

Maintenance Management Process

For

South Tallcree First Nation

# Treatment Plant Systems

## Raw Water Intake System

The function of the raw water intake is to aerate water from Lake Isle and pump it to the clarifier in the water treatment plant.

### System Components

#### Air Compressors

**Function:** To provide air for the aeration halo.

**Functional Failure:** Does not provide air for the aeration halo.

**Failure Consequence:** Pre aeration of the raw water will not exist. Iron and organic matter removal will be impaired.

**Failure Cause:** Compressor is worn out.

**Failure Cause:** Motor or compressor is seized.

**Failure Cause:** Electrical interruption to the compressor motor.

**Failure Detection:** Check for bubbles on the surface of the raw water holding ponds.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Check the compressor status immediately if no bubbles are visible.

**Failure Detection:** Check the compressor outlet air pressure and compare with historical values.

**Failure Detection Test Frequency:** Weekly during operator rounds.

**Required Action:** Troubleshoot the cause of the failure. Arrange repair trade resources and parts as soon as possible.

**Failure Detection:** Switch other compressor to the service position. Ensure spare compressor starts.

**Failure Detection Test Frequency:** Weekly.

**Required Action:** Troubleshoot the cause of the failure. Arrange repair trade resources and parts as soon as possible.

### **Raw Water Pumps**

**Function:** To provide potable water flow and pressure to the distribution.

**Functional Failure:** Does not provide potable water flow and pressure to the distribution.

**Failure Consequence:** Pressure and flow to the distribution system will be inadequate. Service to the community will essentially be suspended.

**Failure Cause:** Electrical interruption to the pump motor.

**Failure Detection:** Check pressure and flow against previously recorded values. Check that the pump is running and observe the noise level and temperature against normal experience.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Troubleshoot the cause of pump malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Cause:** Motor bearings are seized.

**Failure Detection:** Switch spare pump into service and place service pump to spare.

**Failure Detection Test Frequency:** Weekly

**Required Action:** Troubleshoot the cause of the pump failure. Arrange resources and parts as soon as possible.

**Failure Cause:** Pump is worn out.

**Failure Detection:** Check pressure and flow against historical values from the past year and against the pump curves provided by the manufacturer.

**Failure Detection Test Frequency:** Annually.

**Required Action:** Troubleshoot the cause of pump malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### Clarifier System

The function of the clarifier is to allow mixing of treatment chemicals, allow time and flow characteristics to permit suspended solids removal in the tube settler area and to provide filtration of the water to control turbidity and free chlorine within prescribed limits.

#### System Components

##### **Slow Mixers (x3)**

**Function:** Slow speed agitation of first, second and third flocculation cells.

**Functional Failure:** Inadequate agitation.

**Failure Consequence:** Poor clarifier operation. Turbidity will be high. Filter runs between backwashes will be short.

**Failure Cause:** Motor does not run due to electrical fault.

**Failure Cause:** Motor does not run due to seized bearings.

**Failure Cause:** Mixer paddle is damaged or unattached.

**Failure Detection:** Visually check slow mixers.

**Failure Detection Test Frequency:** Daily during production run.

**Required Action:** Perform immediate repairs. Clarifier function will be compromised. No redundant equipment exists.

## Cell Drain Valves

**Function:** Allows controlled draining of any of the three cells.

**Functional Failure:** Fails to contain or fails to drain cell as desired.

**Failure Consequence:** The other drain valves will need to perform this function. Loss of redundancy will result.

**Failure Cause:** Valve shaft breaks.

**Failure Cause:** Foreign matter blocks valve port.

**Failure Detection:** Observe valve operation when opening and closing. The valve should have a noticeable resistance to movement. The operator should be able to hear water start to flow through the valve. Compare the operating characteristics to the similar valves in the adjacent cells.

**Failure Detection Test Frequency:** Whenever the clarifier is being drained for maintenance.

**Required Action:** Ensure that a replacement valve is ordered and in stock. On the next opportunity that the clarifier is completely drained, remove the drain header and replace the defective valve or clear the valve port as needed. If one valve is being replaced, it may be prudent to replace all of the valves attached to the header. There are three valves in total.

## Chemical Injection Systems

The function of the chemical injection systems is to introduce a measured volume of specific chemicals to the process flow streams.

### System Components

#### Bleach Injection Pump

**Function:** To inject bleach into the potable water prior to the distribution reservoir in measured rates of flow.

**Functional Failure:** Does not inject bleach into the potable water prior to the distribution reservoir in measured rates of flow.

**Failure consequence:** Free chlorine will not be present in adequate amounts to ensure potable water for distribution to the community.

**Failure Cause:** Injection pump check valves are stuck open.

**Failure Cause:** Injection pump diaphragm is damaged.

**Failure Cause:** The bleach tank is empty.

**Failure Detection:** Check the daily free chlorine test results. Check and record the level indication of the bleach tank to ensure that the level has dropped since the last production run records. Look at the level of bleach visible on the tank to ensure it has enough chemical in it.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Correct the failure cause immediately. It may be necessary to rebuild or replace the pump.

