/yr Consumed	394,200	8,465,445
Annual Water Cost	\$1,340	\$28,783
<b>Chemical Use</b>		
DIAS Use	2 gal at start-up + 1 gal/100 ton/month**	
Annual DIAS Consumption (gal)	8	185
DIAS Unit Cost (\$/gal)	\$79.00	\$79.00
Annual DIAS Cost	\$632	\$14,606
<b>Equipment</b>		
Pump Dispenser Unit Cost	\$61	\$61
Pump Dispenser Quantity	1	28
Life Expectancy of Pump Dispenser*** (years)	20	20
Total Annualized Equipment Cost	\$7	\$201
<b>Annual DIAS Chemical Treatment Cost</b>	<b>\$1,979</b>	<b>\$43,589</b>

\* Cycles of concentration do not apply to the DIAS-Aid system due to zero bleed.

\*\* The recommended usage rate for hardness levels up to 300 ppm is 2 gallons/100 ton/month; however, for the relatively soft water (hardness-80 ppm) used at NAS, the recommended usage rate is 1/2 gallon/100 ton/month. Therefore, 1 gallon/100 ton/month is a conservative estimate.

\*\*\* Pump life expectancy is based on proper pump use (i.e., for DIAS chemicals only). The use of other materials in this pump may significantly reduce its expected lifetime.

#### 4.2.5 KDF Process

Annual treatment costs for the KDF process are summarized in Table 11. Since this treatment technology does not typically include the addition of chemicals, costs consist of annual water consumption and annualized equipment costs for the KDF media and associated equipment. Costs include the KDF unit and associated KDF media cartridges. Replacement cartridges cost \$188 each for ten units and \$125 each for a purchase of 26 or more. A prefilter unit for solids removal is included in the associated equipment costs presented, although replacement filter cartridges have not been included in the analysis because the frequency of replacement depends on the site-specific conditions experienced. Installation costs have been estimated to be zero or minimal since NAS on-site personnel should be able to install the new equipment. The equipment costs for the KDF system are based on system volume, in gallons of water. Estimated system volumes for the larger NAS cooling towers were obtained from Naval Base personnel and are presented in Table 1. System volumes for the smaller systems were unavailable. The make and model numbers of representatively sized units were used by KDF personnel to estimate associated system volumes to determine appropriate equipment requirements. Since essentially all of the system volumes are estimated and the cost of replacement filters for solids removal has not been included, the actual sizing of the KDF systems and their associated costs contain some degree of error.

The total chemical consumption rate for DIAS XP-300 treatment of all 28 NAS cooling towers is 185 gallons per year at an annual cost of \$14,606. This represents a substantial savings over the consumption rates and costs associated with conventional chemical treatment, which total approximately 854 gallons per year at an annual cost of \$20,526. Additional savings are realized in water costs. Since the DIAS treatment technology operates with little or no bleed, reductions are achieved in the addition of makeup water. For the purposes of this analysis, makeup water requirements have been estimated to account for tower evaporative losses only. The actual water consumption rates may increase slightly with an increased tower bleed, although representatives of DIAS, Inc., support the assumption that a zero tower bleed can be achieved with XP-300 treatment.

The KDF system may reduce the consumption of makeup water and associated costs. Although the cycles of concentration for operating a system treated with KDF media may be increased over a system treated with conventional chemicals, the actual ability of KDF treatment to achieve an increase in cycles of concentration remains unclear. However, based on the site-specific conditions of the Norfolk NAS cooling tower makeup water, the towers are expected to operate at 5 cycles of concentration when the KDF treatment system is applied. This represents a 25 percent increase in cycles of concentration over the operating cycles estimated for conventional chemical treatment.

Annualized costs for the KDF treatment system are \$2,430 for the 100-ton tower and \$47,750 for treatment of all 28 NAS cooling towers. As described above, the costs are based on estimated system volumes and do not include the costs for replacement filters used for solids removal; therefore, there is some degree of error associated with these costs. The KDF equipment vendor indicated that the capital equipment cost for all 28 NAS towers may represent an overestimate because some of the smaller cooling tower units may not require full-sized KDF equipment.

**TABLE 11. KDF TREATMENT ANNUAL COSTS**

	100-ton Tower	All NAS Towers
<b>Water Consumption</b>		
Cycles of Concentration	5	5
GPH Evaporated	180	3,866
GPH Bleed	45	966
GPH Makeup	225	4,832
Gallons/yr Consumed	492,750	10,581,806
Annual Water Cost	\$1,675	\$35,978
<b>Chemical Use</b>		
None	N/A	N/A
<b>Equipment*</b>		
KDF Equipment Capital Cost**	\$2,759	\$43,062
Life Expectancy of KDF Equipment (years)	10	10
Net Present Value-KDF Equipment	\$3,823	\$59,665
KDF Media Cartridge Unit Cost	\$125	\$125
Quantity of KDF Media Cartridges	2	30
Life Expectancy of KDF Media Cartridge*** (months)	9	9
Net Present Value-KDF Media Cartridge	\$2,599	\$38,982
Installation Cost	\$0	\$0
Total Annualized Equipment Cost	\$754	\$11,587
<b>Annual KDF Treatment Cost</b>	<b>\$2,430</b>	<b>\$47,565</b>

- \* Equipment costs are based on system volume (gallons) as quoted by equipment vendor.
- \*\* The capital equipment cost for all NAS towers may be an overestimate because some of the smaller units at the NAS may not require full size KDF equipment.
- \*\*\* KDF media cartridge life expectancy varies with the makeup water characteristics. The best/worst case scenario is a 12/6 month life; therefore, a 9 month life was chosen for this analysis.

The annualized costs for the KDF treatment system represent a 15 to 20 percent savings over the cost of conventional chemical treatment, and a 10 to 20 percent increase above the cost of applying DIAS-AID Tower Treatment XP-300. However, unlike the DIAS-AID chemical application, the KDF system uses no chemicals and thus produces no wastestream, other than spent metallic alloy which can be sold as metal scrap for recycling. Based on operating experience discussed in Section 4.1.3, biological fouling can be a problem with systems using the KDF treatment technology. As a result, additional biocide may be needed on an occasional basis to control fouling. The associated costs of biocide treatment, along with the additional wastestreams produced, cannot be quantified since the use of biocide would be variable and unpredictable. However, the potential use of additional biocide can be qualitatively considered to make this treatment alternative less attractive, both economically and for pollution prevention.

#### **4.2.6 Magnetic Applications Integrated with Solids and Biofouling Control**

Equipment requirements and annualized costs for equipment, water consumption, and chemical use associated with the proposed magnetic applications technology are presented in Table 12. Equipment costs include magnetic pipe protectors, sidestream centrifuge separators for solids removal, an optional bromine dispenser for control of biological fouling, and a one-time installation fee. Equipment requirements are based primarily on tower size, although for the smaller units a direct correlation cannot be made since a minimum number of units is required to service each unit. A discount has been applied to the installation fee when considering the application of all 28 NAS cooling towers. Additional savings in installation costs could be realized by contracting PWC maintenance personnel to perform the installation activities. Installation costs for all 28 NAS cooling towers total \$11,620, which represent 80 percent of the total annualized equipment costs.

Consumption of makeup water is based on the reported ability of the magnetic treatment application system to increase the operating cycles of concentration by 25 to 50 percent. For the purposes of this analysis, a conservative estimate of 25 percent has been assumed, which reduces the makeup water requirements and associated costs relative to those associated with conventional chemical treatment.

Bromine application at low concentrations (0.25 to 0.5 ppm) by means of a bromine float has been suggested as an optional method for control of biological fouling, although this is not considered standard equipment and is usually applied only in situations which are particularly susceptible to fouling problems. This option was included here to provide an all-encompassing treatment technology, and to remain conservative in suggesting alternatives to chemical treatment. Annual costs for the bromine float have been estimated based on tower size and required dosage rates, and do not consider limitations due to minimum requirements for shipment volumes. If it is determined that the additional protection is unnecessary, elimination of the bromine float and associated equipment would slightly reduce the annualized costs.

The total annualized costs for the proposed magnetic treatment technology option are \$2,286 for the 100-ton unit, and \$51,609 for treating all 28 NAS towers. As described in Section 4.2.2, the annualized costs for the magnetic treatment unit may be slightly inflated by assuming a 20 year lifetime expectancy for the cooling tower; since the magnetic units are guaranteed for the lifetime of the cooling tower, extending the lifetime beyond 20 years would reduce the estimated annualized costs accordingly. These costs may be additionally inflated by including the full installation costs, which may not be applicable in this case since PWC personnel may be available for equipment installation.

**TABLE 12. MAGNETIC TREATMENT ANNUAL COSTS**

	100-ton Tower	All NAS Towers
<b>Water Consumption</b>		
Cycles of Concentration	5	5 (25% > than normal)
GPH Evaporated	180	3,866
GPH Bleed	45	966
GPH Makeup	225	4,832
Gallons/yr Consumed	492,750	10,581,806
Annual Water Cost	\$1,675	\$35,978
<b>Chemical Use</b>		
Annual Bromine Float Consumption*	10	156 lb
Bromine Fleet Annual Cost	\$85	\$1,184
<b>Equipment</b>		
Pipe Protector Unit Cost (Supply & Return Line)	\$975	\$975
Pipe Protector Quantity (Supply & Return Line)	3	84
Life Expectancy of Pipe Protector (years)	20	20
Pipe Protector Unit Cost (Makeup Line)	\$375	\$375
Pipe Protector Quantity (Makeup Line)	1	28
Life Expectancy of Pipe Protector (years)	20	20
Centrifuge Separator Unit Cost	\$295	\$295
Centrifuge Separator Quantity	1	28
Life Expectancy of Centrifugal Separator (years)	5	5
Net Present Value—Centrifuge Separator	\$663	\$18,551
Bromine Dispenser Unit Cost	\$15	\$15
Bromine Dispenser Quantity	1	28
Life Expectancy of Bromine Dispenser (years)	20	20
Installation Cost	\$500	\$11,620
Total Annualized Equipment Cost	\$526	\$14,446
<b>Annual Magnetic Treatment Cost</b>	<b>\$2,286</b>	<b>\$51,608</b>

\*Bromine float may or may not be necessary for control of biological fouling.

The annualized costs for treatment by magnetic applications technology are largely comparable to the KDF treatment system. Costs for treating the 100-ton tower are slightly lower for the magnetic systems, while the KDF system is more economical when treating all 28 NAS cooling towers. This variability is due largely to volume discounts applied to the KDF system equipment prices. Due to the estimating techniques used to develop costs for each of the technologies, and the questionable nature of installation costs and additional biocide requirements, the difference in costs between the magnetic system and the KDF technology is negligible. The magnetic system costs are 20 to 30 percent lower than the costs for conventional chemical treatment and 15 to 18 percent higher than the costs associated with the DIAS-AID chemical treatment program.

As with the KDF system, the magnetic treatment application represents a slightly more expensive treatment option than the DIAS chemical option but may be more attractive for pollution prevention because of the reduction in wastes generated by this process. The proposed treatment system, including the bromine float, would discharge approximately 10 pounds per year of bromine into the 100-ton cooling tower water, or 150 pounds per year into all 28 NAS cooling towers. These bromine wastes may potentially be eliminated depending on site-specific conditions experienced at the Naval Base Norfolk.

#### **4.3 RECOMMENDATIONS FOR FURTHER RESEARCH**

Based on the research performed as part of this PPOA, and based on the results of the analysis presented above, further investigation is recommended. The treatment technologies described in Section 4.2 all represent potential alternatives to conventional chemical treatment. All three options, including the DIAS-AID Tower Treatment XP-300, the KDF process, and the magnetic treatment application combined with integrated technologies, are attractive economically as well as for pollution prevention. Recommendations for further research include site visits to facilities which employ each of these three types of treatment technologies in order to gather operating data and to observe the systems in operation. Additional information gained through site visits would be used to select an appropriate technology option to be used in a demonstration project designed to evaluate the potential for effectively treating the NAS cooling tower water systems.



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**SECTION 6**  
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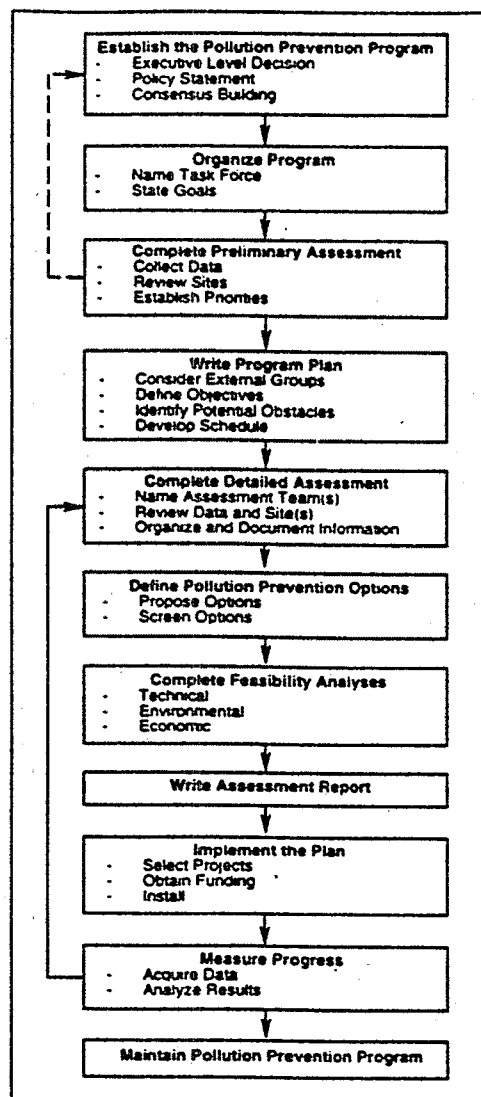
**APPENDIX A**  
**PPOA WORKSHEETS**

Firm <u>Naval Base Norfolk</u>	Pollution Prevention Assessment Worksheets	Prepared By <u>Bowman</u>
Site <u>Norfolk, Virginia</u>		Checked By <u>DeWaters</u>
Date <u>June 20-22, 1994</u>	Proj. No. <u>01645-0111-00008</u>	Sheet <u>1</u> of <u>1</u> Page <u>  </u> of <u>  </u>

**WORKSHEET**

**1**

**ASSESSMENT OVERVIEW**



Firm <u>Naval Base Norfolk</u>	Pollution Prevention Assessment Worksheets	Prepared By <u>Bowman</u>
Site <u>Norfolk, Virginia</u>		Checked By <u>DeWaters</u>
Date <u>June 20-22, 1994</u>	Proj. No. <u>01645-0111-00008</u>	Sheet <u>1</u> of <u>1</u> Page <u>  </u> of <u>  </u>
<div> <div>WORKSHEET 2</div> <div>SITE DESCRIPTION</div> </div>		
Firm: U.S. Navy		
Plant: Naval Base Norfolk		
Department: Naval Air Station		
Area:		
Street Address:		
City:		
State/Zip Code: Norfolk, VA		
Telephone: (205) 639-6451		
Major Products:		
SIC Codes:		
EPA Generator Number:		
Major Unit:		
Product or Service:		
Operations: Management, support, and maintenance of facilities, equipment, and personnel		
employed in U.S. Naval operations		
Facilities/Equipment Age: Variable		

Firm <u>Norfolk Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	<b>Pollution Prevention Assessment Worksheets</b>  Proj. No. <u>10645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>1</u> of <u>2</u> Page <u>  </u> of <u>  </u>				
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="border: 1px solid black; padding: 5px; text-align: center;"> <b>WORKSHEET 3</b> </div> <div style="border: 1px solid black; padding: 5px; text-align: center;"> <b>PROCESS INFORMATION</b> </div> </div>						
Process Unit/Operation: <b>CHEMICALLY TREATED COOLING TOWERS (SP367, SP254, SP256, V53, SP29, V16, SP45, SP81)</b>						
Operation Type: <input type="checkbox"/> Continuous <input checked="" type="checkbox"/> Discrete <input type="checkbox"/> Batch or Semi-Batch <input type="checkbox"/> Other _____						
Document	Status					
	Complete? (Y/N)	Current? (Y/N)	Last Revision	Used in this Report (Y/N)	Document Number	Location
Process Flow Diagram	Y	Y		Y		
Material/Energy Balance						
Design	Y	Y		Y		
Operating	Y	Y		Y		
Flow/Amount Measurements						
Stream water flow	N					
Analyses/Assays						
Stream water quality	Y	Y		Y		
Process Description	Y	Y		Y		
Operating Manuals	N					
Equipment List	Y	Y		Y		
Equipment Specifications	Y	Y		Y		
Piping and Instrument Diagrams	N					
Plot and Evaluation Plan(s)	N					
Work Flow Diagrams	N					
Hazardous Waste Manifests	N					
Emission Inventories	N					
Annual/Biennial Reports	N					
Environmental Audit Reports	N					
Permit/Permit Applications	Y	Y		Y		
Batch Sheet(s)	N					
Materials Applications Diagrams	N					
Product Composition Sheets	N					
Material Safety Data Sheets	Y	Y		Y		
Inventory Records	Y	Y		Y		
Operator Logs	N					
Production Schedules	Y	Y		Y		

Firm <u>Norfolk Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	<b>Pollution Prevention Assessment Worksheets</b>  Proj. No. <u>10645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>2</u> of <u>2</u> Page <u>  </u> of <u>  </u>
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<b>WORKSHEET 3</b>	<div style="border: 1px solid black; padding: 2px; display: inline-block;"> <b>PROCESS INFORMATION</b> </div>
------------------------	---------------------------------------------------------------------------------------------------------------

Process Unit/Operation: <b>UNTREATED COOLING TOWERS (LP13, LP2, LP3, LP4, S33, SP238, SP64, T26, U48, V82)</b>	
Operation Type: <input type="checkbox"/> Continuous <input checked="" type="checkbox"/> Discrete <input type="checkbox"/> Batch or Semi-Batch <input type="checkbox"/> Other _____	

Document	Status					
	Complete? (Y/N)	Current? (Y/N)	Last Revision	Used in this Report (Y/N)	Document Number	Location
Process Flow Diagram	Y	Y		Y		
Material/Energy Balance						
Design	Y	Y		Y		
Operating	Y	Y		Y		
Flow/Amount Measurements						
Stream	N					
Analyses/Assays						
Stream	N					
Process Description	Y	Y		Y		
Operating Manuals	N					
Equipment List	Y	Y		Y		
Equipment Specifications	Y	Y		Y		
Piping and Instrument Diagrams	N					
Pilot and Evaluation Plan(s)	N					
Work Flow Diagrams	N					
Hazardous Waste Manifests	N					
Emission Inventories	N					
Annual/Biennial Reports	N					
Environmental Audit Reports	N					
Permit/Permit Applications	Y	Y		Y		
Batch Sheet(s)	N					
Materials Applications Diagrams	N					
Product Composition Sheets	N					
Material Safety Data Sheets	N					
Inventory Records	N					
Operator Logs	N					
Production Schedules	Y	Y		Y		

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets  Proj. No. <u>01645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>1</u> of <u>1</u> Page <u>  </u> of <u>  </u>
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<b>WORKSHEET</b> <b>4</b>	<div style="border: 1px solid black; display: inline-block; padding: 2px 10px;"> <b>INPUT MATERIALS SUMMARY</b> </div> <b>SEE SECTION 3, TABLE 2</b>
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Attribute	Description		
	Stream No. <u>      </u>	Stream No. <u>      </u>	Stream No. <u>      </u>
Name/ID			
Source/Supplier			
Component/Attribute of Concern			
Annual Consumption Rate			
Overall			
Component(s) of Concern			
Purchase Price, \$ per <u>      </u>			
Overall Annual Cost			
Delivery Mode <sup>1</sup>			
Shipping Container Size & type <sup>2</sup>			
Storage Mode <sup>3</sup>			
Transfer Mode <sup>4</sup>			
Empty Container Disposal Management <sup>5</sup>			
Shelf Life			
Supplier Would			
- accept expired material? (Y/N)			
- accept shipping containers: (Y/N)			
- revise expiration date? (Y/N)			
Acceptable Substitute(s), if any			
Alternate Supplier(s)			

**Notes:**

1. e.g., pipeline, tank car, 100 bbl tank truck, truck, etc.
2. e.g., 55 gal drum 100 lb paper bag, tank, etc.
3. e.g., outdoor, warehouse, underground, aboveground, etc.
4. e.g., pump, forklift, pneumatic transport, conveyor, etc.
5. e.g., crush and landfill, clean and recycle, return to supplier, etc.



