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WATER TREATMENT PLANT

OPERATOR ASSISTANCE PROGRAM

LESSONS LEARNED

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WATER TREATMENT PLANT OPERATOR ASSISTANCE PROGRAM: LESSONS LEARNED

1. Purpose. This Public Works Technical Bulletin (PWTB) transmits the Water Treatment Plant: Lessons Learned Document. The lessons learned improve maintenance, efficiency, reliability, system life and safety of water treatment plant personnel.

2. Applicability. This PWTB applies to all U.S. Army Public Works activities responsible for operating and maintaining water treatment plants.

3. References.

a. Army Regulation 420-49, Facilities Engineering, Utility Services, April 1997.

b. MIL-HDBK-1164, DoD Handbook, Operations and Maintenance of Water Supply Systems, Department of the Army, Navy, and the Air force, March 1997. (Superceeds TM 5-660, 30 August 1984)

4. Discussion. The Army responded to recommendations in a Government Accounting Office (GAO) report "DoD Can Make further Progress in Controlling Pollution From Its Sewage Treatment Plants", February 3, 1994, by initiating the Operator Assistance Program (OAP). The OAP was developed to assist installation commanders in improving wastewater treatment plant operation and maintenance, thereby improving treatment plant efficiency and compliance with regulatory requirements. Additionally, the OAP was expanded to include water treatment plants as well. Many installations across the country are facing problems with water treatment plant operations and maintenance. One of the most common problems is the need for certified operators at military water treatment plants. Progress has been made in increasing the number of certified water treatment plant operators. However, the training needs of water treatment plant operators are changing and increasing and are not being met with existing training programs. This problem impacts the environment negatively and creates environmental liability for the Army. To assist installation commanders in water treatment plant operations and maintenance, a list of lessons learned over a 10 year period has been assembled to indicate the most common problems and their solutions.

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EXECUTIVE SUMMARY

This report is a summary of the Lessons Learned from the conduct of the US Army, Corps of Engineers Center for Public Works, Operator Assistance Program (OAP) at Army Water Supply Treatment Plants during the period 1984 to 1994. The information used to produce this report was taken from facility and plant specific OAP reports documenting on-site evaluations of the condition and operation of water supply treatment plants and collection systems. Below is shown a synopsis of the "Lesson" and a summary of the potential actions that can be taken to make full use of what has been "Learned."

Water Supply Facility Modernization

Many military water treatment plants are in need of modernization. Resources are so limited that, even when plant upgrades are approved, long time delays are normal before modernization occurs. This problem impacts the environment negatively and creates environmental liability for the Army.

Operations
Establish a working contact with local municipal and private water supply system operators and managers through implementation of "best operational practices."

Management
Investigate participation in regional system and privatization while maintaining existing facility.

Operator Training

Progress has been made in increasing the number of certified operators at military water treatment plants. However, the training needs of water treatment plant operators are changing and increasing and are not being met with existing training programs.

Operations
Create a training plan supported by a budget that husbands resources yet provides adequate training opportunity.

Management
Insist on periodically scheduled formal reporting on the status of individual training, certification and overall training needs.

Management Support

Military water treatment facilities have not usually been a high priority for installation facilities managers. This issue, coupled with decreasing resources has resulted in a decline in the morale of operating personnel. Low morale is a major contributor to poor operating, maintenance and housekeeping practices and concomitant degradation of treatment plant performance.

Operations
Seek opportunities to brief management on the operation status of the treatment works, and report fully and in detail all aspects of deficient operation or maintenance.

Management
Require detailed reports on the status of operation and maintenance and visit the plant more frequently.

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Plant Maintenance

Preventative maintenance (PM) on mechanical and electrical equipment is not routinely performed and long delays often occur before critical equipment is repaired and or replaced. There are few established formal preventive maintenance systems and/or critical spare parts inventory systems in place. Consequently, equipment failure rates, spare parts availability and plant performance suffers from the lack of such maintenance.

Operations
Create, implement and enforce a maintenance plan and a critical parts inventory program.

Management
Require formal and frequent reporting of PM practices and critical parts inventory status.

Plant Safety

Safety programs at military water treatment facilities are frequently incomplete and or inadequate. This results in the exposure of plant employees and others to unsafe conditions which may lead to subsequent injury or ill health.

Operations
Create, implement and enforce a safety plan specific to the water treatment facilities, as well as an up-to-date inventory of safety equipment and supplies. Assure that this plant safety program is part of the installation safety program.

Management
Require frequent status of water treatment plant safety program reporting, e.g., accidents, training, etc. to include formal inspections of the water supply treatment plant several times per year.

Treatment Process Control

Insufficient, and often inappropriate, intra-plant sampling and testing is being performed on military water treatment facilities. This inadequate monitoring cannot produce sufficient data to allow operators to control operational processes and, thereby, optimize total plant performance.

Operations
Create implement and enforce an intra-plant sampling and testing plan and review all monitoring data with management and supervision.

Management
Carefully review monthly operations reports, particularly the laboratory results and NPDES (DMR) reports. Look for anomalies.

Water Treatment Chemicals

Water supply chemicals are often used inappropriately because operators frequently do not understand the chemistry involved nor the calibration and adjustment of the chemical feed equipment. Operators need supplemental "update" training on the chemistry of water supply and the proper application of treatment chemicals.

Operations
Conduct frequent water supply chemistry and chemical feed systems training and practice on raw and treated water quality changes and chemical feed responses.

Management
Require reporting of chemical usage vs. daily analytical values and compare results on a month to month and year to year basis.

Sludge Handling

Army water treatment plant operators are not well trained concerning the chemistry, process control or economics of the sludge handling equipment under their control.

Operations
Improve training related to the chemistry of sludge formation as part of the water treatment system to enhance overall plant operation and reduce sludge formation.

Management
Supervisory personnel such as Department Heads must recognize the importance of efficient plant operation and encourage frequent communication between shifts to stabilize and/optimize overall operation to include sludge production and management.

Distribution Systems

Many distribution systems are old and are showing signs of deterioration. Many valves and couplings are not inspected or used unless a leak or break occurs. This leads to problems with isolating the various segments and can lead to contamination when pipes corrode and rupture.

Operations
Periodic flushing and inspection of the water main is necessary to ensure proper operation during times of crises. Periodic exercising of valves and maintenance will preclude problems when sections of the water main need to be diverted or rerouted.

Management
Ensure proper inspections are performed and that leaks and inoperable valves are scheduled for repair and or replacement.

Cross-Connection Control

Cross-Connections between potable water systems and non potable water systems (such as heating and air-conditioning, photographic developing, medical aspirators, swimming pools, lawn sprinklers) can present serious hazard to consumers when pressure changes create a reverse flow of potentially hazardous liquids into the potable water piping system.

Operations
Institute an inspection of all potential cross-connection sites and develop a cross connection control and backflow control plan. Ensure that all new work is properly installed to prevent cross-connections and are inspected on a regular basis.

Management
Review cross-connection regulatory requirements and begin a program of compliance.

Receive and provide training and certification for appropriate personnel.

Institute procedures to inspect, control, and eliminate cross-connections, install, maintain and periodically test cross-connection devices.

Emergency Procedures

Emergency and spill contingency plans are not well defined for the operators. Operators have a knowledge of equipment for emergencies, but spill contingency and emergency response plans, due to outside influences, are not well defined.

Operations
Plans for power outages, spills, pump failure and chemical contamination must be clearly spelled out and each worker must be trained on a continuing basis for the proper response.

