Preventive maintenance program

Guide for small public water systems using groundwater

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If you need this publication in an alternative format, call 1-800-525-0127 (TDD/TTY call 711).

Introduction

Why is a preventive maintenance program important to me?

A preventive maintenance program can prevent problems by helping you maintain your system properly. Knowing the ongoing needs of your system and taking action to meet those needs will enhance public health protection, improve your system's reliability, and reduce the costs of maintaining your water system.

How will this preventive maintenance program guide help me?

This guide provides a schedule of routine operation and maintenance (O&M) tasks for small drinking water systems using groundwater supply. This guide will help you complete your Small Water System Management Program (SWSMP). The SWSMP is a planning tool to help small systems achieve and maintain technical, managerial, and financial capacity and to ensure that they can comply with drinking water regulations. The ***Small Water System Management Program Guide*** **(331-134)** will show you how to incorporate recommended security measures into routine O&M activities, which should link to your emergency response planning needs. For guidance on emergency response planning, see ***Emergency Response Planning Guide for Public Drinking Water Systems*** **(331-211)**.

How is this guide organized?

This guide has four major sections. We designed each section to guide you through developing a preventive maintenance program for your water system.

1. **Recommended Preventive Maintenance**: A narrative of daily, weekly, monthly, and annual operation and maintenance (O&M) tasks.
2. **Recommended Websites and Publications**: Resources to help you find more information or detailed guidance.
3. **Troubleshooting Guides:** Guidance to help you troubleshoot problems with your water system. We organized it by water system component so it is easier to find troubleshooting guidance for a specific component.
4. **Recommended Operation and Maintenance Schedules**: We organized the O&M section by water system component so you can post the schedules where you can see the tasks you need to do. We did not define all tasks in the checklist because they are self-explanatory.

How can I customize these tools for my system?

Based on your system's requirements and state regulations, you can add, subtract, or modify tasks and logs from this guide to meet your preventive maintenance program needs. Maintain a log of all preventive maintenance completed on your water system. It is also important to document quantitative measurements, such as water levels, pressure readings, and so on. Photographs with adequate field notes or videotape with audio explanation can be valuable tools.

We cannot over emphasize the importance of keeping records and documenting maintenance activities. Consistent forms and checklists help to ensure that you inspect and evaluate the same points each time. Organize and store records so they are readily accessible to verify that your water system is performing maintenance tasks and operational surveillance properly. Simple ways to organize your records include filing cabinets or card index files.

Who can help me develop a preventive maintenance program for my system?

Additional assistance and guidance are available from many sources. Our regional offices can help you develop schedules for monitoring and reporting. Other technical assistance providers may be able to provide training and information.

For more information:

Contact our regional office:

Northwest Region, Kent	253-395-6750
Southwest Region, Tumwater	360-236-3030
Eastern Region, Spokane Valley	509-329-2100
Headquarters, Tumwater	360-236-3100
Toll-free within Washington	800-521-0323
After-Hours Emergency	877-481-4901

Visit us online at http://www.doh.wa.gov/ehp/dw/default.htm

Rural Community Assistance Corporation (RCAC)
http://www.rcac.org/people/fdstaff.html#Washington

Evergreen Rural Water of Washington (ERWoW)
800-272-5981 or 360-462-9287
http://www.erwow.org/

Note: ***This guide does not take the place of a complete operation and maintenance program. For specific guidance on your system's current source and distribution monitoring and reporting requirements, please refer to your water quality monitoring report or contact our regional office.***

Recommended preventive maintenance

Daily
Weekly
Monthly
Quarterly
Biannually
Annually
As needed

Daily

Read source water meter and record water production. You should have a working, properly calibrated master water meter at each source of supply to accurately measure and record production. Take routine source-water meter readings and record them in a log. To calculate the amount of water used during a period, usually daily or weekly, subtract the previous meter reading from the current meter reading. You can use data on your water system's water use throughout the year to evaluate source capacity, water rights, unusually high or low flows, excessive leakage, reduced pump output, unauthorized water use, and the adequacy of the treatment system capacity.

Measure and record chlorine residuals. The treatment objective for adding chlorine determines the frequency of free chlorine residual sampling and the required chlorine level.

- **Chlorination for groundwater source treatment (CT6 or 4-log virus disinfection)**
  Some groundwater supplies require disinfection because of concerns over source water quality. For supplies where sampling detected *E. coli* in the untreated well water, you must monitor and record the free chlorine residual every calendar day (no exceptions). For sources deemed at high risk for contamination, such as shallow wells in hydraulic connection to surface water and wells with an unprotected sanitary control area, you must monitor and record free chlorine residual at least five days a week. You must perform this monitoring at the "point of entry" to the distribution system, which is usually at or before the first customer connection downstream of the source. We will specify the frequency of monitoring and the minimum residual concentration required at the point of entry at the time of approval and may subsequently revise these requirements. You must use a digital colorimeter when you perform free chlorine residual monitoring for groundwater source treatment because the device is much more accurate than other methods.

- **Chlorination for maintaining distribution system water quality**
  Some groundwater supplies require disinfection because of water quality problems in the distribution system. Applying chlorine at the source is the best way to ensure a consistent and reliable level of chlorine in the distribution system. If you disinfect your groundwater supply to maintain satisfactory water quality in the distribution system, you must monitor and record free chlorine residual at least five days a week, and maintain a detectable level of free chlorine residual in the distribution system of at least 0.2 milligrams per liter (mg/L).

  We recommend that you use a digital colorimeter when you perform free chlorine residual monitoring in the distribution system because the device is more accurate than other methods. However, you may use a diethyl-p-phenylenediamine (DPD) free chlorine residual test kit for monitoring if the kit reads from 0 to 3.5 parts per million (ppm) of free chlorine with a smallest reading increment of 0.1 ppm or mg/L. Water systems may not use chlorine test strips to measure chlorine residual.

- **Other treatment objectives**
  Some drinking water supplies require chlorine to support a treatment objective other than disinfection (iron removal, for example). If you add chlorine only to support a non-disinfection

treatment objective, we may specify that residual sampling in the distribution system is not required.

Inspect chlorinators for proper operation. Make sure the chemical feed pump is not air locked and the chemical feed suction line is not plugged. Re-fill the chlorine solution tank, as needed. Use proper personal protective gear when handling chemicals. Used improperly, water treatment chemicals may be harmful to human health. Make Material Safety Data Sheets available to ensure proper usage and personal protection.

Conduct security checks. You should inspect source, pumping and storage facilities daily to ensure they continue to provide adequate protection against vandalism and unauthorized entry. Use appropriate fencing, locks, and locked well covers to protect the facilities from stray livestock and tampering. Post warning signs to deter trespassing. Warning signs should indicate a building and phone number for reporting incidents. Inspect fencing and gates for damage and needed repairs. Check hatches, locks, doors, windows, and vents for signs of intrusion or vandalism. Check all security lighting and alarms to ensure proper operation. Make sure all well caps, seals, and vents are intact and sealed. If you suspect any tampering, immediately contact local law enforcement and our regional office.

Check and record water levels in storage tanks. You should check the water level in each atmospheric storage tank and the pressure in your pressure tank system each day to ensure tank levels are within normal operating range. Check for evidence of overflow, erosion under the splash pad, warning lights, wet ground, and so on. If there is evidence of your reservoir overflowing, your pump controls may be malfunctioning. If the tank's level is below normal operating conditions, there may be a problem with your source of supply or water level controls.

Inspect wellheads. Wellhead covers, or seals, keep contaminated water and other material out of the well. Visually inspect all well covers and pump platforms. They should be elevated above the adjacent finished ground level, sloped to drain away from the well casing, and free of cracks or excessive wear. Below grade, wellheads can become flooded seasonally or after severe weather. Check for and remove any potential microbiological or chemical contaminant threats from within 100 feet of the well. For example, damaged electrical conduits can open a pathway for contaminants to enter the well casing.

Record well pump run times and pump cycle starts. If available, you should use the pump run hour meters and cycle counters on the control panel to record the running times and number of cycle starts for your well and booster pumps. You should take these readings about the same time every day and record them in a daily well pump log. Comparing daily numbers will alert you to potential pump or pressure tank problems. If a pump cycles on-off more than 6 times an hour, it may indicate a bladder failure in a bladder tank or a "water-logged" condition in a hydropneumatic tank. High frequency pump cycling wears out the pump motor, switches, and controls. Many water systems use a pump alternator or lead/lag pump controllers. You can use the pump-run hour meter and pump cycle counter to verify these control systems are working properly.

Check for leaks and fix them immediately. Excess moisture in a well house or pump house can lead to premature failure of electrical control systems and create unsafe conditions for operators. Fix any leak you see as soon as possible.

Make sure the heating and cooling systems are working. You should check heaters daily throughout the winter to ensure they work properly. Make sure wiring and heaters are above floor level and not placed where water leakage could cause a safety hazard, an electrical outage, or short any breakers. Check ventilation and cooling systems during the hottest portion of the year to be sure there is proper ventilation in the pump house. Extremely high temperatures may damage electric motors.