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<b>WORKSHEET</b> <b>5</b>	<b>PRODUCT SUMMARY</b> <b>NO PRODUCTS FROM OPERATION</b>		
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Attribute	Description		
	Stream No. <u>      </u>	Stream No. <u>      </u>	Stream No. <u>      </u>
Name/ID			
Component/Attribute of Concern			
Annual Consumption Rate			
Overall			
Component(s) of Concern			
Annual Revenues, \$ <u>      </u>			
Shipping Mode			
Shipping Container Size & type			
Onsite Storage Mode			
Containers Returnable (Y/N)			
Shelf Life			
Rework Possible (Y/N)			
Customer Would			
• relax specification (Y/N)			
• accept larger containers (Y/N)			

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<b>WORKSHEET</b> <b>6</b>	<b>WASTE STREAM SUMMARY</b>	<b>CHEMICALLY TREATED COOLING TOWERS</b>
------------------------------	-----------------------------	------------------------------------------

Attribute	Description		
	Stream No. <u>      </u>	Stream No. <u>      </u>	Stream No. <u>      </u>
Waste ID/Name:	Bleed water	Bleed water	Bleed water
Source/Origin	Chemical addition	Chemical addition	Chemical addition
Component or Property of Concern	See Table 2	See Table 2	See Table 2
Annual Generation Rate (units/gallons)	34.2	607.6	144.4
Overall	Unknown	Unknown	Unknown
Component(s) of Concern	Biocide	Scale/Corrosion treaters	Dispersant/Antifouling
Cost of Disposal	NA		
Unit Cost (\$ per <u>      </u> )	NA		
Overall (per year)			
Method of Management <sup>1</sup>	POTW/NPDES discharges	POTW/NPDES discharges	POTW/NPDES discharges
Containers Returnable (Y/N)	N	N	N
Priority Rating Criteria <sup>2</sup>	Relative Wt. (W)	Rating (R)	R x W
Regulatory Compliance			
Treatment/Disposal Cost			
Potential Liability			
Waste Quantity Generated			
Waste Hazard			
Safety Hazard			
Minimization Potential			
Potential to Remove Bottleneck			
Potential By-product Recovery			
Sum of Priority Rating Scores		$\Sigma(R \times W)$	
Priority Rank			

Notes: 1. For example, sanitary landfill, hazardous waste landfill, on-site recycle, incineration, combustion with heat recovery, distillation, dewatering, etc.  
 2. Rate each stream in each category on a scale from 0 (none) to 10 (high).

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Site <u>Norfolk, Virginia</u>		Checked By <u>DeWaters</u>
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**WORKSHEET  
6**

**WASTE STREAM SUMMARY**

**CHEMICALLY TREATED COOLING TOWERS**

Attribute	Description		
	Stream No. <u>  </u>	Stream No. <u>  </u>	Stream No. <u>  </u>
Waste ID/Name:	Bleed water		
Source/Origin	Chemical addition		
Component or Property of Concern	See Table 2		
Annual Generation Rate (units <u>gallons</u> )	28.1		
Overall	Unknown		
Component(s) of Concern	Nonacid descaler		
Cost of Disposal			
Unit Cost (\$ per: <u>  </u> )			
Overall (per year)			
Method of Management <sup>1</sup>	POTW/NPDES discharge		
Containers Returnable (Y/N)	N		
Priority Rating Criteria <sup>2</sup>	Relative WL (W)	Rating (R)	R x W
Regulatory Compliance			
Treatment/Disposal Cost			
Potential Liability			
Waste Quantity Generated			
Waste Hazard			
Safety Hazard			
Minimization Potential			
Potential to Remove Bottleneck			
Potential By-product Recovery			
Sum of Priority Rating Scores	$\Sigma(R \times W)$	$\Sigma(R \times W)$	$\Sigma(R \times W)$
Priority Rank			

Notes: 1. For example, sanitary landfill, hazardous waste landfill, on-site recycle, incineration, combustion with heat recovery, distillation, dewatering, etc.  
2. Rate each stream in each category on a scale from 0 (none) to 10 (high).

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<b>WORKSHEET</b> <b>6</b>	<b>WASTE STREAM SUMMARY</b>	
<b>UNTREATED COOLING TOWERS</b>		

Attribute	Description		
	Stream No. <u>NA</u>	Stream No. <u>  </u>	Stream No. <u>  </u>
Waste ID/Name:	Bleed water		
Source/Origin	Chemical addition		
Component or Property of Concern	See Table 2		
Annual Generation Rate (units <u>  </u> )			
Overall	Unknown		
Component(s) of Concern	Biocides		
Cost of Disposal	NA		
Unit Cost (\$ per: <u>  </u> )			
Overall (per year)			
Method of Management <sup>1</sup>	POTW/NPDES discharge		
Containers Returnable (Y/N)	N		

Priority Rating Criteria <sup>2</sup>	Relative WL (W)	Rating (R)	R x W	Rating (R)	R x W	Rating (R)	R x W
Regulatory Compliance							
Treatment/Disposal Cost							
Potential Liability							
Waste Quantity Generated							
Waste Hazard							
Safety Hazard							
Minimization Potential							
Potential to Remove Bottleneck							
Potential By-product Recovery							
Sum of Priority Rating Scores		$\Sigma(R \times W)$		$\Sigma(R \times W)$		$\Sigma(R \times W)$	
Priority Rank							

Notes: 1. For example, sanitary landfill, hazardous waste landfill, on-site recycle, incineration, combustion with heat recovery, distillation, dewatering, etc.  
 2. Rate each stream in each category on a scale from 0 (none) to 10 (high).



**NAVAL BASE NORFOLK  
NORFOLK, VIRGINIA  
PPOA BRAINSTORMING SESSION  
COOLING TOWER OPERATIONS  
6/20/94 TO 6/22/94**

**I. OPPORTUNITIES TO REDUCE WASTE GENERATION**

**A. INPUT MATERIALS**

- Identify areas that appear to be candidates for alteration of current practices to reduce input materials
- Investigate use of alternative systems and materials which are environmentally preferable
- Reduce consumption rates where feasible
- Ensure products are purchased in volumes that do not exceed what will be required before shelf lives expire

**B. WASTE MANAGEMENT**

- Reduce waste water volumes from cooling towers where possible
- Ensure wastewater enters appropriate disposal system (i.e., sanitary sewer system, not NPDES stormwater system)- a contractor for the base may perform this task in the near future
- Recycle and reuse materials where possible (e.g., containers for chemicals used in treatment)

**C. AWARENESS**

- Communicate environmental information and objectives to employees
- Periodic "friendly" inspections of areas to assess environmental status
- Ensure employees understand environmental impacts of all processes and materials
- Allow employees latitude to find environmentally preferable methods to performing business

**II. INVESTIGATION BY PROCESS**

**A. CURRENT COOLING TOWER OPERATIONS**

- Reduce water discharge rates by lowering bleed levels and employing scale, corrosion, and biological control techniques

- Reduce chemical usage at towers to minimal levels, while balancing chemical use against wastewater generation
- Ensure all drainage of wastewater enters appropriate discharge system (i.e., sanitary sewer system, not NPDES stormwater system)- a contractor for the base may perform this task in the near future

#### **B. ALTERNATIVE COOLING TOWER OPERATIONS**

- Identify alternative methods for cooling tower operations. The methods identified were as follows:
  - (1) No treatment
  - (2) Continuous bleed-off or blow down
  - (3) Conventional chemical addition programs
  - (4) DIAS-Aid Tower Treatment XP-300
  - (5) pH adjustment
  - (6) Zeolite or base exchange and ion exchange processes
  - (7) KDF process
  - (8) Magnetic applications
  - (9) Ozonation or ultraviolet treatment
  - (10) Sidestream treatment
- Assess feasibility of four selected processes:
  - (1) Conventional chemical addition programs
  - (2) DIAS-Aid Tower Treatment XP-300
  - (3) KDF Process
  - (4) Magnetic applications
- Recommend processes for demonstration at the Naval Base Norfolk

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<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <b>WORKSHEET</b>  <b>8</b> </div> <div style="border: 1px solid black; padding: 2px;"> <b>OPTION DESCRIPTION</b> </div> </div>		
<b>COOLING TOWER MANAGEMENT OPTIONS</b>		
Option Name: <u>Conventional chemical addition programs</u>		
Briefly describe the option: <u>Addition of biocides, scale, and corrosion inhibitors,</u>		
<u>and dispersants/antifoulants. This reduces water consumption and protects the cooling</u>		
<u>units, but increases chemical consumption and waste generation.</u>		
Waste Stream(s) Affected: <u>Cooling tower discharge water</u>		
Input Material(s) Affected: <u>Chemical treatments listed above.</u>		
Product(s) Affected: <u>NA</u>		
Indicate Type: <input checked="" type="checkbox"/> Source Reduction <div style="margin-left: 40px;"> <input type="checkbox"/> Equipment-Related Change  <input checked="" type="checkbox"/> Personnel/Procedure-Related Change  <input checked="" type="checkbox"/> Materials-Related Change         </div> <div style="margin-left: 40px; margin-top: 10px;"> <input type="checkbox"/> Recycling/Reuse         <div style="display: flex; justify-content: space-between; width: 100%;"> <div> <input type="checkbox"/> Onsite  <input type="checkbox"/> Offsite         </div> <div> <input type="checkbox"/> Material reused for original purpose  <input type="checkbox"/> Material used for a lower-quality purpose  <input type="checkbox"/> Material sold         </div> </div> </div>		
Originally proposed by: <u>TRC</u> Date: <u>6/20-6/22/94</u>		
Reviewed by <u>TRC</u> Date: <u>6/20-6/22/94</u>		
Approved for study? <u>X</u> yes                      no                      By: <u>TRC</u>		
Reason for Acceptance or Rejection <u>Potential option for cooling water treatment</u>		

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets  Proj. No. <u>01645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>4</u> of <u>10</u> Page <u>  </u> of <u>  </u>
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <b>WORKSHEET</b>  <b>8</b> </div> <div style="border: 1px solid black; padding: 2px;"> <b>OPTION DESCRIPTION</b> </div> </div>		
<b>COOLING TOWER MANAGEMENT OPTIONS</b>		
Option Name <b>DIAS-Aid Tower Treatment XP-300</b>		
Briefly describe the option: <b>A chemical treatment that is purported to allow no bleed from small cooling towers and minimal bleed from larger ones and uses low application rates.</b>		
Waste Stream(s) Affected: <b>Cooling tower discharge water</b>		
Input Material(s) Affected: <b>Chemical treatments listed above.</b>		
Product(s) Affected: <b>NA</b>		
Indicate Type: <input checked="" type="checkbox"/> <b>Source Reduction</b> <div style="margin-left: 100px;"> <input checked="" type="checkbox"/> <b>Equipment-Related Change</b>  <input checked="" type="checkbox"/> <b>Personnel/Procedure-Related Change</b>  <input checked="" type="checkbox"/> <b>Materials-Related Change</b> </div> <div style="margin-left: 100px;"> <input type="checkbox"/> <b>Recycling/Reuse</b>  <div style="display: flex; justify-content: space-between; width: 100%;"> <div style="width: 45%;"> <input type="checkbox"/> <b>Onsite</b>  <input type="checkbox"/> <b>Offsite</b> </div> <div style="width: 50%;"> <input type="checkbox"/> <b>Material reused for original purpose</b>  <input type="checkbox"/> <b>Material used for a lower-quality purpose</b>  <input type="checkbox"/> <b>Material sold</b> </div> </div> </div>		
Originally proposed by: <b>TRC</b>		Date: <b>6/20-6/22/94</b>
Reviewed by <b>TRC</b>		Date: <b>6/20-6/22/94</b>
Approved for study? <b>X</b> yes                      no                      By: <b>TRC</b>		
Reason for Acceptance or Rejection: <b>Potential option for cooling water treatment</b>		

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets  Proj. No. <u>01645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>1</u> of <u>10</u> Page <u>  </u> of <u>  </u>
<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <b>WORKSHEET</b>  <b>8</b> </div> <div style="border: 1px solid black; padding: 2px;"> <b>OPTION DESCRIPTION</b> </div> </div>		
<b>COOLING TOWER MANAGEMENT OPTIONS</b>		
Option Name <u>No treatment</u>		
Briefly describe the option: <u>Units are not treated for scale or corrosion, although they may receive a biocide. Units are cleaned with brushes in the off-season.</u>		
Waste Stream(s) Affected: <u>Cooling tower discharge water.</u>		
Input Material(s) Affected: <u>Chemical treatments - scale and corrosion inhibitors, biocides, and dispersants/antifoulants.</u>		
Product(s) Affected: <u>NA</u>		
Indicate Type: <input checked="" type="checkbox"/> <b>Source Reduction</b> <div style="margin-left: 100px;"> <input checked="" type="checkbox"/> Equipment-Related Change  <input checked="" type="checkbox"/> Personnel/Procedure-Related Change  <input checked="" type="checkbox"/> Materials-Related Change         </div> <div style="margin-left: 100px; margin-top: 10px;"> <input type="checkbox"/> <b>Recycling/Reuse</b>  <div style="display: flex; justify-content: space-between; width: 100%;"> <div style="width: 45%;"> <input type="checkbox"/> Onsite  <input type="checkbox"/> Offsite         </div> <div style="width: 45%;"> <input type="checkbox"/> Material reused for original purpose  <input type="checkbox"/> Material used for a lower-quality purpose  <input type="checkbox"/> Material sold         </div> </div> </div>		
Originally proposed by: <u>TRC</u>		Date: <u>6/20-6/22/94</u>
Reviewed by <u>TRC</u>		Date: <u>6/20-6/22/94</u>
Approved for study? <u>X</u> yes <u>  </u> no    By: <u>TRC</u>		
Reason for Acceptance or Rejection <u>Potential option for cooling water treatment</u>		

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets  Proj. No. <u>01645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>5</u> of <u>10</u> Page <u>of</u>
<b>WORKSHEET</b> <b>8</b>	<div style="border: 1px solid black; padding: 2px; display: inline-block;"> <b>OPTION DESCRIPTION</b> </div> <b>COOLING TOWER MANAGEMENT OPTIONS</b>	
Option Name <u>pH Adjustment</u>		
Briefly describe the option: <u>By managing pH levels, scale-forming minerals can be</u>		
<u>kept in solution as salts and corrosivity can be kept in check. Increased acidity can damage</u>		
<u>equipment. Requires high level of monitoring. May require corrosion inhibitors as well.</u>		
Waste Stream(s) Affected: <u>Cooling tower discharge water.</u>		
Input Material(s) Affected: <u>Acid added to cooling water and possible corrosion inhibitors.</u>		
Product(s) Affected: <u>NA</u>		
Indicate Type: <input checked="" type="checkbox"/> Source Reduction <div style="margin-left: 40px;"> <input checked="" type="checkbox"/> Equipment-Related Change  <input checked="" type="checkbox"/> Personnel/Procedure-Related Change  <input checked="" type="checkbox"/> Materials-Related Change         </div> <div style="margin-left: 40px;"> <input type="checkbox"/> Recycling/Reuse         <div style="display: flex; justify-content: space-between; width: 100%;"> <div> <input type="checkbox"/> Onsite  <input type="checkbox"/> Offsite         </div> <div> <input type="checkbox"/> Material reused for original purpose  <input type="checkbox"/> Material used for a lower-quality purpose  <input type="checkbox"/> Material sold         </div> </div> </div>		
Originally proposed by: <u>TRC</u> Date: <u>6/20-6/22/94</u>		
Reviewed by <u>TRC</u> Date: <u>6/20-6/22/94</u>		
Approved for study? <u>X</u> yes <u>no</u> By: <u>TRC</u>		
Reason for Acceptance or Rejection <u>Potential option for cooling water treatment</u>		

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets  Proj. No. <u>01645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>6</u> of <u>10</u> Page <u>  </u> of <u>  </u>
<b>WORKSHEET</b> <b>8</b>	<div style="border: 1px solid black; padding: 2px; display: inline-block;"> <b>OPTION DESCRIPTION</b> </div> <b>COOLING TOWER MANAGEMENT OPTIONS</b>	
Option Name <u>Zeolite or base exchange and ion exchange process</u>		
Briefly describe the option: <u>A water softening process in which harmful water constituents are removed and replaced by less harmful materials. May increase corrosivity.</u>		
Waste Stream(s) Affected: <u>Cooling tower discharge water</u>		
Input Material(s) Affected: <u>Acid added to cooling water</u>		
Product(s) Affected: <u>NA</u>		
Indicate Type: <input checked="" type="checkbox"/> <b>Source Reduction</b> <div style="margin-left: 100px;"> <input checked="" type="checkbox"/> Equipment-Related Change  <input checked="" type="checkbox"/> Personnel/Procedure-Related Change  <input checked="" type="checkbox"/> Materials-Related Change         </div>  <div style="margin-left: 50px;"> <input type="checkbox"/> <b>Recycling/Reuse</b>  <div style="display: flex; justify-content: space-between; width: 100%;"> <div style="width: 45%;"> <input type="checkbox"/> Onsite  <input type="checkbox"/> Offsite         </div> <div style="width: 50%;"> <input type="checkbox"/> Material reused for original purpose  <input type="checkbox"/> Material used for a lower-quality purpose  <input type="checkbox"/> Material sold         </div> </div> </div>		
Originally proposed by: <u>TRC</u>		Date: <u>6/20-6/22/94</u>
Reviewed by <u>TRC</u>		Date: <u>6/20-6/22/94</u>
Approved for study? <input checked="" type="checkbox"/> <b>yes</b> <input type="checkbox"/> <b>no</b> By: <u>TRC</u>		
Reason for Acceptance or Rejection <u>Potential option for cooling water treatment</u>		









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<b>WORKSHEET</b> <b>8</b>		
<div style="border: 1px solid black; display: inline-block; padding: 2px 10px;">OPTION DESCRIPTION</div> <b>COOLING TOWER MANAGEMENT OPTIONS</b>		
Option Name <u>Sidestream treatment</u>		
Briefly describe the option: <u>By diverting a portion of the cooling water from the system and constantly treating it, bleed can be drastically reduced or eliminated. Several treatment processes can be applied to the sidestream, including reverse osmosis, ion exchange, softening, electrodialysis, filtration, and centrifuge treatment. These techniques are normally used in conjunction with another treatment technology.</u>		
Waste Stream(s) Affected: <u>Cooling tower discharge water</u>		
Input Material(s) Affected: <u>Treatment equipment and controls</u>		
Product(s) Affected: <u>NA</u>		
Indicate Type: <input checked="" type="checkbox"/> <b>Source Reduction</b> <input checked="" type="checkbox"/> Equipment-Related Change <input checked="" type="checkbox"/> Personnel/Procedure-Related Change <input checked="" type="checkbox"/> Materials-Related Change  <input type="checkbox"/> <b>Recycling/Reuse</b> <input type="checkbox"/> Onsite <input type="checkbox"/> Material reused for original purpose <input type="checkbox"/> Offsite <input type="checkbox"/> Material used for a lower-quality purpose <input type="checkbox"/> Material sold		
Originally proposed by: <u>TRC</u>		Date: <u>6/20-6/22/94</u>
Reviewed by <u>TRC</u>		Date: <u>6/20-6/22/94</u>
Approved for study? <input checked="" type="checkbox"/> yes <input type="checkbox"/> no                    By: <u>TRC</u>		
Reason for Acceptance or Rejection <u>Potential option for cooling water treatment</u>		

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets  Proj. No. <u>01645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>1</u> of <u>4</u> Page <u>  </u> of <u>  </u>
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<b>WORKSHEET</b> <b>9</b>	<div style="border: 1px solid black; display: inline-block; padding: 2px 10px;"> <b>PROFITABILITY</b> </div> <b>CONVENTIONAL CHEMICAL COSTS - 100 TON TOWER<sup>1</sup></b>
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<b>Capital Costs</b>
Purchased Equipment \$2,580
Materials
Installation
Utility Connections
Engineering
Start-up and Training
Other Capital Costs
<b>Total Capital Costs \$2,580</b>
<b>Incremental Annual Operating Costs</b>
Change in Disposal Costs
Change in Raw Material Costs \$-47 <sup>2</sup>
Change in Other Costs
<b>Annual Net Operating Cost Savings \$-47</b>

Payback Period (in years) =	$\frac{\text{Total Capital Costs}}{\text{Annual Net Operating Cost Savings}}$	$= \frac{XXX^3}{-}$
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<sup>1</sup> Costs are compared to no treatment.