**Failure Cause:** Electrical supply to the pump is failed.

**Failure Detection:** Inspect power cord.

**Failure Detection Test Frequency:** Annually

**Required Action:** Repair or replace the cord.

## **Bleach Tank**

**Function:** To contain activated bleach prior to injection.

**Functional Failure:** Fails to contain bleach prior to injection.

**Failure Consequence:** Increased operating cost due to chemical loss, possible environmental issue, failure of bleach injection system.

**Failure Cause:** Mechanical damage.

**Failure Detection:** Visually inspect tank. Watch for spillage.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Assess leakage cause. If product is still leaking, attempt to salvage remaining product. Repair or replace the tank at the first opportunity.

### **Bleach Mixer**

**Function:** To mix bleach and water and maintain good mixing.

**Functional Failure:** Fails to mix bleach and water or to maintain a good mixture.

**Failure consequence:** Poor mixing will cause problems with consistent bleach feed. Free chlorine values may fluctuate.

**Failure Cause:** Motor does not run due to electrical fault.

**Failure Cause:** Motor does not run due to seized bearings.

**Failure Cause:** Propeller is damaged or unattached.

**Failure Detection:** Look in on tank contents and ensure the mixer is running.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Assess the appropriate cause of the failure. Repair as soon as possible.

### **Polymer Injection Pump**

**Function:** To inject polymer into the flocculation cells in measured rates of flow.

**Functional Failure:** Does not inject polymer into the flocculation cells in measured rates of flow.

**Failure consequence:** The floc formed in the clarifier will not have sufficient density to allow the clarifier to operate to maximum performance. Turbidity will increase. Filter run times between back washes will be reduced.

**Failure Cause:** Injection pump check valves are stuck open.

**Failure Cause:** Injection pump diaphragm is damaged.

**Failure Cause:** Polymer tank is empty.

**Failure Detection:** Check the daily turbidity measurements.

Check and record the level indication of the polymer tank to ensure that the level has dropped since the last production run records. Look at the level of polymer visible on the tank to ensure the ultrasonic reading is correctly.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Correct the failure cause at the first opportunity. It may be necessary to rebuild or replace the pump.

**Failure Cause:** Electrical supply to the pump is failed.

**Failure Detection:** Inspect power cord.

**Failure Detection Test Frequency:** Annually

**Required Action:** Repair or replace the cord.

## **Polymer Tank**

**Function:** To contain polymer prior to injection.

**Functional Failure:** Fails to contain polymer prior to injection.

**Failure Consequence:** Increased operating cost, possible environmental issue.

**Failure Cause:** Mechanical damage.

**Failure Detection:** Visually inspect tank. Watch for spillage.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Assess leakage cause. If product is still leaking, attempt to salvage remaining product. Repair or replace the tank at the first opportunity.

## **Polymer Mixer**

**Function:** To mix polymer and water and maintain good mixing.

**Functional Failure:** Fails to mix polymer and water or to maintain a good mixture.

**Failure consequence:** Poor mixing will cause problems with reliable polymer feed. Clarifier function will not be optimal. Run times between filter backwashes will be shortened.

**Failure Cause:** Motor does not run due to electrical fault.

**Failure Cause:** Motor does not run due to seized bearings.

**Failure Cause:** Propeller is damaged or unattached.

**Failure Detection:** Look in on tank contents and ensure the mixer is running.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Assess the appropriate cause of the failure. Repair as soon as possible.

### **Soda Ash Injection Pump**

**Function:** To inject soda ash into the flocculation cells in measured rates of flow.

**Functional Failure:** Does not inject soda ash into the flocculation cells in measured rates of flow.

**Failure consequence:** pH will not be controlled.

**Failure Cause:** Injection pump check valves are stuck open.

**Failure Cause:** Injection pump diaphragm is damaged.

**Failure Cause:** Soda ash tank is empty.

**Failure Detection:** Take pH measurements and compare with historical results. Check and record the level indication of the soda ash tank to ensure that the level has dropped since the last production run records. Look at the level of soda ash solution visible on the tank.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Correct the failure cause at the first opportunity. It may be necessary to rebuild or replace the pump.

**Failure Cause:** Electrical supply to the pump is failed.

**Failure Detection:** Inspect power cord.

**Failure Detection Test Frequency:** Annually

**Required Action:** Repair or replace the cord.

### **Soda Ash Tank**

**Function:** To contain soda ash solution prior to injection.

**Functional Failure:** Fails to contain soda ash solution prior to injection.

**Failure Consequence:** Increased operating cost due to chemical loss, possible environmental issue.

**Failure Cause:** Mechanical damage.

**Failure Detection:** Visually inspect tank. Watch for spillage.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Assess leakage cause. If product is still leaking, attempt to salvage remaining product. Repair or replace the tank at the first opportunity.

### **Soda Ash Mixer**

**Function:** To mix soda ash and water.

**Functional Failure:** Fails to mix soda ash and water.

**Failure consequence:** Poor mixing will cause problems with reliable soda ash feed. pH control will be poor.

**Failure Cause:** Motor does not run due to electrical fault.

**Failure Cause:** Motor does not run due to seized bearings.

**Failure Cause:** Propeller is damaged or unattached.

**Failure Detection:** Look in on tank contents and ensure the mixer is running.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Assess the appropriate cause of the failure. Repair as soon as possible.