Weekly

Check and record water levels in hydropneumatic pressure tanks. Pressure tanks come in all shapes and sizes. Maintaining pressure in these tanks is important for maintaining adequate pressure to the consumers. Hydropneumatic tanks can overfill, or waterlog, at times affecting overall system pressure. Monitoring pressure can help an operator identify leaks, open valves, and even well pump problems. Hydropneumatic tanks should have a sight tube installed so you can visually check the water level in the tank. Often, condensation that forms where water cools the metal on the lower portion of the tank makes the water level obvious. You can also detect this temperature difference by touch.

Record the pumping rate for each well or source water pump. Record the pumping rate from your well or source water pumps. You can do this if your system has a meter that registers flow. A change in pumping rate can indicate a pump problem. Remember, pumping rates will vary based on the water level in the well. For example, the pump produces less when the well draws down from the static water level to the deepest pumping level or the pump is pumping against a high head.

Inspect booster pump stations. Check on the condition of the pumps, such as vibration, heat, seal, and controls to ensure that booster pumps are operating properly. Take care when checking how hot a pump or motor may be. If you have two or more booster pumps, the pump operating times should be roughly equal. You can accomplish this automatically with a lead-lag controller, or by manually switching the lead pump on a set schedule. Check and record meter readings and pressure gauge readings on suction and discharge sides of pumps.

Check water pressure in each well house and each pump house. Check the system pressure in the well house and any place you have booster pumps. You should have accurate gauges to monitor the performance of a pressurized water system. Pressure gauges should be on the suction and discharge lines of pumps. Pressure tanks should have pressure gauges on the discharge lines. You should check the gauges regularly and replace if damaged.

Monthly

Inspect well pumps, motors, and controls. System operators should always be on the lookout for any defects in the system. Look, listen, and feel for unusual sights, sounds, or vibrations. Make sure pump seals are intact and the system is not running hot. Check all timers to ensure that pump operating times are equalized. Operate the controls manually to verify that they are working. When you shut down or turn off equipment for repairs, make sure it won't start up accidentally and cause injury. Observe the function of each control valve and pressure switch,

Take appropriate monthly water quality samples. You must take water quality samples routinely, according to state requirements. You must use approved procedures to take samples and submit them to a certified laboratory for analysis. We can give you an annual schedule for your required sampling. Use state forms and procedures, as required, and use a monthly sampling log to record all water sampling you conduct each month. Even when you are required to sample for a contaminant quarterly or annually, you should still record the month you took the sample. Keep records of all water quality tests for your own use and to respond to customer inquiries. To find out how long you must keep the water quality sampling results, see Chapter 246-290-480 WAC. Contact our regional office if you have questions about your water quality monitoring report.

Check sump pumps, and well and pump house flood prevention or detection systems. Large leaks in a well or pump room can damage motors and other equipment and create unsafe conditions for operators. Leaks may also open pathways for contaminants to enter the water supply. Check any sump pumps for proper operation, and ensure proper operation of any internal leak detection system.

Read customers' meters. If your customers have meters, you should read them monthly or with your billing cycle, total them, and compare them to your system's master meter.

Read electric meter at pump house and record. Monitor and note any unusual or unexpected changes in electricity use over time. If pumping accounts for a large proportion of your system's energy use, track water production and compare it to energy use. In the winter, you will also need to consider energy use for heating. High meter readings can indicate that your booster or well pumps are working harder to perform their jobs. If so, that could mean maintenance is required now, or at least soon.

Submit chlorination reports. Chlorination Reports are due to the Office of Drinking Water by the tenth of the following month. If you have been monitoring chlorine residuals but haven't sent the reports to us, please send a copy of all reports for the current year. If you don't have a chlorination monthly reporting form, contact our regional office.

Maintain a 30 to 60 day supply of chlorine. Rotate stock to reduce decomposition and formation of unwanted byproducts, such as chlorite or chlorate. Sodium hypochlorite will lose strength over time. It will also lose strength when exposed to high temperatures or sunlight. For example, the rate strength is lost doubles with every 5° C rise in temperature. Strong light, especially direct sunlight, causes sodium hypochlorite to break down. Stronger solutions can also lose their strength faster than weak solutions. For example, a 15 percent solution stored under cool, dark conditions might lose 0.1 percent strength over a week, while in sunlight it could drop from 15 percent to 12 percent in one day. Because of this, you should always store your stock in containers with tight lids under cool, dark conditions. You should also

consider the costs of ordering and storing large amounts of stock versus a smaller one- to two-month supply. Remember, when your stock loses strength in storage, you lose money.

Quarterly

Make sure fire hydrants are accessible. Fire hydrants provide water for fighting fires and a means to flush the system. The hydrants should be easy to get to and highly visible. This includes removing snowdrifts during the winter, tall grass or weeds during the summer, and painting the hydrants a highly visible color. Hydrants should be color coded according to available fire flows. During inspection, be sure to check for tampering or vandalism. Record your findings in a logbook. You should develop a logbook to document your findings and standardize the way you check these items.

Clean pump house and grounds. Keeping your pump house and grounds clean will help with overall system maintenance and operation. If dirt gets into lubricants, it can reduce the useful life of bearings. Dirt and moisture also will form an insulating coating on motor windings and can cause motors to burn out. In addition to cleaning, screen all drain and vent openings in the building to keep animals and insects out. During the summer, mow the areas around the pump house and storage tanks. Make sure grounds maintenance addresses fire hydrant accessibility. You should develop a weekly cleanliness log card to record your inspections.

Inspect and clean chlorine solution feed lines and solution tanks. To ensure your chlorine feed system functions properly, inspect the lines for clogs or kinks and make sure the solution tanks are clean. Regular cleaning of the chlorine feed systems will help prevent many breakdowns in this equipment. Inert solids will build up sediment on the bottom of the solution tank and can clog the foot valve or damage the chlorinator.

Calibrate chlorinators. At least every three months, and particularly after the chlorinators have been overhauled, the pumps should be re-calibrated to ensure they deliver the right amount of chlorine solution to the system. Measure the amount of solution the pump withdraws over a given time period, record this value and speed/stroke length settings, and compare this rate with the desired feed rate. Refer to the manufacturer's instructions to adjust the feed pump accordingly. Be sure to record any new speed and stroke settings anytime you make a change.

Inspect and test standby power generation systems. You should test your emergency power generators and switchover controls periodically to ensure they are in proper operating condition.

Follow the manufacturer's maintenance recommendations. You should keep written records of the checks, operational tests, and maintenance performed. The manufacturer may recommend testing more frequently than once every three months.

Inspect storage tanks for sanitary deficiencies. You should inspect storage tanks to ensure they protect drinking water from contamination. Be sure to document the inspection, including photographs that will be useful for the next routine sanitary survey. Check vent screens for any openings to prevent small animals, bats, birds, insects, debris, dust, or organic matter from entering the tank. Check overflows for tight-closing flap valves or intact screens. Check the condition of the storage tank and look for cracks, structural damage, leaks, corrosion, and cathodic protection. Check the condition of the access hatch inner seal.

Biannually

Exercise half of all mainline valves. It is important to exercise all mainline valves in the system at least once a year to ensure you can locate them and confirm that you can open and close them during an emergency shutdown. You should exercise half of the mainline valves in the spring and the rest in the fall. Record the number and direction of turns to closure. Be sure to describe the condition (rusted, new, leaking, failing) of each valve in the appropriate column in a logbook. You should develop a map that identifies the valves and their locations. Keep this information in a secure place. It is important to be able to isolate the system or sections of the system. Be sure to schedule any failures for repair. You should develop forms to track the valve inspections and repairs or to note any scheduled repairs.

Evaluate the water turnover of the stored water. Storage facilities should provide adequate water turnover and routinely fluctuate the water level in the tank. Various factors influence what the water turnover goal should be, including source water quality, disinfection, water use, fire flow, tank design, and so on. Some experts recommend a three-to-five-day water turnover, modified as needed. Water systems with extreme seasonal variations in total water use have additional challenges to adapt operations to maintain good quality water.

Operate all valves inside the well house, treatment plant, and pump house. You should routinely inspect and exercise all valves in a system. The frequency of inspection depends on the type of valve, but you should inspect the valves at least twice a year. The inspection should include completely closing, reopening, and re-closing the valve until it seats properly. Record the number and direction of turns to closure. Be sure to schedule leaking or damaged valves for repair. Use a logbook to track inspections. Update the log card routinely throughout the year.

Check pressure relief valves. All pressure tanks in public water systems must have an American Society of Mechanical Engineers (ASME) certified pressure relief valve (PRV) to protect them for overpressure conditions. Approved PRVs have tags indicating the ASME status and levels you can use to verify function. Use caution and follow the manufacturer's procedures. For more information, see ***Pressure Relief Valves on Pressure Tanks*** **(331-429)**.

Check and record static and pumping levels of each well. This important task will determine the reliability of the aquifer and establish baseline information that can be useful if others tap into the aquifer or take actions that will affect it, such as gravel mining. The static level is the water level in a well when the pump is off. The pumping level is the water level while the pump is operating. You can check these levels by using bubbler lines, electrical sensors, or manual drop lines. You should measure the pumping level at various stages of pumping, and during both the low demand and high demand times of the year. You should also measure the recharge time, which is the time it takes the water level in the well to return to the static level. You must disinfect and handle all equipment in a way to prevent contamination of the well. You should develop a static and pumping level logbook.