<sup>2</sup> This cost is derived by subtracting annual costs for conventional chemical treatment from annual costs for no treatment. Annual costs for treatment can be found in Table 6. No treatment costs are derived by assuming the tower operates at 2 cycles of concentration. Water and sewer costs are \$0.0034 per gallon of water consumed, with an annual consumption of 788,400 gallons. An annual biocide cost of \$15 is added, assuming 1 gallon of biocide is used annually at \$15 per gallon. This totals \$2,696 annually for no treatment.

<sup>3</sup> Since the incremental annual operating costs for chemical treatment are higher than for no treatment, due to chemical costs, the payback period cannot be calculated for this option. Economic analysis of chemical treatment versus no treatment is not a simple issue, since there are many hidden costs associated with non-treatment which cannot be quantified. An untreated tower requires a high degree of maintenance and service activity related to system clogging and down time; additional biocide and acid chemicals may be required; and the overall lifetime of the unit is likely to be less than 20 years, resulting in increased capital demands incurred by the purchase of a new system.

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>2</u> of <u>4</u> Page <u>  </u> of <u>  </u>
WORKSHEET <b>9</b>		<div style="border: 1px solid black; padding: 2px; display: inline-block;">           PROFITABILITY         </div>
DIAS CHEMICAL TREATMENT - 100 TON TOWER <sup>1</sup>		
<b>Capital Costs</b>		
Purchased Equipment \$61		
Materials		
Installation		
Utility Connections		
Engineering		
Start-up and Training		
Other Capital Costs		
Total Capital Costs \$61		
<b>Incremental Annual Operating Costs</b>		
Change in Disposal Costs		
Change in Raw Material Costs \$724 <sup>2</sup>		
Change in Other Costs		
Annual Net Operating Cost Savings \$724		
Payback Period (in years) = $\frac{\text{Total Capital Costs}}{\text{Annual Net Operating Cost Savings}}$ = <u>0.08<sup>3</sup></u>		
<sup>1</sup> Costs are compared to no treatment.		
<sup>2</sup> This cost is derived by subtracting annual costs for DIAS chemical treatment from annual costs for no treatment. Annual costs for treatment can be found in Table 9. No treatment costs are derived by assuming the tower operates at 2 cycles of concentration. Water and sewer costs are \$0.0034 per gallon of water consumed, with an annual consumption of 788,400 gallons. An annual biocide cost of \$15 is added, assuming 1 gallon of biocide is used annually at \$15 per gallon. This totals \$2,696 annually for no treatment.		
<sup>3</sup> Economic analysis of DIAS chemical treatment versus no treatment is not a simple issue, since there are many hidden costs associated with non-treatment which cannot be quantified. An untreated tower requires a high degree of maintenance and service activity related to system clogging and down time; additional biocide and acid chemicals may be required; and the overall lifetime of the unit is likely to be less than 20 years, resulting in increased capital demands incurred by the purchase of a new system.		

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets  Proj. No. <u>01645-0111-00008</u>	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>3</u> of <u>4</u> Page <u>  </u> of <u>  </u>
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<b>WORKSHEET</b> <b>9</b>	<div style="border: 1px solid black; padding: 2px; display: inline-block;"> <b>PROFITABILITY</b> </div> <b>KDF TREATMENT - 100 TON TOWER<sup>1</sup></b>
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<b>Capital Costs</b>
Purchased Equipment \$5,518
Materials
Installation
Utility Connections
Engineering
Start-up and Training
Other Capital Costs
Total Capital Costs \$5,518
<b>Incremental Annual Operating Costs</b>
Change in Disposal Costs
Change in Raw Material Costs \$688 <sup>2</sup>
Change in Other Costs
Annual Net Operating Cost Savings \$688
Payback Period (in years) = $\frac{\text{Total Capital Costs}}{\text{Annual Net Operating Cost Savings}}$ = <u>8.0<sup>3</sup></u>

<sup>1</sup> Costs are compared to no treatment.

<sup>2</sup> This cost is derived by subtracting annual costs for KDF treatment from annual costs for no treatment. Annual costs for treatment can be found in Table 10. No treatment costs are derived by assuming the tower operates at 2 cycles of concentration. Water and sewer costs are \$0.0034 per gallon of water consumed, with an annual consumption of 788,400 gallons. An annual biocide cost of \$15 is added, assuming 1 gallon of biocide is used annually at \$15 per gallon. This totals \$2,696 annually for no treatment.

<sup>3</sup> Economic analysis of KDF treatment versus no treatment is not a simple issue, since there are many hidden costs associated with non-treatment which cannot be quantified. An untreated tower requires a high degree of maintenance and service activity related to system clogging and down time; additional biocide and acid chemicals may be required; and the overall lifetime of the unit is likely to be less than 20 years, resulting in increased capital demands incurred by the purchase of a new system.

Firm <u>Naval Base Norfolk</u> Site <u>Norfolk, Virginia</u> Date <u>June 20-22, 1994</u>	Pollution Prevention Assessment Worksheets	Prepared By <u>Bowman</u> Checked By <u>DeWaters</u> Sheet <u>4</u> of <u>4</u> Page <u>  </u> of <u>  </u>
Project No. <u>01645-0111-00008</u>		
<b>WORKSHEET</b> <b>9</b>	<b>PROFITABILITY</b> <b>MAGNETIC TREATMENT - 100 TON TOWER<sup>1</sup></b>	
<b>Capital Costs</b>		
Purchased Equipment \$4,495		
Materials		
Installation \$500		
Utility Connections		
Engineering		
Start-up and Training		
Other Capital Costs		
Total Capital Costs \$4,995		
<b>Incremental Annual Operating Costs</b>		
Change in Disposal Costs		
Change in Raw Material Costs \$936 <sup>2</sup>		
Change in Other Costs		
Annual Net Operating Cost Savings \$936 <sup>2</sup>		
Payback Period (in years) = $\frac{\text{Total Capital Costs}}{\text{Annual Net Operating Cost Savings}}$ = <u>5.3<sup>3</sup></u>		
<sup>1</sup> Costs are compared to no treatment.		
<sup>2</sup> This cost is derived by subtracting annual costs for magnetic treatment from annual costs for no treatment. Annual costs for treatment can be found in Table 11. No treatment costs are derived by assuming the tower operates at 2 cycles of concentration. Water and sewer costs are \$0.0034 per gallon of water consumed, with an annual consumption of 788,400 gallons. An annual biocide cost of \$15 is added, assuming 1 gallon of biocide is used annually at \$15 per gallon. This totals \$2,696 annually for no treatment.		
<sup>3</sup> Economic analysis of magnetic treatment versus no treatment is not a simple issue, since there are many hidden costs associated with non-treatment which cannot be quantified. An untreated tower requires a high degree of maintenance and service activity related to system clogging and down time; additional biocide and acid chemicals may be required; and the overall lifetime of the unit is likely to be less than 20 years, resulting in increased capital demands incurred by the purchase of a new system.		

**APPENDIX B**  
**NPDES DISCHARGE LIMITS**

## PART I

## A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

- During the period beginning with the permit's effective date and lasting until the permit's expiration date, the permittee is authorized to discharge from outfall(s) serial number(s): 061 (stormwater runoff and industrial drainage from LP sector).

Such discharges shall be limited and monitored by the permittee as specified below:

## EFFLUENT CHARACTERISTICS

## DISCHARGE LIMITATIONS

## MONITORING REQUIREMENTS (a)

EFFLUENT CHARACTERISTICS	Monthly Average	Weekly Average	Minimum		Maximum		Frequency	Sample Type
Flow (MGD)	NA	NA	NA	NA	NA	NA	1/Month	Estimate
pH (Standard Units)	NA	NA	6.0	NA	9.0	NA	1/Month	Grab
Oil & Grease (mg/l)	NA	NA	NA	NA	25	NA	1/Month	Grab
Total Organic Carbon (mg/l)	NA	NA	NA	NA	NA	NA	1/Month	Grab
Dissolved Copper (ug/l) (b)	NA	NA	NA	NA	NA	NA	1/3 Months	Grab
Dissolved Nickel (ug/l) (b)	NA	NA	NA	NA	NA	NA	1/3 Months	Grab
Dissolved Cadmium (ug/l) (b)	NA	NA	NA	NA	NA	NA	1/3 Months	Grab
Dissolved Hexavalent Chromium (ug/l)	NA	NA	NA	NA	160	NA	1/6 Months	Grab
Total Recoverable Cadmium (ug/l)	NA	NA	NA	NA	20	NA	1/6 Months	Grab
Total Phenol (ug/l)	NA	NA	NA	NA	30	NA	1/6 Months	Grab

NA = Not Applicable

ML = No limit, however, reporting is required

1/3 Months = In accordance with the following schedule: 1st quarter (January 1 - March 31); 2nd quarter (April 1 - June 30); 3rd quarter (July 1 - September 30); 4th quarter (October 1 - December 31).

1/6 Months = In accordance with the following schedule: 1st half (January 1 - June 30); 2nd half (July 1 - December 31)

[a] See Parts I.B.3. and I.B.4.b.

[b] Monitoring shall be initiated two years after the effective date of the permit.

- There shall be no discharge of floating solids or visible foam in other than trace amounts.
- See Water Quality Monitoring Condition for appropriate quantification levels.

DRAFT

## PART I

## A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning with the permit's effective date and lasting until the permit's expiration date, the permittee is authorized to discharge from outfall(s) serial number(s): 063 (stormwater runoff and industrial drainage from V-88).

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTICS	DISCHARGE LIMITATIONS			MONITORING REQUIREMENTS (a)	
	Monthly Average	Weekly Average	Minimum	Maximum	Frequency
Flow (MGD)	NA	NA	NA	ML	1/Month
pH (Standard Units)	NA	NA	6.0	9.0	1/Month
Oil & Grease (mg/l)	NA	NA	NA	ML	1/Month
Total Organic Carbon (mg/l)	NA	NA	NA	ML	1/Month
Dissolved Copper (ug/l) (b)	NA	NA	NA	ML	1/3 Months
Dissolved Nickel (ug/l) (b)	NA	NA	NA	ML	1/3 Months
Total Cadmium (ug/l)	NA	NA	NA	60	1/6 Months
Total Phenol (ug/l)	NA	NA	NA	30	1/6 Months
Total Phosphorus (mg/l)	NA	NA	NA	0.57	1/Year
					Estimate
					Grab
					Grab
					Grab
					Grab
					Grab
					Grab
					Grab

NA = Not Applicable

ML = No limit, however, reporting is required

1/3 Months = In accordance with the following schedule: 1st quarter (January 1 - March 31); 2nd quarter (April 1 - June 30); 3rd quarter (July 1 - September 30); 4th quarter (October 1 - December 31).

1/6 Months = In accordance with the following schedule: 1st half (January 1 - June 30); 2nd half (July 1 - December 31)

(a) See Parts I.B.3. and I.B.4.b.

(b) Monitoring shall be initiated two years after the effective date of the permit.

2. There shall be no discharge of floating solids or viable foam in other than trace amounts.
3. See Water Quality Monitoring Condition for appropriate quantification levels.

DRAFT



## PART I

## A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

- During the period beginning with the permit's effective date and lasting until the permit's expiration date, the permittee is authorized to discharge from outfall(s) serial number(s): 100 (stormwater runoff and industrial drainage from V-4 and V-28).

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTICS	DISCHARGE LIMITATIONS			MONITORING REQUIREMENTS (a)	
	Monthly Average	Weekly Average	Minimum	Maximum	Frequency
Flow (MGD)	NA	NA	NA	NL	1/3 Months
pH (Standard Units)	NA	NA	6.0	9.0	1/3 Months
Total Organic Carbon (mg/l)	NA	NA	NA	NL	1/3 Months
Oil & Grease (mg/l)	NA	NA	NA	47	1/3 Months
Dissolved Copper (ug/l) (b)	NA	NA	NA	NL	1/3 Months
Dissolved Nickel (ug/l) (b)	NA	NA	NA	NL	1/3 Months
Dissolved Cadmium (ug/l) (b)	NA	NA	NA	NL	1/3 Months
Dissolved Hexavalent Chromium (ug/l) (b)	NA	NA	NA	NL	1/3 Months
Amonia-Nitrogen (NH <sub>3</sub> -N) (mg/l)	NA	NA	NA	NL	1/3 Months
Total Chlorine (mg/l)	NA	NA	NA	NL	1/3 Months
Total Nickel (ug/l)	NA	NA	NA	110	1/3 Months
Total Chromium (ug/l)	NA	NA	NA	370	1/3 Months
Total Selenium (ug/l)	NA	NA	NA	30	1/3 Months
Total Beryllium (ug/l)	NA	NA	NA	810	1/3 Months
Total Phosphorus (mg/l)	NA	NA	NA	0.85	1/3 Months

NA = Not Applicable

NL = No limit, however, reporting is required

1/3 Months = In accordance with the following schedule: 1st quarter (January 1 - March 31); 2nd quarter (April 1 - June 30); 3rd quarter (July 1 - September 30); 4th quarter (October 1 - December 31).

1/6 Months = In accordance with the following schedule: 1st half (January 1 - June 30); 2nd half (July 1 - December 31)

(a) See Parts I.B.3. and I.B.4.b.

(b) Monitoring shall be initiated two years after the effective date of the permit.

DRAFT

## PART I

## A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

- During the period beginning with the permit's effective date and lasting until the permit's expiration date, the permittee is authorized to discharge from outfall(s) serial number(s): 101 (stormwater runoff and industrial drainage from V-4 and V-28).

Such discharges shall be limited and monitored by the permittee as specified below:

EFFLUENT CHARACTERISTICS	DISCHARGE LIMITATIONS			MONITORING REQUIREMENTS (a)	
	Monthly Average	Weekly Average	Minimum	Maximum	Frequency
Flow (MGD)	NA	NA	NA	NL	1/Month
pH (Standard Units)	NA	NA	6.0	9.0	1/Month
Total Organic Carbon (mg/l)	NA	NA	NA	NL	1/Month
Oil & Grease (mg/l)	NA	NA	NA	NL	1/Month
Dissolved Copper (ug/l) (b)	NA	NA	NA	NL	1/Month
Dissolved Nickel (ug/l) (b)	NA	NA	NA	NL	1/3 Months
Total Recoverable Cadmium (ug/l)	NA	NA	NA	NL	1/3 Months
Total Recoverable Chromium (ug/l)	NA	NA	NA	50	1/3 Months
Total Phenol (ug/l)	NA	NA	NA	410	1/3 Months
Total Phosphorus (mg/l)	NA	NA	NA	150	1/3 Months
Total Selenium (ug/l)	NA	NA	NA	0.71	1/3 Months
Ammonia-Nitrogen (NH <sub>3</sub> -N) (mg/l)	NA	NA	NA	20	1/3 Months
Total Chlorine (mg/l)	NA	NA	NA	NL	1/3 Months
	NA	NA	NA	NL	1/3 Months

NA = Not Applicable

NL = No limit, however, reporting is required

1/3 Months = In accordance with the following schedule: 1st quarter (January 1 - March 31); 2nd quarter (April 1 - June 30); 3rd quarter (July 1 - September 30); 4th quarter (October 1 - December 31).

(a) See Parts I.B.3. and I.B.4.b.

(b) Monitoring shall be initiated two years after the effective date of the permit.

- There shall be no discharge of floating solids or visible foam in other than trace amounts.
- See Water Quality Monitoring Condition for appropriate quantification levels.

DRAFT

## PART I

## A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

- During the period beginning with the permit's effective date and lasting until the permit's expiration date, the permittee is authorized to discharge from outfall(s) serial number(s): 104 (stormwater runoff and industrial drainage from V-42 and V-29).

Such discharges shall be limited and monitored by the permittee as specified below:

## EFFLUENT CHARACTERISTICS

## DISCHARGE LIMITATIONS

## MONITORING REQUIREMENTS (a)

	Monthly Averages	Weekly Averages	Minimum		Maximum		Frequency	Sample Type
Flow (MGD)	NA	NA	NA		NL		1/Month	Estimate
pH (Standard Units)	NA	NA	6.0		9.0		1/Month	Grab
Total Organic Carbon (mg/l)	NA	NA	NA		NL		1/Month	Grab
Oil & Grease (mg/l)	NA	NA	NA		NL		1/Month	Grab
Dissolved Copper (ug/l) (b)	NA	NA	NA		NL		1/3 Months	Grab
Dissolved Nickel (ug/l) (b)	NA	NA	NA		NL		1/3 Months	Grab
Amonia-Nitrogen (NH <sub>3</sub> -N) (mg/l)	NA	NA	NA		NL		1/3 Months	Grab
Total Chlorine (mg/l)	NA	NA	NA		NL		1/3 Months	Grab
Total Cadmium (ug/l)	NA	NA	NA		NL		1/3 Months	Grab
Total Phenol (ug/l)	NA	NA	NA		30		1/6 Months	Grab
Total Chromium (ug/l)	NA	NA	NA		40		1/6 Months	Grab
					80		1/6 Months	Grab

NA = Not Applicable

NL = No limit, however, reporting is required

1/3 Months = In accordance with the following schedule: 1st quarter (January 1 - March 31); 2nd quarter (April 1 - June 30); 3rd quarter (July 1 - September 30); 4th quarter (October 1 - December 31).  
1/6 Months = In accordance with the following schedule: 1st half (January 1 - June 30); 2nd half (July 1 - December 31)

(a) See Parts I.B.3. and I.B.4.b.

(b) Monitoring shall be initiated two years after the effective date of the permit.

- There shall be no discharge of floating solids or visible foam in other than trace amounts.
- See Water Quality Monitoring Condition for appropriate quantification levels.

DRAFT

## A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning with the permit's effective date and lasting until the permit's expiration date, the permittee is authorized to discharge from outfall(s) serial number(s): 112 (stormwater runoff and industrial drainage from V-53, V-31 and V-29).

**Such discharges shall be limited and monitored by the permittee as specified below:**

EFFLUENT CHARACTERISTICS	DISCHARGE LIMITATIONS			MONITORING REQUIREMENTS (a)		
	Monthly Average	Weekly Average	Minimum	Maximum	Frequency	Sample Type
Flow (MGD)	NA	NA	NA	NL	1/Month	Estimate
pH (Standard Units)	NA	NA	6.0	9.0	1/Month	Grab
Total Organic Carbon (mg/l)	NA	NA	NA	NL	1/Month	Grab
Oil & Grease (mg/l)	NA	NA	NA	NL	1/Month	Grab
Dissolved Copper (ug/l) (b)	NA	NA	NA	NL	1/3 Months	Grab
Dissolved Nickel (ug/l) (b)	NA	NA	NA	NL	1/3 Months	Grab
Dissolved Cadmium (ug/l) (b)	NA	NA	NA	NL	1/3 Months	Grab
Ammonia-Nitrogen (NH <sub>3</sub> -N) (mg/l)	NA	NA	NA	NL	1/3 Months	Grab
Total Chlorine (mg/l)	NA	NA	NA	NL	1/3 Months	Grab
Total Phenol (ug/l)	NA	NA	NA	40	1/6 Months	Grab
Total Chromium (ug/l)	NA	NA	NA	110	1/6 Months	Grab
Total Phosphorus (mg/l)	NA	NA	NA	0.69	1/6 Months	Grab
Total Zinc (ug/l)	NA	NA	NA	220	1/6 Months	Grab

NA - Not Applicable

ML = No limit, however, reporting is required

1/3 Months - In accordance with the following schedule: 1st quarter (January 1 - March 31); 2nd quarter

(April 1 - June 30); 3rd quarter (July 1 - September 30); 4th quarter (October 1 - December 31).

