Chapter 9
Operations and Maintenance
CHAPTER 9

Operations and Maintenance

9.1 OBJECTIVES

Operations and maintenance (O&M) of a wastewater collection system can be defined as the activities that result in conveying wastewater safely and efficiently to a wastewater treatment plant. The purpose of the O&M program is to maintain design functionality (e.g.: capacity) and/or restore the system components to their original condition and thus functionality\(^1\). This chapter outlines the O&M program for the wastewater collection system within the City of Lacey. There are four key objectives for Chapter 9 as follows:

1. Provide a Maintenance Plan for operating and maintaining the City’s wastewater collection system;

2. Outline the City’s wastewater collection system, the organization of the City’s Wastewater Department and how the system is supported;

3. Compare the City’s current system performance against other efficiently run organizations using benchmarks; and

4. Recommend the best opportunities for improvement for operations and maintenance of the City’s wastewater collection system.

9.2 ORGANIZATION OF THE WASTEWATER SECTION

The Wastewater Maintenance Section of the Operations Division of the Public Works Department performs sewer operation and maintenance functions for the City of Lacey.

An organizational chart showing the 2004 structure of the Water and Wastewater Maintenance Section is presented in Figure 9.1. The nine staff in light blue are allocated 100% to the wastewater utility, and the five staff in dark blue are allocated 50% to wastewater. The quality control technician in yellow is allocated 37% to wastewater and the locates staff in pink is allocated 16% to wastewater. This represents a total of 12.03 full-time staff allocated to work on wastewater. (The ten remaining staff are allocated entirely to the water utility.)

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\(^1\) Collection Systems: Methods for Evaluating and Improving Performance; Office of Water Programs, California State University, Sacramento, CA, 1998.
The Water/Wastewater Supervisor supervises five senior technicians who oversee the water and wastewater operations. Wastewater utility operations are responsible for operating and maintaining the wastewater main sewers (including gravity sewers, force mains, service connections and manholes), wastewater pump stations, and the low pressure wastewater systems (including the Septic Tank Effluent Pumping (STEP) systems). There are four dedicated 2 person wastewater crews. The four crews are as follows:

1. Main line sewer cleaning;
2. Closed Circuit Television (CCTV) inspection;
3. STEP systems; and
4. Pump stations.
The remaining three field staff who are allocated to work on wastewater are two control technicians and one utility locates staff person.

9.3 SYSTEM CONFIGURATION

The existing system of pump stations, force mains, and major gravity lines within the UGA is detailed in Chapter 5: Existing Facilities. All wastewater is discharged into the LOTT Interceptor, which exits the City to the west along Martin Way. There are two discharge points into the LOTT interceptor, at the Martin Way Pump Station (#16) and at the intersection of Sleater-Kinney Road and the I5. The City is responsible for the system up to manhole U2V01, located on Sleater-Kinney Road south of Martin Way and the Interstate 5.

The following is a summary of the facilities and infrastructure related components the department is responsible for operating and maintaining:

**Sewer Mains:** As of the end of 2003, the City maintained the following inventory of sewer mains:

<table>
<thead>
<tr>
<th>Type</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravity</td>
<td>94.4 miles</td>
</tr>
<tr>
<td>Force</td>
<td>7.8 miles</td>
</tr>
<tr>
<td>STEP(^2)</td>
<td>41.1 miles</td>
</tr>
</tbody>
</table>

**Pump stations:** There were 29 pump stations in service within the City at the end of 2003 (this excludes PS 16, which is operated by LOTT). It should be noted that due to growth, this number is growing rapidly, and that utility staff should be consulted for the most recent number of commissioned pump stations. (Complete information regarding all City pump stations including photographs and map locations is included as the Facilities Inventory section in a separate binder). Detailed operating instructions for pump station components are provided in the O&M manuals at each station. The manuals have been compiled by the pump manufacturers and are on file at the maintenance shop.

**Low Pressure Systems:** There were 2,464 active STEP connections throughout the City at the end of December 2003. The City maintenance personnel are also responsible for four odor control/treatment facilities, 98 air relief valves, five soil bed filters, and an extensive outfall monitoring program. This additional maintenance occurs at the expense of the gravity system maintenance program.

The maintenance department is also responsible for the operation of five community septic systems throughout the Lacey UGA. These are temporary systems, to be abandoned or incorporated into the City system as sewers become available. The residents pay regular connection fees and rates.

Physical details of the above noted facilities are provided in the Facility Inventory portion of this chapter (contained in a separate binder).

\(^2\) Note that the costs associated with maintaining the STEP mains is included under the STEP component of the utility
9.4 MAINTENANCE PLAN

“The goal of maintenance is easy to say, and tough to do – it is to maintain the utility’s facilities in such condition that the successful operation of any important part of the system will never be impeded by the failure of the unavailability of system components because of the physical or mechanical condition”.

An organized maintenance plan is required to ensure continuous service to customers and to maximize the benefit derived from the City infrastructure inventory. Goals of the maintenance plan are to preserve the value of the physical infrastructure and to ensure that all wastewater is conveyed safely, efficiently, and reliably. In general, the City of Lacey’s maintenance plan conforms to the approach recommended in the Wastewater Collection Systems Management Manual of Practice (published by WEF) in that it includes cleaning, inspection, preventative maintenance activities (referred to as Preventative Maintenance or PM), and emergency and scheduled repairs (generally referred to as Corrective Maintenance).

In addition to performing actual maintenance tasks, scheduling, administration, inventory management, and record-keeping are key components of the City’s maintenance plan and are included within the departmental budget. The City’s Computerized Maintenance Management Program (HTE system) is designed to support the informational needs of both preventive and corrective maintenance (see Section 9.11).

Wastewater Utility Components

The City’s wastewater utility maintenance plan is designed to maintain the three primary components that make up the City’s wastewater system:

Sewer Mains (Gravity and Force Mains): Service to customers is provided through connections to the local sewer main. Sewer mains then convey sewage to the wastewater treatment plant. The energy required to move sewage through the main can be provided through gravity or through pressure provided from a pump station. Force and gravity mains are maintained in a similar manner, but force mains are more difficult to access (for inspection and repair activities) due to the contained pressure.

Pump Stations (also known as Lift Stations): Pump stations provide the pressure to lift sewage to higher elevations and to pressurize force mains. Pump stations can range in complexity and size, but normally include a mechanical pump, an electric motor, an enclosure, telemetry and process control to allow remote and/or automatic control, and in many cases, a back up electric generator to ensure continuous service in case of a local power failure. An inventory of the mechanical equipment at each of the City’s pump stations is summarized in the Lift Station Operation and Maintenance Manual for each station.

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3 Managing the Water and Wastewater Utility; Dolan, Rose, et al; Water Environment Federation (WEF); 2003
Low Pressure Systems (including STEP and Hybrid):

Lacey operates and maintains 2,464\textsuperscript{5} low pressure systems known as STEP (Septic Tank Effluent Pumping) systems. Small pumps move the effluent from the City-owned septic tank into a small diameter, low pressure sewer collection system. The low pressure sewer main ultimately connects to the gravity or force main for transmission to the wastewater treatment plant (See Figure 9.2 below).

**Figure 9.2: Typical STEP System**

In Lacey, each STEP service has a pump and float switches that pump septic tank effluent into the collection system. STEP services are equipped with an alarm system to signal failure. Once the wastewater section becomes alerted to a STEP system alarm, the matter is treated as an emergency, which requires immediate attention and maintenance.

The Septic Tank Effluent Pumping system is a complex component of a wastewater collection system. From a functional standpoint, STEP systems are more prone to odor problems, experience higher levels of corrosive gas, and have a greater risk of sewage back ups. It requires the full maintenance of gravity components for transmission of sewage to a treatment facility and yet another series of activities for the STEP-specific components that treat and transmit effluent. Because of the high annual cost of STEP system maintenance, this portion of the utility is described in greater detail than the more conventional gravity-based portions of the system. (The actual cost per STEP connection is almost twice that of a gravity system connection (see Section 9.10 Performance Measurement)).

**Low Pressure System Components and Maintenance Requirements**

The on-site portion of the low pressure systems essentially operates as a septic system, except that it is connected to a pressure main instead of a drain field. Within Lacey, the components that are associated with the STEP systems include:

\textsuperscript{5} As of December 2003
1. On-site 1000/1500/3000 gallon settling and debris tanks with high head, low volume pumps, biofilters, and Flyte balls for level control.
2. Residence mounted control panels with control/alarm features.
3. Ninety-eight air relief valves.
4. Four bioxide injection stations control hydrogen sulfide odor within our neighborhoods.
5. Five soil bed filters designed to reduce/eliminate hydrogen sulfide odors within the system.
6. Hybrid lift stations designed to interface on-site gravity systems with STEP force mains lines.
7. A one of a kind air injection system designed to remove hydrogen sulfide odors.
8. An emergency support plan for up to 2,600 individual units during power outages, depending upon the significance of the outage.

