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PROCEDURE TO DETECT WATER DISTRIBUTION SYSTEM LEAKS

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FACILITIES ENGINEERING
Maintenance and Repair

PROCEDURE TO DETECT WATER DISTRIBUTION SYSTEM LEAKS

1. Purpose. This Public Works Technical Bulletin (PWTB) provides information on a method for early detection of leaks in potable water systems.

2. Applicability. This information applies to all Army installations responsible for operation and maintenance of potable water distribution systems.

3. References.

a. AR 420-46, Water and Wastewater, 1 May 1992.

b. Bandy, J.T., and R.J. Scholze, Distribution of Water Use at Representative Fixed Army Installations, Technical Report N-157/ADA133232, USACERL, August 1983.

c. Maloney, S.W., et al., Preventing Water Loss in Water Distribution Systems: Money-Saving Leak Detection Programs, Technical Report, N-86/05/ADA167556, USACERL, March 1986.

4. Synopsis of Technology.

a. U.S. Army installations distribute water through large piping systems and seldom meter water usage. Implementing the four-step procedure described below can help detect water loss and subsequently locate leaks. Repair of leaks found in the survey can reduce water loss, and yield cost savings. The four steps are as follows:

(1) A "housekeeping" leakage survey of easily accessed water fixtures.

(2) A water audit to determine the extent of leakage problems, including:

(a) Measuring water flow in the distribution system over a 24-hour period.

(b) Comparing minimum night flow (mnf) with average 24-hour flow to estimate the extent of leakage.

(3) A pinpointing survey to locate leaks. This survey may include use of mechanical or electronic sonic technology.

(4) A program to prioritize and do repairs.

b. An explanation of the method is presented as.Appendix A.

5. <u>Point of Contact</u>. Questions and/or comments regarding this subject, which cannot be resolved at the installation or MACOM level, should be directed to U.S. Army Center for Public Works, Directorate of Engineering, CECPW-FU-S, Fort Belvoir, VA 22060-5805, at (703) 704-1540 or DSN 654-1540. The POC at USACERL is CECER-EN, P.O. Box 9005, Champaign, IL 61826-9005, (800) USA-CERL outside Illinois, (800) 252-7122 within Illinois.

FOR THE DIRECTOR:

Frank J. Schmid

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APPENDIX A

PROCEDURE TO DETECT WATER DISTRIBUTION SYSTEM LEAKS

1. Background.

a. Problem. U.S. Army installations have nearly 10,000 miles of water mains, and distribute water much like municipalities. However, Army installations do not meter water at its end point (at an apartment, building, or building complex). Thus, there is no direct way to measure the amount of water used, wasted, or lost in transit. It is common for water distribution systems to experience some leakage, and since the components of a water distribution.system are usually located below grade, it can be hard to detect and correct leaks cost effectively. Locating and repairing leaks in distribution systems that do not monitor water flow at the user is a problem that requires special water-flow measurement and recordkeeping methods.

b. Types of Water Loss. Distribution system efficiency is usually measured by tracking water loss. Water loss is defined either as water that physically escapes from a distribution system or as unrecorded water flow. Water loss can be necessary or unnecessary. Necessary and beneficial losses of water may include street cleaning, sewer and water-main flushing, public irrigation, firefighting, construction, public building supply, and water fountain use. Unnecessary water loss may include distribution system leakage, overflow, evaporation, meter error, and unauthorized connections.

c. Water Loss Measurement. In the private sector, water loss is measured by subtracting the amount of water produced or bought by the utility from the amount of water metered at the end users. In systems that do not meter water flow at the end users, the presence of leaks can be determined by comparing rates of day and night water usage. Controlled studies have documented changes in domestic water use through a normal day. Water demands created by leaks fluctuate abnormally, since they depend on system pressure. System pressure is primarily controlled by the use of elevated storage tanks. During periods of high use, ele-vated storage is depleted, so that overall system pressure (and water loss through leaks) decreases. During periods of low use, water tanks are refilled, and overall water system pressure (and water loss) increases. Maximum water losses occur when elevated tanks are nearly full, typically in the early morning. Distribution system leakage increases the ratio between night and day use.