**1/6 Months - In accordance  
(July 1 - December 31)**

[a] See Parts I.B.3. and I.B.4.b.

(b) Monitoring shall be initiated two years after the effective date of the permit.

2. There shall be no discharge of floating solids or visible foam in other than trace amounts.
3. See Water Quality Monitoring Condition for appropriate quantification levels.

**DRAFT**

PART I

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

- During the period beginning with the permit's effective date and lasting until the permit's expiration date, the permittee is authorized to discharge from outfall(s) serial number(s): 408 (stormwater runoff and industrial drainage from LP area to Bousch Creek culvert).

Such discharges shall be limited and monitored by the permittees as specified below:

EFFLUENT CHARACTERISTICS	DISCHARGE LIMITATIONS			MONITORING REQUIREMENTS (a)	
	Monthly Average	Weekly Average	Minimum	Maximum	Frequency
Flow (MGD)	NA	NA	NA	NA	1/3 Month
pH (Standard Units)	NA	NA	6.0	9.0	1/3 Month
Oil & Grease (mg/l)	NA	NA	NA	NA	1/3 Month
Total Organic Carbon (mg/l)	NA	NA	NA	NA	1/3 Month
Dissolved Copper (ug/l) (b)	NA	NA	NA	NA	4-hr. Comp.
Dissolved Nickel (ug/l) (b)	NA	NA	NA	NA	4-hr. Comp.
Dissolved Cadmium (ug/l) (b)	NA	NA	NA	NA	4-hr. Comp.
Dissolved Hexavalent Chromium (ug/l) (b)	NA	NA	NA	NA	4-hr. Comp.
Dissolved Zinc (ug/l) (b)	NA	NA	NA	NA	4-hr. Comp.
Ammonia-Nitrogen (NH <sub>3</sub> -N) (mg/l)	NA	NA	NA	NA	4-hr. Comp.
Total Chlorine (mg/l)	NA	NA	NA	NA	4-hr. Comp.
Total Recoverable Chromium (ug/l)	NA	NA	NA	410	1/3 Month
Total Recoverable Zinc (ug/l)	NA	NA	NA	430	1/3 Month
Total Cyanide (ug/l)	NA	NA	NA	10	1/3 Month
Total Phenol (ug/l)	NA	NA	NA	200	1/3 Month

NA = Not Applicable

ML = No limit, however, reporting is required

1/3 Months = In accordance with the following schedule: 1st quarter (January 1 - March 31); 2nd quarter (April 1 - June 30); 3rd quarter (July 1 - September 30); 4th quarter (October 1 - December 31).

(a) See Part and I.B.5.e.

(b) Monitoring shall be initiated two years after the effective date of the permit.

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VPDES Permit No. VA0004421  
 Fact Sheet Page \_\_\_\_ of \_\_\_\_  
 UPDATED April 15, 1994

NORFOLK NAVAL BASE - SEWELLS POINT  
 POINT SOURCE DISCHARGES INTO THE ELIZABETH RIVER

OUTFALL NUMBER(S)			FLOW VALUES	SOURCES OF EFFLUENT, UNUSUAL ACTIVITIES, AND/OR GENERAL DESCRIPTION
OLD	NEW	FACTOR		
N/A	001	N/A	0.003 MG	non-contact cooling, deperm station
003	002		~0.44 MG	F/F school site runoff, O/V sep.
004	003	LO3001	0.036 MG	4", large, tank (see 0/1 mg, CEP 114/104/117/162/17/04/103/11, paved
N/A	004	LO3002	N/D	10",
008	005	LO2015	N/D	10", paved areas, D Ave.
N/A	006	LO2008	N/D	8", paved areas, D Ave.
009	007	LO2006	0.002 MG	15", paved areas, parking, 3d St.
010	008	KO2049	N/D	21", CEP 89/65, parking, paved, 3d St.
011	009	KO2015	0.001 MG	18", CEP 12/154, gravel, paved, 3d St.
012	010	JO2020	0.003 MG	18", CEP 8/9/96/121/66/185, B Ave, 3d St.
013	011	JO2017	0.002 MG	18", paved, parking, A Ave., 3d St.
N/A	012	JO2002	N/D	12", parking, A Ave & 3d st.
014	013	JO2003	N/D	12", CEP 7, paved, several sheds
017A	014	JO2042	0.012 MG	4", large, CEP 201/117/112/50, paved, 1 & 2 Ave., vegetated, parking
017B	015	JO2041	0.039 MG	36" x 40", large, CEP 109/103/50/102/151, Eason Blvd, 1 Ave., paved
017C	016	JO2060	N/D	36" x 72", 1-large, CEP 200/121, Eason Blvd, 2d Ave, 4th Ave, paved
N/A	017	JO2059	N/D	36", CEP 154, 2nd St, shot drain (154), paved, parking, vegetated
017D	018	JO2024	N/D	30", parking, paved, roads
017E	019	JO2058	N/D	24", D/D ops, parking, paved
N/A	020	JO1001	N/D	24", parking, road, gravel, paved
N/A	021	JO2004	N/D	15", CEP 203, D/D ops, gravel, paved
18A/B	022	HO2011/001	N/D	unknown size, details obscured by steam
018DT	023	HO2043/075	N/D	paved ditch, 10 40", CEP 154/161, 2nd St, paved, vegetated
018C	024	HO2038	0.12 MG	24", 2 399/3112(CEP facility), 4th Ave, 2nd St, paved, O/V sep, cooling
N/A	025	HO2057	N/D	6", Decatur Ave, paved, limited
N/A	026	HO2059	N/D	6", limited, paved
019	027	HO2052	0.001 MG	10", 2 86, paved, parking, Decatur Ave.
N/A	028	GO2006	N/D	8", Decatur Ave.

N/D-NOT DETERMINED, N/A-NOT APPLICABLE/AVAILABLE, KG-BILLIONS OF GALLONS, O/V-OIL/WATER SEPARATION, A/C-AIRCRAFT

VPDES Permit No. VA0004421

Fact Sheet Page \_\_\_\_ of \_\_\_\_

UPDATED April 15, 1994

NORFOLK NAVAL BASE - SEWELLS POINT  
POINT SOURCE DISCHARGES INTO WILLOUGHBY BAY/ELIZABETH RIVER

OUTFALL NUMBER(S)			FLOW VALUES	SOURCES OF EFFLUENT, UNUSUAL ACTIVITIES, AND/OR GENERAL DESCRIPTION
OLD	NEW	FACTREF		
020	029	CO2054	0.004 MG	4", 210/101/133/107/105, 805, 710/104/101, Harris, ID Ave. paved
N/A	030	CO2070	N/D	10", paved, limited
021	031	CO2001	0.013 MG	24", W 143, paved, parking
N/A	032	FO2074	N/D	10", Decatur Ave., paved
022	033	FO2076	0.004 MG	24", W 135
023	034	FO2073	0.008 MG	8", 8 fuel tanks (2 O/V sep)/124, 1 1/2 days roofs, roads, paved
N/A	035	FO2056	N/D	10", limited, paved, Decatur Ave.
N/A	036	FO2065	N/D	10", same
N/A	037	EO2110	N/D	8", same
N/A	038	EO2109	N/D	8", same
026	039	EO2079	0.008 MG	10", 8 1/4/104/7/130/337, Bester 8111/8111/104/Decatur, paved, parking
N/A	040	EO2006	N/D	8", limited, paved, Decatur Ave.
N/A	041	EO2004	N/D	8", same
027	042	EO2061	0.011 MG	10", 8 1/2/15, paved, parking, 1/2, Ball & Preble Sts.
N/A	043	EO2002	N/D	8", limited, paved, Decatur Ave.
N/A	044	DO2033	N/D	8", same
028	045	DO2047	0.001 MG	30", 3-large, interconnected, O 75, 8. Bayers, paved, gravel, spring
29/30	046	DO2048	N/D	18", Decatur Ave., paved, parking
N/A	047	CO2025	N/D	unknown, paved, parking
031	048	CO2017	0.001 MG	17", restaurant roof, Decatur Ave., paved, parking
032	049	CO2014	0.001 MG	15", Decatur Ave., paved, parking
033	050	CO2003	0.001 MG	24", Q 6, Decatur Ave., paved, parking
N/A	051	CO2001	N/D	12", limited, paved, parking
034	052	EO2013	N/D	34", large/interst, Q 04/11, paved/gravel, parking, 1200 Bayers, 2/8
035	053	EO2003	0.013 MG	30", same, Q 31/34/35/65/12/2/3, 1200 Bayers, paved/gravel, parking
037	054	EO2001	N/D	15", large repair, sediment, basin, paved/gravel, outdoors
037D	055	AO2004	N/D	18", Q 34/34A/34B/34C/32/0 tank farm, paved/gravel, road
038	056	AO2001	0.001 MG	12", Q 37/37A, paved/gravel, road, Beginning Station

N/D=NOT DETERMINED, N/A=NOT APPLICABLE/AVAILABLE, MG=MILLIONS OF GALLONS, O/V=OIL/WATER SEPARATOR, A/C=AIRCRAFT



VPOES Permit No. VA0004421  
Fact Sheet Page \_\_\_\_ of \_\_\_\_  
UPDATED April 15, 1994

NORFOLK NAVAL BASE - SEBELLS POINT  
POINT SOURCE DISCHARGES FROM O/M/LAG/LF AREAS TO HAMPTON ROADS/WILLOUGHBY BAY

OUTFALL NUMBER(S)			FLOW VALUES	SOURCES OF EFFLUENT, UNUSUAL ACTIVITIES, AND/OR GENERAL DESCRIPTION
OLD	NEW	FACREF		
N/A	057	EO3010	N/D	34", I-large, located'd w/ 053003101, 057003101, 063003101, pils'g
039	058	DO4050	0.021 MG	17", II-large, large box 0/7 sep/settling basin, & 127/124/123/121/20 & 01/120, I 330/210/277/120/12/134/134, U 127/193, roads, paved
040	059	DO5001	0.002 MG	14", vegetated, ADM Hughes, paved, golf course
041	060	DO5005	0.001 MG	48", vegetated, ADM Hughes, golf course
N/A	061	DO6001	N/D	18", paved, LAG 77/27, minor boat repair
N/A	062	DO6007	N/D	6", LAG 27, paved, marina ops
N/A	063	DO6009	N/D	4", vegetated, marina ops
042	064	DO6012	N/D	18", M 112, ADM Hughes, vegetated, marina
N/A	065	EO6001	N/D	8", vegetated
043	066	EO6007	0.068 MG	30", I-large, located'd w/ 060000010, paved, bldgs, Parragut to P-1
043A	067	EO6011	-same	48", I-large, same, drain field in E area, bldgs, roads, vegetated
044	068	EO6074	0.006 MG	14", large, located'd w/ 060000010, paved, roads, bldgs, helo ops
045	069	EO6069	0.013 MG	48", large, same, paved, U & E areas, roads, helo ops
N/A	070	EO6057	N/D	6", paved, parking, marina
N/A	071	EO6054	N/D	4", paved, LAG 11/35, parking
N/A	072	DO6002	N/D	6", paved, LAG 108/109, SEABEE ops
046	073	DO6010	0.009 MG	36", W end LAMPS/helo op area, paved
N/A	074	DO6016	N/D	15", gravel, SEABEE ops area, LAG 54
047	075	N/A	0.019 MG	48", cartilage helo ops area to Haffett Ave.
048	076	N/A	0.038	48", N end helo ops area
049	077	N/A	0.01 MG	48", N end helo ops area
050	078	N/A	0.017 MG	18", LP 10, helo & limited A/C ops, avionics
052	079	N/A	0.032 MG	36", LP 10, avionics, industrial drainage
N/A	080	N/A	N/D	4", Heptane tank's burned area, valved
053	081	N/A	0.002 MG	24", LP 50, A/C ops/support
054	082	N/A	0.022 MG	48", LP 50/51/54/51/54/59, & 61/62/63, roads, paved, A/C ops
055	083	N/A	0.008 MG	18", V 88, paved, A/C retrofit/repair ops
36/N/A	084/ 086	N/A	N/D	4", V 88, same

N/D=NOT DETERMINED, N/A=NOT APPLICABLE/AVAILABLE, MG=MILLIONS OF GALLONS, O/S=OIL/WATER SEPARATOR, A/C=AIROPLANE

VPDES Permit No. VA0004421  
 Fact Sheet Page \_\_\_\_ of \_\_\_\_  
 UPDATED April 15, 1994

NORFOLK NAVAL BASE - SEVELLS POINT  
 POINT SOURCE DISCHARGES FROM V-AREA TO WILLOUGHBY BAY

OUTFALL NUMBER(S)			FLOW VALUES	SOURCES OF EFFLUENT, UNUSUAL ACTIVITIES, AND/OR GENERAL DESCRIPTION
OLD	NEW	FACTOR		
057	085	N/A	N/D	12", V 88, paved, parking
058	087	N/A	0.001 MG	15", V 88, A/C retrofit/repair ops
N/A	088	N/A	N/D	4", paved, parking
059	089	N/A	N/D	18", V 88, A/C retrofit/repair
N/A	090	N/A	N/D	4", paved, parking
063	091	N/A	0.009 MG	18", V 88, A/C retrofit/repair, paved rd.
N/A	092	N/A	N/D	12", paved, parking
N/A	093	N/A	N/D	4", same
064	094	N/A	0.029 MG	18", V 144/145/146/147, SIM boat repair & V 14, A/C repairs
N/A	095	N/A	N/D	4", paved, parking
N/A	096	N/A	N/D	4", same
N/A	097	N/A	N/D	4", same
N/A	098	N/A	N/D	4", same
065	099	N/A	0.002 MG	15", V 4/28, paved roadways, A/C repairs
066	100	N/A	0.014 MG	30", V 4/28, same
067	101	N/A	0.033 MG	10", V 28, same
068	102	N/A	0.002 MG	12", V 28, same
069	103	N/A	0.012 MG	12", V 28/29/41, paved rdways, A/C repair
070	104	N/A	0.007 MG	15", V 12/13/14/15/16/17, paved rdways, A/C repair/support
071	105	N/A	0.001 MG	8", V 38/135/143, steam cleaning, O/W sep
N/A	106	N/A	N/D	2.5", V 27, A/C support/repair
072	107	N/A	0.001 MG	10", V 27, same, industrial drainage
073	108	N/A	0.002 MG	8", V 27, same, same
074	109	N/A	0.002 MG	8", V 27, same, same
075	110	N/A	0.002 MG	15", V 47, same, same, paved, roadway
076	111	N/A	N/D	8", roadway, paved
077	112	N/A	0.031 MG	14", V 64/124/133/137/139, A/C repair/support, paved, roadways
078	113	N/A	0.008 MG	21", V 52/53/54, small boat ops, A/C repair/support, paved, roadways

N/D=NOT DETERMINED, N/A=NOT APPLICABLE/AVAILABLE, MG=BILLIONS OF GALLONS, O/W=OIL/WATER SEPARATOR, A/C=ALCRAFT

VPOES Permit No. VA0004421  
Fac Sheet Page \_\_\_\_ of \_\_\_\_  
UPDATED April 15, 1994

NORFOLK NAVAL BASE - SEWELLS POINT  
POINT SOURCE DISCHARGES FROM LP/V/SP AREAS TO BULLOUGHEY BAY

OUTFALL NUMBER(S)		FACREF	FLOW VALUES	SOURCES OF EFFLUENT, UNUSUAL ACTIVITIES, AND/OR GENERAL DESCRIPTION
OLD	NEW			
079	114	N/A	0.034 MG	45", II-large, in Pierway St. near P M. bldg, roadway, vegetated
080	115	BOUSCH CREEK CULVERT	MULTI- MGD, TIDAL	6' x 11", Bousch Cr., internal discharges, LP fuel tank, below repair and ops, jet engine test cell, metal ops, industrial drainage, bldg, paved, roadway, tidally influenced free-flow stream
082	116	N/A	0.019 MG	36", large, paved, roads, A/C runway and op area
083	117	N/A	0.033 MG	2 @ 15", paved, vegetated, limited runway
084	118	N/A	0.002 MG	15", vegetated, road
085	119	N/A	0.001 MG	12", vegetated, W side Mason Ck Bridge
086	120	N/A	0.015 MG	36", large, paved, runway/taxiway ops @ of LP 164, roads
087	121	N/A	N/D	24", vegetated area between paved
088	122	N/A	0.005 MG	18", vegetated @ of SP 312/314, paved, wetlands, Bellinger Blvd.
N/A	123	N/A	0.001 MG	18", paved, SP 312, taxiway
090	124	N/A	0.002 MG	"6", steam, limited storm
N/A	125	N/A	0.001 MG	"6", same
092	126	N/A	0.001 MG	"6", steady volume steam discharge
093	127	N/A	0.001 MG	"6", steam limited storm
N/A	128	N/A	N/D	"6", vegetated, limited storm
094	129	N/A	0.001 MG	12", paved, vegetated, S of SP 65
095	130	N/A	0.001 MG	12", paved, vegetated, S of SP 65
096	131	N/A	0.005 MG	12", paved, W of SP 65
098	132	N/A	0.004 MG	36", paved, SP 112/914, A/C ops/machlog, O/T rep, roadways
104	133	N/A	0.006 MG	36", paved, SP 112/914, A/C ops/machlog, O/T rep, roadways
108	134	MASONS	MGD	28' x 11' box culvert, Bousch Cr., tidal estuary, several internals
110	135	N/A	0.042 MG	45", SP 137/136/74, paved, vegetated, rds, A/C ops, 3 off-base lagoons
N/A	136	N/A	N/D	18", SP 86, paved, matl's storage
N/A	137	N/A	N/D	6", paved, vegetated, road
111	138	N/A	0.001 MG	21", SP 86/87, paved, matl's storage
112	139	N/A	0.006 MG	36", SP 89/88/87, paved, matl's storage
113	140	N/A	0.02 MG	36", O/T rep, track loading (gas), orig. off-base, paved, vegetated
113	141	N/A	0.02 MG	36", orig. off-base, residential, paved, vegetated, thru gas farm

N/D-NOT DETERMINED, N/A-NOT APPLICABLE/AVAILABLE, MG-BILLIONS OF GALLONS, O/T-OIL/WATER SEPARATOR, A/C-AIRCRAFT

**APPENDIX C**  
**MONITORING DATA**



Microbac Mid Atlantic Division  
604 Morris Drive  
Newport News VA 23605  
(804)825-1000

Page 1

AIR • FUEL • WATER • FOOD • WASTES

# CERTIFICATE OF ANALYSIS

Navy Public Works Center  
Attn: Merrill Ashcraft  
Environmental Department, 2140  
Norfolk, VA 23511-3095

Date Reported 4/13/94  
Date Received 4/04/94  
Order No 9404-00108  
Invoice No 0

Cust # N002

Permit No  
Cust P.O. N62470-90-B-4695

Subject: VFDES/OUTFALL #177 SAMPLED BY: A. B. CARPER

PARAMETER	RESULT	UNITS	REL	DATE	TIME	ANALYST	LAB
177 Date/Time Sampled: 04/04/94 17:00							
DO: 5.00	5.00	mg/L	1	04/04/94	17:00	AB	177
DO:	1.0	mg/L	1	04/04/94	17:00	AB	177
Phosphorus	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Phos:	0.02	mg/L	0.05	04/04/94	17:00	AB	177
FE	0.02	mg/L	0.1	04/04/94	17:00	AB	177
Calcium:	0.02	mg/L	0.1	04/04/94	17:00	AB	177
Calcium	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Chromium	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Copper	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Cadm	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Lead	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Mercur	0.02	mg/L	0.05	04/04/94	17:00	AB	177
177 Date/Time Sampled: 04/04/94 17:00							
DO: 5.00	5.00	mg/L	1	04/04/94	17:00	AB	177
DO:	1.0	mg/L	1	04/04/94	17:00	AB	177
Phosphorus	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Phos:	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Calcium	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Chromium	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Copper	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Cadm	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Lead	0.02	mg/L	0.05	04/04/94	17:00	AB	177
Mercur	0.02	mg/L	0.05	04/04/94	17:00	AB	177

RECEIVED APR 13 1994

THIS CERTIFICATE OF ANALYSIS IS CONTINUED ON THE NEXT PAGE

The data and laboratory results contained on this, and other accompanying documents, represent only the company's best estimate and are not to be used for regulatory or other purposes without written consent of the company.