Maintaining the components of the STEP System is labor and equipment intensive. The maintenance activities for each of the following components are considered essential for Lacey’s STEP systems to ensure continued and reliable customer service:

1. STEP Tanks (2,464): The on-site liquid and debris tanks are scheduled on a five year cycle for cleaning and general servicing (this Work Order (WO) activity is referred to as “full service”). The five year service level is based on experience, and the similarity with preventative maintenance (PM) required for septic tanks. Each tank cleaning WO includes pumping the tank with a septic pumper truck. The pumper truck must be staffed by two people, as septic tanks are considered “confined spaces” (and are subject to specific safety procedures).

The truck is capable of handling two service events for 1,000 gallon units and one 1,500 gallon unit. A second truck (authorized for 2005) will be able to handle two 1,500 service events. The second person operates a van that is specially equipped to provide maintenance on the pumps, biofilters, Flyte balls, control, and junction boxes.

This “full service” WO is also performed during emergency repair calls when the service has not been recently performed to re-establish a performance interval for the preventive maintenance. The pumped material from the STEP tank is then transported to one of two deposit sites that are connected to the 27 inch main leading to the Martin Way pumping station. This high flow volume line allows adequate dispersal prior to entering the automated bar screens at the LOTT pumping station. Typically, the City programs two to three “full service” events each workday.
2. Control Panels (2,464): There is a control panel associated with each STEP connection. The control panels require no maintenance and are allowed to run to fail. A service call typically involves the replacement of electronic components and occasionally the entire control box.

3. Air Relief Valves (98): Air relief valves are crucial to the efficiency of the STEP force mains. Failure to service them on a once per year basis can reduce the force main’s capacity. This kind of limitation can/will lead to individual residences inability to pump into the system during high flow periods during the day, potentially resulting in sewage backups into the houses. Preventative Maintenance of each air release valve requires: 1) removing the air release valve, 2) returning to the shop to disassemble, inspect, clean, and reassemble the valve, and 3) reinstalling the valve to the main.

a. Bioxide Injection Stations (4): Odor complaints are treated as emergency events, which require immediate attention and maintenance. Lacey has taken aggressive steps to ensure that the system operates with a minimum of odors. Not only does this improve the level of service to customers, but it saves money. Bioxide\(^6\) injected into the effluent stream at the correct location will reduce odors. A typical Bioxide injection station consists of a split faced block facility, free standing tanks containing from 500 gallons to 6,000 gallons of storage and metering pumps to inject Bioxide. The chemical is injected into the lines at locations designed to maximize the contact time and foster an environment that minimizes the growth of hydrogen sulfide emitting bacteria. Performed correctly, this process can eliminate the “rotten egg” smell associated with hydrogen sulfide at outfalls where the effluent transitions from the force main to the gravity system.

   The target PM service level includes bi-weekly checks on each station and bioxide metering rates. In addition, the overall performance is monitored by frequent checks of data loggers installed in outfalls, soil bed filters and other locations within the system. The monitoring effort is labor intensive because of the large service area, and the cyclical nature of odor control. In areas where the Bioxide contact time or the injection rate cannot keep pace with odor generation, the City installs manhole Bioteg filters beneath the lids to prevent the escape of odors at targeted locations.

   The replenishment of Bioxide is accomplished by scheduled contract delivery directly to the facilities at a current cost (2004) of $120,000 per year.

b. Soil Beds (to treat hydrogen sulfide) (5): Hydrogen sulfide is a gas that emits naturally from sewage. As well as causing odors, it can become dangerous to field staff and residents at high concentrations. Correctly designed and constructed soil beds reduce hydrogen sulfide in areas where H2S is a potential problem.

\(^{6}\) Bioxide is trademarked product of U.S. Filter.
There are five soil bed facilities in the City. Soil beds require frequent observation to ensure the even distribution of odors through the bed. Odors can be short circuited easily on the outside perimeter of the beds, which are made of bark, peat, and lime designed to stimulate bacterial activity to remove the H2S odors. Every three to five years, the material must be removed and replaced. Frequent monitoring of the soil beds with the use of data loggers is essential to measuring the effectiveness. Effectiveness of several of our soil bed filters have been sporadic due to the very high levels of H2S experienced in our collection system. These soil bed filters have been taken out of service.

One location serving a development of fewer than 100 units involves the use of an underground air injection system and a small soil bed filter. While the unit is relatively maintenance free, its proximity to a playground and houses requires constant monitoring. (The facility successfully reduces the levels of hydrogen sulfide odors from over 300PPM down to less that 3 PPM, which is an effective ratio).

The City has searched for alternatives to STEP systems, or methods to reduce the number of individual STEP installations. This investigation has resulted in a number of innovative and successful hybrid systems that have reduced annual O&M costs when compared to equivalent traditional STEP systems.

Hybrid Pump Station: A successful innovation includes the creation of on-site gravity sewer to individual residences within a development to a hybrid pump station. Similar to individual residence units, these stations use large, multiple 10,000-40,000 underground fiberglass tanks to separate and treat the effluent. The sewage material flows to a traditional wet well and is pumped to the force main. The large tanks are pumped out on cycles ranging from three to five years. While the cleaning of the large tanks is expensive, it less expensive than maintaining multiple individual STEP units. This innovation also eliminates service interruptions (and emergency call-outs) as a result of power outages, since the stations are equipped with standby generators.

**Failure of STEP Systems due to Power Outages**

Power outages present challenges to STEP systems that are not faced in a gravity system. Each residential STEP unit is powered by service to the individual home. In the case of a partial or area-wide power outage, the City would be pressed to support over 2,464 STEP units that might be at risk of backing up into the house. The City has a contingency plan using small portable generator sets loaded on pickup trucks to power up a particular individual STEP system and pump it down to minimum levels. Overall, the STEP System is a dynamic system that is more labor intensive than gravity system.

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7 Typically, the design criteria envisioned the scrubbing of hydrogen sulfide up to a rate of 30 PPM. In two locations, the soil bed filters were installed to reduce the volume of Bioxide to be used. At Lift Station 9, the bed was installed to eliminate potential outfall odors that did not get treated before transiting the lift station. At two other locations the soil beds were designed to be the secondary treatment after aeration.
As shown in Figure 9.3, the large number of STEP systems within the City account for about 37% of the total regular maintenance hours spent by the Wastewater Department staff.

**Figure 9.3: Breakdown of the City’s 2003 Total Collection System O&M Regular Hours**

![Pie chart showing the breakdown of total collection system O&M regular hours by category: 37% STEP, 28% MAINS, 35% PUMP STATIONS.]

**Annual Cost of O&M of Collection System Components (2003)**

Figure 9.4 shows the breakdown of the City’s total collection system O&M cost into the above noted asset categories (sewer mains, and pump stations, and low pressure systems (STEP)). It can be seen that STEP accounts for an even great overall percentage of O&M Costs than O&M regular maintenance hours (Figure 9.3).
Figure 9.4: Breakdown of the City’s 2003 Total Collection System O&M Cost

Lacey Total 2003 O&M Cost - $1,359,040

- STEP: $615,015 (46%)
- MAINS: $290,426 (21%)
- PUMP STATIONS: $453,599 (33%)

Collection System Maintenance Activities

In general, the City’s Wastewater O&M program conforms to practices recommended by WEF in the *Wastewater Collection System Management Manual of Practice* (1992). The notable exception is that the City has had to respond to the unusually high O&M requirements of the many STEP systems (the WEF Manual does not deal with STEP in any significant way, and thus has not recommended a specific maintenance program to meet the requirements of STEP). The City has had to rely largely on experience in the establishment of STEP related target levels of service.

The following Tables 9.1 to 9.3 outline the maintenance activities that are presently conducted by City O&M staff. Each activity is presented with a brief summary, and the current target service level. Finally, the actual level of service in 2003 is presented where management commentary or preferably, HTE-based performance data exist. (Note: 2003 is the first year where HTE data is available, and many areas of management reporting are still in development. (Please see Section 9.11 for recommendations regarding the management of HTE-based maintenance data)
# Table 9.1: Maintenance Activities for Wastewater Mains