Management
Set up emergency response test exercises.

Review plans and provide proper response skills training for the various workers/ operators. Ensure each person clearly understands their individual and collective function.

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I. INTRODUCTION

I.1 Purpose And Scope Of Report

This report is a summary of the "Lessons Learned" from the conduct of the US Army Corps of Engineers, Center for Public Works (CPW) World-Wide Operator Assistance Program (OAP) at Army Water Treatment Plants during the period 1984 to 1995. The information used to produce this report was taken from the site-specific OAP reports, prepared by contractor personnel, documenting on-site evaluations of the conditions and operation of water treatment plants and distribution systems. Each Lesson is presented with a synopsis of observations made by the OAP contractors, a general discussion of the problem, existing Army guidance (if available), examples of the problems for different types of treatment equipment and facilities as well as recommended actions where appropriate.

Additionally, each lesson is a summary of related or associated OAP findings and covers comprehensive topic areas such as plant operation, maintenance, management, training and safety. The discussion provided in each section is intended to provide the reader with a sense of the magnitude and significance of each type of problem as it affects different types of equipment, unit processes or facilities. Comparisons between different treatment facilities are difficult to perform, due to size and varying regulatory conventions among other issues, and are generally not included in this document. However, summary data has been included, when available, and if it provided further clarification as to the nature or extent of the problem under consideration.

The intent of the OAP program is to identify site (or treatment plant) specific problems or weaknesses and to suggest methods of correction or remediation. The format does not lend itself to identification of program elements that are performed well, nor does it permit highlighting routine and satisfactory facility operation, which is the norm for these facilities. Therefore, this document does not contain much information about the positive aspects of Army water supply distribution and treatment facilities. Consequently, the reader is cautioned not to generalize the negative aspects of this report. The OAP has also shown that there are many instances of excellent operation at military water supply treatment facilities and many of these have been developed or enhanced by the site specific assistance provided by the OAP program.

I.2 Background

In 1984, the Government Accounting Office issued a report dated February 3,1984, entitled "DOD Can Make Further Progress in Controlling Pollution From Its Sewage Treatment Plants," which found 11 of the 13 DOD plants evaluated, representing all of the armed services, did not consistently meet The National Pollution Discharge Elimination System (NPDES) discharge limitations contained in their permits. As a result of these findings, GAO recommended to the Secretary of Defense that each armed service provide more specific guidance to installation commanders to ensure that adequate treatment plant operation and maintenance are practiced, thereby improving compliance with NPDES permit requirements. The Army responded to the recommendation by initiating the Operator Assistance Program (OAP) in 1984 to identify and correct problems at specific installations. Additionally, the OAP was expanded to include water treatment plants as well. Many installations have benefited from the technical help provided under the OAP. However, with the recent and continuing imposition of new and more demanding federal and state standards, the ability of the Army water treatment plants to consistently comply with the regulations continues to be challenged.

I.3 OAP Concept

The OAP evolved as a three phase program managed by the Army Center For Public Works. In general, the program involves: (1) identification and analysis of water treatment plant deficiencies, (2) direct hands-on assistance and training to address these operational deficiencies, and (3) the presentation of longer term recommendations or strategies designed to correct maintenance and structural deficiencies and/or other infrastructure problems. The specific elements of each program phase are elaborated below.

Identification and Analysis (Phase I):

Phase I consists of an on-site diagnostic evaluation of a treatment plant to determine if it can consistently produce a high quality water that meets all of the state and federal drinking water standards. If it is not producing at optimum operational efficiency, the Contractor will determine the cause which might be equipment oriented, training inadequacies or procedural problems. This requires the contractor's assistance team to evaluate the effectiveness of each unit treatment process as well as the overall treatment system. In addition, water supply sampling and laboratory testing procedures are observed and evaluated, and all current monthly reporting data, submitted to state and federal regulatory agencies, are examined as part of this diagnostic evaluation. The results of this evaluation is summarized in an OAP Phase I report which was submitted to the Center for Public Works and the management team of the facility for comment and to correct misconceptions. When finalized, this Phase I Report becomes the working basis of the next two steps in the OAP process.

Training and Operational Improvement (Phase II):

This segment of the OAP is largely devoted to conducting hands-on training for plant operators and Laboratory technicians. The type and amount of this training is determined by the deficiencies and problems identified during Phase I. Also at this stage, suggestions and assistance are provided to modify operational procedures that are being done incorrectly or do not reflect best practices. Much of this training and operational modification is captured and memorialized in a revised Operating Manual which is prepared for each individual treatment plant based on information and data collected during Phase I. The on-site visits for training in Phase II are used to validate the contents of a Operation and Maintenance (O&M) Manual and assure that it provides exactly the information needed by the operating personnel.

Long Term Improvement Strategy (Phase III):

This segment of the OAP involves a follow-up site visit which is made some months after the Phase II activities. The purpose of Phase III is: 1) to evaluate the amount of improvement that has been accomplished in plant operation and maintenance resulting from other program phases; 2) to tailor any short term improvement strategies that have not proved to be effective; and 3), to determine what additional assistance, if any, may be required. The product of this last phase is a document that itemizes the problems of the facility and suggest short and long term strategies or programs that can potentially remediate these problems. This report is a blueprint for incrementally improving the operation of the facility and also serves as a basis and explanation for whatever capital improvement program might ultimately be required.

The work that has been done in this program has been excellent. It also has been cost effective. It has allowed seasoned engineers and operators to concentrate attention on one facility for a short period of time and develop very effective programs for problem resolution at each specific facility. What follows is a collection of the Lessons that have been hard won in this decade long improvement process.

II. LESSONS

II.1 Water Supply Facility Modernization

Lesson: *Many military water treatment plants are in need of modernization. Resources are so severely constrained that, even when plant upgrades are approved, long time delays are normal before modernization occurs. This problem creates potential safety and health risks as well as compliance and liability issues for the Army.*

II.1.1 Finding: Many, if not most, military water treatment facilities are in need of modernization. Principal causes of this are the age of the plants and the more lenient regulatory standards that were in effect at the time of the plant's design and construction. Other problems include poor equipment reliability, difficulty in obtaining spare parts, problems with the integration of interim process modifications and increases (or decreases) in the treated flow. A more recent problem is the slow down in normal replacement cycles related to the Base Realignment and Closure (BRAC) program, i.e., the postponement of expenditures where facility closure or realignment may be anticipated. Regulatory targets (see Section III.3. & III.4.) have also been in motion making Army Engineers very reluctant to predict design requirements. Also, the high cost of plant upgrading and the time and effort required in both design and regulatory involvement mitigates against plant upgrades when compared with necessary and competing facility priorities. These issues are creating a large backlog of design and construction activities for plant modifications that cannot be reduced quickly. Conversely, regulators are becoming less sympathetic to the plight of Army facility managers and are more insistent upon strict and consistent compliance with all of the environmental statutes.