### **Potassium Permanganate Injection Pump**

**Function:** To inject potassium permanganate into the flocculation cell in measured rates of flow.

**Functional Failure:** Does not inject potassium permanganate into the flocculation cell in measured rates of flow.

**Failure consequence:** Iron and manganese removal will be reduced.

**Failure Cause:** Injection pump check valves are stuck open.

**Failure Cause:** Injection pump diaphragm is damaged.

**Failure Cause:** Clearpac tank is empty.

**Failure Detection:** Check the iron and manganese levels. Check and record the level of the potassium permanganate tank to ensure that the level has dropped since the last production run records. Look at the level of potassium permanganate visible on the tank.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Correct the failure cause immediately. It may be necessary to rebuild or replace the pump.

**Failure Cause:** Electrical supply to the pump is failed.

**Failure Detection:** Inspect power cord.

**Failure Detection Test Frequency:** Annually

**Required Action:** Repair or replace the cord.

### **Potassium Permanganate Tank**

**Function:** To contain potassium permanganate prior to injection.

**Functional Failure:** Fails to contain potassium permanganate prior to injection.

**Failure Consequence:** Increased operating cost because of chemical loss, possible environmental issue.

**Failure Cause:** Mechanical damage.

**Failure Detection:** Visually inspect tank. Watch for spillage.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Assess leakage cause. If product is still leaking, attempt to salvage remaining product. Repair or replace the tank at the first opportunity.

### **Liquid Alum Injection Pump**

**Function:** To inject liquid alum into the flocculation cell in measured rates of flow.

**Functional Failure:** Does not inject liquid alum into the flocculation cell in measured rates of flow.

**Failure consequence:** The floc formation in the clarifier will be poor. Turbidity will increase.

**Failure Cause:** Injection pump check valves are stuck open.

**Failure Cause:** Injection pump diaphragm is damaged.

**Failure Cause:** Liquid alum barrel is empty.

**Failure Detection:** Check the daily turbidity results. Check and record the level of the liquid alum barrel to ensure that the level has dropped since the last production run records.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required action:** Correct the failure cause immediately. It may be necessary to rebuild or replace the pump.

**Failure Cause:** Electrical supply to the pump is failed.

**Failure Detection:** Inspect power cord.

**Failure Detection Test Frequency:** Annually

**Required Action:** Repair or replace the cord.

### **Filter System**

The function of the system is to remove the suspended solids that have not been removed by the clarification process.

### **System Components**

#### **Filter media**

**Function:** To remove residual suspended solids that remains from the clarifier before the water flows into the distribution reservoir at or above minimum specified flow rate.

**Functional Failure:** The filter does not remove residual suspended solids that remain from the clarifier before the water goes into the distribution reservoir.

**Failure Consequence:** Turbidity will be too high.

**Failure Cause:** Insufficient filter media.

**Failure Cause:** Media bed has channelled.

**Failure Cause:** Insufficient rinse flow following a backwash.

**Failure Cause:** Excessive suspended solid content entering the filter.

**Failure Detection:** Review the daily turbidity readings and the flow rate through the filters.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Backwash the filter and observe the results. Check the quality of water going into and out of the clarifier. Ensure the filter rinses after the backwash. If evidence shows the need to replace the media, ensure that it is ordered as soon

as possible. Media replacement may need to be scheduled between several trades and services.

**Functional Failure:** The filter does not put water into the distribution reservoir at or above the minimum specified flow rate.

**Failure Consequence:** Flows will be reduced. Community water demand may exceed production capability.

**Failure Cause:** The filter media is fouled.

**Failure Cause:** A rinse valve is stuck in a partially or fully open position.

**Failure Detection:** Observe and record raw water flow, potable water flow and distribution reservoir level. Compare the values to historical values.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Backwash the filter, if filter production flows remain low, check for stuck filter rinse valves. If the media bed is permanently fouled, it will be necessary to replace the media. If evidence shows the need to replace the media, ensure that it is ordered as soon as possible. Media replacement may need to be scheduled between several trades and services.

### **Clarifier Inlet Valve**

**Function:** To regulate clarifier inlet flow in order to maintain proper water level in the filters.

**Functional Failure:** Does not regulate clarifier inlet flow in order to maintain proper water level in the filters.

**Failure Consequence:** Improper water level will reduce filter effectiveness.

**Failure Cause:** Valve is worn out.

**Failure Detection Test:** Check the water level in the filter; compare with historic levels.

**Failure Detection Test Frequency:** Daily

**Required Action:** Troubleshoot the cause of the failure. Arrange for parts and trades resources as soon as possible.

## **Backwash System**

The function of the backwash system is to remove trapped suspended solids from the filter media and to rinse the filters in preparation for going back in service.

### **System Components**

#### **Backwash Inlet Valves**

**Function:** To allow backwash water to flow at a set flow rate during a backwash event.

**Functional Failure:** Does not allow backwash water to flow at a set flow rate during a backwash event.

**Failure Consequence:** Water flow will be insufficient to properly clean the filter media during the backwash event.

**Failure Cause:** Damaged valve actuator.

**Failure Cause:** Damaged valve.

**Failure Detection:** Check backwash flow rates against historical values; compare them with historical values, if significant deviation from historical values exists, carry on with the following checks. Check if the valve position indicator moves when the valve opens. Check if backwash pump is running.