2. Leak Detection/Mitigation Program. Army installations can detect leaks early with a four-step program. In the first step,

the installation conducts a "housekeeping" leakage survey to locate and correct water loss in the most controllable environment, water fixtures with easy access. The second step, a water audit, is used to determine the extent (and in some cases the approximate location) of water loss. The third step is a pinpointing survey to locate individual leaks in sections of the installation with excessive water loss. The pinpointing survey uses methods of increasing sophistication until the water losses reach an acceptable level, based on local cost and availability of water, and on the cost of required repairs. In the final step, the installation prioritizes and performs the repairs.

a. <u>Step 1 - Housekeeping Leakage Survey</u>. The lack of meters at Army installations means large changes in water use at an individual building can go unnoticed. In an extreme example at an Army installation, one household had a measured usage of 11,000 gallons per day. In a privately owned residence, this could cost over $1000 quarterly. Detecting water leaks on the user's side of the meter is a simple task that can be done by the installation Directorate of Engineering and Housing/Public Works (DEH/DPW). The survey can be limited to areas having a high potential for fixture leaks, such as housing areas. Water loss through easily accessible leaks should be minimized before performing a water audit and searching for distribution system leaks.

(1) Inspect exposed fixtures in housing areas, and any other areas suspected of having high leakage rates. The inspection should include all joints and connections such as water faucets, water heaters, shutoff valves, and exposed plumbing. Water closets can be checked for leaks by placing a few drops of dye (e.g., food coloring) in the toilet tank, and observing the tank 15 minutes later. Dye appearing in the bowl shows a water leak through the toilet tank plunger seal.

(2) Check water-using appliances (e.g., air conditioners, dining facility equipment) for proper connections and water flow within design ranges. Consult with the manufacturer for the specifications of any appliances for which proper water demand is unknown.

b. Step 2 - <u>Water Audit</u>.

(1) Comparing minimum night flow, Q~ f , to average daily flow, $Q_{evs>}$, will indicate if leakage is a prfiem. To do this, take both master meter and storage tank readings. A good source for meter readings is the local water company or the installation's production meter. If the installation has no storage tanks, simply do not consider that factor in the evaluation. In

loop feed systems, it often will be helpful to segment the distribution system into districts, either by closing valves to isolate parts of the distribution system or by measuring flow between districts and taking this flow into account in the calculations. (Note that districting should be coordinated with the fire marshall, and should only be done if the remaining capacity in each district is sufficient to meet normal water demand, and if the valves to be closed are known to be in good working order.)

(2) Use the ratio $Q_{(m,f)}/Q_{(avg)}$ to determine if water loss through leakage is a significant problem in the district being analyzed. If this ratio is greater than about 0.5,* it is likely that excessive leakage is a problem. The more the ratio exceeds 0.5, the greater the water loss. $Q_{(m,f)}$ and $Q_{(avg)}$ are determined from the following equations:

$$Q_{(m,f)} = (M_2 - M_1) - (E_2 - E_1)*DV)/(T_2 - T_1)$$

$$Q_{(avg)} = (M_3 - M_1 - (E_3 - E_1)*DV)/(T_3 - T_1)$$

where:

- M_i = meter reading. This represents the flow into the system.

- E_i = elevation of water level in storage tank. The water level is subtracted from the meter reading to find out if water is flowing into or out of the system. If $(E - E_i)$ is a positive value, then the tanks were filling up, and t6re was a flow out of the system.

- T_i = time expressed as a decimal (e.g., 0315 hours is denoted as 3.25).

- DV = cross-sectional area of the water storage tank, converted into units consistent with the meter readings.

(3) Times 1 and 2 define the period of minimum night flow and would typically be 2400 and 0300, respectively. Time 3 is 24 hours after time 1, i.e. 2400 the next day. If there are no storage tanks, then the expression $(E_i - E_1)*DV$ drops out of the equations. The equations subtract the flow out of the system (if the tanks are filling) from the flow into the system (through

* The 0.5 value is applicable to Army installations with housing areas. Installations with more restricted usage may set the value differently.

the meters), and divides the difference by time (in hours) to get an average flow rate per hour.

