Review of Water and Wastewater Services Maintenance Program

March 4, 2010

Office of the County Auditor
Evan A. Lukic, CPA
County Auditor
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Office of the County Auditor
Executive Summary

This report summarizes the status of implementation of the recommendations contained in the Water and Wastewater Services (WWS) Maintenance Assessment Report dated April 22, 2003 issued by Life Cycle Engineering, Inc. (LCE).

LCE’s 2003 assessment report was an update of their previous maintenance assessment performed in 2001. LCE noted WWS had made improvements in their maintenance program since the original report and improved their Maintenance Excellence score from 0.46 to 0.684 (0.75 is the minimum score to achieve Maintenance Excellence). Improvements cited by LCE included:

- Implementing a Computerized Maintenance Management System (CMMS),
- Establishing a functioning Preventive/Predictive Maintenance Program, and
- Streamlining some operational practices.

LCE’s 2003 report included 63 recommendations for further improvement. Of these recommendations, we reviewed 49 to ascertain the status of WWS’s implementation noting thirty-five of the recommendations had been fully implemented and five more were partially implemented. One-third of the remaining recommendations were dependent on hiring a maintenance Engineer. This position was filled in 2009, providing the means to further improve the maintenance program. Based on LCE’s report and our subsequent review, WWS has made substantial progress in improving its maintenance program over the last several years.

We recommend the Board of County Commissioners direct the County Administrator to:

1. Evaluate LCE’s unaddressed recommendations and develop an implementation plan as appropriate, based on feasibility and cost benefit,

2. Implement routine review of CMMS to ensure that work orders are completed timely, and delinquent work orders kept to a minimum, and

3. Report progress in finalizing the implementation of recommendations to the Board periodically beginning in September 2010.

Purpose and Scope

Our original objective was to evaluate the effectiveness of routine and preventative maintenance processes for capital assets at WWS. However, we found WWS had proactively engaged a consultant to conduct a maintenance assessment review in 2001
and a subsequent update in 2003. As a result, we modified our objective to review the status of WWS’s implementation of the consultant’s recommendations.

**Methodology**

To accomplish our objectives, we:

- Reviewed:
  - The Maintenance Assessment Report issued by Life Cycle Engineering, Inc (LCE) dated April 22, 2003,
  - Maintenance policies and procedures issued by WWS,
  - Selected work orders issued by WWS,
  - Management status update provided by WWS as of August 2009, and
- Interviewed staff at WWS, and
- Toured the facilities.

**Background**

Water and Wastewater Services (WWS) provides retail water distribution to approximately 290,000\(^1\) citizens, wastewater collection services to approximately 650,000\(^2\) citizens and storm water and canal management services supporting aquifer recharge and flood management throughout Broward County. WWS is responsible for maintenance of the following utility systems:

**Potable Water Treatment and Distribution**
- 20 Production Wells,
- 2 Water treatment plants, and
- Over 680 miles of water distribution lines.

**Waste Water Collection and Treatment**
- 1 Waste Water treatment plant – North Regional Wastewater Treatment Plant,
- 18 Master Pumping Stations,
- 225 Retail Pump Stations,
- Over 98 Miles of sewer force main, and,
- Over 370 Miles of gravity sewer mains.

During the last seven years operating expenditures totaled approximately $396.1 million while maintenance expenditures were approximately $59.4 million or 15%.

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\(^1\) Includes the citizens within Broward County’s retail system and one significant bulk user (City of Coconut Creek)

\(^2\) Includes the citizens within Broward County’s retail system and eleven large users.
Table 1 below shows maintenance and operating expenditures along with related percentages for fiscal years 2003 to 2009.