Inspect chemical safety equipment and repair or replace as needed. Review the use of all safety equipment and update safety training once each year. You should check and test the chemical safety equipment at least once each year to ensure it is operable. Follow the manufacturer's instructions on the proper upkeep of all safety equipment, including portable ventilators or respirators, safety harnesses or belts, goggles, gloves, hard hats, and protective clothing. You should also follow the

manufacturer's instructions when calibrating detection devices for hazardous gases. Repair or replace all equipment as needed. Review all safety procedures. You should develop a safety logbook to record routine safety maintenance.

Annually

Flush the distribution system and exercise and check fire hydrant valves. You should flush the entire system in one direction, outward from plant or storage facility, at least once a year, depending on the quality of your source water. Systems with excessive iron or manganese that do not treat to remove these minerals may need to flush as often as monthly. Flushing clears any sediment in the lines. During the flushing, check the operation of the fire hydrant valves and observe the color of the water. Continue flushing until the water is clear. When operating a dry-barrel hydrant, you must close it completely so that the drain will open completely. Otherwise, water remaining in the hydrant could freeze and damage the hydrant. Make sure that any open hydrants are flushing away from private property. Use a logbook to track when you completed flushing.

Conduct a water audit and leak detection program. You should determine water loss by comparing water production records to water use. Water loss isn't always a physical leak in the system. It can result from main breaks, inaccurate or broken meters, theft, and errors in the billing system. Undetected water main leaks create conditions that put a water system's capacity to supply safe and reliable drinking water at risk. Leak detection can be a continuing challenge that strains the expertise and financial resources of a water system. A system may choose to purchase detection equipment and train staff to check for leaks, or they may hire an outside firm to perform leak detection surveys for them. Some systems use a combination of internal checks and contracting. For more information, see our ***Water Use Efficiency Guidebook*** **(331-375).**

Prepare system for winter operations. This includes checking all exposed facilities such as pumps, valves, and pipes. Make sure all exposed facilities are insulated properly, the heaters in the treatment plant and pump house are operable and in good safe working condition, and vents are closed. Also, drain fire hydrants and sprinkler systems, top off all propane or fuel tanks used for heating the pump house, and lower the water level in the storage tank just slightly. Circulating more of your water in storage facilities helps to prevent freezing. You may postpone this task until October or November based on local weather conditions. Be sure to decommission unnecessary equipment properly. For more information, see ***Start-up and Shut-down Assistance for Seasonal Noncommunity Water Systems*** **(331-314)**.

Check aesthetic water quality in storage tanks. Identify aesthetic problems that may be associated with inadequate storage facility design, construction, or operation. Objectionable taste and odor may indicate poor water turnover promoting growth of taste and odor producing microorganisms. Improperly cured coating materials will result in unpleasant taste and odor in the stored water. Sediment build-up, especially from excessive iron or manganese, will harbor and provide nutrients for biofilm forming bacteria. Regular maintenance and thorough cleaning to reduce sediments will improve water quality. Stagnant water in an aboveground storage tank will tend towards the ambient temperature. Warmer water in the summer and fall months will increase biological growth leading to water quality problems. Water will also stratify in the tank further reducing turnover.

Perform preventive maintenance on well house, treatment plant and pump house buildings. You should paint facility piping, buildings, and tanks regularly to prevent deterioration. Store all pipes, plumbing fittings, chemicals, tools, and other materials in a safe place. Check well house ventilation to ensure there are no blockages and that fans are operable. Inspect for excessive rust on exposed metal on pressure tanks, pipes, valves, controls, and fans that may be caused by corrosive

chlorine vapors and poor ventilation. Deep pitting in pressure tank walls can compromise the structural integrity of the vessel. You can check the wall thickness with ultrasonic testing devices.

Inspect, clean, and repair control panels in well house. You should inspect the control panels in the pump house and treatment plant at least once a year for corrosion and other problems that could cause shorts or failures. Clean control panels carefully with air. Repair the panels if needed.

Overhaul chlorinators, including O-rings, check valves, and diaphragms. You should overhaul chemical feed pumps completely at least once a year. The overhaul should include cleaning the feeder head, cleaning and checking all valves and O-rings for wear, and cleaning and checking the condition of check valves and pump control valves. Replace any worn-out parts, including diaphragms. Keep spare parts on hand, so you can repair breakdowns quickly and replace worn parts when you disassemble the feeder for cleaning. You should keep a chemical feed pump repair and spare parts kit in the treatment building. Recalibrate the chlorinators to ensure they deliver the appropriate amount of chlorine solution to the system.

Review your emergency response plan. Review all contacts for accuracy, make sure all equipment is working, and ensure all procedures match the plant conditions, as they presently exist. Contact your local emergency response agency to update contacts, new processes, or chemical inventories.

Review your water facilities inventory. Review your water facilities inventory and update information as needed. Especially important is the contact information (name, address, e-mail, day and night phone numbers), number of people served, number of connections served, and actual in-place pumping capacity and type of treatment applied at each of your sources.

Review your coliform monitoring plan. Review your coliform monitoring plan and update as needed. For guidance on preparing your coliform monitoring plan, see ***Preparation of a Coliform Monitoring Plan for Group A Public Water Systems*** **(331-036)** and ***Preparation of a Coliform Monitoring Plan for the Small Noncommunity Water System*** **(331-240)**.

Check instrumentation for proper signal input/output. Make sure each instrument is working properly. Make a log for each piece of equipment to record readings. Record the manufacturer specifications and notes on the log to make equipment information easily accessible.

Test each alarm. Make sure each alarm system is working properly.

Maintain air compressors. Systems often use air compressors with water level controls to maintain the proper air/water balance in hydropneumatic tanks. To maintain airflow, you must keep the air intake filters clean. Replace and thoroughly clean dirty clogged filters. Moisture traps built into the filter/regulator keep moisture and dirt particles out of the pressure tank. Follow the manufacturer's instructions when cleaning and replacing air filters, and checking moisture traps. You must cover belt-driven air compressors with safety guards. Unprotected belts can cause serious injuries. Check air compressors and motors for any signs of malfunction. You should investigate unusual noises, vibrations, odors, and heat generation immediately; they can indicate mechanical problems. You should evaluate compressors that do not reach preset tank pressure. Bearings on most air compressors need lubrication. You must use food-grade oils and lubricants to prevent contamination of the water in the pressure tank.

As needed

Perform storage tank maintenance. Maintenance activities include cleaning, painting, and repairing structures. State drinking water rules require adherence to American Water Works Association (AWWA) Standards, National Sanitation Foundation (NSF), and American National Standards (ANSI) for disinfection procedures and approval of coatings.

Inspect storage tanks for defects. Systems need to conduct both interior and exterior inspections to ensure maintenance of physical integrity, security, and high water quality. The type and frequency of the inspection depends on the type of tank, its susceptibility to vandalism, age, condition, and time since last cleaning or maintenance, history of water quality, plus other local criteria. Exterior inspections for obvious signs of intrusion or vandalism might occur daily or weekly. Periodic inspections of the storage tank for cracks, structural damage, integrity of hatches and vents, leaks, corrosion, and cathodic protection might occur monthly or quarterly. You should conduct a comprehensive inspection of the interior whenever you drain the tank for cleaning. Industry standards recommend a comprehensive inspection of tanks—inside and out—every five years, except for newly constructed tanks. You should inspect a new tank within 10 years of service and every five years thereafter.

Clean storage tanks. Thoroughly clean tanks after any construction, maintenance, or repairs. Use a high-pressure water jet, sweep, scrub, or other methods to clean wall and floor surfaces thoroughly. You should flush all water and dirt from the tank. There are several AWWA-approved ways to disinfect a storage tank after you take it out of service for cleaning, inspection, or repairs. Here is the simplest way:

> **AWWA Standard C-652 Chlorination Method 3.** Broom-clean the bottom of the tank. Then begin to add potable water until the tank is about 5 percent full. Next, add the appropriate quantity of chlorine directly into this water. The amount of chlorine you add should result in a free chlorine residual between 2.5 and 3.0 parts per million when the tank is completely full. If you use regular household chlorine bleach (6 percent chlorine by weight), add 1 gallon for every 20,000 gallons of tank capacity. Contact our regional office if you are unsure how much chlorine and what type of chlorine to add to your tank.
>
> After adding chlorine, fill the remaining 95 percent of the tank with potable water and wait 24 hours. At the end of 24 hours, measure the free chlorine residual of the water inside the tank. If the water in the tank has a free chlorine residual of at least 2 parts per million, then collect a coliform sample from the tank. If the coliform sample is satisfactory, then you may place the reservoir directly back into service. If the coliform sample shows the presence of coliform, contact your regional office for instruction on further disinfection and testing.
>
> When you plan to take a tank out of service for cleaning and disinfection, be sure to make provisions to maintain an adequate water supply and adequate water pressure in the distribution system at all times. You may need to coordinate this with your local fire protection authority. If you are unsure how to provide service while the tank is off-line, contact our regional office for technical assistance.
>
> If you can't or don't want to take your tank out of service for inspection and cleaning, you should consider the cost and availability of using certified divers trained to inspect and clean a drinking water tank while the tank remains in service.

Contact an electrician to check running amps on well pumps. A change in running amps can indicate a change in the condition of the motors or pumps. When pumps start drawing more amps, it generally means you should repair the motors. Checking the amps and voltage on pumps can be complicated and dangerous. **Do not attempt it yourself**. Contact an electrician to complete this procedure. Perform this task at least once a year and any time you sense a problem with your pump, such as unusual sounds, vibrations, or the pump is running hot.