**Failure Detection Test Frequency:** During each backwash event.

**Required Action:** Troubleshoot the cause of backwash valve malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

#### **Rinse Waste Valves**

**Function:** To allow rinse water to flow at a set flow rate during a rinse event. To isolate rinse water flow any time that a rinse event is not taking place.

**Functional Failure:** Does not allow rinse water to flow at a set flow rate during a rinse event. Does not isolate rinse water flow any time that a rinse event is not taking place.

**Failure Consequence:** Insufficient rinse flow will not allow for an effective rinse to take place after a backwash; turbidity will be elevated. Failure to isolate rinse water flow when a rinse event is not in progress will result in reduced production flow.

**Failure Cause:** Damaged actuator.

**Failure Cause:** Damaged valve.

**Failure Cause:** Damaged valve.

**Failure Cause:** Valve actuator stuck open.

**Failure Detection:** Check rinse flow rates against historical values, if significant deviation from historical values exists, carry on with the following checks. Check if the valve position indicator moves when the valve opens.

**Failure Detection Test Frequency:** During each rinse event.

**Required Action:** Troubleshoot the cause of rinse valve malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### **Filter Outlet Valve**

**Function:** To stop filter outlet flow to the distribution cistern during filter backwash and rinse events.

**Functional failure:** Does not stop filter outlet flow to the distribution cistern during filter backwash and rinse events.

**Failure Consequence:** Backwash events will be ineffective. Potable water turbidity will be high immediately after a rinse.

**Failure Cause:** Filter outlet valve is worn or damaged and will not control flow.

**Failure Detection:** Observe production run durations in relation to clarifier turbidity values. Short production runs could indicate a passing valve.

**Failure Detection:** Observe potable water turbidity after rinse events. Short term high levels could indicate a passing valve.

**Failure Detection Test Frequency:** During backwash and rinse events.

**Required Action:** Troubleshoot the cause of filter outlet valve malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

## **Solenoid Valves**

**Function:** To supply instrument air to backwash, rinse and production valves.

**Functional Failure:** Does not supply instrument air to backwash, rinse and production valves.

**Failure Consequence:** Any or all of production, backwash and rinse events will be unsuccessful.

**Failure Cause:** Instrument air pressure is too low.

**Failure Cause:** Solenoid coil has failed.

**Failure Cause:** Electrical signal to the solenoid has failed.

**Failure Detection:** Observe the valve actuators during any event. Actuator position indicators should all be normal. The solenoid coil may be noticeably warm when the solenoid has been energized for a few minutes. The solenoid coil may also have a slight vibration while it is energized. Ensure the instrument air pressure is sufficient.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Troubleshoot the cause of solenoid malfunction immediately. Correct the problem immediately if possible. Check instrument air drier and filter function; service drier and filters if necessary. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

## **Treated Water Reservoir System**

The function of the treated water reservoir system is used to store potable quality water for distribution and to exclude foreign matter that may jeopardize the water quality.

### **System Components**

#### **Intercell Tie Valves**

**Function:** To isolate reservoir cells from one another.

**Functional Failure:** Does not isolate reservoir cells from one another.

**Failure Consequence:** Reservoir cells cannot be isolated for maintenance.

**Failure Cause:** Valve is seized.

**Failure Detection:** Stroke each valve fully in each direction.

**Failure Detection Test Frequency:** Semi annually.

**Required Action:** Arrange for repair parts to be ordered. Coordination of trade resources will have to be coordinated. The entire reservoir system may need to be emptied for repairs to be made.

### **Intercell Tie Valve Actuator Rods**

**Function:** To allow intercell tie valves to be stroked without having to enter the reservoir.

**Functional Failure:** Does not allow intercell tie valves to be stroked without having to enter the reservoir.

**Failure Consequence:** Reservoir cells cannot be isolated for maintenance.

**Failure Cause:** Mechanical damage.

**Failure Detection:** Stroke the valves fully in each direction.

**Failure Detection Test Frequency:** Semi annually.

**Required Action:** Arrange for repair parts to be ordered. Coordination of trade resources will have to be coordinated. The entire reservoir system may need to be emptied for repairs to be made.

## **Distribution System**

The function of the distribution pump system is to provide pressurized potable water to the distribution piping for use during periods of normal water consumption.

### **System Components**

#### **Distribution Pump**

**Function:** To provide potable water flow and pressure to the distribution. To provide backwash water to the filters.

**Functional Failure:** Does not provide potable water flow and pressure to the distribution. Does not provide backwash water to the filters.

**Failure Consequence:** A redundant pump exists. Pressure and flow will continue to the community but redundancy will be lost.

**Failure Cause:** Electrical interruption to the pump motor.

**Failure Detection:** Check pressure and flow against previously recorded values. Check that the pump is running and observe the noise level and temperature against normal experience.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Troubleshoot the cause of pump malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Cause:** Motor bearings are seized.