USDA-APHIS-APHIS Testing Food Sanitation Consulting Chemical and Microbiological Analysis and Research



NAVY PWC ENVIRONMENTAL LABORATORY  
Bldg 2-148, Code 930  
Norfolk, Virginia 23511-6098  
Phone (804) 443-8850 Fax (804) 443-8852

- SAMPLE ANALYSIS REPORT -

To: NS-CNS-NORCUTINE - NEAMEY  
BLDG 226, CODE 94  
NORFOLK VA 23511

Point of Contact: SEAN NEAMEY

Report Date : 05/11/1994

PH: 444-3009 FAX: 444-3000

Job Order No.: 1252003  
Sample ID : 01-8  
Sample Matrix: LIQUID

Receipt Date : 05/06/1994  
Collected By : GR  
Collection Site : V-53 ROOFTOP COOLING TOWER

Industrial Waste Code:  
Sample Point Code :

PWC LAB#	TEST	RESULT	UNITS	NBL	COLLECT DATE	COLLECT TIME	ANALYSIS DATE	ANALYSIS TIME	ANALYSIS METHOD	ANALYST INITIAL
94PT07195	Cr_205	U	0.007	mg/L	05/05/1994	0750	05/10/1994	12:16:00	200.7	KAB
	Zn_213		0.176	mg/L	05/05/1994	0750	05/10/1994	12:16:00	200.7	KAB

Note: The 3 digit number appearing after the  
element name is the instrument wavelength.

Comments:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Legend: U -Below the Method Limit  
S -Below the Low Limit  
H -Above the High Limit

These results have been reviewed by:

*He Sherry*  
Merrill Aircraft  
Laboratory Manager

NAVY PWC ENVIRONMENTAL LABORATORY  
 Bldg 2-148, Code 938  
 Norfolk, Virginia 23511-6098  
 Phone (804) 445-8850 Fax (804) 445-8852

- SAMPLE ANALYSIS REPORT -

To: NS-CMB-NONROUTINE - NEAREY  
 BLDG 216, CODE 84  
 NORFOLK VA 23511

Point of Contact: SEAN NEAREY

Report Date : 05/11/1994

PH: 444-3009 FAX: 444-3000

Job Order No.: 1252003  
 Sample ID : 02-6  
 Sample Matrix: LIQUID

Receipt Date : 05/04/1994  
 Collected By : GR  
 Collection Site : V-53 ROOFTOP COOLING TOWER

Industrial Waste Codes:  
 Sample Point Code :

PWC LAB#	TEST	RESULT	UNITS	NBL	COLLECT DATE	COLLECT TIME	ANALYSIS DATE	ANALYSIS TIME	ANALYSIS METHOD	ANALYST INITIAL	
94FY07196	Cr_205	U	0.007	mg/L	0.007	05/05/1994	0730	05/10/1994	12:16:00	200.7	KAB
	Zn_213		0.008	mg/L	0.002	05/05/1994	0730	05/10/1994	12:16:00	200.7	KAB

Note: The 3 digit number appearing after the element name is the instrument wavelength.

Comments:

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Legend: U -Below the Method Limit  
 S -Below the Low Limit  
 H -Above the High Limit

These results have been reviewed by:

*[Signature]*  
 Reryl Ashcroft  
 Laboratory Manager

NAME STEWELL'S POINT NAVAL COMPLEX

ADDRESS LANTIDY NAV FAC L-NO CUMM

NORFOLK

FACTORY

LOCATION

74 2:511

FILE NO. 22-4556

TIDEWATER MEDICAL OFFICE  
267 PEMBERNE OFF. PARK  
SUITE 310 PEMBERNE 2  
VIRGINIA BEACH, VA. 2346

NOTE: THIS REPORT AND REPORTED RESULTS ARE FOR INFORMATION ONLY AND DO NOT CONSTITUTE A MEDICAL OPINION.

PARAMETER	REPORTED	AVERAGE	MINIMUM	MAXIMUM	UNIT	REMARKS	AVERAGE	MINIMUM	MAXIMUM	UNIT	REMARKS	DATE
001 FLOW	REPORTED	C. 0.65	C. 0.65	C. 0.65	ML/D							1/11 EST
002 PH	REPORTED											1/11 EST
012 TOTAL PHOSPHORUS	REPORTED											1/11 GRAB
016 TOTAL CHROMIUM	REPORTED											1/11 GRAB
017 TOTAL PHENOL	REPORTED											1/11 GRAB
019 TOTAL COPPER	REPORTED											1/11 GRAB
020 TOTAL ZINC	REPORTED											1/11 GRAB
021 TOTAL NICKEL	REPORTED											1/11 GRAB

REPORTED	TOTAL	TOTAL	TOTAL
001	002	003	004
005	006	007	008
009	010	011	012
013	014	015	016
017	018	019	020
021	022	023	024
025	026	027	028
029	030	031	032
033	034	035	036
037	038	039	040
041	042	043	044
045	046	047	048
049	050	051	052
053	054	055	056
057	058	059	060
061	062	063	064
065	066	067	068
069	070	071	072
073	074	075	076
077	078	079	080
081	082	083	084
085	086	087	088
089	090	091	092
093	094	095	096
097	098	099	100





17400 Old Dominion Road, Suite 103, Norfolk, VA 23502

Microbac Mid-Atlantic Division

484 Morris Drive

Newport News, VA 23606

804/625-1000 FAX: 804/625-1200

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## CERTIFICATE OF ANALYSIS

Navy Public Works Center  
Environmental Department  
Bldg. 2140  
Norfolk, VA 23511-6098

Attn.: Merrill Ashcraft  
Contract #: M62470-90-B-4695

DATE: February 21, 1993  
LOCATION: VERDES/CUTEALY 077  
DATE/TIME RECEIVED: 02/04/93 @ 1630  
CRAB  
LABORATORY I.D.#: 0293 173  
SAMPLER: B. Gates  
DATE/TIME SAMPLED: 02/04/93 @ 1140  
SAMPLE #: 5471-5475

ANALYSIS	PERMIT LIMITS	METHOD/MDL	RESULT	ANALYST	DATE/TIME ANALYZED
O&G	XXX	413.1 1	5 mg/L	C. Martino	02/16/93 @ 0900
TOC	XXX	415.1 1	5 mg/L	J. Willett	02/11/93 @ 1500
pH	6-9	170.1 ***	6.92 @ 13.7°C	B. Gates	02/04/93 @ 1147
Phenol	0.04	420.2 0.01	0.02 mg/L	L. Gaskill	02/09/93 @ 1441
Phosphorous	0.69	365.2 0.05	0.55 mg/L	L. Gaskill	02/11/93 @ 0830
Cadmium	0.04	213.1 0.01	<0.01 mg/L	L. Rivera	02/09/93 @ 1000
Copper	XXX	220.1 0.05	<0.05 mg/L	L. Rivera	02/09/93 @ 0815
Chromium	0.11	218.1 0.10	<0.1 mg/L	L. Rivera	02/09/93 @ 0940
Zinc	0.22	289.1 0.05	0.28 mg/L	L. Rivera	02/09/93 @ 0900
Nickel	XXX	249.1 0.1	<0.1 mg/L	L. Rivera	02/09/93 @ 0830

FLOW: 0.40 Liters/Sec

DELIVERED FEB 24 1993

USDA-EPA-MSDH testing • Food Sanitation Consulting • Chemical and Microbiological Analysis and Research

NAVY PWC ENVIRONMENTAL DEPARTMENT  
Bldg. Z-148, Code 938  
9742 Maryland Avenue  
Norfolk, Virginia 23511-6098  
Phone (804) 443-8850 Ext (804) 443-8852

- SAMPLE ANALYSIS REPORT -

to: COMUSMACV NAS-KONROUTINE  
BLDG 126 CODE 04-044  
NORFOLK VA 23511  
(804) 444-3009

Attn: LT GILLES

Report Date: 09/09/93

Job Order No. : 1252002  
Sample ID : V53 COOLING TOWER-GRAB  
Sample Matrix : L

Receipt Date: 09/01/93

- SAMPLE COLLECTION INFORMATION -

Collection Site: V-53 COOLING TOWER  
Collected By: DG

Comments:

GRAB SAMPLES

PWC Lab#	Test	Result	Units	REL	Collect Date	Collect Time	Analysis Date	Analysis Time	Method	Analyst Init
73FT7819	Cd_1	0.004	U mg/L	0.004	09/01/93	1430	09/07/93	1243	200.7	RRR
	Cr_1	0.019	mg/L	0.007	09/01/93	1430	09/07/93	1320	200.7	RRR
	Cu_1	0.053	mg/L	0.004	09/01/93	1430	09/07/93	1320	200.7	RRR
	Ni_1	0.015	U mg/L	0.015	09/01/93	1430	09/07/93	1320	200.7	RRR
	Pb_1	0.042	U mg/L	0.042	09/01/93	1430	09/07/93	1320	200.7	RRR
	pH	9.0	units	0.100	09/01/93	1430	09/07/93	1330	150.1	RRR
	Zn_1	0.162	mg/L	0.002	09/01/93	1430	09/07/93	1320	200.7	RRR

RESULTS LEGEND

B-BELOW THE LOW LIMIT  
H-ABOVE THE HIGH LIMIT  
U-BELOW THE INSTRUMENT DETECTOR  
LIMIT

LAB MANAGER:

MERRILL ASHCRAFT

**APPENDIX D**  
**MATERIAL SAFETY DATA SHEETS**

PRODUCT NAME: <b>SODIUM HYDROXIDE</b> CAS NO: <b>1310-73-2</b> FORM: <b>100% LIQUID</b> MANUFACTURER: <b>WATKINS</b> DATE: <b>12/22/93</b>		EMERGENCY PHONE NO.: <b>1-800-424-8300</b> TOLL FREE: <b>1-800-424-8300</b> FAX: <b>1-800-424-8300</b>	
SECTION 2: HAZARD IDENTIFICATION HAZARD STATEMENT: <b>FLAMMABLE</b> HAZARD CLASS: <b>2</b> HAZARD CODE: <b>2.1</b> HAZARD DESCRIPTION: <b>FLAMMABLE LIQUID</b> HAZARD CLASS: <b>2</b> HAZARD CODE: <b>2.1</b> HAZARD DESCRIPTION: <b>FLAMMABLE LIQUID</b>			
SECTION 3: Composition INGREDIENTS: <b>SODIUM HYDROXIDE (7632-00-0)</b> <b>POTASSIUM HYDROXIDE (1310-73-2)</b> <b>SODIUM SILICATE (1310-73-2)</b>			
SECTION 4: Physical and Chemical Properties APPEARANCE: <b>WHITE PASTE</b> Odor: <b>NO ODOR</b> Melting Point: <b>NO DATA</b> Boiling Point: <b>NO DATA</b> Flash Point: <b>NO DATA</b> Solubility: <b>WATER SOLUBLE</b> pH: <b>12.5</b> Specific Gravity: <b>1.53</b> Viscosity: <b>100 cP</b> Stability: <b>STABLE</b> Incompatibility: <b>CONCENTRATED MINERAL ACIDS</b> Reactivity: <b>CO, OXIDES OF HYDROGEN WITH INCOMPLETE COMBUSTION</b> Hazardous Reactions: <b>1. ACUTE IRRITATING EYES, HARMFUL IF SWALLOWED.</b>			
SECTION 5: Health Hazards Symptoms: <b>1. CHRONIC DEFATS SKIN WITH PROLONGED CONTACT</b> Overexposure: <b>SENSITIVE SKIN</b> Emergency and First Aid Procedures: 1. INHALATION: <b>N/A IN NORMAL OPERATION.</b> 2. EYES: <b>FLUSH THOROUGHLY WITH FRESH WATER, FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION.</b> 3. SKIN: <b>FLUSH WITH FRESH WATER. REMOVE WETTED CLOTHES AND SHOES.</b> 4. INGESTION: <b>GIVE WATER. DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.</b>			
SECTION 6: Environmental Protection Air: <b>PRODUCING CORROSIVE AEROSOLS FROM SOLID</b> Water: <b>NON-CORROSIVE</b> Soil: <b>FACE SHIELD ON SUCH AS</b> Spills: <b>CLOTHING TO PREVENT PROLONGED SKIN CONTACT. WATER DELUGE SYSTEM.</b> Storage: <b>KEEP FROM FREEZING. IF FROZEN, THAW AND MIX TO MAKE USABLE. KEEP CONTAINER CLOSED. DO NOT PRESSURE CONTAINER TO EMPTY. DO NOT ALLOW TO COME IN CONTACT WITH ACIDS.</b> Disposal: <b>DO NOT ALLOW TO COME IN CONTACT WITH ACIDS.</b> Waste: <b>DO NOT ALLOW TO COME IN CONTACT WITH ACIDS.</b> Emergency and First Aid Procedures: 1. INHALATION: <b>N/A IN NORMAL OPERATION.</b> 2. EYES: <b>FLUSH THOROUGHLY WITH FRESH WATER, FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION.</b> 3. SKIN: <b>FLUSH WITH FRESH WATER. REMOVE WETTED CLOTHES AND SHOES.</b> 4. INGESTION: <b>GIVE WATER. DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.</b>			
SECTION 7: Other Information Reportable Quantity (R.Q.): <b>100 LBS OR 50 GAL</b> Use: <b>UNTIL LESS THAN 1 INCH REMAINS IN CONTAINER, EMPTY CONTAINER TRIPLE RINSE WITH WATER, ADD TO OPERATION</b> Removal or Decontamination: <b>REMOVE OR DECONTAMINATE BEFORE SPILLING CONTAINER OR DISPOSAL IN ADJUSTMENT TO PROPERTIES.</b>			
SECTION 8: Other Information All chemical ingredients are listed on the TSCA inventory. Sodium Hydroxide - CAS 7632-00-0 Potassium Hydroxide - CAS 1310-73-2 Sodium Silicate - CAS 1310-73-2			



# ATERIAL SAFETY DATA SHEET

CARE-8:00-5:00 EST-MON-FRI 1-800-343-4906

IDENTIFIER

GAX-20

MSD-CAS (COLLECT); 303-592-1111  
CSC-H-100 1-800-424-9300

EMERGENCY PHONE NO.

3:3-458-5000

REFERENCE

DIVERSITY CORP  
22025 ECH CENTER DRIVE  
EVONIA, MICHIGAN 48150  
PREPARED BY: REGULATORY  
ON 08/24/93

ABBREVIATIONS: C-CYLING MP-MAXIMUM PEAK NVA-NOT APPLICABLE N/K-NOT KNOWN P-POTENTIAL PEL-PERMISSIBLE EXPOSURE UL-  
IT-PLA-PESTICIDE MATERIALS S-SIGN ST-SHORT TERM TLV-THRESHOLD LIMIT VALUE TWA-TIME WEIGHTED AVERAGE

COMMON NAME USED ON LABEL: GAX-20 CODE: 00073

CHEMICAL FAMILY: 2,2-DIBROMO-3 NITRILOPROPIONAMIDE

PRINCIPAL HAZARDOUS COMPONENT(S) CHEMICAL & COMMON NAME: 2,2-DIBROMO-3 NITRILOPROPIONAMIDE (10222-01-2)

EPA REGISTERED PRODUCT #875-132

EXPOSURE LIMITS (TWA 8 HOUR UNLESS OTHERWISE SPECIFIED): NONE ESTABLISHED

UNITS

APPEARANCE & COLOR: GREENISH-BROWN LIQUID, VISC

FLASH POINT: 190 °F TOC EXTENSION: N/A & BLAST BY VOLUME: NONE

EXTINGUISHING MEDIA: DRY CHEMICALS WATER FOR ALCOHOLIC FOAM

PREFIGHTING: WEAR SELF-CONTAINED BREATHING APPARATUS AND GOGGLES

SPECIAL PROCEDURES: NONE

UNUSUAL FIRE AND EXPLOSION HAZARDS: NONE

STABILITY: STABLE POLYMERIZATION: NONE

INCOMPATIBLE WITH: FOR STORAGE STABILITY, AVOID WATER.

DECOMPOSITION PRODUCTS: METHYLENCHLORIDE, ETHYLENCHLORIDE, HYDROGEN CYANIDE, NITRIC OXIDE

PRIMARY ROUTES OF ENTRY: INHALATION: NO SKIN: NO INGESTION: YES

1. ACUTE CAUSES SKIN IRRITATION; CONTACT WITH EYES MAY CAUSE EYE DAMAGE.

AND

SYMPTOMS 2. CHRONIC SAME AS ACUTE

OF

OVEREXPOSURE

MEICAL CONDITIONS USUALLY AGGRAVATED BY EXPOSURE: SENSITIVE SKIN

LISTED CARCINOGEN: NONE

EMERGENCY AND FIRST AID PROCEDURES: NTP NO MAR NO GSHA

1. INHALATION: N/A IN NORMAL OPERATIONS

2. EYES: FLUSH THOROUGHLY WITH FRESH WATER, FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION.

3. SKIN: FLUSH WITH FRESH WATER, WASH WITH SOAP AND WATER REMOVE CONTAMINATED CLOTHES AND SHOES

4. INGESTION: GIVE MILK OR WATER, INDUCE VOMITING. GET MEDICAL ATTENTION. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

RESPIRATORY PROTECTION: NONE

VENTILATION MECHANICAL: NORMAL AIR DILUTION SPECIAL: NONE VENTILATION LOCAL: NO

PROTECTIVE GLOVES: YES

EYE PROTECTION: CHEMICAL GOGGLES

OTHER PROTECTIVE CLOTHING/EQUIPMENT: NONE

HANDLING AND STORAGE: PREVENT EYE CONTACT. AVOID ALL SKIN CONTACT. AVOID BREATHING MISTS AND VAPORS FROM HEAD SPACE OF NEWLY OPENED CONTAINERS. AVOID DILUTION WITH WATER. STORE BELOW 95°F, 35°C. KEEP CONTAINERS CLOSED WHEN NOT IN USE. DO NOT PRESSURE CONTAINER TO EMPTY.

PRECAUTIONS: D.O.T. CLASS: CORROSIVE LIQUIDS, N.O.S., (2,2-DIBROMO-3-NITRILOPROPIONAMIDE), 8, UN1760, PG II

OTHER: IF MATERIAL IS RELEASED/SPILLED: COLLECT IN BUILDING TANK AND INACTIVATE WITH SODA ASH OR LIME. MAINTAIN PH OF 8.1 OR MORE FOR 18 HOURS BEFORE DISPOSAL.

PRECAUTIONS: MAINTAIN PH OF 8.1 OR MORE FOR 18 HOURS BEFORE DISPOSAL.

IF MATERIAL IS RELEASED/SPILLED: MAINTAIN PH OF 8.1 OR MORE FOR 18 HOURS BEFORE DISPOSAL.