<table>
<thead>
<tr>
<th>Maintenance Activity</th>
<th>Definition</th>
<th>Benefit to the City</th>
<th>Target Service Level</th>
<th>Rationale for the Service Level</th>
<th>2003 Actual Service Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line Cleaning</td>
<td>Cleaning of gravity sewers using high pressure flushing. (Preventive Maintenance)</td>
<td>Reduces blockages and sewer overflows and maintains pipe capacity. Minimizes odor and corrosion.</td>
<td>Clean 20% of system per year (5 year cycle)</td>
<td>City can defend against claims if cleaning occurs every 5 years</td>
<td>21% of system length (5 year cycle)</td>
</tr>
<tr>
<td>Television Sewer Inspection</td>
<td>Visual inspection of main condition using Closed Circuit Television. (Preventive Maintenance)</td>
<td>Assesses condition of sewers to prioritize repairs</td>
<td>20% of system per year (5 year cycle)</td>
<td>Prioritization of repairs to reduce breaks and blockages</td>
<td>19% of system length (5 year cycle)</td>
</tr>
<tr>
<td>Vehicle/Equipment Maintenance</td>
<td>Weekly cleaning, fuelling and stocking of the line cleaning and TV inspection vehicles to ensure they are ready for work. (Includes servicing of equipment in vehicles, other small equipment and tools.) (Preventive Maintenance)</td>
<td>Ensures rapid and efficient mobilization of crews. Improves reliability of vehicles and equipment.</td>
<td>Weekly maintenance of vehicles (presently conducted at end of shift on Fridays)</td>
<td>Preparation of vehicles in advance of weekends (when emergency callouts may occur)</td>
<td>Generally met the service level</td>
</tr>
<tr>
<td>Manhole Washing</td>
<td>Washing manholes using high pressure flushing (this activity is part of the line cleaning program) (Preventive Maintenance)</td>
<td>Reduces blockages and sewer overflows. Minimizes odor and corrosion.</td>
<td>20% annually (5 year cycle) in association with line cleaning program. More frequent washing of priority manholes (trouble spots)</td>
<td>Based on the past experiences of O&amp;M staff</td>
<td>21% of manholes (5 year cycle)</td>
</tr>
<tr>
<td>Manhole Inspection</td>
<td>Physical inspection of manhole condition for the purpose of identifying defects. (Preventive Maintenance)</td>
<td>Assesses condition of manholes to prioritize repairs</td>
<td>20% of system per year (5-year cycle)</td>
<td>Based on the past experiences of O&amp;M staff</td>
<td>100% of goal</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Maintenance Activity</th>
<th>Definition</th>
<th>Benefit to the City</th>
<th>Target Service Level</th>
<th>Rationale for the Service Level</th>
<th>2003 Actual Service Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manhole Repairs</td>
<td>Emergency and routine repairs to manholes (Corrective Maintenance)</td>
<td>Improves reliability of manholes and ensure continued system reliability</td>
<td>Immediate response to emergencies. Routine work is scheduled as available.</td>
<td>Based on the past experiences of O&amp;M staff</td>
<td>As required</td>
</tr>
<tr>
<td>HTE Support (CMMS)</td>
<td>Updating the HTE system (Record Keeping and Administration)</td>
<td>Maintains currency of CMMS</td>
<td>Daily, as required</td>
<td>Complete and timely information is required for management purposes</td>
<td>All data input into system</td>
</tr>
<tr>
<td>Minor Maintenance</td>
<td>Minor repairs and maintenance related activities including customer service, cut brush, locates, air release maintenance, odor complaint response etc. (Corrective Maintenance) (In 2003, there were 17 tasks each consuming less than 4% of the total wastewater mains maintenance hours).</td>
<td>Ensures system reliability and responds to the needs of customers</td>
<td>As required. Immediate response to emergencies. Routine work is scheduled as available.</td>
<td>Based on the past experiences of O&amp;M staff</td>
<td>As required</td>
</tr>
<tr>
<td>Spill incidents</td>
<td>Cleaning up sewage spills that emit outside of the sewer system (Corrective Maintenance)</td>
<td>Protects the environment, private and public property. Responds to the needs of customers.</td>
<td>0 spills. Immediate response to spills that do occur.</td>
<td>Spills are unacceptable since they are a health and environmental hazard.</td>
<td>3 spills occurred in 2003</td>
</tr>
</tbody>
</table>
### Table 9.2:
Maintenance Activities for Wastewater Pump Stations

<table>
<thead>
<tr>
<th>Maintenance Activity</th>
<th>Definition</th>
<th>Benefit to the City</th>
<th>Target Service Level</th>
<th>Rationale for the Service Level</th>
<th>2003 Actual Service Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Well Cleaning</td>
<td>Flushing, jetting and evacuating wet wells. (Preventive Maintenance)</td>
<td>Minimizes odor and corrosion and ensures reliable level control.</td>
<td>Frequency of flushing and jetting varies based on type of station, flows and location</td>
<td>Based on the past experiences of O&amp;M staff.</td>
<td>Data records to be developed in the future</td>
</tr>
<tr>
<td>Service Electrical Control Panels</td>
<td>Inspection, cleaning and calibration of electrical control panels (15 tasks). (Preventive Maintenance)</td>
<td>Ensures efficient and reliable operation</td>
<td>Weekly inspection, quarterly calibration and annual cleaning and testing</td>
<td>Based on the past experiences of O&amp;M staff.</td>
<td>Generally met the service level. (HTE records to be developed in the future)</td>
</tr>
<tr>
<td>Maintain Buildings and Enclosures</td>
<td>Building cleaning, inspection and maintenance including grounds maintenance. (Preventive Maintenance)</td>
<td>Ensures security and protection of equipment in buildings</td>
<td>Monthly, quarterly and annually cleaning and inspection</td>
<td>Based on the past experiences of O&amp;M staff.</td>
<td>100% of target</td>
</tr>
<tr>
<td>Service Pumps</td>
<td>Pump/rail internal/external component cleaning, inspection, service and replacement of pump filters (12 tasks). (Preventive Maintenance)</td>
<td>Improves pump station reliability Identifies need for pump repairs</td>
<td>Annual pump inspections and quarterly pump filter replacements</td>
<td>Based on the past experiences of O&amp;M staff.</td>
<td>100% of target</td>
</tr>
<tr>
<td>L/S Checks/Readings</td>
<td>Checks and readings of pump stations. (Preventive Maintenance)</td>
<td>Records pump run times</td>
<td>Weekly and year end pump hour readings</td>
<td>Modified manufacturers’ recommendations</td>
<td>100% of target</td>
</tr>
<tr>
<td>Service Telemetry Systems</td>
<td>Telemetry system testing and inspection. Annual professional services contract for telemetry and radio. (Preventive Maintenance)</td>
<td>Improves SCADA reliability and accuracy</td>
<td>Continuous checks of system through program control every 3 to 5 minutes</td>
<td>Ensures immediate response if alarm occurs</td>
<td>100% of target</td>
</tr>
<tr>
<td>Maintenance Activity</td>
<td>Definition</td>
<td>Benefit to the City</td>
<td>Target Service Level</td>
<td>Rationale for the Service Level</td>
<td>2003 Actual Service Level</td>
</tr>
<tr>
<td>----------------------------</td>
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</tr>
<tr>
<td>Generator Inspections</td>
<td>Generator inspection and testing. (Preventive Maintenance)</td>
<td>Confirms operation to ensure that generators will function when required in emergency situations.</td>
<td>Portables monthly during summer and weekly during winter. Fixed generators weekly based on program control plus semi-annual preventative maintenance.</td>
<td>Manufacturers’ recommendations and other users’ experience</td>
<td>95% of target</td>
</tr>
<tr>
<td>Vehicle/Equipment Maintenance</td>
<td>Weekly cleaning, fuelling and stocking of the line cleaning and TV inspection vehicles to ensure they are ready for work. (Includes servicing of equipment in vehicles, other small equipment and tools.) (Preventive Maintenance)</td>
<td>Ensures rapid and efficient mobilization of crews. Improves reliability of vehicles and equipment.</td>
<td>Weekly maintenance of vehicles (presently conducted at end of shift on Fridays)</td>
<td>Preparation of vehicles in advance of weekends (when emergency callout may occur)</td>
<td>Generally met the target</td>
</tr>
<tr>
<td>HTE Support (CMMS)</td>
<td>Updating the HTE system (Record Keeping and Administration)</td>
<td>Maintains currency of CMMS</td>
<td>Daily, as required</td>
<td>Complete and timely information is required for management purposes</td>
<td>All data input into system</td>
</tr>
<tr>
<td>Minor Maintenance</td>
<td>Includes a range of maintenance activities including start-ups, priming, supervision, level control, etc. (24 tasks each consuming less than 3% of the total pump station maintenance hours). (Corrective Maintenance)</td>
<td>Ensures system reliability and responds to the needs of customers</td>
<td>As required. Immediate response to emergencies. Routine work is scheduled as available.</td>
<td>Based on the past experiences of O&amp;M staff.</td>
<td>As required</td>
</tr>
<tr>
<td>Maintenance Activity</td>
<td>Definition</td>
<td>Benefit to the City</td>
<td>Target Service Level</td>
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<tr>
<td>STEP Full System Maintenance</td>
<td>Complete service overhaul of individual STEP sites, includes pumps, power cord inspection, Flygt balls, tank cleaning, control box inspection etc. (Preventive Maintenance)</td>
<td>Improves reliability of STEP systems and reduces STEP system failures. Ensures customer service.</td>
<td>20% of sites per year (5 year cycle)</td>
<td>Based on the past experiences of O&amp;M staff to minimize STEP failures</td>
<td>12.6% of sites (8 year cycle) Did not meet target.</td>
</tr>
<tr>
<td>STEP System Repairs</td>
<td>Emergency &amp; routine work performed on a STEP system due to failure eg basket collapsed, pump failure, control box failure etc. (Corrective Maintenance)</td>
<td>Improves reliability of STEP systems. Ensures customer service.</td>
<td>Immediate response to emergencies. Next working day for routine work.</td>
<td>Customer service</td>
<td>As required</td>
</tr>
<tr>
<td>STEP System Turn-Ons</td>
<td>Commissioning new STEP system connections</td>
<td>Commences new customer service.</td>
<td>As required</td>
<td>Customer service</td>
<td>As required</td>
</tr>
<tr>
<td>STEP Odor Control – Bioxide Injection</td>
<td>Maintenance of odor control facilities including readings. Includes emergency and routine repairs to the facilities as identified by odor complaints. (Corrective Maintenance)</td>
<td>Improves reliability of odor control facilities and reduces odor complaints. Ensures customer service.</td>
<td>Quarterly maintenance on facilities and bi-weekly readings.</td>
<td>Eliminate complaints and improve customer service</td>
<td>100% of target</td>
</tr>
<tr>
<td>STEP Odor Control Monitoring</td>
<td>Monitoring H2S levels</td>
<td>Preclude corrosion within gravity sewers, ensure H2S treatment is effective. Ensures customer service.</td>
<td>Bi-weekly monitoring</td>
<td>System optimization and customer service</td>
<td>100% of target</td>
</tr>
<tr>
<td>STEP Odor Complaints</td>
<td>Investigating and resolving the cause of odor complaints. (Corrective Maintenance)</td>
<td>Ensures customer satisfaction.</td>
<td>0 odor complaints. Immediate response to complaints.</td>
<td>Based on experience</td>
<td>8 odor complaints</td>
</tr>
<tr>
<td>Maintenance Activity</td>
<td>Definition</td>
<td>Benefit to the City</td>
<td>Target Service Level</td>
<td>Rationale for the Service Level</td>
<td>2003 Actual Service Level</td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------</td>
<td>----------------------</td>
<td>---------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>STEP Air Release Maintenance</td>
<td>Cleaning of air release valves on STEP force mains</td>
<td>Ensures adequate flows in STEP force mains</td>
<td>Annual cleaning</td>
<td>Based on experience</td>
<td>100% of target</td>
</tr>
<tr>
<td>STEP Hybrid Tank Maintenance</td>
<td>Clean large STEP hybrid tanks ranging in size from 7,000 to 50,000 gallons</td>
<td>Ensures uninterrupted system operation</td>
<td>33% of tanks per year (3 year cycle)</td>
<td>Based on experience (frequency was increased from 5 years to 3 years, as tanks were at risk of overflow under 5 year cycle)</td>
<td>100% of target</td>
</tr>
<tr>
<td>HTE Support (CMMS)</td>
<td>Updating the HTE system (Record Keeping and Administration)</td>
<td>Maintains currency of CMMS</td>
<td>Daily, as required</td>
<td>Complete and timely information is required for management purposes</td>
<td>As required</td>
</tr>
<tr>
<td>Minor Maintenance</td>
<td>Includes special city projects, electrical control panels, sewer breaks, locates etc (19 tasks each consuming less than 2% of the total low pressure system maintenance hours). (Corrective Maintenance)</td>
<td>Ensures system reliability</td>
<td>As required</td>
<td>Based on experience</td>
<td>As required</td>
</tr>
</tbody>
</table>
**Allocation of Maintenance Hours (by Component)**