**Failure Detection:** Switch spare pump into service and place service pump to spare.

**Failure Detection Test Frequency:** Weekly

**Required Action:** Troubleshoot the cause of the pump failure. Arrange resources and parts as soon as possible.

**Failure Cause:** Pump impeller clearance is excessive.

**Failure Cause:** Pump is worn out.

**Failure Detection:** Check pressure and flow against historical values from the past year and against the pump curves provided by the manufacturer.

**Failure Detection Test Frequency:** Annually.

**Required Action:** Troubleshoot the cause of pump malfunction immediately, remember that impeller clearance issues will probably only exist after pump rebuild or replacement. Correct the problem immediately if possible. If parts or additional

resources are required, arrange for parts order and resource coordination at the first possible time.

### **Distribution/Backwash Pump Cross Tie Valve**

**Function:** To allow the backwash pump to provide pressure and flow of potable water to the distribution system.

**Functional Failure:** Does not allow the backwash pump to provide pressure and flow of potable water to the distribution system.

**Failure Consequence:** The backwash pump will not be able to provide water to the distribution system. This is a hidden failure as this valve is not normally open.

**Failure Cause:** Valve is seized in the closed position.

**Failure Detection:** Open and close the tie valve.

**Failure Detection Test Frequency:** Semi annually.

**Required Action:** Troubleshoot the cause of valve malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### **Pressure Control/Relief Valve**

**Function:** To maintain distribution system pressure at a preset maximum level.

**Functional Failure:** Does not maintain distribution system pressure at a preset maximum level.

**Failure Consequence:** System pressure may be too high or too low. High pressure can endanger the distribution piping. Low pressure can equate to loss of service to the community.

**Failure Cause:** The pressure control/relief valve needs to be rebuilt or replaced.

**Failure Detection:** Observe pressure and flow; compare them with historical values. Observe pressure control/relief valve for unusual characteristics such as chattering, leakage etc.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Troubleshoot the cause of valve malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### **Isolation Valves**

**Function:** To isolate selected pieces of equipment from the distribution system.

**Functional Failure:** Does not isolate selected pieces of equipment from the distribution system.

**Failure Consequence:** Failure to isolate will create a need for greater scope of isolation in order to perform maintenance on a given piece of equipment.

**Failure Cause:** Valve fails to seal tightly.

**Failure Detection:** Open a telltale system, such as a gage isolator with the gage removed, to ensure that the equipment being worked on is isolated from system pressure.

**Failure Detection Test Frequency:** During maintenance activities on equipment that needs isolation to be worked on safely.

**Required Action:** Do not work on equipment that is influenced by system pressure. If repeated attempts at isolation do not result in effective isolation, the work must be postponed until safe, or the system must be de-energized via other means such as locking out all of the pumps on the distribution system. A valve that will not isolate must be rebuilt or replaced. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Cause:** Valve is seized in any position.

**Failure Detection:** Fully open and close valves to ensure full range of travel.

**Failure Detection Test Frequency:** Semi-annually

**Required Action:** Alternately attempt to close and open the valve in an attempt to free it up. Sometimes applying lubricant such as penetrating oil can assist in freeing the valve up. If the valve will not free up, arrange for parts order and resource coordination at the first possible time.

## **Check Valves**

**Function:** To prevent reverse flow in a system. Note; check valves are not to be considered to be effective isolation for maintenance efforts.

**Functional Failure:** Does not prevent reverse flow in a system.

**Failure Consequence:** Pressure in the system will be reduced due to flow losses through the check valve.

**Failure Cause:** A foreign object such as a piece of scale can cause a slight hang up of the check valve internal components.

**Failure Cause:** Wear and tear or corrosion of internal components can cause the check valve to fail.

**Failure Detection:** Check for excessive flow indications or reduced pressure in the distribution system. It may be possible to hear leakage past a failed check valve. A mechanics stethoscope may assist in hearing leakage.

**Failure Detection Test Frequency:** Semi annually.

**Required Action:** If a check valve is suspected of serious leakage, it should be replaced as soon as possible. Ensure that all necessary replacement parts are on hand prior to starting work.

## **Fire Pump System**

The function of the fire pump system is to provide pressurized potable water to the distribution system during times of abnormally high volume of water consumption. This would typically be during a fire event or when the distribution system is being flushed.

### **System Components**

#### **Diesel Engine**

**Function:** To drive the fire pump so that sufficient water will be provided for fire fighting.

**Functional Failure:** Does not drive the fire pump so that sufficient water will be provided for fire fighting.

**Failure Consequence:** Insufficient water flow and pressure will be available to provide for distribution system flushing and firefighting efforts.

**Failure Cause:** Engine will not start (turn over)

**Failure Cause:** Engine will not start (fuel supply)

**Failure Cause:** Engine does not provide sufficient power to provide flow and pressure needed.

**Failure Detection:** Start engine and observe its operation. Pay attention to oil pressure and coolant temperature; compare these with historical values. When performing distribution system flushing, observe system pressure and flow rate; observe engine rpm and governor position (is the governor wide open or does it still have some room to move).

**Failure Detection Test Frequency:** Perform engine test start weekly. Check fuel tank volume as a part of this test, maintain a minimum tank level of ½ full. Perform distribution system flushing annually.