### Table 1
Maintenance and Operating Expenditures
Fiscal Years 2003 to 2009

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Actual Maintenance Expenditures</th>
<th>Actual Operating Costs</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>$6,114,460</td>
<td>$47,752,660</td>
<td>13%</td>
</tr>
<tr>
<td>2004</td>
<td>6,971,181</td>
<td>50,241,316</td>
<td>14%</td>
</tr>
<tr>
<td>2005</td>
<td>6,334,029</td>
<td>53,578,124</td>
<td>12%</td>
</tr>
<tr>
<td>2006</td>
<td>9,819,818</td>
<td>58,274,939</td>
<td>17%</td>
</tr>
<tr>
<td>2007</td>
<td>9,549,029</td>
<td>58,939,462</td>
<td>16%</td>
</tr>
<tr>
<td>2008</td>
<td>10,314,924</td>
<td>62,573,385</td>
<td>16%</td>
</tr>
<tr>
<td>2009</td>
<td>10,249,931</td>
<td>64,788,684</td>
<td>16%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$59,353,372</strong></td>
<td><strong>$396,148,570</strong></td>
<td>15%</td>
</tr>
</tbody>
</table>

Source: County Auditor Analysis of Data Provided by WWS Fiscal Operation

The FY 2010 operating budget for WWS is $87.8 million, the organization has eight operational districts, and 418 employees.

**WWS Maintenance:**
Maintenance in the context of this report is defined as the work necessary to maximize the useful life of an asset. Preventative maintenance (PM) is the care and servicing by personnel for maintaining equipment and facilities in satisfactory operating condition. PM is accomplished by providing for systematic inspection, detection, and correction of incipient failures either before they occur or before they develop into major defects. PM programs are essentially time-based inspections and maintenance of assets performed by a qualified maintenance team coupled with a database to maintain historical data, current trends and forecasting.

In preparation for an effective preventative maintenance team to guide the program, WWS implemented a certification program for key individuals in the following aspects of maintenance:
- Reliability Excellence for Managers
- Maintenance Excellence for Managers
Typically the maintenance process begins when new equipment is purchased. The WWS Reliability Center Maintenance (RCM) team comprising of certified individuals mentioned above, meets to review the manufacturer’s suggested maintenance schedule, the proposed equipment utilization, and establish a PM frequency. If the RCM team determines that PM is necessary for the equipment, the PM frequency is established and entered in the Computerized Maintenance Management System (CMMS). The RCM team also establishes a job plan, which details the maintenance procedures that should be performed and the parts that should be used during PM; and a route, which includes the location of similar equipment requiring the same job plan and PM frequency. Both the job plan and route are entered in the Computerized Maintenance Management System.

**The Computerized Maintenance Management System (CMMS)**

The CMMS is one of the modules in the Maximo asset management software which serves as a means to identify, estimate, plan, schedule, and document PM and corrective maintenance work orders. The system is also used to document cost, measure performance, evaluate repair/replacement conditions, and maintain the historical information for the entire repair and maintenance programs.

In addition to CMMS, the Maximo software is used to document, and track approximately $6.6 million in inventory and supplies. The inventory is used for the purpose of maintaining the WWS service infrastructure and equipment. Inventory purchases are entered in Maximo and in the Advantage financial systems to track inventory usage and purchases. Daily the warehouse staff receives electronic inventory requests through the CMMS. The requests result in transactions that decrease the inventory balance in the Maximo inventory system. On a biweekly basis, WWS staff runs a report of all inventory items issued in the Maximo system and prepares a journal voucher to decrease the inventory balance in Advantage.

The standard maintenance practices include both preventative and corrective maintenance work orders:

- **Preventative Maintenance (PM)**
  
The maintenance process begins each week when WWS personnel generate the scheduled PM work orders from the CMMS. The PMs, applicable job plans, and routes are provided to the Maintenance Supervisor for assignment to the

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3 The RCM team consists of a Supervisor I, Chief Plant Operator, Mechanics, Electricians, Plant Operator, and an Electronic Technician.

4 Equipment with the same make and model are assigned the same frequency. PM frequencies can be weekly, monthly, quarterly, annually, etc.

5 Inventory and CMMS are two of the nine distinct modules within the Maximo asset management software.

6 Repairs are work completed to restore damaged or worn out facilities and assets to their normal operating condition. Repairs are corrective, while maintenance is preventative.