II.1.2 Discussion: Almost every Army installation, at one time or another, has been served by its own water treatment plant. However, none of these treatment facilities have been large in comparison with typical municipal plants. A good number of these facilities are old, having been built in the 1940's. Some older plants have been replaced and others have been modified in order to meet current drinking water standards. Nearly all Army water treatment plants meet regulatory requirements with some degree of consistency. However, as the drinking water standards increase in stringency, many presently marginal facilities will require modernization and or upgrade. Most recently, the downsizing trend and BRAC activities have created situations where existing water treatment facilities have excess capacity. This inadvertent oversizing often results in inefficient operation and, in some situations, operational failures. The age of the treatment plants causes them to be relatively labor intensive and often more manpower intense due to the absence of modern automation and computer assisted control. The relatively small size of these facilities (average 5 mgd) does not favor the economies of scale for the purchase of chemicals, supplies or materials. It is often difficult for the Army to support contract operators or to recruit and retain qualified operators who can obtain greater advancement in large plant operations. These issues suggest the need for a large and ever growing capital improvement program for the military if other alternatives are not utilized, e.g., regionalization and privatization. The Army has recognized this problem and has encouraged facility engineers to seek out potential alternatives. Specifically, the Army has encouraged privatization where BRAC actions are contemplated. These initiatives have been hampered by the absence of privatization and or regionalization expertise at the facility level and the potential privatizer's negative impression of the age, condition and operating capacity of the relevant military water treatment plants.

II.1.3 Existing Army Guidance: Army Regulation 420-49, Facilities Engineering, Utility Services, 28 April 1997, Chapter 2, Paragraph 2-1. Army Policy:

a. In providing Utility Services, including water supply and wastewater services, Army installations will comply with all applicable Federal State and local laws and regulations.

b. Army policy is to obtain utility services, including water supply and wastewater services from local, municipal or regional authorities rather than expand, build, or
c. operate and maintain Army-owned facilities, when feasible. (Also see Amy Regulation 200-1, Environmental Protection and Enhancement, 21 February 1997, Paragraph 2-8.)

II.1.4 Summary: Many Army treatment plants are in need of modernization and upgrade. In general, resources are limited to make the capital investment required in the time frame necessary. Managers need to continually review their present situation and seek out opportunities for regionalization, privatization and contract operations. Similarly, facility engineers should move forward to modernize and update plants where other alternatives are not available. In any event, optimum operation and strict compliance with law and regulation should be the norm.

II.1.5 Recommended Actions:

System Operators and Managers

- Optimize existing plant operations.
- Establish a working contact with local system operators and managers through implementation of "best operational practices.

Base Commanders, Facility Managers, and Public Works Managers

- Investigate participation in regional system and/or privatization.
- Pursue contract operation opportunities.

II.2 Operator Training

Lesson: *Progress has been made in increasing the number of certified operators at military water treatment plants. However, the training needs of water treatment plant operators are changing and increasing and are not being met with existing training programs.*

II.2.1 Finding: Few operators of Army water treatment plants benefit from off-post certification training courses; some just volunteer to take them in hopes of building up their qualifications for a promotion. Funding for this training, which can be expensive, does not receive high priority by management.

The plant-specific training provided by the OAP has been praised by both management and plant operators and appears to be the most effective way to upgrade plant performance. In the past, contractor-operated WTPs have also benefited from the program; however, who should now bear the cost, the Army or the contractor, needs to be resolved. Further, there appears to be a continuing requirement for this type of training because of the turnover in plant personnel.

II.2.2 Discussion: Today, most State regulatory authorities require a treatment plant manager and lead operators to become certified to operate the size plant serving the installation. This procedure normally requires designated personnel to attend classes off post at some community college, and to do so during the daytime. The cost of attending these certification and any subsequent periodic recertification courses that may be required, and the associated absence from work of those undergoing training, can be a strain on installation resources. Unfortunately, this training is generic and academic in nature, and appears to have little direct benefit to operating the plant on the installation. Past experience conclusively shows plant-specific hands-on training given under the OAP produces much greater dividends. This training, however, is not accepted by state authorities for the initial certification of operators, but it is usually accepted for recertification purposes when part of an approved continuing education program that awards Continuing Education Units (CEUs).

II.2.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August, 1984.

> 1-2.c. "**Operator Certification.** Most states have statutes that require water treatment plant operators to be properly trained and certified. The Safe Drinking Water Act (SDWA) of 1974 (Public Law 93-523) requires all water treatment plants in states that

have primary enforcement responsibility to comply with state statutes regarding water quality standards, operator training, and operator certification."

1-2.d "**Training Needs.** After an operator is certified, continual training is essential to maintain high standards of service, ensure efficient operation, and keep personnel informed of all current technical developments."

(1) All personnel must be made aware that the health and safety of those residing at the installation depend on their conscientious execution of their duties.

(2) Short courses of water treatment conferences should be attended periodically by all personnel who are involved in operating the installation's water treatment facilities. Such short courses and conferences are sponsored by state health departments, university extension programs, community colleges, and the American Water Works Association (AWWA). In addition, local training programs can be held on the installation with supervisory personnel conducting the training."

II.2.4 Summary: The many negative work factors associated with water treatment plant operation can cause a downward spiral of performance and performance expectation. Management needs to stress the importance of good operation and the effect it has on the local community. They need to establish a sense of pride in excellent operation so that the operators strive to produce the best quality water they can produce from the existing plant. It is especially important that supervisors show concern and provide good administrative, morale and motivational related activities.

II.2.5 Recommended Actions:

System Operators and Managers

- Create a training plan and budget that husbands resources but provides training opportunity.
- Seek innovative training solutions and vehicles such as teleconferencing and videos.
- Plan once a year open house as part of earth week or other base activity.
- Make connections with industry groups or societies and budget for participation.
- Make contact with operators of local municipal, regional or industrial treatment plants.

Base Commanders, Installation Managers and Public Works Managers

- Insist on annual reporting of the status of training, certification and training needs.
- Formally inspect the water treatment plant several times per year.
- Insist on monthly "red flag" report of the top two or three problems facing the plant.

- Participate in the OAP evaluation and training program.
- Support training and professional activities for operators and publicly recognize excellence.

II.3 Management Support:

Lesson: *Military water treatment facilities have not usually been a high priority of facilities managers. This issue, coupled with decreasing resources has resulted in a decline in the morale of operating personnel. Low morale is a major cause for poor operating, maintenance and housekeeping practices and concomitant degradation of treatment plant performance.*

II.3.1 Findings: Some water treatment plants are operating in a mode that produces poor quality drinking water that often tastes bad and potentially can have harmful effects. Many installations have provided drinking water in bottles to reduce employee and residence concerns. Many operators do not see the need to produce better results as management does not seem to care since they do not provide adequate funding to maintain the water treatment plant in good operating condition. The consequence of the lack of support at the management level can be the issuance of a Notice of Noncompliance to the post commander and this can bring about adverse publicity when covered in the local press.

II.3.2 Discussion: Knowledge and interest in water treatment is limited outside the medical community and the Department of Public Works until there is a health problem. Seldom, if ever, do members of the commander's staff visit a plant because its out-of-the-way location is not conducive to frequent visits. Also, the release of funds for training, purchase of repair parts and replacement equipment is not given much priority.

The following Table summarizes the changes in plant support activities as a result of conducting the OAP at treatment plants from 1984 to 1991. The small percent of increase between Phase I and the later Phases can only be attributed, to lack of management support and supervision.

Water and Wastewater Treatment Plant Support Functions

Installations with Formal or Active Programs (Percent)

Activity	Phase I	Phase II or III
Maintenance Plan	38	50
Safety Plan	37	48
Process Control (Sampling/Analysis)	<1	<5
Laboratory Quality Control	<1	<1
Spill Control	42	55
Sludge Management	30	39
Operator Training	<10	<10
Computerized Records Keeping	9	11

II.3.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August, 1984.

> 1-1. **Command Responsibility.** Operating and maintaining water treatment facilities and appurtenant equipment are a command responsibility. They are considered maintenance-of-installation functions.