Pressure tank supports. You must support pressure tanks to prevent tipping or falling. Hydropneumatic tanks tend to be large and very heavy when filled with water. Supports must be sturdy and maintained in good condition. Stacked blocks or boards can fail during an earthquake. Evaluate the structural condition of the supports and level of the seismic protection provided. Consult a qualified authority if you are unsure. Failure will result in extensive damage to any facilities near the pressure tank. Water leaks will damage more equipment.

Purchase a backup chlorinator. We highly recommend that you have a spare chlorinator on hand for emergencies when repairs are impossible and disruption to service is unacceptable. Other approaches may offer a similar level of reliability.

Maintain a log of water line repairs. You should document repairs to the water distribution line, especially repair clamps placed on water lines. These clamps are not long-term or permanent repairs, so identifying the date and location of such repairs is very important in planning for future pipeline replacement. A thorough record of line replacements can also help to identify areas of the distribution system more prone to failure due to age, pipe material, soil conditions, vibration, or other causes.

Maintain physical protection of wellheads. Protect the wellhead from vehicular damage by installing barriers. Vehicles can severely damage vulnerable wellheads, potentially putting the continued operation of the system at risk.

Overhaul control valves. Pressure reducing valves, pump control valves, and surge anticipation valves require periodic maintenance for proper functioning. A factory-certified technician normally does this work.

Recommended websites and publications

Websites

Department of Health Office of Drinking Water http://www.doh.wa.gov/ehp/dw

U.S. Environmental Protection Agency (EPA) Groundwater and Drinking Water http://www.epa.gov/safewater/

EPA Small Systems Information and Guidance http://www.epa.gov/safewater/smallsys/ssinfo.htm

U.S. EPA Publications Search http://www.epa.gov/epahome/pubsearch.html

National Drinking Water Clearing House http://www.nesc.wvu.edu/ndwc/

American Water Works Association http://www.awwa.org/

Publications

You can access the following ODW and EPA publications through our publications database at https://fortress.wa.gov/doh/eh/dw/publications/publications.cfm

Pub. number	Title	Publisher
331-036	*Preparation of a Coliform Monitoring Plan for Group A Public Water Systems*	ODW
331-123	*Water System Design Manual*	ODW
331-134	*Small Water System Management Program Guide*	ODW
331-211	*Emergency response planning guide for public drinking water systems*	ODW
331-240	*Preparation of a Coliform Monitoring Plan for the Small Noncommunity Water System*	ODW
331-259	*Nitrate Public Health Advisory Packet (Blue folder)*	ODW
331-260	*Coliform Public Health Advisory Packet (Red folder)*	ODW
331-314	*Start-Up and Shut-Down Assistance for Seasonal Noncommunity Water Systems*	ODW
331-317	*Emergency drinking water sources*	ODW
331-327	*Water rates: Paying for drinking water*	ODW
331-375	*Water Use Efficiency Guidebook*	ODW
331-380	*Hydropneumatic Tanks*	ODW
331-429	*Pressure Relief Valves on Pressure Tanks*	ODW
816-R-03-002	*Cross-Connection Control Manual*	EPA
816-R-03-015	*Strategic planning: A handbook for small water systems*	EPA
816-R-03-016	*Asset management: A handbook for small water systems*	EPA
816-R-05-006	*Setting small drinking water system rates for a sustainable future*	EPA
817-R-05-001	*Drinking water security for small systems serving 3,300 or fewer persons*	EPA

Troubleshooting Guides

Groundwater sources
Submersible well pump systems
Pressure tanks
Storage facilities
Hypochlorination problems
Distribution systems
Cross connections
Sampling and monitoring

Troubleshooting guide for groundwater sources		
Problem	**Possible cause**	**Possible solution**
Well pump won't start.	Circuit breaker or overload relay tripped.	Reset breaker or manual overload relay.
	Burned out fuse.	Check for cause and correct, replace fuse(s).
	No power to switch box.	Check incoming power supply. Contact power company.
	Short, broken or loose wire.	Check for shorts and correct, tighten terminals, replace broken wires.
	Low voltage.	Check incoming line voltage. Contact power company if low.
	Defective motor.	Contact electrical contractor.
	Defective pressure switch.	Check voltage of incoming electric supply with pressure switch closed. Contact power company if voltage low. Perform maintenance on switch if voltage normal.
Well pump won't shut off.	Defective pressure switch.	Check switch for proper operation. Replace switch.
	Cut-off pressure setting too high.	Adjust setting.
	Float switch or pressure transducer not functioning.	Check and replace components or cable as needed.
Well pump starts and stops too frequently (excessive cycle rate).	Pressure switch settings too close.	Adjust settings.
	Pump foot valve leaking.	Check for backflow. Contact well contractor.
	Waterlogged hydropneumatic tank.	Check air volume. Add air if needed. If persistent, check air compressor, relief valve, air lines, and connections. Repair as needed.
Sand sediment in the water.	Problems with well screen or gravel envelope.	Contact well contractor.
Well pump operates with reduced flow.	Valve on discharge partially closed or line clogged.	Open the valve and unclog the discharge line.
	Well is over-pumped.	Check static water level and compare to past readings. If significantly lower, notify well contractor.
	Well screen clogged.	Contact well contractor.

Troubleshooting guide for groundwater sources (Cont.)		
Problem	**Possible cause**	**Possible solution**
Well house flooded without recent precipitation.	Check valve not operating properly.	Repair or replace check valve.
	Leakage occurring in discharge piping or valves.	Inspect and repair or replace as necessary.
Red or black water complaints.	Water contains excessive iron (red brown) or manganese (black water).	Test for iron and manganese at well. If levels exceed 0.3 mg/L iron or 0.005 mg/L manganese, contact our regional office, your technical assistance provider or water treatment contractor.
	Complainant's hot water needs maintenance.	Check hot water heater and flush if needed.
Raw water appears turbid or a light tan color following rainfall.	Surface water entering or influencing well.	Check well for openings that allow surface water to enter. Check area for sinkholes, fractures, or other physical evidence of surface water intrusion. Check water turbidity. Contact our regional office if >0.5 NTU. Check raw water for coliform bacteria. Contact our regional office immediately if positive.
Coliform tests are positive.	Recent flooding, recent well or well pump maintenance, or loss of power.	Contact our regional office immediately.
	Sanitary protection of well has been breached or wellhead is observed to be damaged	Contact our regional office immediately.

Troubleshooting guide for submersible well pump systems		
Problem	**Possible cause**	**Possible solution**
Pump won't start.	No power to switch box.	Check the position of the main electrical disconnect arm (main switch) to ensure it is in the up (energized) position. If main power supply interrupted, you should start the auxiliary power system (generator).
	Circuit breaker or overload relay tripped.	Reset breaker or overload relay. If pump does not start, start motor by turning the Hand/Off/Automatic (HOA) Switch to the HAND (manual) position for about 2 to 5 minutes (do not over pressurize the distribution system). If motor runs, return the HOA switch to the AUTO position. If motor does not run, see other probable causes below.
	Fuses burned out.	Check for cause and replace fuses with correct type and size fuses. Make sure to pull down (de-energize) the main electrical disconnect arm (main switch) before opening the panel and replacing the fuses.
	Defective pressure switch or automatic control system.	Turn the HOA Switch to the HAND (manual) position for a short period. If pump starts, the problem is in the automatic control system. Contact electrician experienced with industrial controls to repair automatic control system. Pump can be operated in manual position to supply water; however, the operator must monitor the discharge pressure (pressure on the distribution system) to ensure it doesn't exceed normal working pressure.
	All of the above checked and pump won't run.	Contact electrician experienced with industrial controls.
Pump won't shut off.	Defective pressure switch or automatic control system. The pressure switch may need adjustment or replacement.	Turn the HOA Switch to the OFF position. If pump stops, the problem is in the automatic control system. Contact electrician experienced with industrial controls to repair automatic control system. Pump can be operated in manual position to supply water; however, the operator must monitor the discharge pressure (pressure on the distribution system) to ensure it doesn't exceed normal working pressure or drop below normal minimum working pressure.

Troubleshooting guide for submersible well pump systems (Cont.)		
Problem	**Possible cause**	**Possible solution**
Pump starts too frequently.	Leaking foot valve or check valve.	During the OFF cycle, listen for water running back into the well and check the water flow meter to see if it is running backward. If there is a swing-type check valve in the discharge pipe in the well station it may be stuck in the open position. With the well pump running (on), try manually lifting and lowering the operating arm on the check valve. With the well pump off, slowly and gently push the operating arm to the closed position. If the problem persists, contact well service company.
	Water logged hydropneumatic tank.	See ***Simple control systems: Hydropneumatic tanks* (331-380)**.
	Defective pressure switch or automatic control system. High- or low-pressure cutoff switches may need adjustment.	Contact electrician experienced with industrial controls.
Fuses blow, circuit breaker or overload relays trip when pump is in operation.	Insufficient discharge head causing a high amperage (electrical current) draw.	Check water flow meter to see if the discharge rate is much higher than normal and the discharge pressure gauge to see if the pressure is lower than normal. If so, the water system could be out of water (no pressure) or there could be a very large leak in discharge line or in the distribution system. At the well station, with the pump running, try throttling back on the discharge gate valve until the pressure reached the normal operating pressure. DO NOT close the valve completely or operate the pump for an extended period time against a throttled valve. Immediately notify your supervisor.
	Incorrect voltage, excessive heat in control panel, motor overloaded, incorrect fuses, breakers, or overload relays.	Contact electrician experienced with industrial controls.
Pump won't deliver normal amount of water.	Discharge valve partially closed.	Fully open discharge valve and see if pump rate increases. Make sure pump does not break suction.
	Pump breaking suction, water level in well near or below pump intake. Air may be present in water drawn from sample tap.	Partially throttle discharge valve. The discharge rate may actually decrease, but the water level in the well should rise and the pump should no longer break suction. Contact well service company.
	Pump worn, hydraulic problems, intake plugging.	Contact well service company.