The following pie charts in Figures 9.5 to 9.7 show the percentage of time spent under each maintenance activity within the three utility components.

**Wastewater Mains**

Figure 9.5 shows the breakdown of the City’s 2003 wastewater main line sewer maintenance hours into the key activities. These maintenance hours are from all water and wastewater staff who worked on main line sewers, not only the dedicated two person sewer maintenance crews. Minor maintenance includes customer service, cut brush, locates, air release maintenance etc (each consuming less than 4% of the total maintenance hours).

**Figure 9.5 Breakdown of City of Lacey’s 2003 Main Line Sewer Maintenance Hours**

![Pie chart showing maintenance activities]

The pie chart above shows that the 2003 staff time spent related to main line sewers was spent primarily on assisting the water department, followed by CCTV inspection, cleaning, vehicle and equipment maintenance, administration/meetings/training and minor maintenance.

**Wastewater Pump Stations**

The following pie chart in Figure 9.6 shows the breakdown of the City’s 2003 wastewater pump station maintenance hours into the key activities. These maintenance hours are from all water and wastewater staff who worked on main line sewers, not only the dedicated two person pump station maintenance crew. Minor maintenance includes start-ups, priming, supervision, level control etc (each consuming less than 3% of the total maintenance hours).
Figure 9.6: Breakdown of City of Lacey’s 2003 Pump Station Maintenance Hours

The pie chart above shows that the 2003 staff time related to pump stations was spent on a wide variety of tasks, with slightly more on wet wells than minor maintenance, followed by electric control panels and building maintenance.

Low Pressure Systems (STEP)

The following pie chart in Figure 9.7 shows the breakdown of the City’s 2003 STEP maintenance hours into the key activities. These maintenance hours are from all water and wastewater staff who worked on low pressure systems, not only the dedicated two person STEP maintenance crew. Minor maintenance includes field supervision, special city projects, electrical control panels, sewer breaks etc (each consuming less than 2% of the total maintenance hours).
Figure 9.7 Breakdown of City of Lacey’s 2003 STEP System Maintenance Hours

The pie chart above shows that the 2003 staff time related to STEP systems was spent primarily on full system maintenance (full service), followed by odor control, STEP system calls/repairs and minor maintenance.

**Summary of Maintenance Statistics**

By and large, the City is able to meet most of their maintenance activity service levels with the notable exception of STEP system preventative maintenance. As shown in Figure 9.8, the causes for interruptions to planned maintenance work include primarily:

- Maintenance staff being interrupted to respond to water utility high priority (emergency) work orders.
- Maintenance staff being interrupted to respond to Pump Station and STEP system emergencies (odor complaints, STEP failures, alarms, etc.)

Figure 9.8 shows the breakdown of wastewater collection staff maintenance time by Work Order type (see Section 9.11 for complete descriptions of Work Order Types). (It should be noted that all MT hours (meeting and training), and hours assisting other departments have been excluded.) (Supporting data from the HTE system is presented in Table 9.4)
Figure 9.8: Breakdown of 2003 Wastewater Staff Maintenance Hours by WO Type

(EM = Emergency Maintenance, RM = Routine Maintenance, PM = Preventative Maintenance, SP = Special Projects). (See Table 9.10 Work Order Classification System in Section 9.11 for definitions)

Table 9.4: 2003 Wastewater Department Staff Wastewater Maintenance Hours

<table>
<thead>
<tr>
<th></th>
<th>Pump Stations</th>
<th>Mains</th>
<th>STEP</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours</td>
<td>%</td>
<td>Hours</td>
<td>%</td>
</tr>
<tr>
<td>Emergency - Assist Water Department</td>
<td>0</td>
<td>0%</td>
<td>1,323</td>
<td>27%</td>
</tr>
<tr>
<td>Emergency (EM, SB, SBN)</td>
<td>1,421</td>
<td>29%</td>
<td>324</td>
<td>7%</td>
</tr>
<tr>
<td>Routine (RM)</td>
<td>1,329</td>
<td>27%</td>
<td>787</td>
<td>16%</td>
</tr>
<tr>
<td>Preventative (PM)</td>
<td>1,995</td>
<td>40%</td>
<td>2,406</td>
<td>50%</td>
</tr>
<tr>
<td>Other, Special Projects (SP)</td>
<td>203</td>
<td>4%</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td><strong>4,947</strong></td>
<td><strong>33%</strong></td>
<td><strong>4840</strong></td>
<td><strong>32%</strong></td>
</tr>
</tbody>
</table>
Analysis of Maintenance Statistics

Based upon the statistics presented in Figure 9.8, it can be seen that almost 70% of all maintenance hours can be classified as “proactive” as opposed to “reactive”. The underlying assumption is that only emergency work is considered “reactive” and cannot be scheduled and planned in advance. It should be noted that 9% of total maintenance hours was consumed by water utility emergency response. Had this time been available for use on the wastewater system (as planned and budgeted), more PM targets could have been met, which may have resulted in a reduction in wastewater emergency work orders. It is therefore recommended that in the future, efforts be made to ensure that wastewater staff will be fully available for wastewater maintenance (see Section 9.13 for recommendations).

Even if the wastewater section is able to utilize its full staff compliment for wastewater work, it will be important for Lacey to monitor the overall percentage of emergency work for trends. (eg: a growing percentage of emergency work may indicate that current levels of service are inadequate to ensure reliable system operation). Finally, it is important that Senior Technicians, who conduct maintenance planning, factor the historical level of emergency work into their day-to-day work plans. For example, Senior Technicians will need to continue to plan for about 25% of regular time being spent on unspecified emergency work orders. This will result in fewer work interruptions (eg; plan for emergency work).