# MATERIAL SAFETY DATA SHEET

DATE-8:00-5:00 EST-MON-FRI 1-800-543-8908

QUICK IDENTIFIER

GCO-10

6

MEDICAL (COLLECT.)

303-592-...

CHEMTREC

1-800-424-9...

DIVERSEY CORP.  
12025 TECH CENTER DRIVE  
LIVONIA, MICHIGAN 48150  
PREPARED BY: REGULATORY  
ON 03/24/93

EMERGENCY PHONE NO

313-458-5000

REFERENCE

PRECAUTIONS: COOLING TOWER TREATMENT COMPOUND  
IF PUMP SKY MARINE 3-SIGN, ST-SHORT TERM TLV-THRESHOLD LIMIT VALUE, TWA-TIME WEIGHTED AVERAGE  
COMMON NAME USED ON LABEL: GCO-10  
CHEMICAL FAMILY: COOLING TOWER TREATMENT COMPOUND  
PRINCIPAL HAZARDOUS COMPONENTS: CHEMICAL & COMMON NAME: POLY(OXYETHYLENE-(DIMETHYLIMINIO)ETHYLENE-(DIMETHYLIMINIO)ETHYLENE DICHLORIDE 31075-24-8  
EPA REGISTRATION NO. 875-140

EXPOSURE LIMITS (TWA 8 HOUR UNLESS OTHERWISE SPECIFIED) 100%  
% <2 NONE ESTABLISHED (EYE IRRITANT)  
CODE 02320

APPEARANCE & COLOR: CLEAR LIQUID, MILD ODOR  
BOILING POINT: 17.5°C  
MELTING POINT: 100°C

FLASH POINT: NONE  
EXTINGUISHING MEDIA: CO2, FOAM, DRY CHEMICALS  
SPECIAL PRECAUTIONS: NONE

UNUSUAL FIRE AND EXPLOSION HAZARDS: NONE

STABILITY: STABLE  
POLYMERIZATION: NONE

INCOMPATIBLE WITH: CONCENTRATED MINERAL ACIDS  
DECOMPOSITION PRODUCTS: CO WITH INCOMPLETE COMBUSTION

PRIMARY ROUTES OF ENTRY: INHALATION NO, SKIN NO, INGESTION YES

SIGNS: 1. ACUTE MAY IRRITATE EYES

AND

SYMPTOMS: 2. CHRONIC SAME AS ACUTE

OF

OVEREXPOSURE

MEDICAL CONDITIONS GENERALLY AFFECTED BY EXPOSURE: SENSITIVE SKIN

EMERGENCY AND FIRST AID PROCEDURES: 1. INHALATION N/A IN NORMAL OPERATION.

2. EYES FLUSH THOROUGHLY WITH FRESH WATER. GET MEDICAL ATTENTION.

3. SKIN FLUSH WITH FRESH WATER, WASH WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHES AND SHOES.

4. INGESTION IF SWALLOWED, DRINK PROMPTLY A LARGE QUANTITY OF MILK, EGG WHITE GELATIN SOLUTION, OR IF THESE ARE NOT AVAILABLE, DRINK LARGE AMOUNTS OF WATER. AVOID ALCOHOL. CALL A PHYSICIAN IMMEDIATELY.

RESPIRATORY PROTECTION: NONE

VENTILATION MECHANICAL: NORMAL AIR DILUTION

PROTECTIVE GLOVES: CHEMICAL RESISTANT

EYE PROTECTION: SAFETY GLASSES WHEN HANDLING

CLOTHING/SHOES: NONE

HANDLING: KEEP CONTAINER CLOSED. IF FROZEN, THAW AND MIX TO MAKE USABLE. DO NOT PRESSURE CONTAINER TO EMPTY.

STORAGE: NONE

OTHER PRECAUTIONS: DOT CLASS: NOT REGULATED.

IF MATERIAL IS RELEASED/SPILLED: FLUSH SMALL AMOUNTS TO DRAIN. COLLECT AND RETURN LARGE AMOUNTS TO CONTAINER. PREVENT SPILLS FROM ENTERING OPEN BODIES OF WATER.

RE-8:00-5:00 EST-MON-FRI 1-800-543-4908

MSD-TAY

MEDICAL (COLLECT)

303-592-1111

CHEMTREC

1-800-424-9212

DIVENSEY CORP.  
12025 TECH CENTER DRIVE  
LIVONIA, MICHIGAN 48150  
PREPARED BY: REGULATORY  
ON 02/15/94

EMERGENCY PHONE NO

313-458-3000

REFERENCE

HAZARD STATEMENTS: C-CORING, MP-MEDIUM, FLAM-N/A-NOT APPLICABLE, HX-NOT KNOWN, A-POTENTIAL, PEL-PERMISSIBLE EXPOSURE  
IT, PM-PENSKY MARTENS, S-SKIN, ST-SHORT TERM, TLV-THRESHOLD LIMIT VALUE, TWA-TIME WEIGHTED AVERAGE.

COMMON NAME USED ON LABEL

GAX-26

CODE 06166

CHEMICAL FAMILY

CUTTING FLUID BIO-CIDE

PRINCIPAL HAZARDOUS COMPONENT(S) CHEMICAL &amp; COMMON NAME

EPA REGISTERED PRODUCT #875-138  
5-CHLOR-2 METHYL-4-ISOTHIAZOLIN  
3-ONE  
(CAS #26172-55-4)

2-METHYL-4-ISOTHIAZOLIN-3-ONE  
(CAS #2682-20-4)

EXPOSURE LIMITS (TWA 8 HOUR UNLESS OTHERWISE SPECIFIED)  
UNIT  
TLV 0.1, STEL 0.3 FOR TOTAL  
ISOTHIAZOLONES AS  
RECOMMENDED BY SUPPLIER  
LD50 457 MG/KG (ORAL)  
LD50 660 MG/KG (DERMAL)

MG/M

APPEARANCE & COLOR PALE YELLOW TO GREEN LIQUID. WILD AROMATIC ODOR  
FLASH POINT NONE  
EXTENSION N/A  
FLAMMABLE LIMITS LOWER UPPER  
IN AIR BY VOLUME NONE NONE  
TEMPERATURE N/A

WEAR MESA/NIOSH APPROVED SELF-CONTAINED BREATHING APPARATUS.  
SCHEDULE 13. USE WATER SPRAY TO COOL FIRE-EXPOSED CONTAINERS.

DO NOT ALLOW SOLUTION TO EVAPORATE TO DRYNESS. DRY NITRATES IN  
COMBINATION WITH ORGANIC MATERIAL CAN BE EXPLOSIVE.

POLYMERIZATION

STABLE NONE

INCOMPATIBLE WITH NONE KNOWN

DECOMPOSITION PRODUCTS  
OXIDES OF CARBON, SULFUR, HCL  
AND NITROGEN.

PRIMARY ROUTES OF ENTRY  
INHALATION YES SWALLOW YES INGESTION YES

SIGNS AND SYMPTOMS 1 ACUTE CORROSIVE TO SKIN AND EYES. BURNS TO SKIN MAY NOT BE  
IMMEDIATE. HARMFUL IF INHALED. HARMFUL IF ABSORBED  
THROUGH SKIN. MAY BE FATAL IF SWALLOWED.

SYMPTOMS 2 CHRONIC MAY CAUSE ALLERGIC SKIN REACTION.

OVEREXPOSURE

MEDICAL CONDITIONS GENERALLY SENSITIVE SKIN AND EYES. IMPAIRED PULMONARY FUNCTION

AGGRAVATED BY EXPOSURE

LISTED CARCINOGEN NONE

NTP NO LARC NO OSHA

EMERGENCY AND FIRST AID PROCEDURES

1. INHALATION REMOVE TO FRESH AIR. APPLY ARTIFICIAL RESPIRATION IF NEEDED.

2. EYES FLUSH THOROUGHLY WITH FRESH WATER, FOR AT LEAST 15 MINUTES, GET  
MEDICAL ATTENTION.

3. SKIN FLUSH WITH FRESH WATER, WASH WITH SOAP AND WATER  
REMOVE CONTAMINATED CLOTHES AND SHOES

4. INGESTION GIVE MILK OR WATER, DO NOT INDUCE VOMITING. GET MEDICAL  
ATTENTION. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS  
PERSON.

RESPIRATORY PROTECTION MESA/NIOSH APPROVED RESPIRATOR.

VENTILATION MECHANICAL YES SPECIAL NONE VENTILATION LOCAL NONE

PROTECTIVE GLOVES IMPERVIOUS

EYE PROTECTION FACE SHIELD/GOGGLES

OTHER PROTECTIVE CLOTHING/EQUIPMENT IMPERVIOUS PROTECTIVE APRON, EYEWASH FACILITY, EMERGENCY SHOWER.

HANDLING AND STORAGE DO NOT PRESSURE CONTAINER TO EMPTY. MATERIAL IS STRONG IRRITANT.  
SKIN AND EYES. AVOID BODILY CONTACT. WORKERS SHOULD WASH AFTER EACH  
USE AND SHOWER AT END OF WORK PERIOD. MATERIAL MAY BE SKIN  
SENSITIZER IN SUSCEPTIBLE INDIVIDUALS.

OTHER PRECAUTIONS DOT CLASS: COMPOUND, DEODORANTS OR DISINFECTANTS, N.O.D., LIQ.

IF MATERIAL IS RELEASED/SPILLED DIKE AND ABSORB SPILL USING HYPOCHLORITE SOLUTION WITH SAND,  
EARTH, ETC. TRANSFER TO SUITABLE CONTAINER FOR DISPOSAL.

REPORTABLE QUANTITY (R.Q.) OF PRODUCT: D002, 100 LBS.

WASTE PRECAUTIONS KEEP SPILL OUT OF MUNICIPAL SEWERS AND OPEN BODIES OF WATER.



# ATERIAL SAFETY DATA SHEET

ARS-8:00-5:00 EST-MON-FRI 1-800-543-4908

QUICK IDENTIFIER

DICATOR

7

MEDICAL (COLLECT)

303-592-0021

800-424-9300

EMERGENCY PHONE NO.

313-458-5000

REFERENCE

DIVERSEY CORP  
12025 TECH CENTER DRIVE  
TIVONIA, MICHIGAN 48150  
PREPARED BY: REGULATORY  
ON 12/02/93

ABBREVIATION	C-CEILING, M-MAXIMUM PEAK, N/A-NOT APPLICABLE, N/K-NOT KNOWN, P-POTENTIAL, P-L-PERMISSIBLE EXPOSURE, L-M		
IT, P-M, N-SKY, M-TENE, S-SOM, ST-SHORT TERM, T-LV-THRESHOLD LIMIT VALUE, T-WA-TIME WEIGHTED AVERAGE			
COMMON NAME USED ON LABEL	DICATION		
CHEMICAL FAMILY	COOLING TOWER DESICCANT		
PRINCIPAL HAZARDOUS COMPONENT(S) CHEMICAL & COMMON NAME	SODIUM HYDROXIDE (1310-73-2)		
EXPOSURE LIMITS (TWA & HOUR UNLESS OTHERWISE SPECIFIED)	TLC C 2; PEL C 2		
UNITS	MG/M3		
APPEARANCE & COLOR	BROWN, NO COLOR		
FLAME	NONE		
EXTINGUISHER MEDIA	N/A		
FLAME	NONE		
EXTENSION	N/A		
FLAMMABLE LIMITS	NONE		
ALTO IGNITION TEMPERATURE	N/A		
PREFIGHTING	WEAR PROTECTIVE GEAR AND SELF CONTAINED BREATHING APPARATUS IN		
SPECIAL PROCEDURES	FIRE AREA.		
UNUSUAL FIRE AND EXPLOSION HAZARDS	NONE		
STABILITY	POLYMERIZATION		
INCOMPATIBLE WITH	CONCENTRATED MINERAL ACIDS		
DECOMPOSITION PRODUCTS	CO, H2O WITH INCOMPLETE COMBUSTION		
PRIMARY ROUTES OF ENTRY	INHALATION YES, SKIN NO, INGESTION YES		
SIGNS	1. ACUTE IRRITATING TO EYES, MISTS ARE RESPIRATORY IRRITANTS.		
SYMPTOMS	2. CHRONIC SAME AS ACUTE		
OVEREXPOSURE			
MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE	SENSITIVE SKIN		
LISTED CARCINOGEN	NONE		
EMERGENCY AND FIRST AID PROCEDURES			
1. INHALATION	N/A IN NORMAL OPERATION.		
2. EYES	FLUSH THOROUGHLY WITH FRESH WATER FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION.		
3. SKIN	FLUSH WITH FRESH WATER. WASH WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHES AND SHOES.		
4. INGESTION	GIVE WATER. DO NOT INDUCE VOMITING. GET MEDICAL ATTENTION. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.		
RESPIRATORY PROTECTION	NONE		
VENTILATION MECHANICAL	PRODUCING NORMAL AIR DIRECTION		
PROTECTIVE GLOVES	ALKALI RESISTANT		
EYE PROTECTION	FACE SHIELD		
OTHER PROTECTIVE CLOTHING/EQUIPMENT	CLOTHING TO PREVENT PROLONGED SKIN CONTACT.		
HANDLING AND STORAGE PRECAUTIONS	KEEP BUNG IN DRUM; STORE INSIDE OR OUTSIDE. IF FROZEN, THAW AND MIX TO MAKE USABLE. DO NOT PRESSURE CONTAINER TO EMPTY.		
OTHER PRECAUTIONS	DOT CLASS: CORROSIVE LIQUIDS, H.O.S., (SODIUM HYDROXIDE), 8, UN1760, PG III		
IF MATERIAL IS RELEASED/SPILLED	FLUSH SMALL AMOUNTS TO DRAIN. COLLECT AND RETURN LARGE AMOUNTS TO CONTAINER.		

# MATERIAL SAFETY DATA SHEET

UNSAFE-8:00-5:00 EST-MON-FRI 1-800-543-4908

QUICK IDENTIFIER

GCO-10-1V

MSDS (COLLECT) 1-800-543-4908

DIVERSITY CORP  
2025 ALCO CENTER DRIVE  
LIVONIA, MICHIGAN 48150  
PREPARED BY: REGULATORY  
ON 07/16/91

EMERGENCY

313-451

REFERENCE

136

ABBREVIATIONS: C-CORING MP-MAXIMUM PEAK N/A-NOT APPLICABLE N/K-NOT KNOWN L-POTENTIAL PEL-PERMISSIBLE EXPOSURE  
IT-PRA-PENSKY MARTENS 2-SKIN ST-SHORT TERM TLV-THRESHOLD LIMIT VALUE TWA-TIME WEIGHTED AVERAGE

COMMON NAME USED ON LABEL		GCO-10-1V		CODE G2225	
CHEMICAL FAMILY		COOLING FLUIDS		CONCENTRATION	
PRINCIPAL HAZARDOUS COMPONENT(S) CHEMICAL & COMMON NAME		%		EXPOSURE LIMITS (TWA 8 HOUR UNLESS OTHERWISE SPECIFIED)	
SODIUM MOLYBDATE (7631-95-0)		<10		TLV 5: PEL 5	
POLY(OXYETHYLENE-(DIMETHYLIMINO)ETHYLENE-(DIMETHYLIMINO)ETHYLENE DICHLORIDE; 31075-24-8		<2		NONE ESTABLISHED (EYE IRRITANT)	
EPA REGISTRATION NO. 875-141					
APPEARANCE & COLOR		CLEAR - COLORLESS WITH ODOR		FLAMMABLE LIMITS LOWER UPPER AUTO IGNITION TEMPERATURE	
FLASH POINT		WATER		EXTENSION	
EXTINGUISHING MEDIA		CO2		FOAM DRY CHEMICALS	
PREPACKAGING		NONE		SPECIAL PROCEDURES	
UNUSUAL FIRE AND EXPLOSION HAZARDS		NONE			
STABILITY		POLYMERIZATION			
INCOMPATIBLE WITH		CONCENTRATED MINERAL ACIDS			
DECOMPOSITION PRODUCTS		CO WITH INCOMPLETE COMBUSTION			
PRIMARY ROUTES OF ENTRY		INHALATION		NO	
SIGNS		1. ACUTE		IRRITATE SKIN; MAY IRRITATE EYES	
SYMPTOMS		2. CHRONIC		SAME AS ACUTE	
OVEREXPOSURE					
MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE		SENSITIVE SKIN			
LISTED CARCINOGEN		NONE		MTP NO LAC NO OSHA NC	
EMERGENCY AND FIRST AID PROCEDURES					
1. INHALATION		N/A IN NORMAL OPERATION.			
2. EYES		FLUSH THOROUGHLY WITH FRESH WATER. GET MEDICAL ATTENTION.			
3. SKIN		FLUSH WITH FRESH WATER. WASH WITH SOAP AND WATER. REMOVE CONTAMINATED CLOTHES AND SHOES.			
4. INGESTION		GIVE MILK OR WATER. INDUCE VOMITING. GET MEDICAL ATTENTION. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.			
RESPIRATORY PROTECTION		NONE		VENTILATION LOCAL NO	
VENTILATION MECHANICAL		NORMAN AND DAVENPORT		SPECIAL NONE	
PROTECTIVE GLOVES		NONE			
EYE PROTECTION		SAFETY GLASSES WHEN HANDLING			
OTHER PROTECTIVE CLOTHING/EQUIPMENT		NONE			
HANDLING AND STORAGE PRECAUTIONS		DO NOT PRESSURE CONTAINER TO EMPTY. KEEP CONTAINER CLOSED. IF FROZEN, THAW AND MIX TO MAKE USABLE.			
OTHER PRECAUTIONS		D.O.T. CLASS: NOT REGULATED.			
IF MATERIAL IS RELEASED/SPILLED		FLUSH SMALL AMOUNTS TO DRAIN. COLLECT AND RETURN LARGE AMOUNTS TO CONTAINER. PREVENT SPILLS FROM ENTERING OPEN BODIES OF WATER.			

# MATERIAL SAFETY DATA SHEET

SCANS-8:00-5:00 EST-MON-FRI 1-800-543-4908

QUICK IDENTIFIER

PENTREX

MEDICAL (COLLECT)

303-592-1000

CHEMTREC

1-800-424-9300

DIVERSITY CORP.  
12025 TECH CENTER DRIVE  
LIVONIA, MICHIGAN 48150  
PREPARED BY: REGULATORY  
ON 01/16/91

EMERGENCY PHONE NO.

313-458-5000

REFERENCE

IDENTIFICATION: C-BELUNG MP-MAXIMUM PEAK N/A-NOT APPLICABLE N/A-NOT KNOWN A-POTENTIAL PEL-PERMISSIBLE EXPOSURE U  
IT, PEL-PERMISSIBLE EXPOSURE U, N/A-NOT KNOWN, T.V.-THRESHOLD LIMIT VALUE, TWA-TIME WEIGHTED AVERAGE.

COMMON NAME USED ON LABEL: PENTREX

CHEMICAL FAMILY: CONCENTRATED RINSE AID

CODE: 03152

PRINCIPAL HAZARDOUS COMPONENT(S) CHEMICAL & COMMON NAME

NONE

EXPOSURE LIMITS (TWA 8 HOUR UNLESS OTHERWISE SPECIFIED)

UNITS

214

APPEARANCE & COLOR: CLEAR LIQUID, MILD ODOR

FLASH POINT: N/A

EXTINGUISHING MEDIA: CO2, FOAM, DRY CHEMICALS

PRESERVATION: NONE

SPECIAL PROCEDURES

FLAMMABLE LIMITS: LOWER, UPPER, AUTO IGNITION TEMPERATURE

STABILITY: POLYMERIZATION, STRONG OXIDIZERS

INCOMPATIBILITY: WITH, DECOMPOSITION

DECOMPOSITION: CO WITH INCOMPLETE COMBUSTION

PRIMARY ROUTES OF ENTRY: INHALATION, NO, NO, NO

SIGNS: 1. ACUTE, MAY CAUSE EYE IRRITATION; DEFATS SKIN.