II.3.4 Summary: Commanders should ensure that the management of water treatment systems has a high priority so that Operators are anxious to present both the excellent operations and the problems. Open houses and frequent site visits will ensure high visibility and proper operation of the facilities.

II.3.5 Recommended Actions:

System Operators and Managers

Seek opportunities to brief management on the operation status of the treatment works, and report fully and in detail all aspects of deficient operation or maintenance.

Base Commanders, Facility Managers and Public Works Managers

Require detailed reports on the status of operation and maintenance and visit the plant.

II.4 Plant Maintenance

Lesson: *Preventative maintenance on mechanical and electrical equipment is not routinely performed and long delays often occur before critical equipment is repaired. There are few formal preventive maintenance systems and/or critical spare parts inventory systems in place. Equipment failure rates and spare parts and plant performance suffer from these failures.*

II.4.1 Findings: Any approach to treatment plant maintenance requires a written program that includes maintenance schedules and records keeping. OAP visits found very few plants had such formalized maintenance programs and, even when plans had been written, they were often outdated and/or ignored. Because the funds are often not available to stock parts for repairs, quick fixes were often precluded and the attitude of the worker was one of non-urgency. OAP reviews determined that, at many locations, insufficient, inappropriate or nonexistent spare parts precluded rapid repair of critical equipment. Delays affecting repairs were also found to be caused by cumbersome procurement procedures. Frequently, job descriptions precluded operators from doing maintenance, including painting and lubrication. The plant rules and/or union agreements required that such work be done by trade specialists, e.g., painter, mechanic, electrician, etc. Other findings included the following:

1. General housekeeping practices were poor.
2. Routine inspection and lubrication of equipment was often ignored.
3. Maintenance record keeping was inconsistent and incomplete.
4. Maintenance and maintenance safety training was absent.
5. Equipment and maintenance manuals for equipment was often absent.
6. Reliance on operators to maintain the treatment plant ground.

Since Commanders often do not consider the water treatment plant high priority because they take it for granted that water will be available, Operators do not always feel the requirement to perform in the best most effective manner. In addition, cumbersome procedures and requirements often slow down or divert resources from being available to complete maintenance unless it is critical to the operation.

II.4.2 Discussion: Water treatment plant maintenance like wastewater treatment maintenance has always been the "step child" of public works. The Army's policy is to provide effective maintenance. In order to do this it is necessary for the installations to have a written program with prescribed schedules and an established record keeping procedure. Many plants have an O&M manual but few have been kept up to date and many are not followed since they are not emphasized by the management. At some plants operators are not allowed to maintain the equipment and the chain of command is not well defined to have the work performed on a priority basis. This means quick timely repairs are not performed and the operators loose interest in proper maintenance since no action seems to be forthcoming. Another problem which inhibits good maintenance is the method of procurement. Many installations are not able to local purchase items required for quick turnaround for repairs and/or the supply personnel often buy from the lowest bidder which means that parts are not compatible and delays are incurred to get repairs accomplished.

II.4.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August, 1984.

> 1-1. **Command Responsibility.** Operating and maintaining water treatment facilities and appurtenant equipment are a command responsibility. They are considered maintenance-of- installation functions.

11-1. **Maintenance Requirements.** Maintenance is the recurring routine work required to keep a facility in such condition that it may be continuously used (at its original or designated capacity and efficiency) for its intended purpose.

II.4.4 Summary: The creation and implementation of an excellent maintenance program for a military water facility requires a good plan which includes schedules for maintenance on all plant equipment and contingency planning for major repair work. Additional requirements include adequately trained maintenance people, good record keeping, continued maintenance training, an emphasis on good housekeeping, adequate spare parts and appropriate procurement practices. Nevertheless, the most important component is management attention to the maintenance program.

II.4.5 Recommended Actions

System Operators and Managers

Create, implement and enforce a maintenance plan and a critical inventory program.

Base Commanders, Installation Managers and Public Works Managers
Require formal and frequent reporting of inventory.

II.5 Plant Safety

Lesson Learned: *Safety programs at military water treatment facilities are frequently incomplete and/or inadequate. The result is the exposure of employees and others to unsafe conditions and subsequent injury or ill health. Water treatment plant and facility management needs to focus on this issue and significantly reduce the potential for accidents and the concomitant costs and liabilities.*

II.5.1 Findings: The water treatment plant is often not included in the overall installation safety program. As a result, few military water treatment plants hold regular safety meetings, and plants are seldom visited by installation safety inspectors. Frequently, no plant safety officer has been designated so that, even well designed programs, were frequently ineffective. Other important findings included the absence of regular practice on the use of safety equipment, e.g., self contained breathing apparatus. Operators were often unfamiliar with the "Right to Know" program that is OSHA mandated for every workplace. Consequently, operators often did not take proper precautions when handling chemicals or dealing with chemical spills. Equipment guards were missing, ladders and catwalks were hazardous, exposed wires were common, housekeeping practices were poor. The OAP visits have revealed that there is a direct positive correlation between good housekeeping practices and good safety performance. Lack of management attention has created a demoralizing sense of frustration, about safety and safety procedures, among the employees. Lastly, written procedures on contingency plans for spills and other emergencies were either absent or not in use.

II.5.2 Discussion: A meaningful and technically correct safety program requires the following as a minimum:

- Conduct regular safety meetings.
- Showering and laundering facilities.
- Periodic training on:
  - self contained breathing apparatus,
  - CL_2 Institute cylinder repair kits,
  - chemical handling and safety,
  - leak detection equipment, and
  - "right–to–know" and contingency plans.
- Correction of safety hazards, a safety coordinator, and management time and attention.

Safety has always been "good business" due to the savings that result from reduced lost time and lower medical expenses. Also, high quality safety programs demonstrate management's concern for the well–being of the employees and have important and positive effects on morale and performance. Unfortunately, the converse is also true. Moreover, with the passage of the Occupational Safety and Health Act (OSHA) in 1971, good safety practices are now also the law. Accordingly, while the principal motivation for safety programs should always be the health of the employees, military facility management should not forget that they expose themselves and the Army to significant liability by not insisting upon very aggressive and high quality safety programs.

II.5.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August, 1984, Chapter 12.

OSHA. This Act specifies that individual workers are personally responsible to follow safe procedures, properly use the safety equipment provided, and to perform their tasks in a safe manner.

II.5.4 Summary: The OAP Phase I inspections found that, in general, water treatment plant safety was well below industry standards and clearly not in conformance with Army guidance. Significant unacceptable findings included inadequate training of personnel, infrequent safety meetings, serious deficiencies in safety equipment and supplies, few periodic inspections, little contingency planning, and poor housekeeping. This situation represents serious liability for the Army and the facility management.

II.5.5 Recommended Actions:

System Operators and Managers

Create implement and enforce a safety plan as well as an up to date inventory of safety equipment and supplies. Make sure that the plant safety program is part of the facility safety program.

Base Commanders, Facility Managers and Public Works Managers

Require frequent reporting of status of safety program, e.g., accidents, training, etc. and formally inspect the water supply treatment plant several times per year.