9.5 INTERFACE WITH CAPITAL PROGRAMS

A major step towards preventing problems associated with maintaining newly constructed capital facilities within the sewer collection system is proper installation at the time of construction. To improve the process of integrating new facilities within the system, the City has adopted the “Capital Project Process” policy (June 4th, 2003). (Please consult this policy for details on the interface of maintenance staff with City capital programs.) Essentially, this policy documents the processes that relate to the following:

- There is a benefit in allowing Maintenance staff to provide input to capital programs before construction.

- Presently, Maintenance staff provide input at scoping, plan review, inspection and acceptance.

- The Quality Controls Tech is responsible for providing the interface between Maintenance and Capital projects.

9.6 INTERFACE WITH DEVELOPMENT REVIEW

There is no documented process for a formal interface of maintenance with development review. Developers are required to meet the City’s Design Guidelines. The City has also adopted Developer Standards pertaining to the sanitary sewer system.
It should be noted that:

- There is a benefit in allowing Maintenance staff to provide input to capital programs before construction.
- Presently, Maintenance staff provides input to the Development Plan. Occasionally, maintenance staff provides input at pre-construction meetings.
- The Quality Controls Tech is responsible for providing the interface between Maintenance and Development Review.

These standards and guidelines should be continually reviewed and updated by engineering and maintenance personnel. Standard designs should be developed to minimize total life cycle costs which include capital, O&M, and financing costs.

## 9.7 STAFFING SUMMARY

### Programmed versus Actual Staffing

In 2004, the City had a total complement of 26 staff to serve both the water and wastewater utilities (in 2003 the total was 24 staff). The City’s wastewater staff are shown in the Organization Chart in Figure 9.1. The nine staff in light blue are allocated 100% to the wastewater utility and the five staff in dark green are allocated 50% to wastewater. The quality control technician in yellow is allocated 37% to wastewater and the locates staff in pink is allocated 16% to wastewater. This represents a total of 12.03 full-time staff allocated to work on wastewater.

The Wastewater Section’s 12.03 full time staff can be divided into three categories as follows:

1. Field staff – those that predominantly work outside (i.e. maintenance personnel);
2. Field support staff; and
3. Supervisor staff.

The Senior Technicians undertake both field and field support work, therefore their time was split between the field and field support categories (75% field and 25% field support). The 12.03 full time staff allocated to the wastewater department in 2003 have been divided into 10.81 field, 0.72 field support, and 0.5 supervisor.

Support required on the water system reduces the amount of time that wastewater staff have available for wastewater operations and maintenance activities. This is illustrated in Figure 9.9:
The impact of this on the wastewater utility is twofold:

1. This is time that cannot be spent on wastewater WOs, as planned, and

2. In most cases where wastewater staff are diverted to the water utility, the wastewater crew must respond to a water system emergency, which forces them to interrupt the work they had originally planned. This often results in a higher overall cost to the original wastewater WO, as the crew must spend more time in travel and mobilization.

Traditionally, time spent by wastewater staff on water work orders is not budgeted or planned. Table 9.5 shows the difference between time allocated to wastewater and time actually spent in 2003 for all staff in the Water and Wastewater Maintenance Section. The maintenance staff are aligned under their Senior Technicians. For the wastewater department staff, the time actually spent on wastewater work was less than the percentage allocated. This is problematic if the wastewater preventative maintenance work is interrupted to perform work for other departments.
Table 9.5:  
2003 Data for % of Regular Hours Spent on Wastewater versus Allocated

*NOTE: WW = wastewater and W = water*

<table>
<thead>
<tr>
<th>Position</th>
<th>% of Total Regular Hours spent on WW (excl overtime)</th>
<th>% of Regular Hours allocated to WW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervisor</td>
<td>41%</td>
<td>50%</td>
</tr>
<tr>
<td>Wastewater Senior Tech</td>
<td>64%</td>
<td>100%</td>
</tr>
<tr>
<td>WW Main Tech Journey Level</td>
<td>74%</td>
<td>100%</td>
</tr>
<tr>
<td>WW Main Tech Journey Level</td>
<td>54%</td>
<td>100%</td>
</tr>
<tr>
<td>WW Main Tech Journey Level</td>
<td>52%</td>
<td>100%</td>
</tr>
<tr>
<td>WW Main Tech Journey Level</td>
<td>85%</td>
<td>100%</td>
</tr>
<tr>
<td>WW Main Tech Journey Level</td>
<td>81%</td>
<td>100%</td>
</tr>
<tr>
<td>Water Facilities Senior Tech</td>
<td>2%</td>
<td>50%</td>
</tr>
<tr>
<td>Controls Tech</td>
<td>22%</td>
<td>50%</td>
</tr>
<tr>
<td>Controls Tech</td>
<td>20%</td>
<td>50%</td>
</tr>
<tr>
<td>W Main Tech Journey Level</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>W Main Tech Journey Level</td>
<td>3%</td>
<td>0%</td>
</tr>
<tr>
<td>Quality Control Senior Tech</td>
<td>5%</td>
<td>37%</td>
</tr>
<tr>
<td>Main Tech Journey Level Locates</td>
<td>41%</td>
<td>16%</td>
</tr>
<tr>
<td>W Main Tech Journey Level</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>W Main Tech Journey Level</td>
<td>15%</td>
<td>0%</td>
</tr>
<tr>
<td>Water Distribution Senior Tech</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>W Main Tech Journey Level</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>W Main Tech Journey Level</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>W Main Tech Journey Level</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>W Main Tech Journey Level</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Senior Program Support</td>
<td>40%</td>
<td>50%</td>
</tr>
</tbody>
</table>

**Recommendations for Staffing Levels**

There are no recommended additions for wastewater staff. Staffing levels should be reviewed on a yearly basis to evaluate the impact of new development and growth. Before adding staffing there are a range of options that should be investigated to optimize the use of existing staffing and equipment, including the following:

1. Spend the allocated time for wastewater staff on wastewater work orders (eg: no diversion of time to other departments);

2. Review water system preventative maintenance program and reduce low priority and non-essential preventative maintenance work orders;
3. Review wastewater system preventative maintenance program and reduce low priority and non-essential preventative maintenance work orders;

4. Re-evaluate the use of the two FTEs for flushing team during summer months;

5. Re-evaluate equipment needs in the water department to avoid use of the wastewater equipment (specifically the Vacuum truck).

As the system grows due to regional and local populating growth, it will become necessary to adjust staffing level to meet the O&M requirements of new infrastructure.

Training/Qualifications Summary

Well-trained staff are an essential part of an effective operation and maintenance program. In addition to the workforce possessing the education and skills necessary to operate and maintain a utility system that is becoming increasingly complex with automation and computerization, staff training and education is seen as an important aspect of workforce retention and recruitment.

Maintenance personnel should be familiar with current equipment and procedures, as well as all applicable regulations. Training criteria should be established for each job description and reviews conducted accordingly. Training activities should be considered to be as important as any other maintenance activity and should be included and budgeted into the regularly scheduled tasks. Efficient and effective maintenance departments budget up to $1,000 per year per employee for technical training and certification. The Wastewater Maintenance section currently budgets $9,042 for technical training of the Wastewater Maintenance staff. On average, City Wastewater Maintenance staff is allocated five full training days per year.

The City’s current status in relation to best practices for staff training and qualifications is shown in the following table:

Table 9.6: Best Practices for Staff Training and Qualifications

<table>
<thead>
<tr>
<th>Best Practice</th>
<th>Progress/Status</th>
<th>Notes/ Desired Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job Descriptions complete with Minimum Training and Educational Requirements</td>
<td>Conformance with Best Practice</td>
<td>Well defined and documented for each position.</td>
</tr>
<tr>
<td>Exists for All Positions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time and Budget is Allocated for Staff Training</td>
<td>Conformance with Best Practice</td>
<td>City’s Wastewater Maintenance Section budgets $9,042 and five days per year for staff training.</td>
</tr>
<tr>
<td>Succession Plan Documented with “At Risk” Positions identified and training programs in place</td>
<td>No strategy currently in place</td>
<td>The average age of the workforce is consistent with municipal utility average (50 years of age). Few staff have earned the years of service to retire in the immediate future.</td>
</tr>
<tr>
<td>Operator Certification</td>
<td>Conformance with Best Practice</td>
<td>The City is currently in compliance with mandatory certification.</td>
</tr>
<tr>
<td>Cross Training of staff to perform multiple functions</td>
<td>Conformance with Best Practice</td>
<td>All job descriptions mandate multi-disciplined staff and cross training.</td>
</tr>
</tbody>
</table>
Many organizations are now facing the challenge of an aging workforce that is close to the age of retirement. Besides the need to ensure that adequate staff will be trained and available as individuals leave the organization, is the challenge of knowledge transfer. In many cases, senior staff departs with a vast amount of system knowledge which may or may not be documented in city records (e.g., as-built drawings, maintenance procedures, etc.). It is vital that organizations be aware of their risk and exposure to knowledge loss in advance of large scale retirements, so that adequate skill-based training and knowledge transfer strategies can be implemented beforehand.