AND

SYMPTOMS: 2. CHRONIC, SAME AS ACUTE

OF

OVEREXPOSURE

MEDICAL CONDITIONS GENERALLY AFFECTED BY EXPOSURE: SENSITIVE SKIN

LISTED CARCINOGEN: NONE

EMERGENCY AND FIRST AID PROCEDURES

1. INHALATION: N/A IN NORMAL OPERATION

2. EYES: FLUSH THOROUGHLY WITH FRESH WATER FOR AT LEAST 15 MINUTES, GET MEDICAL ATTENTION.

3. SKIN: FLUSH WITH FRESH WATER, WASH WITH SOAP AND WATER REMOVE CONTAMINATED CLOTHES AND SHOES

4. INGESTION: GIVE MILK OR WATER. INDUCE VOMITING, GET MEDICAL ATTENTION.

RESPIRATORY PROTECTION: NONE

VENTILATION MECHANICAL: PRODUCING NORMAL AIR DILUTION

PROTECTIVE GLOVES: NONE

EYE PROTECTION: NONE

OTHER PROTECTIVE CLOTHING/EQUIPMENT: NONE

HANDLING: DO NOT PRESSURE CONTAINER TO EMPTY. KEEP FROM FREEZING. KEEP BUNGS IN CONTAINER. IF FROZEN, THAW AND MIX TO MAKE USABLE.

PRECAUTIONS: DOT CLASS: NOT REGULATED.

PRECAUTIONS: FLUSH SMALL AMOUNTS TO DRAIN; COLLECT AND RETURN LARGE AMOUNTS TO CONTAINER.

PRECAUTIONS: FLUSH SMALL AMOUNTS TO DRAIN; COLLECT AND RETURN LARGE AMOUNTS TO CONTAINER.

M/F PA _____ Rating _____ Health _____ Flammability _____ Reactivity _____ Special _____		Dmg _____ Rating _____ Health _____ Flammability _____ Reactivity _____ Personal Protection _____	
<b>Material Safety Data Sheet</b> This MSDS complies with OSHA's Hazard Communication Standard 29 CFR 1910.1200 and OSHA FORM 174.		<b>NOT HAZARD CLASSIFICATION</b> <b>Non-Hazardous</b>	
MANUFACTURED FOR: COASTLINE LTD. ADDRESS: P. O. BOX 1247 ALEXANDRIA, VA 22303 Phone Number (For Information): (703) 461-0200 Emergency Phone Number: CHEMTREC 1-800-424-9300		Identity (Trade Name as Used On Label): <b>FORMULA 1100</b> MSDS Number: _____ Date Prepared: <b>2/3/93</b> Prepared By: <b>CS/IAB</b>	
<b>SECTION 1 - MATERIAL IDENTIFICATION AND USE</b>		<b>NOTICE: JUDGEMENT BASED ON INDIRECT TEST DATA</b>	

**SECTION 1 - MATERIAL IDENTIFICATION AND INFORMATION**

[illegible]

**Open Access**

cc Chemical Listing  
of Cartridges or  
Potential Cartridges



**UAC Monograph**



**Not Valid**

### **I. Summary**

**Sale Only**

**SECTION 2 - PHYSICAL / CHEMICAL CHARACTERISTICS**

PHYSICAL / CHEMICAL CHARACTERISTICS			
Boiling Point	312° F.	Specific Gravity (H <sub>2</sub> O = 1)	1.22
Vapor Pressure PSIG @ 78°F (Aerosols)	N/A	Vapor Pressure (Non-Aerosols) (mm Hg and Temperature)	17
Vapor Density (Air = 1)	N/A	Evaporation Rate (— Water) — g	1
Solubility in Water	Total	Water Residue	None
Appearance and Color	Clear, slightly turbid, non-viscous fluid, amber color, disinfectant odor.		

### SECTION 3 - FIRE AND EXPLOSION HAZARD DATA

FLAMMABILITY AND EXPLOSION HAZARD DATA				
FLAMMABILITY as per USA FLAME PROJECTION TEST (ASTM D3036)	N/A	Auto-Ignition Temperature	N/A	Flammability Limits in Air % by Volume
Flash Point and Method Used (Non-Aerosols)	None.			LEL N/A UEL N/A
Extinguisher Media	Not considered flammable.			
Special Fire Precautions	None.			
Unusual Fire and Explosion Hazards	None identified.			

Form 1100, 2

**SECTION 4 - REACTIVITY HAZARD DATA**

<b>STABILITY</b> <input checked="" type="checkbox"/> Stable <input type="checkbox"/> Unstable	<b>Conditions To Avoid</b> None noted.	<b>HAZARDOUS POLYMERIZATION</b> <input type="checkbox"/> May occur <input checked="" type="checkbox"/> Will Not Occur
<b>Instability (Materials to Avoid)</b> Do not mix product with anything but water.		
<b>Hazardous Decomposition Products</b> None noted.		

**SECTION 5 - HEALTH HAZARD DATA**

<b>PRIMARY ROUTES OF ENTRY</b>	<input checked="" type="checkbox"/> Inhalation	<input type="checkbox"/> Ingestion	<input type="checkbox"/> Not Hazardous
	<input checked="" type="checkbox"/> Skin Absorption	<input type="checkbox"/> Eye	

**ACUTE EFFECTS** Non-hazardous to dermal absorption or inhalation.

Inhalation Prolonged inhalation may cause irritation to mucous membranes.

Eye Contact Irritant.

Skin Contact None.

Ingestion May cause nausea.

**CHRONIC EFFECTS** None noted.**Medical Conditions** Generally Approved by Exposure None noted.**EMERGENCY FIRST AID PROCEDURES -**

Eye Contact Wash with clear water for 15 minutes.

Skin Contact Wash with soap and water, apply skin cream, if desired.

Inhalation Remove to fresh air.

Ingestion Do not induce vomiting. Drink milky acid water, then seek medical attention.

**SECTION 6 - CONTROL AND PROTECTIVE MEASURES****Respiratory Protection** None required.  
(Specify Type)**Protective Gloves** Rubber, if desired.**Eye Protection** Goggles or face shield, if desired.**VENTILATION REQUIREMENTS**

Local exhaust is adequate.

**Other Protective Clothing and Equipment** Boots and apron, if desired.**Hygienic Work Practices** Wash face and hands after use.**SECTION 7 - PRECAUTIONS FOR SAFE HANDLING AND USE / LEAK PROCEDURES****Steps to be Taken if Material is Spilled Or Released** Absorb spilled material on clay or sawdust. Clean residue into 5 gallon container for disposal. Wash surface off with water.**Waste Disposal Methods** Consult local, state or federal officials about approved method of disposal for germicidal wastes.**Precautions to be Taken in Handling and Storage** Keep out of reach of children. Store in closed original container. Protect from freezing. Store in cool dry area.**Other Precautions and / or Special Hazards** Product is toxic to fish and birds. Read label carefully before use. Shelf life 1 year.

We believe the statements, technical information and recommendations contained herein are reliable, but they are given without warranty or guarantee of any kind. Express or implied.



## MATERIAL SAFETY DATA SHEET

PRODUCT NAME: FORMULA 1109 MANUFACTURED FOR:  
DATE PREPARED: May 1, 1990  
EMERGENCY PHONE #: (703) 461-0200

COASTLINE LTD.  
P. O. BOX 1247  
ALEXANDRIA, VA 22315  
(703) 461-0200

### PRODUCT IDENTIFICATION

Active Ingredient Formulas:  $\text{Na}_2(\text{CS}_2\text{NHCH}_2)_2$ ;  $\text{C}_2\text{H}_4\text{NS}_2\text{Na}_2$  CAS No: 142-59-6/123-04-1  
Chemical Names/Synonyms: Blend of disodium ethylene bisdithiocarbamate/  
sodium dimethyldithiocarbamate; Nabam/Sodam  
DOT Shipping Name: Non-hazardous (not regulated)  
DOT Hazard Class: Non-hazardous CERCLA RQ: 10,000 lb

### PHYSICAL DATA (TYPICAL)

Appearance: Light amber colored liquid pH: 11.5  
Odor: slight ammonia odor Solubility In Water: Complete  
Specific Gravity ( $\text{H}_2\text{O}=1$ ): 1.04

### HAZARDOUS INGREDIENTS

Components	1	2
Disodium ethylene bisdithiocarbamate	4.5	Not available
Sodium dimethyldithiocarbamate	4.5	Not available
Ethylene thiourea CAS No. 96-45-7	Approx. 0.1	Not available

### FIRE AND EXPLOSION DATA

Flash Point (method):  $>200^\circ\text{F}$  (Pensky-Martens)  
Extinguishing Media: No fire hazard.  
Special Fire Fighting Procedures: Not applicable.  
Unusual Fire And Explosion Hazards: Hydrogen sulfide and flammable by-products may be generated under extreme heat or contact with strong acids.

### HEALTH HAZARD DATA

Threshold Limit Value: Not available.  
Effects Of Overexposure: Exact effects unknown. Material is harmful if swallowed and may cause irritation on skin or eye contact. Acute oral  $\text{LD}_{50}$  for rats on Nabam is 395 mg/kg and on Sodam 1 g/kg.

### Emergency First Aid Procedures:

Eyes:	Flush immediately with water. Get medical attention.
Skin:	Wash with soap and water. Get medical attention if irritation persists.
Ingestion:	Drink promptly a large quantity of milk, egg whites, gelatin solution or if these are not available, drink large quantities of water. Call a physician immediately.
Inhalation:	Move to fresh air. Get medical attention immediately.

Form 1109

Pg 2

**REACTIVITY DATA**

**Stability:** Material is stable.  
**Incompatibility:** Strong acids and oxidizing agents.  
**Hazardous Decomposition Products:** Hydrogen sulfide may be produced if heated to high temperatures. Carbon disulfide may be produced on contact with strong acids. Dimethylnitrosamines may be produced on contact with a combination of strong acids and nitrosating compounds.  
**Hazardous Polymerization:** Will not occur.

**SPILL OR LEAK PROCEDURES**

**Steps To Be Taken In Event Material Is Released Or Spilled:** Collect all spilled material. Do not flush directly to waste treatment facility or water courses.  
**Waste Disposal Method:** Material is a pesticide and must be disposed of in a manner approved by EPA Resource Conservation and Recovery Act. RCRA waste code: U116.

**SPECIAL PROTECTION INFORMATION****Specific Personal Protective Equipment:**

**Eyes:** Chemical goggles which are dust- and splash-proof or face shield.  
**Skin:** Impervious clothing, rubber gloves and boots.  
**Respiratory:** None.  
**Other:** Safety shower/eye wash located in immediate area.  
**Ventilation Requirements:** Provide local exhaust.

**SPECIAL PRECAUTIONS**

**Precautions To Be Taken In Handling And Storing:** Keep from freezing and temperatures >140°F. Store in a cool place away from acids.  
**Other Precautions:** Insure containers are tightly closed when not in use.

**REGULATORY STATUS INFORMATION**

**TOXIC SUBSTANCES CONTROL ACT (TSCA):** All components of this product are listed in the Toxic Substances Control Act inventory.

**COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION AND LIABILITY ACT (CERCLA):**  
 Reportable Quantity - 3,300 pounds.

**SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA Title III) - Section 311 Hazard Categories:**

Acute Health:	Yes
Chronic Health:	Yes
Fire:	No
Sudden Release of Pressure:	No
Reactive:	No

**Chronic Health:** Ethylene thiourea (CAS No. 96-45-7) is listed as an anticipated human carcinogen (NTP) and as a possible human carcinogen (Group 2B - IARC).

**SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA Title III) - Section 313: Components of this product subject to reporting:** Ethylene thiourea (CAS No. 96-45-7).

The information and recommendations contained in this Material Safety Data Sheet have been compiled from sources believed to be reliable and to represent the best opinion on the subject of the data on this sheet. However, no warranty, guarantee or representation, express or implied, is made by the manufacturer as to the correctness or sufficiency of this information or to the results to be obtained from the use thereof.

MSDS Rating: Health _____ Flammability _____ Reactivity _____ Special _____  <h2 style="margin:0;">Material Safety Data Sheet</h2> <p>This MSDS complies with OSHA's Hazard Communication Standard 29 CFR 1910.1200 and OSHA FORM 174.</p>		MSDS Rating: Health <u>3</u> Flammability <u>2</u> Reactivity <u>2</u> Personal Protection <u>B</u>  <b>GHS HAZARD CLASSIFICATION:</b> Corrosive Material  Identity (Trade Name As Used On Label) <b>FORMULA - T200</b>  MSDS Number _____				
<b>COASTLINE LTD.</b>  ADDRESS <b>P. O. BOX 1247</b>  <b>ALEXANDRIA, VA 22313</b>  Phone Number (For Information) <b>(703) 461-0200</b>  Emergency Phone Number <b>(703) 461-0200</b>		<b>EMERGENCY RESPONSE NUMBER: (703) 461-0200</b>  Date Prepared <b>2/93</b>  Prepared By <b>ME</b>  <b>NOTICE: JUDGEMENT BASED ON INDIRECT TEST DATA</b>				
<b>SECTION 1 - MATERIAL IDENTIFICATION AND INFORMATION</b>						
COMPONENTS — Chemical Name & Common Name (Hazardous Components 1% or greater Carcinogens 0.1% or greater)		CAS Number	APPROX. % (wt)	OSHA PEL (ppm)	ACGIH TLV (ppm)	CARCINOGEN REFERENCE SOURCE **
<b>POTASSIUM HYDROXIDE</b>		1310-58-3	8 - 10	2mg/m <sup>3</sup>	2mg/m <sup>3</sup>	-
<b>1-Hydroxyethylidene-1, 1-Diphosphonic Acid</b>		2809-21-4	< 10			
*Optional: N/A = Not Applicable N/D = Not Determined N/E = Not Established		** Chemical Listed as Carcinogen or Potent Carcinogen <input checked="" type="checkbox"/> NTP <input checked="" type="checkbox"/> IARC Monographs <input type="checkbox"/> OSHA <input type="checkbox"/> Not Listed <input type="checkbox"/> Animal Data Only				
<b>SECTION 2 - PHYSICAL / CHEMICAL CHARACTERISTICS</b>						
Boiling Point	100° C.	Specific Gravity (H <sub>2</sub> O = 1)		1.10		
Vapor Pressure	PSIG @ 70°F (Aerosols)	Vapor Pressure (Non-Aerosols) (mm Hg and Temperature)		N/D		
Vapor Density (Air = 1)	N/D	Evaporation Rate (Water = 1)		1.0		
Solubility in Water	Soluble	Water Reactivity		No		
Appearance and Odor: Clear, light yellow liquid. Slight ammonia odor.						
<b>SECTION 3 - FIRE AND EXPLOSION HAZARD DATA</b>						
FLAMMABILITY by per USA FLAME PROJECTION TEST (AEROSOLS)		Auto-Ignition Temperature		Flammability Limits in Air % by Volume		LEL
Flash Point and Method Used (Non-Aerosols)		None		None		UEL
extinguisher		Any media appropriate for outstanding lit.		None.		None.
Special fire fighting procedures		None.				
Unusual fire and explosion hazards: Material may react with exposed metal surfaces (such as aluminum) to generate flammable hydrogen gas.						



Form 2055

# SECTION 4 - REACTIVITY HAZARD DATA

<b>STABILITY</b> <input checked="" type="checkbox"/> Stable <input type="checkbox"/> Unstable	<b>Conditions To Avoid</b> Avoid excessive temperatures	<b>HAZARDOUS POLYMERIZATION</b> <input type="checkbox"/> May occur <input checked="" type="checkbox"/> Will Not Occur
<b>Instability (Materials to Avoid)</b> Strong Oxidizing Agents, Strong Alkali		
<b>Hazardous Decomposition Products</b> Carbon Monoxide, Carbon Dioxide, Small Amounts of Hydrocarbons		

# SECTION 5 - HEALTH HAZARD DATA

<b>PRIMARY ROUTES OF ENTRY</b> <input type="checkbox"/> Inhalation <input checked="" type="checkbox"/> Skin Absorption <input type="checkbox"/> Eye	<input type="checkbox"/> Ingestion <input type="checkbox"/> Not Hazardous
<b>ACUTE EFFECTS</b> Aqueous solution is irritant to all body tissues. May be fatal if directly inhaled. Inhalation: Inhalation of spray or mist will cause respiratory tract irritation. Eye Contact: Will cause irritation. May cause tissue damage. Skin Contact: May cause irritation. Prolonged contact may cause damage. Ingestion: Will cause GI tract irritation. May cause damage, may be fatal.	
<b>CHRONIC EFFECTS</b> None known.	
<b>Medical Conditions</b> Generally Aggravated by Exposure Strong irritant to existing cuts and abrasions on contact.	

# EMERGENCY FIRST AID PROCEDURES -

<b>Eye Contact</b> Flush with clear water for 15 minutes. If irritation persists, get medical attention.	<b>Skin Contact</b> Wash with soap and water. If irritation persists or ulceration develops, get medical attention.
<b>Inhalation</b> Remove to fresh air. If irritation persists, get medical attention.	<b>Ingestion</b> Do not induce vomiting. Drink large quantity of water. Seek medical attention.

# SECTION 6 - CONTROL AND PROTECTIVE MEASURES

<b>Respiratory Protection (Specify Type)</b> Wear NIOSH/OSHA approved mist respirator if mists are generated.	<b>Protective Clothing</b> Rubber or plastic	<b>Eye Protection</b> Chemical splash goggles.
<b>VENTILATION REQUIREMENTS</b> Normal ventilation is adequate.		
<b>Other Protective Clothing and Equipment</b> Impervious apron or clothing and footwear. Eye bath and safety shower.		
<b>Hygiene Work Practices</b> Do not eat or drink in work areas. Wash hands before using rest room facilities.		

# SECTION 7 - PRECAUTIONS FOR SAFE HANDLING AND USE / LEAK PROCEDURES

<b>Steps to be Taken if Material is Spilled or Released</b> Flush to sewer with copious quantities of water.
<b>Waste Disposal Method</b> Product may be defined as a hazardous waste due to the characteristic of corrosivity.
<b>Precautions to be Taken in Handling and Storage</b> Keep container closed when not in use. Do not breath mists or get on eyes, skin or clothing. Wash thoroughly after handling.
<b>Other Precautions and / or Special Hazards</b> Keep out of reach of children.

We believe the statements, technical information and recommendations contained herein are given without warranty or guarantee of any kind, express or implied.

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Form 7200  
292

## SECTION 4 - REACTIVITY HAZARD DATA

<b>STABILITY</b> <input checked="" type="checkbox"/> Stable <input type="checkbox"/> Unstable	<b>Conditions To Avoid</b> None	<b>HAZARDOUS POLYMERIZATION</b> <input type="checkbox"/> May occur <input checked="" type="checkbox"/> Will Not Occur
<b>Instability (Materials to Avoid)</b> Strong acids, exposed active metal (aluminum) surfaces.		
<b>Decomposition Products</b> Potassium oxide, oxides of nitrogen, oxides of carbon.		

## SECTION 5 - HEALTH HAZARD DATA

<b>PRIMARY ROUTES OF ENTRY</b> <input type="checkbox"/> Inhalation <input checked="" type="checkbox"/> Skin Absorption <input type="checkbox"/> Ingestion <input type="checkbox"/> Eye <input type="checkbox"/> Not Hazardous	<b>ACUTE EFFECTS</b> Inhalation: Not expected to occur. Inhalation of spray or mist can be highly irritating. Prolonged contact can be corrosive. Eye Contact: Highly irritating. Prolonged contact can be corrosive. Skin Contact: Irritating. Prolonged contact can be corrosive. Ingestion: Corrosive to gastrointestinal, mouth, and throat tissues. Large quantities can be toxic.
<b>CHRONIC EFFECTS</b> None known.	
<b>Medical Conditions</b> Generally aggravated by exposure. None known.	