II.6 Treatment Process Control

Lesson Learned: *Insufficient, and often inappropriate, sampling and testing is being performed on military water treatment facilities. This inadequate monitoring cannot produce sufficient data to allow operators to modify individual unit processes and, thereby, optimize total plant performance.*

II.6.1 Findings: Process control involves the collection and analysis of samples at intermediate locations in the treatment sequence to determine the efficiency and effectiveness of key unit processes. *The specific sampling locations and tests must be determined for each facility.* On most military facilities, testing is limited to the final effluent since the primary concern has been to satisfy requirements. Despite operational benefits of unit process control, testing unit processes to determine performance efficiencies is not being required by those in management. Supervisory and management personnel do not usually consider the additional work and expense to be justified as long as the requirements are met. As a result, operators refrain from doing this type of testing due to lack of materials, fear of censure and to avoid additional work. Therefore, operators of military facilities run their plants by "rule of thumb" rather than by procedures based on sound technical principles and good analytical data. This results in frequent violations of the requirements and the concomitant liability for the military and the facility management.

II.6.2 Discussion: Water sampling and testing are performed routinely on plant effluent to verify plant performance because it is a requirement. However, the same actions are seldom, if ever, taken to check the influent and effluent from individual treatment units, such as clarifiers and filters. Only when there is such a routine is it possible to determine the effectiveness of a treatment process and to make timely adjustments before plant effluent fails to meet prescribed standards. Additionally, when sampling and testing are limited to checking plant effluent, there is a tendency to withhold test results from the operators; this is especially true when the sampling and testing is done by an outside contract laboratory. As a result of this procedure, operators tend to lose interest in their work and are not motivated to improve plant performance.

II.6.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August, 1984 and Water Treatment Plant Operation, Third Edition, Volume 1, Chapter 2. Water Sources and

Treatment, California Department of Health Services Sanitary Engineering Branch and U. S. Environmental Protection Agency, Office of Drinking Water, pp. 23-34.

II.6.4 Summary: Process control sampling and testing, above that required for state reporting, should be made standard practice at every plant to ensure optimum control over unit treatment processes. This practice will increase the operator's understanding of the treatment facility and its unit processes which will markedly improve morale and performance.

II.6.5 Recommended Actions:

System Operators and Managers

Create implement and enforce an intra-process sampling and testing plan and review all monitoring data with management and supervision.

Base Commanders, Facility Managers and Public Works Managers

Carefully review monthly operations reports, particularly the laboratory and NPDES reports. Look for anomalies.

II.7 Use Of Water Treatment Chemicals

Lessons Learned: *Water supply chemicals are often used inappropriately because operators frequently do not understand the chemistry involved nor the calibration and adjustment of the chemical feed equipment. Operators need supplemental "update" training on the chemistry of water supply and the proper application of treatment chemicals.*

II.7.1 Findings: Chemicals used in the treatment of water for softening, specific ion removal, and process control are often used in excess. The theory of many of the operators is that if a little is good, a whole lot more should be better. This often leads to excess waste and increased sludge production without an increase in treatment efficiency. This results from a lack of good analysis and operator instructions.

II.7.2 Discussion: Operators often are trained in the operation of new plants and then, due to promotion and cutbacks, leave without training replacements. In addition, operators on different shifts do not always understand the subtle changes in the treatment requirements from season to season and from day to night time operation. Each operator requires an excellent understanding of the chemical treatment as applied to their system. They need to understand the effect of overdosing and frequent discussions need to take place between operators so that experience can be passed along to all operators.

II.7.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August, 1984, Chapter 6, Water Treatment.

II.7.4 Summary: The Directors of the water supply operation should conduct frequent training on water supply chemistry and chemical feed systems and practice quality changes and chemical feed responses. Chemicals should not just be added by rote but rather a complete understanding of the purpose is necessary by the operators to ensure proper usage. The Director should require reporting of chemical usage vs. daily analytical values and compare results on a month to month and year to year basis. This will ensure proper treatment and avoid excess chemical usage.

II.7.5 Recommended Actions:

System Operators and Managers

Conduct frequent training on water supply chemistry and chemical feed systems and practice quality changes and chemical feed responses.

Base Commanders, Facility Managers and Public Works Managers

Require reporting of chemical usage vs. daily analytical values and compare results on a month to month and year to year basis.

II.8 Sludge Handling / Treatment / Disposal

Lesson Learned: *Army water treatment plant operators are not well trained concerning the chemistry, process control or economics of the sludge handling equipment under their control.*

II.8.1 Finding: The water treatment facilities of the Army represent a variety of sludge handling equipment used for disposal of sludge primarily from surface water treatment. Some of the sludge is generated by softening processes. Universally, operators are not well informed about the sludge handling processes at their plants. Operators are often unclear as to how these processes worked, e.g., factors effecting production sludge, recycle rate impacts, etc. They seldom sample for, or try to interpret the results of analytical tests for, parameters such as temperature, acid/alkalinity ratios. Operators reported that they had been given an operational scheme, e.g., sludge feed and withdrawal rates and valve and pump settings, and they did not understand the technical basis of the scheme nor did they know how to modify it to reflect changing plant conditions. Operators need to be trained in sludge handling equipment, theory, practice and "trouble shooting," with primary emphasis given to the operation of the specific equipment at each individual plant.

II.8.2 Discussion: Due to differences in the time of construction, specific state regulations and local conditions, the Army has a wide range of solids handling equipment. For those reasons, the operational requirements vary between plants and facilities. Also, the disposal methods and requirements are practically unique to each facility and differ due to climate, geology and demographics of the region. Furthermore, the solids/sludge handling processes can be extraordinarily complex and technically different from the remainder of the water unit processes. It is also often the case that the solids handling portion of the water process is the most cost intensive. The operation of this type of equipment requires that the operator have a clear understanding of the theory. It also requires an operational scheme that is based upon continuous monitoring of the physical parameters involved and review of analytical testing. Moreover, these operations almost always require the maintenance of good records and trend plotting of significant control values. The maintenance of the equipment is also critical to quality operation. When these elements are missing or inadequate, the operation of sludge handling and disposal equipment is usually inefficient. In the circumstance of changing process characteristics, operators fall back on "rules of thumb" that they may not understand thoroughly and which may not be appropriate or efficacious. The most frequent outcome of these situations is the degradation of the sludge handling capability of the plant, often requiring Herculean efforts to reverse or improve. Another result can be a quality discontinuity of the effluent caused by the need to recirculate more sludge than the design allows. In any event, the outcomes are negative for the facility in either costs or compliance. Better and more frequent training and greater management involvement with plant operations are required to turn this situation around.

II.8.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August 1984, Chapter 6, Para. 6-31 to 6-37.

II.8.4 Summary: Water sludge handling, treatment and disposal are technically challenging and expensive. The unit processes involved must be managed carefully using careful process monitoring and a comprehensive operating scheme. Presently, water treatment plant operators at Army facilities are not adequately prepared to assure consistent high quality solids handling and disposal. The effects of this deficiency are process upsets, inefficient operation, excess costs and potential compliance difficulties. Additional operator training and closer management and supervision oversight is required.

II.8.5 Recommended Actions:

System Operators and Managers

Better training in the chemistry of sludge formation as part of the treatment train will enhance operation and reduce sludge formation.

Base Commanders, Facility Managers and Public Works Managers

Department heads must become better aware of the plant operation and encourage frequent communication between shifts to optimize operation.

II.9 Water Distribution Systems

Lesson Learned: *Most plants do not put maintenance of the distribution system at the top of the priority list until an event takes place that causes a failure. Pumps which are underground do not get adequate servicing and valves used to redirect flows are often inoperative when needed. Corrosion is a constant factor in the distribution system and, because it occurs out of sight, the first indication that a problem exists is when something fails.*

II.9.1 Finding: The maintenance program for the water distribution system should require periodic inspection of the water storage tanks, to include the cathodic protection for elevated tanks; inspection and periodic maintenance servicing of the pumping stations; annual flushing of distribution lines; and a schedule for exercising all the valves in the distribution system. When valve maintenance is ignored, the problem of closing valves and rerouting water flow whenever it is time to repair leaks and broken lines becomes very difficult.