Troubleshooting guide for submersible well pump systems (Cont.)		
Problem	**Possible cause**	**Possible solution**
Sand in the water.	Problems with well screen or gravel envelope.	Partially throttle discharge valve until sand reduces or disappears. Contact well service company.
Air in the water.	If there is a check valve between the well pump and the hydropneumatic tank, and air is present on the well side of the check valve, then the pump may be breaking suction. In this case the water level in well is near or below the pump intake.	Partially throttle discharge valve. Contact well service company.
	If there is a check valve between the well pump and the hydropneumatic tank—and air is present only on the hydropneumatic tank side of the check valve and in the distribution system—then air from hydropneumatic tank may be entering water.	See troubleshooting guide for Hydropneumatic Tanks.
Auxiliary power system (generator) won't activate during loss of power supply.	Automatic transfer switch (ATS) is not functioning.	Manually start the auxiliary power system.
	No fuel.	Check fuel and add if necessary.
	Dead battery.	Jump-start or charge battery.
	Mechanical problem with engine/generator.	Contact auxiliary power system service company.

Troubleshooting guide for pressure tanks		
Problem	**Possible cause**	**Possible solution**
Well pump won't start.	Circuit breaker or overload relay tripped.	Reset breaker or manual overload relay.
	Fuse burned out.	Check for cause and correct, replace fuse(s).
	No power to switch box.	Check incoming power supply. Contact power company.
	Short, broken, or loose wire.	Check for shorts and correct, tighten terminals, replace broken wires.
	Low voltage.	Check incoming line voltage. Contact power company if low.
	Failed motor.	Contact electrical contractor.
	Defective pressure switch.	Check voltage of incoming electric supply with pressure switch closed. Contact power company if voltage low. Perform maintenance on switch if voltage normal.
Well pump won't shut off.	Defective pressure switch.	Refer to troubleshooting guide on Pumps and Pumping Facilities. Note: If the water supply pump runs constantly, excessive pressure can develop in the hydropneumatic tank and distribution system. The tank should be equipped with a pressure-relief valve that opens at about 100 psi. This may protect the tank from damage but could damage the distribution system if pressure exceeds normal working pressures. Contact an electrician experienced with industrial controls.
	Cut-off pressure setting too high.	Same as above.
	Float switch or pressure transducer not functioning.	Same as above.
Well pump starts and stops too frequently (excessive cycle rate).	Leaking foot valve or check valve.	Contact well specialist.
	Defective pressure switch or automatic control system. High- or low-pressure cutoff switches may need adjustment.	Contact well specialist or electrician.

Troubleshooting guide for pressure tanks (Cont.)		
Problem	**Possible cause**	**Possible solution**
	Excessive water use or major leak in water distribution system.	Locate and repair leak.
	Waterlogged hydropneumatic tank.	Check air-to-water ratio from sight tube (if provided). If water completely fills the tube or the water level exceeds ⅔ of the tank volume, you will have to introduce air into the tank. Check tank and air system for leaks. The optimum air-to-water ratio in the hydropneumatic tank should be ⅔ water to ⅓ air at the “pump off” level. If the problem persists or there is no sight tube, contact a water system specialist.
	Air-logged hydropneumatic tank.	Check air-to-water ratio from sight tube (if provided). If air completely fills the tube or the water level is less than ½ the tank volume at the “pump off” level, you will have to bleed air from the tank. The optimum air-to-water ratio should be ⅔ water to ⅓ air. If the problem persists or there is no sight tube, contact a water system specialist.
Sand or sediment in the water.	Problems with well screen or gravel envelope.	Contact well contractor.
	There is iron or manganese in the well water: If you don’t remove it before it reaches the hydropneumatic tank and the air in the hydropneumatic tank comes into direct contact with the water in the tank, the iron and manganese could oxidize and settle in the tank. In addition, sediment could be present in the distribution system.	Improve iron and manganese removal. If the hydropneumatic tank is equipped with a drain, open the drain valve and discharge the sediment to waste.
Air in the water.	If there is a check valve between the well pump and the hydropneumatic tank, and air is present on the well side of the check valve, then the pump may be breaking suction. In this case, the water level in well is near or below the pump intake.	Partially throttle discharge valve. Contact well service company.

Troubleshooting guide for pressure tanks (Cont.)		
Problem	**Possible cause**	**Possible solution**
Oil in the water.	Oil leaking from air compressor.	Check the oil separator on the discharge side to the air compressor. Notify a water system specialist. Consider replacing the unit with a non-oil lubricated type unit.
Dirt and or bacteria in the water.	Inadequate disinfection.	Refer to troubleshooting guide on hypochlorinators.
	Intake filters on air compressor broken or dirty.	Replace filter. Also, review troubleshooting guide on hypochlorinators. Contact water system specialist.
Excessively high distribution system pressure (greater than 70 psi).	Automatic pressure controls need adjustment or pump-off sequence won't function.	Refer to troubleshooting guide for Pumps and Pumping Facilities.
Excessively low distribution system pressure - normal working pressure below 40 psi or occasional pressures below 20 psi during peak usage.	Automatic pressure controls need adjustment or cut-in sequence is not functioning.	Refer to troubleshooting guide for Pumps and Pumping Facilities.
Corrosion on the outside of the tank.	Inadequate protective coating (paint).	Clean area with a wire brush. Prime and paint the surface. Do not chip rust from the tank unless it is drained and out of service. If chipping is required, contact a tank corrosion specialist. The tank may not be structurally sound and re-pressurizing could cause further damage or personal injury. Note: 50 psi exerts a pressure of 3.5 tons per square foot. Never paint the tank interior without first consulting with our regional office.
Tank is unstable and easily moved, or piping is supporting the tank.	Tank supports are inadequate.	Provide suitable, permanent supports so the tank can't be moved and piping no longer holds the weight of the tank. While making these repairs, you may need to take the system out of service. Never try to move a pressurized tank. Contact your water system specialist.

Troubleshooting guide for storage facilities		
Problem	**Possible cause**	**Possible solution**
Loss of disinfectant residual.	Long detention time. Increase in temperature. Depletion of disinfectant from exposure to sunlight. Entry of chlorine demanding contaminants.	Cover reservoir. Reduce detention time with baffles, recirculation, inlet diffuser, mechanical mixer, pumps. Relocate inlet/outlet in tank. Size facility for more frequent turnover. Check screens on vents. Install bird wires and fences if necessary. Clean and disinfect storage facility.
Increase in heterotrophic plate count.	Loss of chlorine residual or contaminant entry.	Prevent loss of chlorine residual (see above) and re-chlorinate the storage tank. Check seals on hatches and screens on vents. Install bird wires and fences if necessary. Clean and disinfect storage facility.
Coliform bacteria occurrence.	Loss of chlorine residual. Contaminant entry. Sediment or biofilm build-up	Check seals on hatches and screens on vents. Install bird wires and fences if necessary. Clean and disinfect storage facility.
Disinfection byproducts formation.	Long detention time. Increase in pH or chlorine residual. Boosting chlorine. Organic matter contamination or algae growth.	Reduce detention time with baffles, recirculation, inlet diffuser, mechanical mixer, pumps. Relocate inlet/outlet in tank. Size facility for more frequent turnover. Look at alternative disinfectants.
Nitrification	Long detention time.	Reduce detention time with baffles, recirculation, inlet diffuser, mechanical mixer, pumps. Relocate inlet/outlet in tank. Increase turnover rate or size facility for more frequent turnover.
Sediment build-up	Excess suspended materials, lime, iron or manganese in source water. Minimal velocities allowing depositions. Contaminant entry.	Improve influent water quality. Reduce detention time with baffles, recirculation, inlet diffuser, mechanical mixer, pumps. Avoid scouring. Inspect and clean tank more frequently.
Floating material or surface film.	Build-up of iron or manganese sediments. Growth of iron or manganese forming bacteria.	Improve influent water quality. Avoid scouring. Inspect and clean tank more frequently.
Taste and odor complaints.	Long detention time. Growth of algae or other organisms. Contaminant entry. Leaching from internal coatings or new concrete tank. Source water potential for taste and odor such as high levels of hydrogen sulfides.	Cover open reservoirs. Check seals on hatches and screens on vents. Install bird wires and fences if necessary. Improve influent water quality. Chlorinate. Flush distribution system. Clean and disinfect storage tank.