7 The amount represents the inventory balance in Advantage as of September 30, 2009
electricians, mechanics, electronic technicians, or other maintenance staff. For optimal efficiency, PMs for equipment with similar make and model are scheduled during the same week and assigned to the same route, and employee.

- **Corrective Maintenance Program (CMP)**
  If corrective maintenance or other repair issues are discovered during regular PM the staff either reports the issue to the supervisor who generates a CMP work order or the staff initiates a CMP work order which is provided to the supervisor. The CMP work order is assigned a minimum priority “3”\(^8\) and entered into the CMMS for approval and future assignment to the maintenance staff.

Upon receipt of the PM or CMP, the maintenance staff obtains the necessary parts and supplies listed in the job plan from the inventory warehouse. After the PM or CMP work order is completed it is signed by the maintenance staff and provided to the supervisor who performs field reviews to validate the completed work, and approves the work order. In addition to supervisory review, WWS has implemented a post job evaluation process in District IV\(^9\) which provides for written quality assurance feedback from the Operations staff regarding the effectiveness of selected repair and maintenance work. The completed work orders along with the post job evaluation, if applicable, are provided to data entry for input into CMMS. The information in the CMMS provided the data to evaluate implementation of some of the recommendations made by LCE.

**LCE Maintenance Excellence Analysis:**
In 2001, WWS contracted with LCE to conduct a Maintenance Assessment review of its facilities. The purpose of the review was to establish a baseline assessment of the maintenance process in the quest to obtain Maintenance Excellence. In 2003, LCE conducted a follow-up review to determine the progress made over the years and to determine whether the facility qualified to achieve "Maintenance Excellence".

\(^8\) Priority 3 work orders are assigned high priority and generally completed after emergencies, which are classified as Priorities 4 and 5.

\(^9\) The post job evaluation process has not been implemented in the remaining seven maintenance districts.
Table 2 below delineates some of the key components that an organization has to demonstrate in order to achieve Maintenance Excellence:

### Table 2
**Key Components of Maintenance Excellence**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Productive Maintenance</td>
<td>Providing assistance and guidance to aid in developing or enhancing equipment care and improvements.</td>
</tr>
<tr>
<td>Maintenance Effectiveness Assessment</td>
<td>Assessing existing maintenance practices.</td>
</tr>
<tr>
<td>Storeroom Design</td>
<td>Providing an efficient storeroom and material control system.</td>
</tr>
<tr>
<td>Planning and Scheduling</td>
<td>Providing solid maintenance planning and scheduling system.</td>
</tr>
<tr>
<td>Preventive Maintenance</td>
<td>Implementing an effective interval-based service program, including documented tasks and procedures.</td>
</tr>
<tr>
<td>Predictive Maintenance</td>
<td>Implementing an effective interval-based service program, including documented tasks and procedures.</td>
</tr>
<tr>
<td>Process Safety Management</td>
<td>Ensuring compliance with OSHA mechanical integrity requirements.</td>
</tr>
<tr>
<td>Maintenance Relationship Interfacing</td>
<td>Fostering improved relationships between maintenance, purchasing, accounting, engineering, and other functional areas</td>
</tr>
<tr>
<td>Maintenance Management</td>
<td>Establishing general or specific maintenance management systems to plan, regulate, monitor, budget, and improve maintenance processes.</td>
</tr>
</tbody>
</table>

Source: Excerpt from April 22, 2003 LCE Maintenance Assessment Report

The LCE Maintenance Assessment Report, issued on April 22, 2003, noted that WWS accomplished the following objectives since the original assessment:
- Streamlined some operational practices,
- Implemented a functional Computerized Maintenance Management System,
- Instilled work order discipline within the organization,
- Established a functioning Preventive/Predictive Maintenance Program,
- Selected and trained Planner/Schedulers, and
- Educated much of the organization on the principles of “Maintenance Excellence”.

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The report also noted that while WWS made progress since the initial review conducted in 2001 significant work was needed to accomplish the goal of “Maintenance Excellence” which is a composite score of at least 0.750. The composite assessment score assigned by LCE to WWS, pictured in Chart 1 below, was increased from 0.460 in 2001 to 0.684 in 2003.