(4) Tests should be run when there is no ongoing irrigation. Tests should generate at least 2 weeks of data to determine a firm average figure for the minimum night flow ratio. If some activity on the installation continuously uses large amounts of water, subtract its usage from both the minimum night flow and the average daily flow, and recalculate the ratio. If the minimum night flow exceeds 50 percent of the average daily flow, leak detection/correction will likely be cost effective. USACERL has developed a spreadsheet to assist installation personnel in estimating the cost effectiveness of performing a detailed leak survey and repair program. These spreadsheets incorporate values for average daily flow, minimum night flow, length of main on the installation, cost of leak survey per mile, cost of repair per leak, number of leaks per mile, and cost of water per 1000 gallons. Default values are available if figures are unknown.

(5) A water audit should be performed before and after any general leak detection and repair program, to directly determine the program's effectiveness.

c. Step 3 - Leak Detection Survey.

(1) After completing the water audit, the installation can contract with a local company for a leak detection survey of any areas suspected of having high leakage rates. Leak detection methods vary greatly in cost and sophistication. The most common leak detection method is sonic technology (mechanical, electronic, amplitude attenuation, and noise correlation). Public and private utilities also use several other techniques, such as visual observation, mini-probe sensors, tracer gases, and infrared photography.

(2) In general, water leaking out of a distribution system has three characteristic sounds that help identify and locate leaks. Sound waves propagate from a leak in all directions. Good sounding points may include fire hydrants, valve boxes, curb stops, and air blowoffs. To detect leaks along long stretches of buried main where there are no surface attachments, an operator can make sounding points by inserting metallic rods to contact the pipe, taking care not to damage the pipe coating. Sound is dampened through the pipe material and also through each connection in the system (i.e., between sections of pipe, and at all tees, elbows, crosses, etc.), so that the sound intensity of leaking water at any location gives an indication of the distance to the leak. Leaks can be further pinpointed by using noise correlation from two sounding points.

(3) Both mechanical and electronic sonic techniques use sound amplification and noise filters. With these techniques, an operator can strengthen the sound of the leak while eliminating noise outside the range of the three characteristic sounds.

d. Step 4--Program To Prioritize_ and_ Do Repairs.

3. Benefits.

a. A cost-benefit analysis of leak detection and repair will determine if the program has been effective. There are two methods to calculate benefits. The first method considers all existing costs of treatment and distribution of water (O&M costs). Costs before and after leak detection and repair are compared. The second method consists of calculating the cost of resupplying the water lost from leakage as if new facilities were needed to replace the lost water. The second method includes both O&M costs, and costs of construction or expansion of facilities. Installations with water demands at or near their maximum treatment capacity will benefit from leak control at the marginal cost, because leak repair may forestall building new facilities. Installations with excess capacity for water treatment can meet users' water demand despite leaks, and will save only the operating and maintenance costs.

b. Evidence from both public and private sectors shows that leak detection and repair can yield great cost savings. In many cases, the savings in operation and maintenance costs over a 2 year period can justify the cost of a leak detection survey. The USACERL spreadsheet can assist installations in determining what the payback period would be under local conditions.

c. A continuous program of leak detection and repair reduces the chance of leaks creating or adding to other, larger problems, such as breakage of water mains, water damage from flooding of base-ents or low-lying areas, and inflow of potable water into sanitary sewers.

d. Efficient use of water resources is an area of increasing public concern. In 1992, Congress amended the Energy Policy and Conservation Act (42 U.S.C. 6201) to elevate efficient water use to the status of efficient energy use. An effective program of leak prevention and repair is also good public relations since it presents the U.S. Army as conserver and protector of U.S. resources.

4. Summary.

a. A preventive maintenance program to detect leaks in potable water systems on Army installations consists of four steps: (1) a "housekeeping" leak detection survey, (2) a water audit, (3) a leak pinpointing survey, and (4) a program to prioritize and do repairs.

b. When applied as a regular part of **facility maintenance,** leak detection surveys can yield notable cost savings by preventing costly water loss, by forestalling expansion of water **treat** ment facilities, and by eliminating **small leaks before** they create major problems.