II.9.2 Discussion: The typical water distribution system includes elevated and/or below ground water storage tanks, pumping facilities, and the associated piping routing the water to the various users. For the most part, these components do not fail very frequently, and as a result, they are often neglected until they do. Some of the more common type of failures include corrosion in elevated tanks, mechanical and electrical breakdowns at pumping stations, leaks or ruptures in the water lines, and inoperable valves in the distribution system.

II.9.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August, 1984, Chapter 8.

II.9.4 Summary: Routine maintenance which includes the distribution system should be performed. Corrosion will soon make a system inoperable and could create a major failure. Valves and pumps need to be constantly tested and exercised to ensure proper operation when required.

II.9.5 Recommended Actions:

System Operators and Managers

Periodic flushing and inspection of mains is necessary to ensure proper operation during times of crises. Exercising of valves will preclude problems when sections of the main need to be diverted or rerouted.

Base Commanders, Facility Managers and Public Works Managers

Ensure proper inspections are performed and that leaks and inoperable valves are scheduled for repair and or replacement.

II.10 Cross-Connection Control

Lesson Learned: *Cross-Connections between potable water systems and nonpotable water systems (such as heating and air-conditioning, photographic developing, medical aspirators, swimming pools, lawn sprinklers) can present a serious hazard to consumers when pressure changes create a reverse flow of potentially hazardous liquids into the water piping.*

II.10.1 Findings: Cross-Connection Control and Backflow Prevention programs have been implemented at some Army installations. Currently, the number of installations that have active programs is unknown. For those installations that have implemented this program, CPW assisted through its AE indefinite-type delivery order contracts which provide a tool for conducting building surveys to identify cross-connections and recommending actions required to eliminate or control the potential hazards. Existing backflow prevention devices are identified, inventoried, and tested for proper operation. Additionally, management plans are prepared and management and technical training is provided to installation personnel. Existing backflow prevention devices in the distribution system are generally ignored once installed and seldom inspected, tested or maintained. Installation of devices according to regulations, guidelines and plumbing codes is rare. The devices are found improperly installed against ceilings, walls or floors rendering access difficult or dangerous. Many are found in confined spaces or directly over electrical boxes, switches and transformers. In some cases, when a device is leaking, a plug is forced into the relief valve to stop the leak, or the relief valve opening is piped to the closest floor drain. A leaking device will not stop backflow. Most likely, the individual does not have the knowledge or training necessary and is reluctant to disassemble or attempt repair of the device.

II.10.2 Discussion: Although public health concerns about cross-connections have been around since the 1930's and the number of documented cases resulting in sickness, injury and death have increased, many health officials, water purveyors and the general public have been lulled into complacency in assuming their water is safe. Even some federal and state agencies have not yet complied with existing laws that mandate precautions in handling water systems. Many plumbing systems on Army installations were designed and installed prior to the implementation of the new laws. Also, many military and civilian employees are not up-to-date with current federal and state regulations, current plumbing codes, or with technological advances in equipment. Although some generally know its definition, they do not know how to identify a cross-connection, the degree of hazard it presents, nor can recommend the proper type of backflow prevention device needed and method of installation to meet regulations and codes. Effective management of a cross-connection control and backflow prevention program is a full-time endeavor. Plumbing systems are constantly being installed, altered or extended. Identifying and eliminating cross-connections is assumed to be elementary and obvious, but actually, cross-connections may appear in subtle forms and in unsuspected places. Pressure changes in water systems are unpredictable, therefore, even the most unlikely potential hazard can allow pollution or contamination to enter the potable water system. Army installations are not equipped to handle a cross-connection control program on a full-time basis. Existing plumbing shops are understaffed. There is a constant flow of routine and emergency service orders to complete, or to catch up with the backlog. The lack of training in backflow prevention device maintenance generally results in replacement versus repair, and ultimately, increased maintenance costs.

II.10.3 Existing Army Guidance: Army Regulation (AR) 420-49, "Facilities Engineering, Utility Services," 28 April 1997, Chapter 4 states that potable water will be supplied according to the Safe Drinking Water Act (SDWA) of 1974 and all applicable State and local regulations. Sanitary control and surveillance of potable water supplies will be as specified in AR 40-5 and TB Med 576 or applicable State and local regulations. Operation, maintenance and repair of water supply

systems will comply with TM 5-660. Chapter 3 states that a cross-connection control program will include backflow prevention devices for those facilities that have the potential to contaminate the water supply system (for example: pest control shops, photographic laboratories, medical facilities). A routine inspection and maintenance program by State certified personnel of backflow prevention devices will be established.

Design, operation and maintenance of cross-connection components will be per AR 40-5, TM 5-660, and TB MED (Technical Bulletin Medical) 576. AR 40-5, "*Preventive Medicine*," June 1985, Chapter 12 states that cross-connections between potable and nonpotable distribution systems are not permitted. TB MED 576 and TM 5-660 discuss cross-connections and provide proper references. The current National Standard Plumbing Code will be followed in the testing, maintenance and renovation of water distribution systems and in the selection of all plumbing fixtures. TB MED 576, March 1982, "*Sanitary Control and Surveillance of Water Supplies at Fixed Installations*", Chapter 4 states that no interconnection between a potable water distribution system and a sanitary sewage system shall be permitted.

Each installation shall undertake an organized program that includes instruction, inspection, and required improvements in order to detect and remove all potential and existing cross-connection, and to ensure that proper measures (e.g., air gaps and backflow prevention devices) are taken to prevent backsiphonage. Only through routine inspection and periodic surveys can the control and elimination of existing and potential hazards be accomplished. EPA Publication 430/9-73-002 and AWWA Publication No. 20106 provide excellent information concerning methods and devices for backflow prevention, testing procedures for backflow prevention, and administration of a cross-connection control program.

II.10.4 Summary: "*The results of inadequate cross-connection control and backflow prevention programs at Army installations increases the risk of personal injury, sickness, and possible death from interconnections between potable and nonpotable water systems. Additionally, operation and maintenance costs are inefficient, compliance with applicable regulations and codes is less than adequate or nonexistent, and there is an ever increasing risk of liability*".

II.10.5 Recommended Actions:

Water System Managers and Operators

- Review regulatory requirements and begin a program of compliance.
- Receive and provide training and certification.
- Initiate procedures to form a specialized group within your department for cross-connection control.
- Establish procedures to inspect for, control or eliminate cross-connections, and install and maintain backflow prevention devices.

Base Commanders, Facility Managers and Public Works Managers

- Implement comprehensive cross-connection control and backflow prevention programs.
- Insist on annual reporting of the magnitude and trend of the cross-connection problem.
- Comply with Army, State and local regulations.

II.11 Emergency Procedures

Lesson Learned: *Water treatment plants are subject to various problems created by outside influences such as loss of power, breaks, contamination, and corrosion. These problems often create emergencies for the crew which are outside of the normal operation. Since they do not occur frequently personnel may not be properly trained unless there has been a special effort towards advanced planning. This planning is often neglected in favor of other more pressing problems and funding restrictions until problems occur which highlight the need for emergency planning.*

II.11.1 Finding: Contingency plans of any type covering the above types of emergency situations were not observed in written form during past OAP site visits. However, staff personnel were aware that emergency generators were available in the event of a power outage, and that standby items were available to backup certain critical equipment. Responses to chemical spills and leaks occurring within the plant were vaguely addressed by plant operators when questioned. Off-plant chemical and oil spills were considered to be covered by the installation SPCC Plan, but none included specific provisions for protecting the plant and its equipment.