![Chart 1](image)

Source: Prepared by County Auditor from LCE 2003 Maintenance Assessment Report

**Observations and Recommendations**

The 2003 Maintenance Assessment Report issued by LCE contained 63 recommendations designed to achieve the goal of Maintenance Excellence. Neither the LCE report nor WWS management established time lines for implementation. We reviewed 49 of the recommendations to assess the action taken by management and confirmed that thirty-five recommendations were fully implemented as of August 2009. Another five recommendations were partially implemented (See Appendix A for details). The remaining nine recommendations had not been implemented (See Appendix B for details). Management advised that three of these nine were dependent on hiring a maintenance engineer which was accomplished in 2009, providing the means to further improve the maintenance program.
In addition, our review found some work orders were not completed timely and others were incomplete and delinquent (See Appendix C for details). Timely completion of work orders was the subject of two implemented LCE recommendations, suggesting some “slippage” on these issues. Notwithstanding this slippage, it is evident from our observations, that WWS made substantial progress in improving its maintenance program over the last several years.

Recommendations:

We recommend that the Board of County Commissioners direct the County Administrator to:

1. Evaluate LCE’s unaddressed recommendations and develop an implementation plan as appropriate, based on feasibility and cost benefit,

2. Implement routine review of CMMS to ensure that work orders are completed timely, and delinquent work orders kept to a minimum, and

3. Report progress in finalizing the implementation of recommendations to the Board periodically beginning in September 2010.
## Appendix A

### FIVE PARTIALLY IMPLEMENTED RECOMMENDATIONS

<table>
<thead>
<tr>
<th>LCE Recommendation Dated April 22, 2003</th>
<th>WWS Update Dated August 2009</th>
<th>Auditor's Observation</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Implement a “Post-Job Evaluation” process</td>
<td>The program has begun at our District 4 facility and will be expanded to the others sections.</td>
<td>The post job evaluation process has not been implemented at all WWS locations (we reviewed a sample of work orders for District IV and noted that post job evaluations were performed).</td>
<td>The post job evaluation process provides quality assurance feedback from Operations personnel regarding the effectiveness of repairs and maintenance. Without the feedback, rework of ineffective repairs may be delayed.</td>
</tr>
<tr>
<td>2. Revise [Preventative Maintenance] PM procedures in all areas and refine PM frequencies</td>
<td>The PM program was reviewed for each section. We reviewed the frequency of the PM compared to the follow up work generated by the PM. Our goal is to achieve a 7 to 1 ratio of PM to CMP. The resulting CMP work order is high priority to ensure that this work is among the first to be scheduled. The PM frequency is a dynamic process requiring continual refinement.</td>
<td>Approximately 109,000 PMs were cancelled over the last 6 years. This includes approximately 10,900 cancelled in 2009 therefore the PM frequency has not been refined.</td>
<td>Failure to properly refine the PM frequency may result in ineffective time management, and reduce the work effort for other needed repairs.</td>
</tr>
<tr>
<td>3. Implement bar coding to improve the accuracy and efficiency for the materials effort.</td>
<td>Some bar coding has been implemented and is being used on a limited basis.</td>
<td>Bar coding was implemented for some large parts.</td>
<td>Bar coding(^{10}) could improve the inventory tracking process and reduce the cost of inventory counts.</td>
</tr>
</tbody>
</table>

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\(^{10}\) A barcode is an optical machine-readable representation of data. Barcodes can be read by optical scanners called barcode readers, or scanned from an image by special software.
### APPENDIX A (continued)