9.8 SAFETY PROGRAM

City of Lacey’s wastewater staff has an excellent record of safety over the past few years. The City’s last lost time accident occurred in 2001, when there was 1 lost time accident with 34 days lost. The City has well documented safety training procedures, which are readily available to all field staff in a consolidated manual, and regular safety training is well established. Required training is monitored, scheduled, and documented by City HR staff in accordance with all local, State, and Federal regulations.

Safety Meetings

The City conducts monthly safely related “tailgate” meetings.

Safety related “tailgate” meetings are also part of regular safety procedures. The purpose of tailgate meetings is to identify, communicate, and resolve miscellaneous safety related topics that arise from regular field operations. It is important that the outcome of all tailgate meetings be documented in a standardized form so that outstanding issues can be escalated to the appropriately level for resolution. Items identified for action must be addressed in a timely manner, with the final outcome being incorporated into the Safety Manual. It is important that minutes and notes from these meeting be accessible to all employees.

If there is a safety incident (e.g., accidents or potential accident situation), the City conducts immediate follow-up with all staff, including re-training where necessary.

Safety Inspections

Senior Technicians evaluate safety procedures on work in progress in the field on a regular basis.

Confined Space Entry

City staff are frequently required to work in spaces that are considered confined space, therefore appropriate training and refreshing is vital. The City’s confined space entry policy is in accordance with all applicable regulations. Required training is accomplished annually. These procedures are reviewed with maintenance personnel on a regular basis and revised as regulations evolve. The City has a trained Confined Space rescue team with a Confined Space rescue trailer.
Electrical and Mechanical Equipment

The presence of electrical and mechanical equipment at the pump stations may present hazards to personnel during the performance of operation and maintenance tasks. Precautions should be taken whenever working on or near the pump station’s mechanical and electrical equipment. The City has an established lock-up tag-out procedure which is followed.

Health Safety

The City trains their staff on safety barriers as required. All staff has a First Aid card.

The possibility exists that any particle of wastewater may contain disease causing bacteria. City operators take stringent precautions to avoid disease at all times. Principle water-borne diseases include typhoid fever, dysentery, Giardia, Cryptosporidium, infectious jaundice, and tetanus. Immunization against some of the diseases is possible and all operators are vaccinated periodically. City operators have stringent procedures to avoid disease, including the following:

- Keep hands below collar when working at sewer facilities
- Wear rubber gloves whenever directly handling sewage
- Disinfect hands with hot water and soap or antibacterial lotion before eating
- Treat minor cuts and wounds immediately

Additionally, an emergency first aid kit is kept in each City vehicle, and in each occupied building and warehouse.

Conclusions on Safety

Safety procedures and guidelines are well established and documented. The City HR department is responsible for keeping safety policies and procedures up to date, and maintained.

Regular checks are made to ensure that safety related consumables are replenished and checked on a regular basis.

9.9 EMERGENCY RESPONSE PROCEDURES

The operation of the sewer system under emergency conditions is an important responsibility of the City’s staff. Emergency response procedures should be rehearsed and reviewed by personnel. The City has a comprehensive Emergency Management Plan that is integrated with Operations and County/State officials. The City has adopted the Incident Command Management System. This Plan enables the City to leverage its own resources and those needed outside the City’s resources to satisfy any emergency.
An overview of the potential effects and recommended actions for emergency situations is presented in Tables 9-7 through 9-9. The five emergency situations considered are power loss, flooding, hazardous waste spill, earthquake, and sabotage/vandalism. The potential effects and recommended actions are identified for sewage pump stations, force mains, and the gravity sewer system.

**Table 9-7: Emergency Response Actions for Pump Stations**

<table>
<thead>
<tr>
<th>Emergency</th>
<th>Potential Effects</th>
<th>Recommended Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Loss</td>
<td>Pumps rendered inoperable, Auxiliary generators activated to run pumps.</td>
<td>Transport portable generators to Lift Stations that do not have auxiliary power, check other lift stations to ensure generators are operating.</td>
</tr>
<tr>
<td>Flooding</td>
<td>Station overflow</td>
<td>Pump to trucks until flooding effects subside.</td>
</tr>
<tr>
<td>Hazardous Waste Spill</td>
<td>Spill enters wet well at a Lift Station</td>
<td>Isolate Lift Station receiving spill, pump out of wet well and dispose of hazardous material, notify Thurston County, LOTT, Health, and DOE of situation.</td>
</tr>
<tr>
<td>Earthquake</td>
<td>Wet well damaged, inlet and outlet piping severed or damaged.</td>
<td>Pump to trucks while repairs are made.</td>
</tr>
<tr>
<td>Sabotage/Vandalism</td>
<td>One or more pumps rendered inoperable</td>
<td>Isolate damaged Lift Station damage, operate other pumps while repairs are made.</td>
</tr>
</tbody>
</table>

**Table 9-8: Emergency Response Actions for Force Mains**

<table>
<thead>
<tr>
<th>Emergency</th>
<th>Potential Effects</th>
<th>Recommended Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Loss</td>
<td>No anticipated effects</td>
<td>No actions anticipated</td>
</tr>
<tr>
<td>Flooding</td>
<td>No anticipated effects</td>
<td>No actions anticipated</td>
</tr>
<tr>
<td>Hazardous Waste Spill</td>
<td>No anticipated effects</td>
<td>No actions anticipated</td>
</tr>
<tr>
<td>Earthquake</td>
<td>Breaks in force main pipes</td>
<td>Bypass pumping where necessary</td>
</tr>
<tr>
<td>Sabotage/Vandalism</td>
<td>Force mains plugged or broken</td>
<td>Isolate damaged area, pump from affected lift station to trucks until affected area is functional.</td>
</tr>
</tbody>
</table>
The City has heightened its priority to secure the public infrastructure from a variety of threats, local, national and international. In conjunction with recommendations for the water system, the wastewater system has received improved security features.

### Table 9-9:
Emergency Response Actions for Gravity Sewers

<table>
<thead>
<tr>
<th>Emergency</th>
<th>Potential Effects</th>
<th>Lift Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Loss</td>
<td>No anticipated effects</td>
<td>No actions anticipated</td>
</tr>
<tr>
<td>Flooding</td>
<td>Manholes surcharged</td>
<td>Implement bypass pumping at critical areas.</td>
</tr>
<tr>
<td>Hazardous Waste Spill</td>
<td>Spill enters sewer system</td>
<td>Isolate Lift Station receiving spill, pump out of wet well and dispose of hazardous material, notify Thurston County Health, and DOE of situation.</td>
</tr>
<tr>
<td>Earthquake</td>
<td>Breaks in sewer lines, Damaged Manholes</td>
<td>Isolate damaged area, implement bypass pumping until affected area is repaired</td>
</tr>
<tr>
<td>Sabotage/Vandalism</td>
<td>Gravity Sewers plugged or broken, Manholes damaged</td>
<td>Isolate damaged area, implement bypass pumping until affected area is repaired</td>
</tr>
</tbody>
</table>

### 9.10 PERFORMANCE MEASUREMENT

**Introduction to Performance Measurement**

In order to improve anything, you must be able to measure it. Many municipalities are embarking on extensive performance improvement initiatives, but what is surprisingly less understood, is what and how to measure, and where to get performance data that is relevant, accurate, and current. One of the first steps of performance management is that utility and City managers must agree on meaningful “key performance indicators” and then identify the source of the data that needs to be recorded and tracked.

This analysis conducted two types of performance measurement for review in this study:

1. Utility Comparisons (Benchmarking); which are useful for identifying areas of strength and weakness; and
2. Trend Analysis; which is useful for identifying whether performance is improving or diminishing.

**Utility Comparisons**

The City of Lacey was compared to the collection systems of four comparable Canadian municipalities operating in the Lower Mainland of British Columbia on the following three performance measures:

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8 These municipal systems were selected due to similar climate, geography and population and the fact that the consultant had access to data that was reliable and comparable.
• Sewer Mains Field FTEs/100 mile length of gravity sewer
• Pump Station Field FTEs/pump station
• Field Staff Productive Hours/Field Staff Total Regular Hours

Sewer Mains Field FTEs/100 mile Length of Gravity Sewer

The following staffing comparisons are based on the City’s 2003 collection system FTEs of 9.25 field staff (i.e. based on actual regular hours spent on field work excluding field support and supervisor hours). This is less than the 2003 programmed field staff of 10.813 as staff spent less time on wastewater than allocated due to time spent assisting the water department. The 9.25 field FTEs are further split into mains 2.61 (28%), pump stations 3.27 (35%) and STEP systems 3.37 (37%).

Figure 9.10 below shows the comparison of the City’s 2003 sewer mains Field FTEs per unit gravity sewer length (i.e. 2.61 / 94.44 miles = 2.8/100 miles) compared to the comparable Canadian wastewater collection systems. The systems are in order of increasing system length.