Troubleshooting guide for storage facilities (Cont.)		
Problem	**Possible cause**	**Possible solution**
Growth of algae or other biological organisms.	Exposure to sunlight. Loss of chlorine residual. Long detention time. Sediment or biofilm build-up.	Cover open reservoirs. Check seals on hatches and screens on vents. Install bird wires and fences if necessary. Improve influent water quality. Flush distribution system. Clean and disinfect storage tank.
Contaminant entry.	Uncovered reservoirs or improper design of floating cover. Damaged or missing screens on vents and entry of bats, birds, rodents, or insects. Cross connection at drain or overflow.	Cover open reservoirs. Check seals on hatches and screens on vents. Install bird wires and fences if necessary. Flush distribution system. Clean and disinfect storage tank.
Increase in pH.	Long detention time in concrete storage.	Provide coating on concrete walls. Increase turnover rate. Fluctuate water levels more frequently.
Biodegradation of internal coatings.	Loss of chlorine residual allowing biological growth. Selection of wrong internal coating.	Prevent loss of chlorine residual. Chlorinate. Clean and disinfect storage tank.
Biofilm growth.	Loss of chlorine residual. Nutrients from coatings or contaminants. Corrosion of surface promoting biological and algae growth. Bacterial seeding.	Prevent loss of chlorine residual. Chlorinate. Clean and disinfect storage tank. Flush distribution system.
Color.	Decaying vegetative material. Algae growth in uncovered reservoirs. Sediment scouring. Iron or manganese.	Improve source water quality. Install treatment for iron and manganese. Increase cleaning frequency.
Red water.	Metals uptake from metal surfaces from lack of or improper cathodic protection. Iron or manganese.	Provide proper corrosion treatment. Install or calibrate cathodic protection. Use sequestering agent. Apply coatings properly.
Build-up of iron and manganese.	Iron and manganese in source water and long detention times. Oxidation and settling of iron or manganese. Improper sequestering agent dose.	Improve source water quality. Install or optimize sequestering system. Increase cleaning frequency.

Troubleshooting guide for hypochlorination problems		
Problem	**Possible cause**	**Possible solution**
Chemical feed pump won't run.	No power.	Check to see if plug is securely in place. Ensure that there is power to the outlet and control systems.
	Electrical problem with signal from well pump or flow sensor.	Check pump motor starter. Bypass flow sensor to determine if pump will operate manually. If you have a liquid level control, check the low-level cut-off switch. Repair or replace if necessary.
	Motor failure.	If the motor is cool and the power is on, you may need to repair or replace the motor. Check manufacturer's information.
	Motor overheating.	The motor is over-heated. The overload protection in the motor has opened. The motor will start again when it cools. Make sure that you have a proper voltage supply. Try to turn the motor shaft. If it does not turn, check for a binding pump mechanism.
Motor runs but diaphragm doesn't move.	The stroke adjustment may be set at zero.	Reset stroke-adjustment control knob.
	The gear train may be stripped.	Replace any defective parts.
Motor runs, diaphragm moves but doesn't pump solution.	Solution tank may be empty.	Check the solution level in the tank. If it is too low, refill the tank.
	The pump may not be primed.	If not, prime it.
	Suction line may have an air lock.	Check the suction line for air locks. If there is an air lock, remove the anti-siphon spring from the discharge valve until the air lock is removed.
	The fittings may be loose.	Remove the fittings, clean off the old tape, put on new Teflon tape, and replace FINGER tight.
	Leaks from the pump housing.	If there is solution dripping from the pump housing just behind the pump head, replace the diaphragm.

Troubleshooting guide for hypochlorination problems (Cont.)		
Problem	**Possible cause**	**Possible solution**
Motor runs, diaphragm moves but pumps no solution.	Valves and O-rings may be dirty.	Check the valves. Clean them if they are dirty. Replace damaged O-rings. Be sure to seat them well.
	Blocked discharge line.	Check the discharge line for kinks or blockages.
Abnormal noise.	Chlorinator probably damaged.	Check with your service representative. Switch operation to back up chlorinator.
Motor starts and stops.	The motor may be overheating.	If it is, a thermal protection switch may be causing the start-stop action. Check with the service representative.
Low chlorine residual at point of entry.	Improper procedure for running chlorine residual test or expired chemical reagents.	Check expiration date on chemical reagents. Check test procedure as described in test kit manual. Speed or stroke setting too low.
	Pump not feeding an adequate quantity of chlorine.	Damaged diaphragm or suction leak.
	Change in raw water quality.	Test raw water for constituents that may cause increased chlorine demand, such as iron and manganese.
	Pump air bound.	Check foot valve.
	Chlorine supply tank empty.	Fill supply tank.
	Reduced effectiveness of chlorine solution.	Check chlorine receipt date. Sodium hypochlorite solution may lose effectiveness after 30 days. If that's the case, you must increase the feed rate to obtain the desired residual.
	Damaged suction or discharge lines (cracks or crimps).	Clean or repair lines with problems.
	Connection at point of injection clogged or leaking.	Flush line and connection with mild acid such as acetic or muriatic. Replace any damaged parts that may be leaking.
Discharge line is blocked.	Speed and stroke setting inadequate.	Check manufacturer's recommendations for proper settings to prime pump.
	Suction lift too high due to feed pump relocation.	Check maximum suction lift for pump and relocate as necessary.

Troubleshooting guide for hypochlorination problems (Cont.)		
Problem	**Possible cause**	**Possible solution**
	Discharge pressure too high.	Check well pump discharge pressure. Check pressure rating on chemical feed pump.
	Suction fitting clogged.	Clean or replace screen.
	Trapped air in suction line.	Ensure all fittings are tight.
	Suction line not submerged in solution.	Add chlorine solution to supply tank.
Loss of prime.	Solution tank empty.	Fill tank.
	Air leaks in suction fittings.	Check for cracked fittings.
	Foot valve not in vertical position.	Adjust foot valve to proper position.
	Air trapped in suction tubing.	Check connections and fittings.
Excessive chlorine residual at point of entry (POE).	Pump speed or stroke setting too high.	Verify dose rate and calibrate pump to get desired dose.
	Siphoning from solution tank.	Ensure the 4-in-1 anti-siphon valve on chemical feed pump is operating properly.
	Low well pump discharge pressure.	Ensure well pump discharge pressure is at least 25 psi.
Failure to pump against pressure.	Worn seal rings.	You may need to replace worn seal rings and cartridge valves. Use spare parts kit.
	Injection pressure may exceed the pump's maximum pressure rating.	Injection pressure cannot exceed the pump's maximum pressure. See information plate on pump.
	Ruptured diaphragm.	Replace pump diaphragm.
	Incorrect stroke length setting.	Check zero on pump and re-zero pump. See manufacturer's instructions.
	Tubing run on discharge is too long.	Longer tubing runs may create friction loss sufficient to reduce the pump's pressure rating. Consult manufacturer for more information.
	Clogged foot valve strainer.	Remove foot-valve strainer when you pump slurries or when solution particles clog the strainer.

Troubleshooting guide for distribution systems		
Problem	**Possible cause**	**Possible solution**
Dirty water complaints.	Localized accumulations of debris, solids/particulates in distribution mains.	Collect and preserve samples for analysis if needed. Isolate affected part of main and flush.
	Cross connection between water system and another system carrying non-potable water.	Collect and preserve samples for analysis if needed. Conduct survey of system for cross connections. Contact our regional office.
Red water complaints.	Iron content of water from source is high. Iron precipitates in mains and accumulates.	Collect and test water samples from water source and location of complaints for iron. If high at both sites, contact our regional office, your technical assistance provider, consulting engineer or water conditioning company for help with iron removal treatment.
	Cast iron, ductile iron, or steel mains are corroding causing rust in the water.	Collect and analyze samples for iron and corrosion parameters. Contact our regional office, your technical assistance provider, consulting engineer or water conditioning company for help with corrosion control treatment.
No or low water pressure.	Source of supply, storage or pumping station interrupted.	Check source, storage and pumping stations. Correct or repair as needed.
	System cannot supply demands.	Check to see if demands are unusually high. If so, try to reduce demand. Contact our regional office, your technical assistance provider or consulting engineer.
	Service line, meter or connections shutoff or clogged with debris.	Investigate and open or unclog service.
	Broken or leaking distribution pipes.	Locate and repair break or leak.
	Valve in system closed or broken.	Check and open closed isolation and pressure-reducing valves. Repair or contact contractor if valves are broken.
Excessive water usage.	More connections added to the system.	Compare increase in usage over time with new connections added over same period. If correlation evident, take action to curtail demand or increase capacity if needed. Contact our regional office, your technical assistance provider, or consulting engineer.
	Excessive leakage (>15% of production) is occurring, meters are not installed or not registering properly.	Conduct a water audit to determine the cause. If leakage is the cause, contact our regional office, your consulting engineer or leak detection contractor.
	Illegal connections made.	Conduct survey to identify connections.

Troubleshooting guide for cross connections		
Problem	**Possible cause**	**Possible solution**
Sudsy or soapy water.	Hose connected to an unprotected hose bib with the other end in a bucket or sink of soapy water.	Equip all hose bibs with an Atmospheric Vacuum Breaker.
Positive coliform.	Hose connected to an unprotected hose bib with the other end lying on the floor of the pump house, on the ground in the car wash area, in the wading or swimming pool or other nonpotable liquid.	Equip all hose bibs with an Atmospheric Vacuum Breaker.
	Unprotected potable water line feeding a lawn irrigation system.	Install a backflow preventer on the potable water line feeding the irrigation system.
	Submerged inlet, e.g. faucet submerged.	Relocate faucet above flood level.
Color in the water (unusual colors such as bright blue).	Backflow from toilet.	Get help. Bring in someone who understands cross connections to evaluate your system.
Organic odors.	Handheld pesticide/herbicide applicator attached to unprotected hose.	Don’t use these devices.