II.11.2 Discussion: Because emergency situations can arise at water treatment plants and within distribution systems, there needs to be some contingency planning. The most obvious emergencies are power failures and pumps breaking down unexpectedly. These problems are often overcome quickly by starting the emergency generators and switching to a standby pump. There are some less obvious emergencies because they occur so rarely and for which little or no prior planning is done. Those considered most serious include major leaks or spills of the chemicals used in the water treatment process, such as chlorine gas, alum, and ferric chloride. An even more serious situation that could face a water treatment facility is a chemical or oil spill that could contaminate the water source for the plant, particularly a surface water source.

II.11.3 Existing Army Guidance: Army Technical Manual, TM 5-660, dated 30 August, 1984, Chapter 1, Section D-Emergency Protective Measures.

II.11.4 Summary: Concern on the part of users has tightened the controls on operators especially in the area of emergency response. When water is supplied from surface sources or wells subjected to the surface water infusion of contamination, the operator must be prepared to react quickly and effectively to avoid contaminating an entire water supply system. Power failure, breakages, and repairs often cause regionalized emergencies but other more subtle problems occur when spills or underground contamination might invade the water supply. Plans must be in place and practiced to avoid problems.

II.11.5 Recommended Actions:

Water System Managers and Operators

Plans for power outages, spills, pump failure and chemical contamination must be clearly spelled out and each worker must be trained on a continuing basis for the proper response.

Base Commanders, Facility Managers and Public Works Managers

Set up emergency test exercises. Review plans and provide proper responses for the various workers. Ensure each person clearly understands their function.

III. GENERAL LESSONS

III.1 Surface Water Treatment

Surface water primarily comes from one of several sources today; direct runoff, rivers, streams, lakes, reservoirs and to a lessor extent oceans. Due to urbanization many of the surface sources suffer from some form of pollution. Generally surface waters may be characterized by the types of contamination they can contain. Some of the more common contaminants are; turbidity, suspended solids, color, and microbial contamination. In city areas, there may be man made pollutants such as oil from roads and parking lots, acids from incinerators and heavy metals from leaded gasoline and industrial wastes. Various treatment processes are needed to treat the contaminants effectively. Processes such as coagulation, filtration, carbon adsorption, pH adjustment and chlorination are commonly applied to surface water. The most effective way to treat groundwater sources is to monitor them closely and adjust the treatment for the current water conditions. Poor monitoring practices can lead to risk of contamination of large water distribution systems.

III.2 Ground Water Treatment

Ground water is characterized by higher concentrations of dissolved solids, gases such as Hydrogen sulfide, lower color, high hardness, and freedom from microbial contamination unless the wells are shallow. When shallow wells are used they can be prone to the same pollutants as those occurring in surface water. These waters are known as under the influence of surface water. Some naturally occurring pollutants found in groundwater are iron, manganese, fluorides, arsenic, and hardness from calcium and magnesium. Some of the pollutants are esthetically undesirable such as iron and hardness and others, such as arsenic and fluorides, may be harmful to portions of the population, i.e., babies, pregnant women and older people. Typical treatment processes used on groundwater are iron and manganese removal by natural zeolites; fluoride and arsenic reduction by electrodialysis (EDR) and membrane processes (reverse osmosis); and hardness reduction by ion exchange and membrane softening.

III.3 Primary Drinking Water Standards

Customers in past days were mainly concerned with the taste, odor and clarity of the water they drank. As customers became more aware of the effect of chemicals and bacteria on their lives they have grown to demand a better standard for water quality. Standards are set by both State and Federal Governments. The Federal Government passed the Safe Drinking Water Act (PL 93-523) in 1974 and the U. S. Environmental Protection Agency (EPA) was charged with the responsibility of developing and implementing national drinking water regulations. A summary of the maximum contaminant levels (MCLs) established by these regulations is shown in the attached Table III-1 on the next page.

Primary regulations establish MCLs based on the health significance of the contaminants. States could gain primary enforcement responsibility for public water systems by adopting regulations at least as stringent as the EPA regulations and would implement adequate monitoring and enforcement procedures.

III-1

TABLE III-1

ENVIRONMENTAL PROTECTION AGENCY PRIMARY DRINKING WATER REGULATIONS

CONSTITUENT	MAXIMUM CONTAMINANT LEVEL
Inorganic Chemicals	
Antimony[a]	0.006 mg/*L*
Arsenic	0.05 mg/*L*
Asbestos	7 million fibers/*L*
Barium	2.0 mg/*L*
Beryllium[a]	0.004 mg/*L*
Cadmium	0.005 mg/*L*
Chromium	0.1 mg/*L*
Copper	1.3 mg/*L*[b] (at tap)
Cyanide[a]	0.2 mg/*L*
Fluoride	4.0 mg/*L*
Lead	0.015 mg/*L*[b] (at tap)
Mercury	0.002 mg/*L*
Nickel[a]	0.1 mg/*L*
Nitrate (as N)	10.0 mg/*L*
Nitrite (as N)[c]	1.0 mg/*L*
Selenium	0.05 mg/*L*
Thallium[a]	0.002 mg/*L*
Organic Chemicals	
VOLATILE ORGANICS	
Benzene	0.005 mg/*L*
Carbon Tetrachloride	0.005 mg/*L*
o-Dichlorobenzene	0.6 mg/*L*
p-Dichlorobenzene	0.075 mg/*L*
1,2-Dichloroethane	0.005 mg/*L*
1,1-Dichloroethylene	0.007 mg/*L*
cis-1,2-Dichloroethylene	0.07 mg/*L*
trans-1,2-Dichloroethylene	0.1 mg/*L*
Dichloromethane[a]	0.005 mg/*L*
1,2-Dichloropropane	0.005 mg/*L*
Ethylbenzene	0.7 mg/*L*
Monochlorobenzene	0.1 mg/*L*
Styrene	0.1 mg/*L*
Tetrachloroethylene	0.005 mg/*L*
Toluene	1.0 mg/*L*
1,2,4-Trichlorobenzene[a]	0.07 mg/*L*
1,1,1-Trichloroethane[a]	0.2 mg/*L*
1,1,2-Trichloroethane	0.005 mg/*L*
Trichloroethylene (TCE)	0.005 mg/*L*
Vinyl Chloride	0.002 mg/*L*
Xylenes	10.0 mg/*L*
PESTICIDES AND SYNTHETIC ORGANICS	
Alachlor	0.002 mg/*L*
Atrazine	0.003 mg/*L*
Benzo(a)pyrene	0.0002 mg/*L*
PESTICIDES AND SYNTHETIC ORGANICS (cont'd.)	
Carbofuran	0.04 mg/*L*
Chlordane	0.002 mg/*L*
Dalapon	0.2 mg/*L*
Dibromochloropropane (DBCP)	0.0002 mg/*L*
Di(2-ethylhexyl)adipate	0.4 mg/*L*
Di(2-ethylhexyl)phthalate	0.006 mg/*L*
Dinoseb	0.007 mg/*L*
Diquat	0.02 mg/*L*
Endothall	0.1 mg/*L*
Endrin	0.002 mg/*L*
Ethylene Dibromide (EDB)	0.00005 mg/*L*
Glyphosate	0.7 mg/*L*
Heptachlor	0.0004 mg/*L*
Heptachlor Epoxide	0.0002 mg/*L*
Hexachlorobenzene	0.001 mg/*L*
Hexachlorocyclopentadiene	0.05 mg/*L*
Lindane	0.0002 mg/*L*
Methoxychlor	0.04 mg/*L*
Oxamyl (Vydate)	0.2 mg/*L*
PCBs	0.0005 mg/*L*
Pentachlorophenol	0.001 mg/*L*
Picloram	0.5 mg/*L*
Simazine	0.004 mg/*L*
Toxaphene	0.003 mg/*L*
2,4-D	0.07 mg/*L*
2,3,7,8-TCDD (Dioxin)	0.00000008 mg/*L*
2,4,5-TP (Silvex)	0.05 mg/*L*
Microbial	
*Total Coliform	1 per 100 m*L* <40 samples/mo - no more than 1 positive >40 samples/mo - no more than 5% positive
Giardia lamblia	3-log (99.9%) removal[d]
Legionella	treatment technique[d]
Enteric viruses	4-log (99.99%) removal[d]
Heterotrophic bacteria	treatment technique[d]
Physical	
*Turbidity[d]	0.5 to 5 NTU
Radionuclides	
Gross alpha particles	15 pCi/*L*
Gross beta particles[e]	4 mrem/yr
Radium 226 & 228	5 pCi/*L*
Disinfection By-products	
TTHMs[f]	0.1 mg/*L*