Figure 9.10: WW Mains Field FTEs / 100 mi Length 2003 – System Comparison

This graph shows that the City has the lowest per unit staffing levels (2.8 mains field FTEs/100 mi length) compared to the Canadian systems, 25% below the average of 3.8 mains field FTEs/100 mi length.
Pump Station Field FTEs/Pump Station

Figure 9.11 below shows the comparison of the City’s 2003 pump station Field FTEs per pump station compared to the same comparable Canadian systems (i.e. 3.27 / 29 pump stations = 0.11/pump station). The systems are in order of increasing number of pump stations.

Figure 9.11: Pump Station Field FTEs / Pump Station 2003 – System Comparison

![Graph showing the comparison of pump station Field FTEs per pump station for different systems.](image)

This graph shows that the City has the second highest per unit staffing levels for pump stations in 2003, (0.11 FTEs/pump station) compared to the group of 3 systems, and 22% above the average of 0.08. Pump station staffing requirements vary greatly depending on the size (installed pump capacity and horsepower), level of complexity, level of automation and the scheduled maintenance routine (including generators).

Field Staff Productive Hours/Field Staff Total Regular Hours

One of the most important factors that can affect work productivity is the amount of productive time employees have each day to spend on work. Factors such as vacation, sick time, and others non-work activities are important, but they reduce the total number of hours that can be spent on actual Work Orders. While there may be little that can be done to change productive hours, it is important to recognize non-work factors in the planning of work.

Field staff productive work hours can be assessed by subtracting unproductive hours (sick time, vacation, holidays, compensation used and safety training) from paid regular hours (2080 hours in total). The City’s field staff were productive for 82% of the 2003 year which is higher than the average for the Canadian systems (80%). 82% of the 2080 total paid regular hours is
equivalent to 1,706 hours, very close to the City’s standard estimate for productive hours of 1,734 hours. The following graph in Figure 9.12 shows a breakdown of unproductive time compared to the Canadian west coast municipal average.

**Figure 9.12: Breakdown of Unavailable Time for Lacey and Canadian Wastewater Staff**

![Graph showing breakdown of unproductive time]

In this comparison, it can be seen that Lacey experiences less unproductive time than the averaged other municipalities due largely to less annual vacation time. Sick time and other non-work factors are similar.

**Trend Analysis**

Trends analysis is very useful in identifying factors that require proactive management. If factors are changing from year to year, it is important to understand the reason for the change. If it is a change for the worse, it may be a matter that requires urgent attention.

The trends in Lacey’s wastewater system operations were analyzed from 1999 to 2003 on the following four measures:

- Wastewater System Connection Growth
- Total O&M Wastewater System Cost
- Total O&M Cost Per Connection
- STEP vs Gravity System Cost Per Connection
The total number of connections to the Lacey Collection System for gravity and STEP Systems has grown by 18% since 1999. Of that growth, the gravity system has experienced only minor growth compared to the STEP System which has grown by 60%. (This includes five odor control facilities and 2 hybrid lift stations. These stations allow on-site gravity flow to a consolidated treatment/lift station facility, which minimizes the growth of residential facilities.)

The implication of this is that the most expensive portion of the system (on a per connection basis) in terms of annual maintenance cost has expanded the most. If this rate of STEP system growth were to continue, it is reasonably to expect that more resources (staff and equipment) will be required by the utility in future years.
The Lacey Collection System has experienced a modest rise in annual O&M cost over the five year period of $468,054, or less than 5%. This includes all wage escalations, new equipment costs, reductions in older equipment rental rates, and the creation of a new preventive maintenance crew to service residential STEP systems. (Labor costs are somewhat lower in some years due to the reallocation of resources to higher priority work in the Water utility and support to other City agencies.)

LOTT costs, (which reflects contract wastewater treatment costs and associated capital costs), are charged to the Operations and Maintenance account. LOTT costs have increased by 40% over the same period of time (but primarily between 1999 and 2000). It should be noted that the O&M section has little or no control over LOTT costs.
The customer is charged a utility rate that includes both the cost of wastewater collection (the responsibility of City staff) and the cost of treatment (the responsibility of LOTT). In Figure 9.15, total system cost is broken down to cost per connection to present a clearer picture of the total cost of operations. The total cost per connection has ranged between $546.00 to a high of $665.00. The driving factor in the year-to-year change in cost has been the LOTT allocations. The Collection System cost per connection has been relatively flat, ranging from a low of $188.00 to a high of $206.00.
STEP Systems typically cost substantially more per connection than gravity service within Lacey’s Collection System. This is driven by the increase in the number of facilities for each residence, the increased maintenance due to on-site treatment, and the need for odor and corrosion control at outfalls to eliminate the presence of hydrogen sulfide. STEP is also allocated a pro-rata portion of the gravity system costs as those lines and lift stations transmit the effluent for LOTT treatment. Over the last five years STEP systems typically range from a low of 80% to over 120% more expensive to maintain than gravity systems. Although not finalized at the time of this report, the 2004 numbers are tracking to the 2003 expenditures. Fiscal year 2005 will see an increase in operational costs associated with STEP Systems as the City adds one additional preventive maintenance crew and associated vehicles/equipment priced a slightly over $350,000 for the first year of operation. Successive years will be less as capital costs have been expended.

9.11 MAINTENANCE MANAGEMENT SYSTEM

The City is in the process of completing the installation of its computerized maintenance management system (CMMS) within the wastewater utility. The HTE Data Management system was originally installed as a financial tool in the Finance Department and its deployment was rolled out to the water and subsequently, the wastewater utility. Presently, the computer system is installed and work order data is being entered into the system on a regular basis.
A CMMS is a proven tool to help organize maintenance work by imposing a process that is consistent with modern maintenance engineering. According to well documented maintenance management best practices, however, the installation of a complete maintenance management program requires that the practice of managing maintenance be a logical management cycle, where past work order performance history is taken into account for developing forecasts for future maintenance work and in analyzing work order productivity. Once the installation is fully complete the maintenance management system should be instrumental in the following important productivity factors:

- control the utility’s list of maintainable assets through an asset register
- control accounting of assets, purchase price, depreciation rates, etc.
- schedule planned preventive maintenance routines
- control preventive maintenance procedures and documentation
- control the issue and documentation of planned and unplanned maintenance work.
- facilitate WO analysis (problem identification)
- provide maintenance budgeting and costing statistics
- process condition monitoring inputs
- provide analysis tools for maintenance performance.

One of the most significant benefits of a CMMS is the ability to generate a wide range of management and planning level reports to assist all levels of utility management. In order to produce complete and reliable reports from the system, however, the data must be complete and accurate.

**WO Classification System**

In general, Lacey’s HTE Work Order classification system conforms to the Best Practice as published by WEF (Wastewater Collection Systems Management Manual of Practice). This classification system will facilitate good work analysis to plan future work, provided all relevant data is completed and stored reliably within the HTE system. Table 9.10 provides a summary of the City’s Work Order classification system:
### Table 9.10:
City of Lacey HTE Work Order Classification System

<table>
<thead>
<tr>
<th>Type</th>
<th>Detail</th>
<th>Include</th>
<th>Result</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency: (EM)</td>
<td>Breakdown that may result in loss of service or other severe detriment to the utility (e.g.; spill, etc.)</td>
<td>Response to failures in the wastewater system</td>
<td>Deploy maintenance as soon as possible</td>
<td>Disrupts maintenance schedules, may incur overtime, and high costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Requires in order to provide uninterrupted service to community</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poses a risk to life, property or the environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine Maintenance (RM)</td>
<td>Various maintenance tasks as identified through observation,</td>
<td>Repairs that are not emergencies</td>
<td>Planned and scheduled maintenance</td>
<td>Disrupts preventative maintenance schedules</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Work requests that do not require immediate response</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tasks that can be planned ahead of time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preventative Maintenance (PM)</td>
<td>Regularly scheduled and periodic maintenance as directed by vendor or procedures</td>
<td>Not failure related, but required in order to assure the continued operations of wastewater systems and infrastructure</td>
<td>Planned and scheduled maintenance</td>
<td>None</td>
</tr>
<tr>
<td>Special Projects</td>
<td>Designed to track costs associated with tasks not directly related to maintenance</td>
<td>Construction and enhancements to City facilities</td>
<td>Planned and scheduled maintenance</td>
<td>Disrupts preventative maintenance schedules</td>
</tr>
</tbody>
</table>

The City of Lacey’s standard response time for conducting the initial assessment of an emergency situation (for example, a sewer back-up) is 15 minutes if it occurs during work hours, or 1 hour if it occurs after work hours (as people on standby need to call a crew). The City’s response time for a non-acute emergency is 24 hours (usually first thing next morning if notified in afternoon).