Troubleshooting guide for sampling and monitoring		
Problem	**Possible cause**	**Possible solution**
Positive total coliform.	Improper sampling technique.	Check distribution system for low-pressure conditions, possibly due to line breaks or excessive flows that may result in a backflow problem.
	Contamination entering distribution system.	Ensure all staff receive training on sampling and transport procedures (described by lab procedures).
	Inadequate chlorine residual at the sampling site.	Check the chlorination system operation. Refer to issues described in the chapter on pumps and hypochlorination systems. Ensure sampler performs residual test properly.
	Growth of biofilm in the distribution system.	Thoroughly flush affected areas of the distribution system. Severe cases may require super-chlorination.
Chlorine taste and odor.	High total chlorine residual and low free chlorine residual.	The free chlorine residual should be at least 85% of the total chlorine residual. Increase the chlorine dose-rate to get past the breakpoint to destroy some of the combined residual that causes taste and odor problems. Additional system flushing may also be required.
Inability to maintain adequate free chlorine residual at the furthest points of the distribution system or at dead end lines.	Inadequate chlorine dose at treatment plant.	Increase chlorine feed rate at point of application.
	Problems with chlorine feed equipment.	Check operation of chlorination equipment.
	Ineffective distribution system flushing program.	Review distribution system flushing program and implement improvements to address areas of inadequate free chlorine residual.
	Growth of biofilm in the distribution system.	Increase flushing in area of biofilm problem.

Recommended operation and Maintenance schedules

Groundwater sources
Pumps and pumping facilities
Pressure tanks
Storage facilities
Chlorine disinfection treatment
Distribution systems

We recommend that you use these O&M schedules as a starting point for developing your own operation and maintenance program. The operator should document all routine operational checks and maintenance activities. Be sure to create a logbook for each major system component. The logbook should document the date and the name of the person performing each maintenance activity. Including actual dates in the maintenance schedules will help budget the time spent on maintenance activities.

Recommended O&M schedule for groundwater sources	
Daily or weekly	
❑	Check well house interior and grounds for general cleanliness and condition, and for any threats to water quality.
❑	Check any warning lights or alarms – low water level in the well, intrusion, power outage, pump failure, etc.
❑	Read source water meter. Record water-production data in well house log.
❑	Read pump run hour meters and record data in well house log (unless automatic data storage is available).
❑	Check pump-cycling rate. If it runs continuously or cycles more than 6 times per hour, see pump troubleshooting.
❑	Check well house buildings for signs of security problems – graffiti, vandalism, doors or locks damaged, entry, etc.
❑	Check wells source site after any adverse weather – high winds, heavy snow, ice, rains, etc.
Monthly	
❑	Check well water level if source capacity is marginal or there are drought conditions.
❑	Check area for excessive vegetation or dangerous conditions – uncut grass, brush, dead trees, fire hazard, etc.
❑	Check well house control valves for proper positions, open or closed. You should post this information.
❑	Check source control system – pressure switch settings, cycling, pressure tanks, storage tank water levels, etc.
❑	Check well house control valves for damage or leaks.
❑	Check for leaks – read source meter when you expect the water usage to be zero.
❑	Check source pump cycling and pressure switch settings, on/off pressures and line pressures.
Annually or seasonally	
❑	Check well site for water ponding, poor drainage areas, excessive vegetation, unhealthy trees, fire hazards, etc.
❑	Check source facilities conditions – corrosion, vent screens, vehicular or other damage, animal activity, etc.
❑	Check cold weather protection – insulation, heating system, alarm system, etc.
❑	Verify sanitary integrity of the sources – screened vents, no unprotected openings, electrical box sealed, etc.
❑	Evaluate source use designations (permanent, seasonal, emergency, or inactive). See ***Emergency drinking water sources* (331-317)**.
❑	Exercise valves and test run emergency source wells to waste. Do not supply distribution system without WQ tests.
❑	Evaluate Emergency Response Plan and update as required.
❑	Review source related customer complaints and evaluate corrective actions and planning.
❑	Implement seasonal start-up or shut-down procedures as outlined in your Seasonal Operations Plan.
❑	Review Wellhead or Watershed Protection Plans and check for new Sanitary Control Area threats.
❑	Review source water quality test results for trends, such as increasing nitrate or seasonal coliform problems.
Less than once a year	
❑	Measure source pump capacity in gallons per minute (GPM) to detect pump output problems.
❑	Evaluate general source capacity to meet water system demand. Use water use and production records.
❑	Evaluate capacity of source water to provide water of a reliable quantity and quality acceptable to customers.
❑	Consider television inspection of the well interior and the well screens.
❑	If the source capacity is marginal or drought conditions are present, develop and implement a Conservation Plan.

Recommended O&M schedule for pumps and pumping facilities	
Daily or weekly	
❑	Check motor for unusual pump motor conditions, such as: • Unusual pump noises in operation, hum, chattering, clicking, rapid knocking, etc. • Motor fails to start or to come up to speed normally. • Blackened or excessive sparking at commutator or brushes. • Fine dust under couplings with rubber butters or pins. • Smoke or charred insulation. • Excessive vibration.
❑	Check any warning lights or alarms for low pressure, pump failure, intrusion, power outage, etc.
❑	Check pump house interior and grounds for general cleanliness and condition
❑	Check pumps for leaks or seepage for pumps that are not water lubricated.
❑	Check pump cycle rate – troubleshoot excessive pump cycling (about 6 cycles per hour).
❑	Verify start and stop pressure settings and operability of water pressure gauges - reference O&M manual.
❑	Check bearing temperatures – if a temperature gauge is available. Take care when checking how hot it may be.
❑	Check pump run hours – if this information is available.
❑	Check condition of the pump house and booster pump stations for damage and deterioration.
❑	Check area around the pump house and booster station for security concerns, vandalism or unauthorized access.
Monthly	
❑	Check oil or grease lubricant reservoirs for proper levels and any leakage or unusual conditions.
❑	Measure the pump capacity, compare with the expected output – from performance records or design parameter.
❑	Perform routine operation of emergency generator (diesel, gas or propane) per manufacturer's instructions.
❑	Check condition of emergency generator batteries, fuel levels, oil levels, instruments and controls.
❑	Check that existing pressure gauges, pump run meters and flow meters are functioning properly.
❑	Check that pump controls are functioning properly – reference your operations and maintenance (O&M) manual.
❑	Check pump house lighting, ventilation, heating and animal proofing (bats, birds, rodents).
Annually or seasonally	
❑	Evaluate the working condition of all pumps and schedule maintenance, overhaul or replace.
❑	Seasonal water systems: Follow start-up and shut-down procedures. See ***Start-up and Shut-down Assistance for Seasonal Noncommunity Water Systems* (331-314).**
❑	Review your Emergency Response Plans and update as necessary. See ***Emergency Response Planning Guide for Public Drinking Water Systems* (331-211).**
❑	Review your O&M manual and update as necessary.
❑	Review the adequacy, reliability and redundancy of the current pumping facilities and plan for improvements.
❑	Review financial capacity to complete expected maintenance or replacement to existing pumping facilities.
❑	Measure source pump capacity in gallons per minute (GPM) to detect pump output problems.
❑	Evaluate the design of existing pump facilities and plan for improvements.

❑	Verify that pressure gauges are available to monitor pump capacity. See ***Water System Design Manual (*** **331-123).**

Recommended O&M schedule for pressure tanks	
Daily or weekly	
❑	Check bladder tanks for waterlogged condition – use manufacturer's procedures.
❑	Check air-to-water ratios in hydropneumatic tanks by visually checking sight tube.
❑	Check for sediments in hydropneumatic tanks by visually checking sight tube.
❑	Complete security inspection of pump house or well house and surrounding areas.
❑	Check for leaks in pressure tank lines, valves, and connections.
❑	Check water line pressures using pressure gauges installed in the pump house.
❑	Check condition of exterior surface of pressure tanks, note corrosion or damage.
❑	Calculate the number of pump cycles per hour.
❑	Check the functioning of any air compressors used to maintain water levels in pressure tank.
Monthly	
❑	Maintain air compressors on hydropneumatic tanks.
❑	Verify control systems and alarms are functioning properly and settings are proper.
❑	Check ASME pressure relief valve function.
Annually	
❑	Check pressure tank supports for anchor, structural condition, and seismic integrity.
❑	Check pressure tanks for rust, corrosion, and damage.