<table>
<thead>
<tr>
<th>LCE Recommendation Dated April 22, 2003</th>
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<th>Auditor's Observation</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.</strong> Identify more applications for the use of predictive maintenance. Corrosion and erosion were noted on the facility tour of areas of immediate concern.</td>
<td>More maintenance tasks such as lubrication will become part of the PM program as it is further developed. This includes protective coatings and paints.</td>
<td>WWS management stated that corrosion is an ongoing issue. The auditor also noted comments regarding corrosion in the Annual Bond Report.</td>
<td>Failure to inhibit the effects of corrosion could reduce the useful life of the equipment and increase maintenance costs.</td>
</tr>
</tbody>
</table>
| **5.** Implement the following metric:  
  - Maintenance Spending / Volume Delivered | This recommendation was not implemented pending the hire of the new position of CMMS Administrator. Now that this position is filled, it has been decided the metric should be “operations and maintenance” cost per million gallons treated, which is consistent with American Water Works Association standards. WWS will begin reporting this metric by August 31, 2010. | One of the Four metrics has not been implemented (Maintenance Spending /Volume Delivered) | Failure to implement this metric limits the ability to compare their performance with others in the industry. |
## Appendix B

### NINE RECOMMENDATIONS NOT IMPLEMENTED

<table>
<thead>
<tr>
<th>LCE Recommendation Dated April 22, 2003</th>
<th>WWS Update Dated August 2009</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Complete the interface between Maximo and the accounting system.</td>
<td>There currently are no &quot;interfaces&quot; between Maximo and Advantage; however, inventory transactions in Maximo are monitored, reconciled on a monthly basis, and a Journal Voucher (JV) is prepared bi-weekly to update Advantage. When the current upgrade of Maximo is complete it will automate the JV process and run on a daily basis.</td>
<td>Without integrated financial, maintenance, and inventory systems information such as inventory balances in Advantage will require manual updates.</td>
</tr>
<tr>
<td>2. Develop the necessary interfaces to integrate LGFS [Advantage] and Maximo. It is important to note that because of this issue points were lost during this assessment in numerous areas.</td>
<td>This task will be further developed by the Maintenance Superintendent and staff in FY10.</td>
<td>Without an equipment history review there is no method to establish additional reliability metrics (such as downtime trends, PM to corrective ratio, and high repair equipment reports).</td>
</tr>
<tr>
<td>3. Implement a structured Equipment History review</td>
<td>This program will be undertaken formally now that WWS has filled the position of Maintenance Superintendent to perform the duties of Maintenance Engineer. WWOD will look to an outside vendor for this training.</td>
<td>Without adequate OJT there may be potential inefficiencies in the planning and scheduling of maintenance activities.</td>
</tr>
<tr>
<td>4. Develop a Planner/Scheduler [On the Job Training] OJT program. Combine this OJT with some coaching and mentoring from a Maintenance Planner/Scheduler instructor.</td>
<td>This task will be further developed by the Maintenance Superintendent and staff in fiscal year 2010.</td>
<td>The failure to establish and report the ratios could permit inefficiencies in the maintenance program to go undetected.</td>
</tr>
<tr>
<td>5. Establish the additional necessary reliability metrics:  — Downtime trends  — PM to corrective ratio  — High repair equipment reports  — PM associated costs</td>
<td>This training will potentially be explored in fiscal year 2010. This will go beyond the process safety management procedure.</td>
<td>Lack of appropriate training could result in improper diagnosis and lead to more serious equipment failures.</td>
</tr>
<tr>
<td>6. Provide appropriate training to Maintenance Engineering personnel (Root Cause Failure Analysis, Failure Modes and Effects Analysis, RCM, etc.).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## APPENDIX B (continued)