**Required Action:** Troubleshoot the cause of engine functional failure immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Cause:** Engine is seized.

**Failure Detection:** Change lubricant

**Failure Detection Test Frequency:** Annually

**Required Action:** Change oil, oil filters and fuel filters. After servicing is completed, test run the unit and observe oil pressure and operating characteristics.

## **Drive Line**

**Function:** To smoothly transmit torque from the engine to the gearbox.

**Functional Failure:** Does not smoothly transmit torque from the engine to the gearbox.

**Failure Consequence:** Rough operation of the drive line is a symptom of possible imminent catastrophic failure. Failure of this nature will render the fire pump unavailable for service.

**Failure Cause:** Universal joint failure.

**Failure Detection:** Listen for a “clunking” noise in the drive line, especially during sudden deceleration.

**Failure Detection Test Frequency:** At the instant that the fire pump engine is shut off during any test or operation of the pump.

**Failure Detection:** Lock out the fire pump to ensure it will not operate. Grasp the drive line at the universal joints and shake the shaft to apply stress to the universal joint yoke, first in one radial plane, and then ninety degrees from the first direction. Observe if there is looseness or noise.

**Failure Detection Test Frequency:** Any time the above described test indicates there may be a drive line failure. Also perform this test whenever fire pump annual servicing is being done.

**Required Action:** Troubleshoot the cause of drive line failure immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### **Angle Gear Box**

**Function:** To smoothly and quietly transmit torque from the driveline to the pump shaft.

**Functional Failure:** Does not smoothly and quietly transmit torque from the driveline to the pump shaft.

**Failure Consequence:** Noisy and rough gearbox operation is a symptom of possible imminent catastrophic failure. Failure of this nature will render the fire pump unavailable for service.

**Failure Cause:** Insufficient lubrication.

**Failure Cause:** Bearing failure.

**Failure Cause:** Gear failure.

**Failure Detection:** Observe the lubricant level in the gearbox.

**Failure Detection Test Frequency:** Weekly prior to fire pump test.

**Required Action:** Top up the oil level if it is found to be low. Inspect the gearbox and surrounding area to determine if a leak exists. Repair the leak as soon as possible.

If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Detection:** Listen to the gearbox whenever it is in operation.

**Failure Detection Test Frequency:** Weekly during the test run.

**Required Action:** Troubleshoot the cause of gearbox functional failure immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### **Vertical Turbine Pump**

**Function:** To pump sufficient water for fire fighting.

**Functional Failure:** Does not pump sufficient water for fire fighting.

**Failure Consequence:** Insufficient water flow and pressure will be available to provide for distribution system flushing and firefighting efforts.

**Failure Detection:** Observe the pressure, flow, and engine RPM during test runs; compare the values with historical readings.

**Failure Detection Test Frequency:** Weekly during pump tests.

**Required Action:** Troubleshoot performance issues immediately. Significant changes from recent test results will not likely be due to pump wear and tear. Correct the root cause as soon as possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Detection:** Observe the pressure, flow and engine RPM during distribution line flushing events; compare the values with minimum performance specifications.

**Failure Detection Test Frequency:** Annually, during distribution system flushing events.

**Required Action:** Troubleshoot performance issues immediately. Significant changes from the minimum performance specifications are a strong indicator of pump wear and tear. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### **Pressure Control/Relief Valve**

**Function:** To maintain distribution system pressure at a preset maximum level while the fire pump is in service.

**Functional Failure:** Does not maintain distribution system pressure at a preset maximum level while the fire pump is in service.

**Failure Consequence:** System pressure may be too high or too low. High pressure can endanger the distribution piping. Low pressure can result in the inability to respond effectively to an emergency.

**Failure Cause:** The pressure control/relief valve needs to be rebuilt or replaced.

**Failure Detection:** Observe pressure and flow; compare them with historical values. Observe pressure control/relief valve for unusual characteristics such as chattering, leakage etc.

**Failure Detection Test Frequency:** Weekly during fire engine tests.

**Required Action:** Troubleshoot the cause of valve malfunction immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### **Engine Controller**

**Function:** To initiate a fire pump engine start upon sufficient distribution system loss of pressure.

**Functional Failure:** Does not initiate a fire pump engine start upon sufficient distribution system loss of pressure.

**Failure Consequence:** The pump will not start automatically. The pump will have to be started manually and this may result in a delay in providing emergency services.

**Failure Cause:** Engine controller is in "manual".

**Failure Detection:** Check that the controller is in "automatic".

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Switch controller to “automatic.” If the engine fires up, troubleshoot the cause and make arrangements for repairs as soon as possible.

**Failure Cause:** Failure of one or more electronic components in the engine controller.

**Failure Cause:** Inaccurate sensing of system pressure, causing the engine to fail to start.

**Failure Detection:** Reduce pressure in the pressure sensing line to the controller. The engine should start.

**Failure Detection Test Frequency:** Weekly, during fire pump tests.

**Require Action:** Troubleshoot the cause of engine start failure immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Consequence:** The engine will nuisance start while the distribution system pressure is still adequate. This will result in the control panel being taken out of automatic mode.