[a] MCL effective date: 1/17/94.
[b] Action level for treatment.
[c] Applies to community transient and non-transient water systems.
[d] Applies to systems using surface water or groundwater under the influence of surface water.
[e] Applies to surface water systems serving more than 100,000 persons and any system determined by the state to be vulnerable.
[f] Applies to systems serving more than 10,000 persons and also to all surface water systems that meet the criteria for avoiding filtration.

**NOTE:* Only coliforms and turbidity are more or less under the control of the operator; all other items are not influenced significantly by plant treatment processes.

NOTE: YOUR REGULATORY AGENCY MAY HAVE STRICTER REGULATIONS. CONTACT APPROPRIATE OFFICIALS TO DETERMINE THE REGULATIONS WHICH APPLY TO YOUR PLANT.

III.4 Secondary Drinking Water Standards

Secondary drinking water standards were established based on aesthetic considerations and are a state option. A table of secondary standards is shown in the table below.

TABLE III-2

ENVIRONMENTAL PROTECTION AGENCY SECONDARY DRINKING WATER REGULATIONS

CONSTITUENT	MAXIMUM CONTAMINANT LEVEL[a]
Aluminum	0.05 - 0.2
Chloride	250
Color*	15 Color Units
Fluoride	2
Foaming Agents (MBAS)	0.5
Iron*	0.3
Manganese	0.05
Odor	3 Threshold Odor Number
pH*	6.5 - 8.5
Silver	0.1
Sulfate	250
TDS	500
Zinc	5

[a] - mg/L unless noted.

*NOTE: All items marked * are more or less under the control of the operator; all other items are not influenced significantly by plant treatment processes.

NOTE: YOUR REGULATORY AGENCY MAY HAVE STRICTER REGULATIONS CONTACT APPROPRIATE OFFICIALS TO DETERMINE THE REGULATIONS WHICH APPLY TO YOUR PLANT.

IV. RECOMMENDATIONS-NEXT STEPS

IV.1 Interpretation Of The Lessons: As noted in the introduction, a casual reader of this document might come to the conclusion that the operation of Army water treatment plants is uniformly bad. That is not a correct conclusion. There are examples of exemplary operation and the large majority of operators are hard working and dedicated to doing a good job. Moreover, it should be noted again that the majority of Army water treatment plants routinely produce treated water that meets all potable water standards.

Moreover, the OAP program has brought about very significant improvements and continues to be a major force for positive change in the Army water treatment plants. However, as the Lessons demonstrate, there is room for improvement and institutional and economic incentives to make these improvements. For the sake of an overall look, the lessons are GENERALLY summarized as follows.

IV.2 Lessons

IV.2.1 General Lessons

- Many plants need upgrades or modernization.
- Operator training needs should refocus on operation and process control.
- Insufficient management support and attention continues to cause problems.
- Plant maintenance is a significant problem that is causing considerable liability.
- Plant safety needs attention.
- Treatment process control is not done well.
- Water treatment chemicals are both over and underfed and frequently handled improperly.

IV.2.2 Process Specific Lessons

- Chemical softening is not well controlled and as a result creates excess sludge.
- Fluoride reduction has not been upgraded to current technology thus using too many chemicals and in addition may not be maximizing recovery.
- Not only are cross-connection inspectors inadequately trained, they have little or no power over contractors who are installing the equipment wrong.

These lessons suggest specific remedies as shown in the individual sections and the executive summary. However, some very fundamental problems seem to persist with the facility management system of the Army. These fundamental problems are:

- Lack of capital and engineering resources to update water options as required.
- Lack of capital and operating resources to aggressively address training of operators in
  new technology.

- Insufficient management understanding and support of system operations and military requirements, leading to:
  - Inadequate training for:
    a) Process Control
    b) System Requirements
    c) Safety
    d) Chemical Handling
    e) Others

- Inadequate and often inappropriate maintenance and inventory systems that lead to long repair times and degraded plant performance.

The plant specific problems are, likewise, outgrowths of the fundamental issues noted above.

IV.3 Remedies

These reflect either resource deficiencies or training and supervision problems.

The potential remedies are similarly installation specific and can be seen in each of the individual sections and the Executive Summary. However, they can be summarized into a small number of initiatives that will have many sub-initiatives at the implementation level. In the last analysis, these initiatives will require the Army to make a determination of how water treatment plants will be operated and how the Army will be judged as a steward of our national resources, i.e., The Army Environmental mission states - "The Army will be a national leader in environmental and natural resource stewardship for present and future generations as an integral part of our mission."

The Lessons and the Remedies suggest that there is progress being made but further actions are required to meet all of the current regulations. Specifically, the OAP program is an integral part of achieving the elements of the Army vision. However, as we have noted throughout this document, implementation of OAP recommendations have been very slow. Indeed, often those recommendations have been ignored. The OAP recommendations are always based upon achievement of compliance with environmental law and regulations. Therefore, the slowness or absence of implementation increases the risk of non-compliance and degradation of resources. Our evaluation is that greater acceptability must be created at the facility management level for implementation of OAP recommendations and compliance issues.

IV.4 Next Steps

- Continue the OAP process.
- Create training products that are uniform plant to plant with supplements for plant specific issues.
- Develop multi-media training products as well as self help forms, etc. to increase availability of training.
- Generate annual guidance for Facility Managers concerning water issues, new regulations, etc., along with benchmark costs.
- Have MACOMS generate an annual report card of water treatment plants.
- Update an annual water budget for the Army and review expenditures against budget each year.
- Publicize compliance problems to elevate their visibility.

- Organize a compliance conference each year that stresses new approaches/solutions, as well as case studies.

- Most importantly, assure that Facility Managers understand the importance of their personal concern and attention in achieving compliance at the water treatment plant.

IV.5 Summary

The OAP has made good strides in improving water treatment plant performance. More needs to be done. More resources, training and use of new management technology tool, such as computer management systems, can make greater improvements. However, the concern of the operation, supervisors and managers will be the most critical element of system improvement.