**Work Order Detail and Format**

The information and layout of the printed HTE Work Order is generally good, but could be improved with the following features (according to Best Practices):

1. Labor and material estimates should be confirmed in advanced and noted on the Work Order: Estimates should be realistic but reflect the requirements of the job with no complications or problems.
2. Reference to procedures and applicable procedures, standards, and codes: Ideally, documented procedures should be stored within the system and printable by the employee performing the work in advance.

3. Any relevant OH&S requirements and needs (as above):

4. Work Order Issues/Notes: This is a field where the employee can note problems or issues that occurred while performing the Work Order. This information is important in conducting Work Order Variance Analysis.

These types of business process improvement efforts are labor intensive and require staffing that is not available to the City of Lacey Wastewater Section. To the extent that it can be done, it will be done internally. It is expected to be a long and laborious process.

**Work Order Completion and Analysis**

It is understood that most of the data from completed Work Orders is now being entered into the HTE system. The following activities are recommended to complete the process:

1. Work Order Variance Analysis: This is one of the most overlooked but crucial elements of maintenance management. Work Orders that were completed as expected (e.g.: in the allotted timeframe and according to the WO estimate) can be entered directly into the system and closed. Work Orders that experience a variance, either in terms of the time it took to complete, or the allotted schedule should be examined by the Senior Technicians under the following general criteria:
   - What caused the problem?
   - Does this happen frequently?
   - What can be done to ensure that the problem does not reoccur?

2. The outcome of WO Variance Analysis should be documented, and stored within the HTE system

**Maintenance Program Reporting**

The aspect of HTE reporting is still in its infancy, and few standard reports are presently being generated from the system. The development and use of reports should be targeted to assist utility staff to make decisions to improve maintenance efficiency (both in terms of labor and assets). Examples of improvement activities include failure analysis, lost time analysis, budget variance analysis, common work-associated problem identification and resolution, and reliability centered maintenance analysis. Until the “reporting” subsection of the Maintenance Management loop is addressed, the overall system cannot realize its full benefits.
Reports should be designed to present the appropriate data to allow staff to make informed decisions regarding equipment maintenance strategies, maintenance work practice improvements, manpower scheduling, and equipment design modifications.

**Integrating the HTE Data Management System with the Maintenance Plan**

The City has completed the installation of a CMMS module in its HTE Data Management System. The fundamental principles, standards and tools that have been implemented so far appear to be current with documented Best Practices. The installation of a complete *maintenance management system* however, is not yet complete, and effort is required to organize the overall utility management processes.

All too often, most of the focus in CMMS implementations is on the successful installation of the computer-based hardware and software. Yet the major productivity and efficiency improvement opportunities lie outside this area. Computerization must be associated to a complete process management system (with regard to people, processes, and technology). In general terms, the process of organizing a maintenance management system is similar with organizing any management system. There needs to be a continuous information loop that provides the right information at the right time in order to achieve the correct actions. This loop must close on itself so that the system can “learn” from the previous cycle, and be used to improve the next iteration. There is a weakness in the system in that the reliability and consistency of the data is questionable due to the large number of people making input to the database. Despite efforts to develop consistency, there is insufficient staffing and management analysis to properly address this function.

The following recognized best practices are recommended for Lacey’s consideration as it completes the overall CMMS installation:

1. **Utilize Past Years Maintenance Performance to Improve Forecasting and Budgeting:** Most organizations prepare maintenance budgets that are based on a bottom-up assessment of the maintenance activities that they expect to perform. By incorporating feedback from the previous annual cycle in the form of work-based variance analysis and ultimately actual costs against those budgeted activities; process improvement can be incorporated into the upcoming budget. The ability to utilize previous year’s maintenance performance records will allow a closer connection between the budgeting process and the means to controlling costs within those budgets.

2. **Perform Weekly Scheduling Control and Management:** An effective Weekly Scheduling system permits the allocation of jobs to specific days, so that any required parts or specialized equipment can be available, and so that the facility can be shutdown or otherwise prepared prior to the field staff arriving to perform the maintenance task. The goal is to work towards a steady increase in the amount of scheduled work, relative to unscheduled work.

3. **Daily Scheduling and Job Control:** A good CMMS can provide a quick and easy way for supervisors to schedule work on a daily basis. As an example, the use of
time-line type bar charts allow supervisors to easily allocate work to field staff, and rapidly assess the impact of changes to the day’s schedule. It can also allow crews to record data that permits future analysis of job delays with a view to eliminating or reducing those delays.

9.12 SYSTEM AUTOMATION AND SCADA

The City of Lacey operates a modern SCADA system for the benefit of the water and wastewater system. This system provides typical supervisory and control functionality on an interrogation basis. The system reports both alarm status and certain instrumentation levels. Like most SCADA systems, the data historian is difficult to access for the purpose of analyzing historical information. One major piece of operational information that can be recorded by the SCADA system that would be of benefit to the utility is pump station run time and flow meter readings, which can be used to estimate sewage flows within the City. The City should explore the feasibility of developing this capability.

Since it is not presently feasible, the City may wish to examine the possibility of installing a SCADA Data Historian as a conventional relational database management system (RDMS) to allow conventional PC access for a range of ad hoc queries for the purposes of utility management and system optimization. Possible applications of this data would include:

- Identifying recurring problems and problem areas
- Tracking pump station mechanical components
- Estimation of man-hours required for various maintenance tasks
- Spotting the collection system components that are nearing capacity
- Diagnosing and addressing inflow and infiltration issues
- Monitoring the sewage flows to LOTT.

A detailed feasibility study of the SCADA system and technical alternatives alone with budget estimates is required in order to determine the cost effectiveness of this strategy.

9.13 SUMMARY OF RECOMMENDATIONS

This review has shown that the City’s Wastewater O&M section is a productive and cost effective organization. It is able to maintain high levels of service to its customers in an efficient manner as demonstrated by:

- All customer complaints are treated as emergencies and receive immediate response;
- The total collection system O&M cost has increased less than 5% since 1999 in spite of the fact that STEP connections (that require a much higher level on maintenance than convention gravity connection) have increased by 60% in the same period;
- Lacey compares well in terms of system costs to a number of similar municipal wastewater systems.

Looking ahead to the future, the following are the most important recommendations for the City to consider in terms of improving the cost effectiveness and efficiency of Operations and Maintenance activities.
1: No Addition to Staffing

The City maintains high levels of service to customers. This is demonstrated by the simple fact that all customer complaints are treated as “emergencies”, which require immediate service and repair. This even applies to odor complaints, which are often downgraded to “routine” maintenance calls (the use of overtime or interruption of present work assignment is not applied) by many municipal wastewater utilities. By and large, the City is able to maintain this level of service, at least when its full compliment of wastewater staff are available for wastewater work orders (see Recommendation 2 below). This study has therefore concluded that the present staffing complement is able to operate and maintain the current wastewater collection system. Please note, however, that as the collection system grows due to new connections (and especially with the addition of new STEP systems), staffing will have to be revaluated.

2: Optimize Use of Present Staffing and Equipment

It was noted that wastewater staff (and equipment purchased for wastewater O&M work) have been seconded to the water section for portions of the previous few years (9% of total hours in 2003). This impacts wastewater utility in two ways:

1. This is time that cannot be spent on wastewater work, as planned and budgeted, and;

2. In most cases, the seconded wastewater crew must respond to a water system emergency, which forces them to interrupt the work they had originally planned. This often results in a higher overall cost to the original wastewater work order, as the crew must spend more time in travel and mobilization.

This has led to a growth in the backlog of some preventive maintenance work orders. For example, the utility is presently performing STEP full service over an 8 year rotation instead of the target service level of 5 years (see Table 9.3). The ongoing practice of deferring maintenance will pose a growing risk to the utility if this situation is allowed to continue. Should the present number of wastewater staff and associated equipment be completely available to the wastewater section, the utility should be able to eliminate the PM backlog and reasonably expect to complete all required and necessary O&M work.

3: Manage HTE data

The HTE computerized maintenance management system is not yet able to assist the utility with management level reporting. The department is making a considerable effort to input all relevant WO detail into the system on a daily basis. As the system accumulates work history, maintenance information has the potential to become a valuable resource. At present, the system produces daily work orders, and a base level of annual and periodic maintenance statistics (at considerable manual effort), but the system has not been configured to meet the needs of a fully functional maintenance management information system. As a first step, the utility should define a series of management and planning level reports that would assist in the overall management of the utility. (Many of the required reports are generic in nature, as Maintenance Management is a well documented process and there are many Manuals of Best Practice...
available to provide assistance). Following the definition of the required reports, the City may need to retain an expert on the HTE system to design and program the required reporting functions.

4: STEP is Expensive to Maintain

The STEP system services an important role in the City, but it comes at considerable expense. On a per connection basis STEP systems cost almost twice as much as gravity systems to operate and maintain, yet the annual utility charge for each connection type is the same. At the point of this writing, it was understood that new STEP systems will no longer be a strategy for the utility (however existing STEP systems will remain as is). It is recommended that STEP related O&M costs be accurately tracked so that city system planners can ensure that the most cost effective and equitable infrastructure solutions can be incorporated into growth plans.