**Failure Cause:** Inaccurate sensing of system pressure, causing the engine to nuisance start.

**Failure Detection:** Ensure the engine starter is in automatic mode. If the engine starts, check the distribution system pressure. If the pressure is normal, this would be considered a nuisance start.

**Failure Detection Test Frequency:** Daily during operator rounds or any time the engine controller is found to be in manual mode without any explanation.

**Required Action:** Troubleshoot the cause of engine nuisance start immediately. Correct the problem immediately if possible. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

### **Battery Charger**

**Failure:** To automatically maintain full charge on the engine batteries without over charging.

**Functional Failure:** Does not automatically maintain full charge on the engine batteries without over charging.

**Failure Consequence:** The batteries will be undercharged or overcharged and will not start the engine. Battery damage may also result.

**Failure Cause:** Electrical interruption to the battery charger.

**Failure Cause:** The automatic charge circuitry is damaged in the battery charger.

**Failure Detection:** Observe charge indicators on the battery charger. Observe how the engine cranks over and compare with historical knowledge. Observe battery for indication of acid on top of the battery or around the battery vents. Check battery voltage.

**Failure Detection Test Frequency:** Weekly during fire pump tests.

**Required Action:** Troubleshoot the charger problem. Check the power supply to the charger. If the charger appears to be defective, take the charger out of service and arrange for the charger to be replaced as soon as possible. The alternator on the engine should be able to maintain the battery function if weekly fire pump tests are performed as planned.

## **Batteries**

**Function:** To provide voltage and current to the engine starting and ignition systems to allow the engine to start.

**Functional Failure:** Does not provide voltage and current to the engine starting and ignition systems to allow the engine to start.

**Failure Consequence:** The engine will not be available for emergency use or distribution system flushing.

**Failure Cause:** Batteries have reached the end of their service life.

**Failure Cause:** The batteries have become discharged through overuse or undercharging.

**Failure Detection:** Start the engine. Observe how the engine turns over.

**Failure Detection Test Frequency:** Weekly during fire engine tests.

**Required Action:** Troubleshoot the battery problem. Clean the battery terminals. Check electrolyte level in the battery if the battery cell caps can be removed. Ensure

that the battery charger is energized and working properly. If the batteries appear to be at the end of their service life, arrange for replacement at the first possible opportunity.

**Failure Cause:** The batteries have insufficient electrolyte level.

**Failure Cause:** The battery connections are corroded.

**Failure Detection:** Check electrolyte level and clean the terminal connections.

**Failure Detection Test Frequency:** Annually.

**Required Action:** Check electrolyte level and top up as needed with distilled or demineralised water. Clean the terminal connections.

### **Fuel Delivery System**

**Function:** To deliver fuel to the fire pump engine in sufficient quantities to provide full power.

**Functional Failure:** Does not deliver fuel to the fire pump engine in sufficient quantities to provide full power.

**Failure Consequence:** The engine will not be able to produce full horsepower. The engine may not run at all.

**Failure Cause:** Diesel fuel flow has been interrupted to the fire engine.

**Failure Detection:** The engine will not start or starts and spontaneously stops very quickly. Subsequent attempts to start will be unsuccessful. Check the fuel tank level. Maintain a minimum level of ½ full.

**Failure Detection Test Frequency:** Weekly during fire pump tests.

**Required Action:** Check the fuel tank level and change the fuel filters. Test run the engine after the filters have been changed.

### **Isolation Valves**

**Function:** To isolate the fire pump from the distribution system.

**Functional Failure:** Does not isolate the fire pump from the distribution system.

**Failure Consequence:** Performing maintenance on the fire pump or drive components will require the entire distribution system to be depressurized.

**Failure Cause:** Valve fails to seal tightly.

**Failure Detection:** Open a telltale system, such as a gage isolator with the gage removed, to ensure that the equipment being worked on is isolated from system pressure.

**Failure Detection Test Frequency:** During maintenance activities on equipment that needs isolation to be worked on safely.

**Required Action:** Do not work on equipment that is influenced by system pressure. If repeated attempts at isolation do not result in effective isolation, the work must be postponed until safe, or the system must be de-energized via other means such as locking out all of the pumps on the distribution system. A valve that will not isolate must be rebuilt or replaced. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Cause:** Valve is seized in any position.

**Failure Detection:** Fully open and close valves to ensure full range of travel.

**Failure Detection Test Frequency:** Semi-annually

**Required Action:** Alternately attempt to open and close a stuck valve. Sometimes applying lubricant such as penetrating oil can assist in freeing the valve up. If the valve will not free up, arrange for parts order and resource coordination at the first possible time.

### **Check Valve**

**Function:** To prevent reverse flow through the fire pump. Note; check valves are not to be considered to be effective isolation for maintenance efforts.

**Functional Failure:** Does not prevent reverse flow through the fire pump.

**Failure Consequence:** Pressure in the distribution system will be reduced due to flow losses through the check valve.

**Failure Cause:** A foreign object such as a piece of scale can cause a slight hang up of the check valve internal components.

**Failure Cause:** Wear and tear or corrosion of internal components can cause the check valve to fail.

**Failure Detection:** Check for excessive flow indications or reduced pressure in the distribution system. It may be possible to hear leakage past a failed check valve. A mechanics stethoscope may assist in hearing leakage.