## EMERGENCY FIRST AID PROCEDURES -

<b>Eye Contact</b> Immediately flush with water for at least 15 minutes. Get immediate ophthalmological attention.
<b>Skin Contact</b> Flush with water for at least 15 minutes.
<b>Inhalation</b> Remove to fresh air.
<b>Ingestion</b> Get immediate medical attention.

## SECTION 6 - CONTROL AND PROTECTIVE MEASURES

<b>Respiratory Protection (Specify Type)</b> None needed.	<b>Protective Gloves</b> Rubber or chemical resistant.	<b>Eye Protection</b> Chemical goggles.
<b>VENTILATION REQUIREMENTS</b> No special ventilation needed.		
<b>Other Protective Clothing and Equipment</b> Eyewash station and safety shower. Rubber boots and apron under spraying conditions.		
<b>Hygiene and Welfare Precautions</b> Do not eat, smoke, or drink in work area. Wash after handling.		

## SECTION 7 - PRECAUTIONS FOR SAFE HANDLING AND USE / LEAK PROCEDURES

<b>Steps to be Taken if Material is Spilled or Released</b>	Soak up in absorbent material and place in properly labeled, sealed, leak-proof container.
<b>Waste Disposal Methods</b>	Consult with appropriate regulatory agencies to determine best legal method of disposal.
<b>Precautions to be Taken in Handling and Storage</b>	Store in original shipping containers. Keep closed when not in use. Protect from extreme heat or cold. Shelf life 1 year.
<b>Other Precautions and / or Special Handling</b>	Read and follow label directions in use. Keep out of the reach of children.

We believe the statements, technical information and recommendations contained herein are reliable, but they are given without warranty or guarantee of any kind, express or implied.

**APPENDIX E**

**HAMPTON ROADS SANITATION DISTRICT  
COOLING TOWER WASTE DISCHARGE POLICY  
INDUSTRIAL WASTEWATER POLLUTANT LIMITATIONS  
AND DISCHARGE REQUIREMENTS**



## COOLING TOWER WASTE DISCHARGE POLICY

Cooling tower chemicals containing the following constituents should not be discharged to the sewer system without prior authorization from the Industrial Waste Division:

- 1) Copper (Cu)
- 2) Chromium (Cr)
- 3) Zinc (Zn)
- 4) Tributyl tin (TBT)

Material Safety Data Sheets (MSDS) may not always reflect the presence of the above constituents. The user is responsible for ensuring that these parameters are not present in their cooling tower chemicals.

The discharges of cooling tower chemicals/wastes to the sewer system are also subject to the District's limitations (attachment 1) and to Section 301 (attachment 2) of the District's Industrial Wastewater Discharge Regulations, items (h), (n), (r), (s), (u), (x), and (y).

Wastes generated as a result of cooling tower system start-up cleaning, periodic maintenance, or system shut-down shall not be discharged to the District's system without specific authorization from the Industrial Waste Division. The District may require that the wastewater be collected from these operations and held until analysis showing compliance with District limitations is received and District authorization is given.

All cooling tower discharges which are accepted by the District must be metered for billing purposes. Billing based on estimates or proration of short duration metering studies will not be allowed.

The use of cooling tower maintenance chemicals which contain phosphorus (P), usually present in the form phosphate ( $PO_4$ ), may result in a surcharge for total phosphorus concentrations in excess of 6 mg/l. The surcharge is in accordance with the District's Rate Schedule and is assessed at the rate of \$114.00 per hundred pounds.

10/5/92

Attachment (3)



# **INDUSTRIAL WASTEWATER POLLUTANT LIMITATIONS (ATTACHMENT 1)**

**ALL PARAMETERS IN mg/l EXCEPT pH**

PARAMETER	FLOW IN THOUSAND GALLONS PER DAY (K)					
	0-10K	10-20K	20-30K	30-40K	40-200K	200-400K
ARSENIC	0.5	0.4	0.3	0.2	0.1	0.05
CADMIUM	0.5	0.4	0.3	0.2	0.1	0.05
✓ CHROMIUM	10.0	8.0	6.0	4.0	2.0	1.0
✓ COPPER	10.0	8.0	6.0	4.0	2.0	1.0
CYANIDE	2.5	2.0	1.5	1.0	0.5	0.25
LEAD	5.0	4.0	3.0	2.0	1.0	0.5
MERCURY	0.05	0.04	0.03	0.02	0.01	0.005
NICKEL	5.0	4.0	3.0	2.0	1.0	0.5
PHENOLIC COMPOUNDS	5.0	4.0	3.0	2.0	1.0	0.5 —
SILVER	*NOTE	1.0	0.75	0.5	0.25	0.125
✓ ZINC	10.0	8.0	6.0	4.0	2.0	1.0
O&G (NON-SAPONIFIABLE)	500	400	300	200	100	50
pH	≥5.0	≥5.0	≥5.0	≥5.0	≥5.0	≥5.0

\*NOTE: SILVER

GPD  
0-1000  
6.25

GPD  
1000-5000  
3.125

GPD  
5000-10000  
1.25

### PART III

#### DISCHARGE REQUIREMENTS (ATTACHMENT 2)

301

##### Prohibited Waste Discharges

No person shall discharge or cause to be discharged into any portion of the sewerage system, directly or indirectly, any wastes which may violate any law or governmental regulation or have an adverse or harmful effect on the sewerage system, maintenance personnel, wastewater treatment plant personnel, processes, or equipment, treatment plant effluent quality, sludge quality, public or private property, or which may otherwise endanger the public, the local environment or create a nuisance. Discharges of the following are prohibited:

- (a) Any gasoline, benzene, naphtha, solvent, fuel oil or any liquid, solid, or gas that may cause flammable or explosive conditions, including, but not limited to, wastestreams with a closed cup flashpoint of less than 140 degrees Fahrenheit or 60 degrees Centigrade using test methods specified in 40 CFR 261.21.
- (b) Any toxic or poisonous solids, liquids or gases in such quantities that, alone or in combination with other wastewater constituents, may interfere with the sewage treatment process or sludge disposal, cause acute worker health and safety problems, materially increase the cost of treatment, or constitute a hazard to any beneficial stream use, including recreation, ascribed to the receiving waters of the effluent from the sewage treatment plant.
- (c) Any waste having a pH lower than 5.0 or having any detrimental characteristics that may cause injury or damage to persons or property.
- (d) Any solids or viscous substances that may cause obstruction to flow or be detrimental to sewerage system operations. These objectionable substances include, but are not limited to, asphalt, dead animals, offal, ashes, sand, mud, straw, industrial process shavings, metals, glass, rags, feathers, tar, plastics, wood, whole blood, paunch manure, bones, hair and fleshings, entrails, paper dishes, paper cups, milk containers, or other similar paper products, either whole or ground.
- (e) Any significant quantities of unpolluted water such as rainwater, stormwater, groundwater, street drainage, yard drainage, water from yard fountains pond or lawnsprays.

- (f) Any water added for the purpose of diluting wastes which would otherwise exceed applicable maximum concentration limitations for any wastewater constituent.
- (g) Any petroleum or mineral based oils (non-saponifiable) and/ or any animal or vegetable based oils, fats, or greases which in excess concentrations would tend to cause interference, pass through, or adverse effects on the sewerage system, as determined by the District.
- (h) Any wastes with excessively high BOD, COD, or decomposable organic content or any significant quantities of wastewater with a COD to BOD ratio exceeding six to one.
- (i) Any strongly odorous wastes or waste tending to create odors.
- (j) Any waste containing dissolved sulfides in amounts which would be hazardous; cause damage to the sewerage system, or create a public nuisance.
- (k) Any substance promoting or causing the promotion of toxic gases.
- (l) Any wastes that will increase the temperature of the treatment plant influent to greater than 104°F (40°C).
- (m) Any wastes requiring the introduction of an excessive quantity of chlorine or any other compound for sewage treatment purposes.
- (n) Any excessive amounts of deionized water, distilled water, steam condensate, heating and/or air conditioning condensate or cooling water, and discharges from heat pumps.
- (o) Any waste producing excessive discoloration of wastewater or treatment plant influent.
- (p) Any waste containing substances that may precipitate, solidify, or become viscous at temperatures between 50°F (10°C) and 100°F (38°C).
- (q) Any significant quantities of garbage or waste that is not ground sufficiently to pass through a 3/8 inch screen.
- (r) Any excessive quantity of blown-down or bleed water from cooling towers or other evaporative coolers exceeding one-third of the makeup water.
- (s) Any significant quantities of single pass cooling water.



- (t) Any quantities of radioactive material wastes which are in violations of applicable local, State, and Federal regulations.
- (u) Any significant quantities of inorganic material.
- (v) Any discharge of any pollutant released at a flow rate and/or pollutant concentration that would result in interference, cause adverse effects or pass through at the treatment plant.
- (w) Any discharge not in compliance with all standards as set forth in 40 CFR Chapter I, Subchapter N, Parts 401-471 (National Categorical Standards).
- (x) Any significant quantity of Total Toxic Organics (TTO) which exceeds 2.13 mg/l, or in which any one toxic organic compound exceeds 1.0 mg/l, or in which the BTEX (Benzene, Toluene, Ethylbenzene and Xylene) concentration exceeds 1.0 mg/l.
- (y) Concentrations of any constituent listed in Appendix D which exceed the particular limitations set forth therein will not be discharged by any person who discharges 50,000 gallons or more on any day of the calendar year, directly or indirectly, into the sewerage system. Dischargers with a flow of less than, or significantly greater than, 50,000 gallons per day will be given limitations for constituents included in Appendix D on a case-by-case basis, taking into consideration, but not limited to, the following:
  - 1) Quantity, rate, and method of discharge.
  - 2) Proximity to the District treatment plant receiving the waste.
  - 3) Size and type of the treatment plant which receives the waste.
  - 4) Method of sludge disposal employed by the treatment plant receiving the wastes.
  - 5) Other discharges to the same treatment plant which may, in combination with the aforementioned discharge, form toxic substances or any constituent having adverse effects on treatment structures and processes or which cause a nuisance.

**APPENDIX F**

**MSDS FOR DIAS-AID TOWER TREATMENT XP-300**

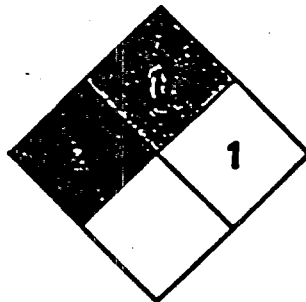


## MATERIAL SAFETY DATA SHEET

XP-300

Revision Date: 11/25/92

DIAS, Incorporated  
4510 Commercial Ave.  
Kalamazoo, MI 49001



Phone 1-800-332-DIAS

24 Hour Emergency Phone  
1-800-442-4112

### SECTION 1

#### OSHA HAZARD CLASSIFICATIONS

Corrosive to eyes and irritating to skin.

### SECTION 2

#### HAZARDOUS COMPONENTS

The components of this product comprise proprietary information.

### SECTION 3

#### PRECAUTIONARY LABEL INFORMATION

This section not applicable to non-biocides.

### SECTION 4

#### FIRST AID INFORMATION

**EYE EXPOSURE:** Flush immediately with copious amounts of tap water or normal saline (minimum of 15 minutes). Take exposed individual to a health care professional, preferably an ophthalmologist, for further evaluation.

**SKIN EXPOSURE:** Wash exposed area with plenty of soap and water. Repeat washing. Remove contaminated clothing and wash thoroughly before reuse. If irritation persists consult a health care professional.

**INHALATION:** If exposure by inhalation is suspected, immediately move exposed individual to fresh air. If individual experiences nausea, headache, dizziness, has difficulty in breathing or is cyanotic, seek a health care professional immediately.

**INGESTION:** DO NOT INDUCE VOMITING. Rinse mouth with copious amounts of water or milk, first. Irrigate the esophagus and dilute stomach contents by slowly giving one (1) to two (2) glasses of water or milk. Avoid giving alcohol or alcohol related products. In cases where the individual is semi-comatose, comatose or convulsing, DO NOT GIVE FLUIDS BY MOUTH. In case of intentional ingestion of the product seek medical assistance immediately; take individual to nearest medical facility.

**NOTE TO PHYSICIAN:** No specific antidote is known. Probable mucosal damage may contraindicate the use of gastric lavage. Treat symptoms. Call DIAS, Inc. for product information at 1-800-332-3427.

### SECTION 5

#### PRIMARY ROUTES OF EXPOSURE

Effects from acute exposure:

**Eye Exposure:** Corrosive. Effects may range from moderate to severe (corrosion) depending on the length of exposure, solution concentration and first aid measures.

**Skin Exposure:** IRRITANT. Irritation will depend on solution strength, length of exposure and first aid measures.

**Inhalation:** May cause irritation or corrosion of mucous membranes and the lungs. Exposed individuals should be monitored.

**Ingestion:** No data is available on human ingestion.

**SECTION 6****TOXICOLOGICAL INFORMATION****Acute Effects:**

Acute Oral LD50: 2,000 mg/kg

Acute Dermal LD50: 2,500 mg/kg

Acute inhalation LC50: 2.0 mg/l

**Irritant Effects:**

Mild transient irritation.

**Sensitization Effects:** No evidence of sensitization.**Carcinogenic Potential:** Not listed in any of OSHA Standard, section 1910.1200, not tested by DIAS, Inc.**Other Health Effects:** None known.**SECTION 7****ENVIRONMENTAL TOXICOLOGICAL INFORMATION****SECTION 8****PHYSICAL AND CHEMICAL PROPERTIES**

Appearance \_\_\_\_\_ Dark Amber Liquid

Odor \_\_\_\_\_ Mild

Density @ 25° C \_\_\_\_\_ 1.20 G/ML

Flash Point \_\_\_\_\_ 212° F

Freezing Point \_\_\_\_\_ 0° C

Boiling Point \_\_\_\_\_ 212° F

Solubility \_\_\_\_\_ Completely in water

pH \_\_\_\_\_ 1.0

pH (100 ppm in water) \_\_\_\_\_ 6.0

Vapor Pressure \_\_\_\_\_ Not Tested

D/W Partition Coefficient \_\_\_\_\_ Not Tested

Oxidizing/Reducing Prop \_\_\_\_\_ Not Tested

**SECTION 9****FIRE AND EXPLOSION INFORMATION****Flammable Limits:** Not applicable.**Extinguishing Media:** Water fog, carbon dioxide, foam, dry chemicals.**Special Fire Fighting Procedures:** Self contained breathing apparatus.**SECTION 10****REACTIVITY INFORMATION****Stability:** Stable.**Incompatibility:** Strong acids, strong oxidizers, anionic polymers.**Hazardous Decomposition Products:** Exposure to fire can generate oxides of phosphorous, nitrogen, and/or carbon.**SECTION 11****HANDLING PRECAUTIONS**

Rubber gloves and safety glasses or goggles required.

Body-protective clothing and shoes are required.

Eye-wash fountains in the work area are recommended.

**SECTION 12****SATISFACTORY MATERIALS OF CONSTRUCTION**

Flexiglas  
Teflon  
PVC  
Buna-n Rubber  
Viton  
Neoprene  
Polyethylene

**Note:** The materials listed above have been tested with XP-300. The use of other materials not listed above may be hazardous and result in damages to such materials and other property and personal injuries. No data concerning such materials not listed above should be implied by the user.

**SECTION 13****SPILL, LEAK, AND DISPOSAL PROCEDURES**

**IMPORTANT:** Before responding to a spill or leak of this product, review each section of this MSDS. Follow the recommendations given in the Handling Precautions sections. Check the Fire and Explosion Data section to determine if the use of non-sparking tools is merited. Insure that spilled or leaked product does not come into contact with materials listed as incompatible. If irritating fumes are present, consider evacuation of enclosed areas.

Immediately minimize area affected by the spill or leak. Block any potential routes to water systems (e.g., sewers, streams, lakes, etc.). Based on the product's toxicological and chemical properties, and on the size and location of the spill or leak, assess the impact on contaminated environments (e.g., water systems, ground, air equipment, etc.). There are no methods available to completely eliminate any toxicity this product may have on aquatic environments. Minimize adverse effects on these environments. Determine if federal, state, and/or local release notification is required (see Regulatory Classifications section of this MSDS). Recover as much of the pure product as possible into appropriate containers. Later, determine if this recovered product can be used for its intended purpose. Address clean-up of contaminated environments. Spill or leak residuals may have to be collected and disposed of. Clay, soil, or commercially available absorbents may be used to recover any material that cannot readily be recovered as pure product. Flushing residual material to an industrial sewer, if present at the site of a spill or leak incident, may be acceptable if authorized approval is obtained. If product and/or spill/leak residuals are flushed to an industrial sewer, insure that they do not come into contact with incompatible materials. Contact the person(s) responsible for the operation of your facility's industrial sewer system prior to intentionally flushing or pumping spills or leaks of this product to the industrial sewer.

**DISPOSAL GUIDELINES**

**Note:** Follow federal, state and local regulations governing the disposal of waste materials.

**Contaminated Materials:** Determine if waste containing this product can be handled by available industrial effluent system or other on-site waste management unit. If off-site management is required, contact a company experienced in industrial waste management. This product is not specifically listed in 40 CFR 261 as a Resource Conservation and Recovery Act (RCRA) hazardous waste. However, spill or leak residuals may meet the criteria of a characteristic hazardous waste under this Act. Check the characteristics of the material to be disposed of and/or the physical and reactivity data given in this MSDS for the next product.

**Container Disposal:** Empty containers, as defined by appropriate sections of the RCRA, are not RCRA hazardous wastes. However, insure proper management of any residuals remaining in container.

**SECTION 14****TRANSPORTATION AND SHIPPING INFORMATION**

DOT Shipping Name: ORM-B, N.O.S. (XP-300 Acid), NA 1760

**SECTION 15****REGULATORY INFORMATION**

The following regulations are known to apply to the use and disposal of this product. Additional federal, state and local regulations may also be applicable.

SAHA (Superfund Amendments and Reauthorization Act)

SARA 302 Extremely Hazardous Substances List (40 CFR 300) Corrosivity

SARA 312 Immediate (Acute) Health Hazard

SARA 313 Toxic Chemicals List: No Section 313 Listed Substances are present above de minimus levels.

CERCLA (Comprehensive Environmental Response, Compensation and Liability Act: No components of this product are listed.

RCRA (Resource Conservation and Recovery Act) Listed Hazardous Wastes: No components of this product are listed.

CWA (Clean Water Act): No components of this product are listed.

FDA: This product not approved for food contact uses.

TSCA: All components are listed on TSCA inventory.

FFRMA: This product is not a registered pesticide.

HMIS/NFPA Ratings: Health 2; Flammability 1; Reactivity 1

NFPA RATINGS: Health 2; Flammability 1; Reactivity 1

**STATE REGULATIONS:**

Various state Right To Know Acts: Proprietary information is available should you require further information on specific proprietary chemicals or inerts. Please contact DIAS, Inc.

Information on this Material Safety Data Sheet reflects the latest information and data that we have on hazards, properties, and handling of this product under the recommended conditions of use. Any use of this product or method of application which is not described in the Product Data Sheet is the responsibility of the user. This Material Safety Data Sheet was prepared to comply with the OSHA Hazard Communication regulations.

DIAS, Inc. warrants that this product conforms to its chemical description and is reasonably fit for the purpose referred to in the directions for use when used in accordance with the directions under normal conditions. Buyer assumes the risk of any use contrary to such directions.

Seller makes no other warranty or representation of any kind, express or implied, concerning the product, including NO IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS OF THE GOODS FOR ANY OTHER PARTICULAR PURPOSE. No such warranties shall be implied by law and no agent of seller is authorized to alter this warranty in any way except in writing with a specific reference to this warranty.

The exclusive remedy against seller shall be a claim for damages not to exceed the purchase price of the product, without regard to whether such a claim is based upon breach of warranty or tort.

Any controversy or claim arising out of or relating to this contract, or breach thereof, shall be settled by arbitration in accordance with the commercial arbitration rules of the American Arbitration Association, and judgement upon the award rendered by the arbitrator(s) may be entered in any court having jurisdiction thereof.