Recommended O&M schedule for storage facilities	
Daily or weekly	
❑	Check any warning lights or alarms – low water level, high water level, intrusion, power outage, and so on.
❑	Check storage tank for signs of security breaches – damaged fences, open gates, graffiti, vandalism, etc.
❑	Check water level indicator – functioning, adequate amount of stored water, excessive water use.
❑	Check the overflow line, vents, ladder access locks, roof access hatches, and controls that are readily visible from the ground for damage, vandalism, or other conditions.
❑	Check storage tank and site after any adverse weather – high winds, heavy snow, ice, rains, etc.
Monthly	
❑	Check water level indicator.
❑	Verify all openings are protected from surface runoff, windblown contaminants, insects, birds and animals.
❑	Check tank overflow lines for signs of damage, such as, screens, flapper valves, check valves, splash plate , etc.
❑	Check area for excessive vegetation or dangerous conditions – uncut grass, brush, dead trees, fire hazard, etc.
❑	Check control valves for proper positions, open or closed.
❑	Check control valves for damage or leaks.
❑	Check low water temperature alarm – cold weather only.
❑	Check high water temperature limit switch – when heating system in service.
Quarterly	
❑	Check water level indicator.
❑	Visually inspect tank exterior and roof for signs of damage, corrosion, degradation, leakage, or structural problems, with particular focus on all openings into the reservoir (reservoir roof and sidewall vents, access hatch, overflow outlet, and so on).
❑	Check tank-supporting structure for signs of damage, corrosion, degradation, structural or seismic inadequacy.
❑	Check tank foundation for signs of damage, corrosion, degradation, structural inadequacy.
❑	Tank catwalks/ladders free from signs of damage, corrosion, degradation, structural condition, vandalism, etc.
❑	Tank area for water ponding, poor drainage areas, excessive vegetation, unhealthy tress, fire hazards, etc.
❑	Tank area free from combustible storage, trash, debris, brush, or other material that could present a fire hazard.
❑	Tank area free of accumulation of material on or near parts possibly resulting in accelerated corrosion or rot.
❑	Tank and support free of ice buildup.
❑	Check earth embankments for erosion, burrowing animals, improper drainage and leakage.
Annually or seasonally	
❑	Check storage tank structural, seismic and sanitary integrity – leaks, corrosion, cracks, supports, warping, etc.
❑	Inspect storage tank interior for pitting, concrete spalling, rot, corrosion, rust, water level sensors, biofilm build-up etc.
❑	Exercise valves and make repairs as needed.
❑	Document inspection and maintenance activity as part of an O&M program.
❑	Inventory and evaluate storage facilities capacity, condition, replacement costs and plan for improvements.
❑	Evaluate stored water for clarity, sediments, floating materials or films, unusual odors, insects, birds or animals.
❑	Plan for storage facility improvements and budget for the associated cost.

Recommended O&M schedule for storage facilities (Cont.)	
Three to five year inspections	
❑	Tank indicator inspected – every three years for steel storage tanks without corrosion protection.
❑	Tank indicator inspected – every five years for storage tanks other than steel without corrosion protection.
❑	Drain, inspect, clean and disinfect storage tank or use a diving maintenance service without draining tank.
❑	Respond to any evidence of storage tank problems – see storage tank troubleshooting guide.

Recommended O&M schedule for chlorine disinfection treatment	
Daily	
❑	Check for any security issues at the treatment plant and surrounding area - fences, gates, doors, locks, any evidence of tampering or vandalism.
❑	Check solution level in the tank: Refill if necessary and be sure to replace the cover. We recommend posting procedure to mix chlorine solution in the treatment building. The solution tank should be visibly marked to make measuring the number of gallons remaining easy and accurate.
❑	Verify that the supply of sodium hypochlorite is adequate for normal operation – 30 to 60 days.
❑	Check for leaks or excessive chlorine smell. Locate and repair any leaks and improve ventilation, if needed.
❑	Check pump for unusual vibrations or warmth, indicating worn or damaged bearings or gears. Take care; it may be hot!
❑	Test the free chlorine residual in the distribution system using an EPA approved test kit. Evaluate and log results into a monthly chlorination residual report form. Are free chlorine levels consistent?
❑	Adjust the pump feed-rate control as needed. Adjust the controls only when the pump is running and never force the controls. Typically, the feed-rate control should be in the middle of its range. This makes it possible to adjust the dosage easily. If adjustments to controls no longer meet chlorine demand, you may have to adjust your solution strength, or possibly get a different size hypochlorinator.
❑	Record results of all tests, chemical use, water production, and maintenance in a daily logbook.
❑	Check records of logbooks for unusual data, trends and other indicators or possible problems.
❑	Keep copy of chlorination treatment system O&M manual in treatment building.
Quarterly	
❑	Calibrate chemical feed pump to verify the performance of the pump output – follow manufacturer's instructions.
❑	Wash and clean the chlorine solution tank if there is any sediment build-up. Clean the chlorinator, lines and foot valve as needed - follow manufacturer's instructions.
Annually or seasonally	
❑	Clean the chlorinator and replace the O-rings, valves and worn or damaged parts – use the spare parts kit to make repairs and follow manufacturer's instructions. You should have a back-up chemical feed pump to provide continuous disinfection.

Recommended O&M schedule for distribution systems	
Daily	
❑	Check any warning lights or annunciators – low water level, high water level, power outage, pump failure, etc.
❑	Investigate any customer complaints related to distribution system – low pressure, water quality problems, taste and odor, etc.
❑	Check free chlorine residuals in distribution system (if chlorinating) – evaluate high and low levels.
❑	Measure and record water production to monitor water demands and calculate leakage.
❑	Check and log distribution system conditions – storage tank water levels, leaks, vandalism, etc.
Monthly	
❑	Check service pressures throughout distribution systems – investigate the cause of any low pressures.
❑	Read service meters for billing, determining water demand, detecting leaks, monitoring conservation, etc.
❑	Collect routine bacteriological samples and test for total coliform – follow up on unsatisfactory sample results. See ***Coliform Public Health Advisory Packet* (331-260).**
❑	Conduct distribution system maintenance and keep records of all repairs and changes.
Quarterly	
❑	Flush the distribution system as necessary based on the potential for sediments such as iron and manganese.
❑	Initiate leak detection as necessary – low pressure complaints, wet or green spots, unaccounted-for-water, etc.
Annually or seasonally	
❑	Evaluate condition of the distribution system, including pressure, and flow capacity.
❑	Exercise distribution system valves – record inspections and repairs in logbook.
❑	Do a water audit and calculate unaccounted-for-water by comparing water production and usage – goal of < 10%.
❑	Prepare system for seasonal start up and shut down. See your O&M manual or ***Start-up and Shut-down Assistance for Seasonal Noncommunity Water Systems* (331-314).**
❑	Conduct a preventive maintenance program on service meters – calibration, replacement, etc.
❑	Evaluate safety programs and equipment – traffic safety, trench safety, confined space, ladder safety, etc. State Labor and Industries or private safety consultants can help here.
❑	Evaluate Emergency Response Plan – loss of water pressure, contamination, cross connections, overfeeds, etc.
❑	Update system map of the distribution system – lines (size, material, age), valves, meters, hydrants, etc.
❑	Evaluate capacity to conduct flushing as needed – training, equipment, availability of hydrants or blowoffs.
❑	Have backflow prevention assemblies tested by certified backflow assembly tester (BAT) – record results and take corrective maintenance as needed.
❑	Determine daily and monthly peak water-demand periods.
❑	Conduct Cross-Connection Control Program activities according to your program plans.
Less than once a year	
❑	Perform flow tests on all fire hydrants at least once every three years – with local fire departments.
❑	Develop an Asset Management Plan to ensure financial capacity to serve safe and reliable water. See EPA's ***Asset management: A handbook for small water systems* (816-R-03-016)** for guidance.
❑	Develop a Strategic Plan to guide you in planning for important capital improvements, priorities, and resources. See EPA's ***Strategic Planning: A handbook for small water systems* (816-R-03-015)** or ***Drinking Water Security for Small Systems Serving 3,300 or Fewer Persons* (817-R-05-001)** for guidance.

Template: Create your own preventive maintenance program

Table of responsibilities

Daily responsibilities			
Task	Primary	Secondary	SOP Reference

Primary means the name of the individual primarily responsible for completing this task

Secondary means the name of the individual who will perform this task if the primary individual is unavailable

SOP Reference means reference section to your standard operating procedure manual for your utility

Weekly responsibilities			
Task	Primary	Secondary	SOP Reference

Primary means the name of the individual primarily responsible for completing this task

Secondary means the name of the individual who will perform this task if the primary individual is unavailable

SOP Reference means reference section to your standard operating procedure manual for your utility

Monthly responsibilities			
Task	Primary	Secondary	SOP Reference

Primary means the name of the individual primarily responsible for completing this task

Secondary means the name of the individual who will perform this task if the primary individual is unavailable

SOP Reference means reference section to your standard operating procedure manual for your utility

Quarterly responsibilities			
Task	Primary	Secondary	SOP Reference

Primary means the name of the individual primarily responsible for completing this task

Secondary means the name of the individual who will perform this task if the primary individual is unavailable

SOP Reference means reference section to your standard operating procedure manual for your utility

Biannual responsibilities			
Task	Primary	Secondary	SOP Reference

Primary means the name of the individual primarily responsible for completing this task

Secondary means the name of the individual who will perform this task if the primary individual is unavailable

SOP Reference means reference section to your standard operating procedure manual for your utility

Annual responsibilities			
Task	Primary	Secondary	SOP Reference

Primary means the name of the individual primarily responsible for completing this task

Secondary means the name of the individual who will perform this task if the primary individual is unavailable

SOP Reference means reference section to your standard operating procedure manual for your utility

As-needed responsibilities			
Task	Primary	Secondary	SOP Reference

Primary means the name of the individual primarily responsible for completing this task

Secondary means the name of the individual who will perform this task if the primary individual is unavailable

SOP Reference means reference section to your standard operating procedure manual for your utility