<table>
<thead>
<tr>
<th>LCE Recommendation</th>
<th>WWS Update</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dated April 22, 2003</td>
<td>Dated August 2009</td>
<td></td>
</tr>
<tr>
<td>7. Perform the appropriate level of Root Cause Analysis on all unexpected equipment failures.</td>
<td>This process will begin again after training has taken place. This training will potentially be undertaken in FY10.</td>
<td>Lack of proper root cause analysis could lead to more serious equipment failures.</td>
</tr>
<tr>
<td>8. Implement a PM program for spare rotating equipment.</td>
<td>This program is being investigated and will be established by the warehouse team.</td>
<td>Spare parts that are not maintained may not be operational when needed or in an emergency.</td>
</tr>
<tr>
<td>9. Identify parts that are no longer used and purge the storeroom of obsolete inventory.</td>
<td>By July 30, 2010 Water and Wastewater Services will undertake a complete count of all items held in inventory. Upon completion of this count all items held in inventory that have not experienced any issuance in the past 3 years will be evaluated to determine if that item should be considered a critical part and retained or should be considered obsolete and purged from the inventory. Those parts considered obsolete will be disposed of through the County surplus disposal procedure. Items with no assigned value are held in the warehouse for security and tracked through the Maximo inventory system for accountability reasons. These items are primarily spare parts that were acquired as a component of a construction project that expanded or upgraded a treatment plant. Doing so insures WWS will have the exact critical spare part available should the need arise while obtaining the best price.</td>
<td>Obsolete inventory may increase handling and storage cost.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undervalued inventory balance in Maximo and the Advantage Financial systems.</td>
</tr>
</tbody>
</table>

Our review of inventory disclosed:

- Inventory items totaling approximately $1.5 million have not experienced an issuance in the last three years and were not designated as critical parts, and

- Approximately 20,200 inventory items have no value in Maximo and have not experienced an issuance in the last three years. Approximately 7,600 of the items were not designated as critical parts.
Appendix C

WORK ORDERS WERE NOT COMPLETED TIMELY AND WERE DELINQUENT

<table>
<thead>
<tr>
<th>LCE Recommendation Dated April 22, 2003</th>
<th>WWS Update Dated August 2009</th>
<th>Auditor’s Observation</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate the priority of CMP activities to ensure that these repairs are accomplished in a timely manner.</td>
<td>The priority of all CMP work orders is a minimum of priority “3”, which is high priority, and CMPs are first on the schedule to be completed after priority 4 and 5 work orders are assigned.</td>
<td>We reviewed 1740 closed work orders and found 26 (2%) that were not completed timely:\n  - <strong>One</strong> Priority 4 work order was completed in 7 days.\n  - <strong>Twenty-one</strong> Priority 3 work orders were completed in 10 to 137 days.\n  - <strong>Three</strong> Priority 2 work orders were completed in 13 to 26 days.\n  - <strong>One</strong> priority 1 work order was completed in 41 days</td>
<td>Critical work orders that are not completed timely could result in further damage or impact down-time and production.</td>
</tr>
</tbody>
</table>

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11 WWS procedures require that work orders are assigned priority codes 5 to 1 as follows:  
- Priority 5 is an emergency and should be immediately completed.  
- Priority 4 requires completion within 4 hours  
- Priority 3 generally requires an average completion time (To be completed after Priorities 4 and 5)  
- Priorities 1 & 2 are assigned below average priority and are generally assigned after priorities 3, 4, & 5 are completed
## APPENDIX C (continued)

<table>
<thead>
<tr>
<th>LCE Recommendation Dated April 22, 2003</th>
<th>WWS Update Dated August 2009</th>
<th>Auditor’s Observation</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigate all work orders that have been identified as delinquent, resolve and remove these from the database</td>
<td>The work orders that are delinquent are canceled within the system</td>
<td>We found approximately 112,600 work orders have been cancelled in CMMS during fiscal years 2003 to 2009. We reviewed incomplete work orders in CMMS and noted no delinquent work orders dating back to 2003 (date of the LCE report)</td>
<td>Critical work orders that are not completed timely could result in further damage or impact down-time and production.</td>
</tr>
</tbody>
</table>

We found 225 CMP work orders dated from 2005 to 2009 that were not cancelled or completed as of October 29, 2009 and aged as follows:

- **Six** Priority 5 work orders aged 29 to 279 days.
- **Seventeen** Priority 4 work orders aged 14 to 1,338 days.
- **186** Priority 3 work orders aged 15 to 1,413 days.
- **Fourteen** Priority 2 work orders aged 128 to 728 days.
- **One** priority 1 work orders aged 814 days.
- **One** work order was not assigned a priority and aged 1438 days.