**Failure Detection Test Frequency:** Semi-annually.

**Required Action:** If a check valve is suspected of serious leakage, it should be replaced as soon as possible. Ensure that all necessary replacement parts are on hand prior to starting work.

### **Distribution System**

The function of the distribution system is to provide pressurized potable water to the community.

#### **System Components**

##### **Above Ground Piping**

**Function:** To contain pressurized water.

**Functional Failure:** Does not contain pressurized water.

**Failure Consequence:** A visible leak will occur. Slip or electrical hazard are possible.

**Failure Cause:** Corrosion through pipe walls or leaking fittings.

**Failure Detection:** Observe above ground piping.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Perform repairs to leaking fittings as needed. Leaks in the body of a steel pipe should be repaired by replacement of that section of pipe. Initiate parts order and resource availability at the first possible opportunity.

## **Buried Piping**

**Function:** To contain pressurized water.

**Functional Failure:** Does not contain pressurized water.

**Failure Consequence:** A non visible leak will occur. Soil saturation and buried piping destabilization are possible. Water consumption may exceed the plants ability to produce water.

**Failure Cause:** Failure of joint seals or pipe structure.

**Failure Cause:** Thrust block shifting.

**Failure Detection:** Check water flow and pressure against historical values. Unexplained high water flow and/or low pressure may indicate a serious buried leak.

**Failure Detection Test Frequency:** Daily during operator rounds.

**Required Action:** Notify public works personnel of potential buried leak.

**Failure Detection:** Drive through the community and watch for water flowing up from the ground.

**Failure Detection Test Frequency:** Any time leak is suspected.

**Required Action:** Notify public works personnel of potential buried leak.

## **Isolation Valves**

**Function:** To isolate other distribution system components to allow for maintenance to be performed.

**Functional Failure:** Does not other distribution system components to allow for maintenance to be performed.

**Failure Consequence:** The isolation of the system will need to be enlarged to allow for necessary repairs to be done.

**Failure Cause:** Valve fails to seal tightly.

**Failure Detection:** Open a hydrant downstream of the isolation valve to ensure that the equipment being worked on is isolated from system pressure.

**Failure Detection Test Frequency:** During maintenance activities on equipment that needs isolation to be worked on safely.

**Required Action:** Do not work on equipment that is influenced by system pressure. If repeated attempts at isolation do not result in effective isolation, the work must be postponed until safe, or the system must be de-energized via other means such as locking out all of the pumps on the distribution system. A valve that will not isolate must be rebuilt or replaced. If parts or additional resources are required, arrange for parts order and resource coordination at the first possible time.

**Failure Cause:** Valve is seized in any position.

**Failure Detection:** Fully open and close valves to ensure full range of travel.

**Failure Detection Test Frequency:** Annually during system flushing.

**Required Action:** Alternate closing and opening efforts in an attempt to free up the valve. If the valve will not free up, arrange for parts order and resource coordination at the first possible time.

## **Fire Hydrants**

**Function:** To allow large volumes of water to be accessed at ground level, in a frost protected manner, for the purpose of fire fighting and distribution system flushing.

**Functional Failure:** Does not allow large volumes of water to be accessed at ground level, in a frost protected manner, for the purpose of fire fighting and distribution system flushing.

**Failure Consequence:** Firefighting efforts may be compromised.

**Failure Cause:** Hydrant base is washed out.

**Failure Detection:** Hydrant is sitting at an unusual angle or is sinking into the ground.

**Failure Detection Frequency:** Observe hydrants whenever the chance exists. Take note of any that are in an odd position.

**Required Action:** Arrange parts and resources for repairs to be done as soon as possible.

**Failure Cause:** A foreign object is preventing the hydrant valve to seat.

**Failure Detection:** Ensure the flow stops completely during distribution line flushing.

**Failure Detection Test Frequency:** Annually during distribution line flushing.

**Required action:** Isolate the hydrant and repair the hydrant before freeze up.

**Failure Cause:** Hydrant drain is plugged off.

**Failure Detection:** Water level does not drop in the hydrant barrel after the hydrant is closed. In winter, the hydrant barrel will be cracked.

**Failure Detection Test Frequency:** Annually during distribution line flushing.

**Required action:** Isolate the hydrant and repair the hydrant before freeze up.

## **Drain Sump System**

The function of the drain sump system is to dispose of backwash water from the treatment plant building.

### **System Components**

#### **Submersible Sump Pump**

**Function:** To dispose of backwash and rinse waste water.

**Functional Failure:** Does not dispose of backwash and rinse waste water.

**Failure Consequence:** The sump will overflow and flood the floor of the water treatment plant.

**Failure Cause:** Electrical interruption to pump motor.

**Failure Cause:** Pump motor bearings are seized.

**Failure Cause:** Pump inlet is plugged with debris.

**Failure Detection:** Check sump level after each backwash and rinse event to ensure that it is pumped out.

**Failure Detection Test Frequency:** After each backwash and rinse event.

**Required Action:** Check the electrical supply to the pump. If it is okay, lock out and pull the pump out of the sump and check the suction for debris. If the pump suction is clear, make arrangements for immediate repair or replacement of the pump.