Remote Facility Condition Inspections and Subsequent Integration into the City of St. Petersburg's Asset Management Program

Laura Baumberger, Robert Labrie, and Rebecca Overacre

The City of St. Petersburg (City) initiated an asset management program in 2008 to assist in documenting asset condition, criticality, and risk; provide data and justification to develop repair and replacement (R&R) funding needs; and support knowledge transfer among employees. While all City departments are migrating to the same asset management software, the approach and schedule for developing asset management programs varies throughout the City. This project focused on the City's Water Resource Department (WRD) remote wastewater and stormwater facility sites, including the City's 84 lift stations, four stormwater pump stations, and six alum chemical feed systems located at stormwater retention ponds. Rigorous condition inspections were performed at all facilities and included non-destructive testing using infrared thermography. After completion of the assessment process, inspection findings were loaded into the City's asset management software. The WRD is now using the asset management program developed during this project to prioritize R&R projects at the City's remote lift station and stormwater facilities.

Maintenance Management System Conversion

The City of St. Petersburg provides water and wastewater service to a population of approximately 250,000 residents throughout a 133 square mile service area. The City purchases potable water from Tampa Bay Water, in addition to treating groundwater at its Cosme Water Treatment Plant.

The City converted its work order, inventory, and maintenance management system to an Oracle Work and Asset Management (WAM) system in June 2008. Since that time, the WRD began integrating condition assessment information for its wastewater collection system gravity pipes and manholes into WAM in support of developing a comprehensive asset management program for the City's water, wastewater, and stormwater infrastructure. The City's next step was to develop a condition assessment program for its remote wastewater and stormwater facilities and then incorporate that information into WAM to assist in prioritizing R&R projects. The methodology, techniques, and technologies used for the remote facility condition inspections; development of an approach for assigning criticality to WRD assets; calculation of asset risk scores; and subsequent integration of this data into the City's asset management program are discussed.

Asset Management Overview

The overall goal of an asset management program is to optimize planning, operation and maintenance (O&M), and financial decisions for an organization's infrastructure. Asset management entails optimizing O&M costs and capital expenditures for the lowest total cost at an acceptable level of risk.

One of the primary functions of an asset management program is to serve as a framework for making, documenting, and justifying near- and long-term decisions on asset renewal and replacement. Developing an asset management program balances the requirements for asset maintenance against the eventual need for rehabilitation or replacement. An asset management program provides the basis for prioritizing the R&R projects and also serves as a communication tool—both internal and external—to an organization.

Asset management typically relies on an evaluation of asset risk in order to prioritize expenditures for asset rehabilitation or replacement. The risk of failure of an asset is calculated as the product of that asset's criticality and vulnerability scores. Risk is a calculated numerical value and is a relative indicator of priority or need for corrective or preventive actions. In a standard asset management program, the risk associated with each asset is calculated with the following equation:

Risk = Vulnerability X Criticality

The vulnerability metric reflects the "likelihood of asset failure." Vulnerability is primarily based on an asset's physical condition and/or remaining economic service life. Criticality describes the "consequence of failure." Criticality rankings are established to reflect the impact on level-of-service goals when an

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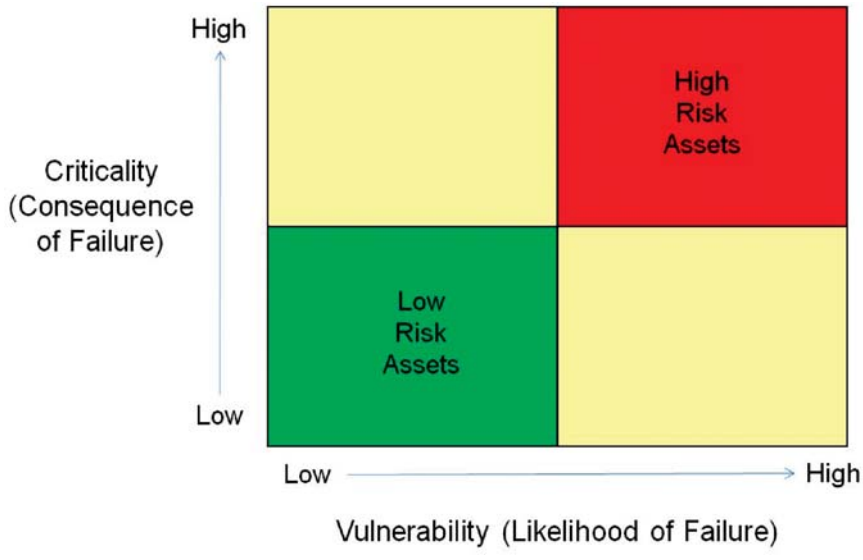

Laura Baumberger, P.E., is an associate with Carollo Engineers Inc. in Sarasota, Rebecca Overacre, P.E., is an associate with Carollo Engineers Inc. in Walnut Creek, Calif., and Robert Labrie is computer system coordinator with City of St. Petersburg Water Resources Division.

Table 1. Asset Types

Separate condition assessment templates with specific criteria relevant to 18 different asset types provided a detailed method for inspecting each type of asset.

- Building	-Pump	- Electrical
- Generator	- Meter	- Instrument
- Odor Control	-Valve	- Wetwell
- Site	- Tank	- Motor
- Fan	- HVAC	- Switchgear
- Transmitter	- VFD	- Safety Shower

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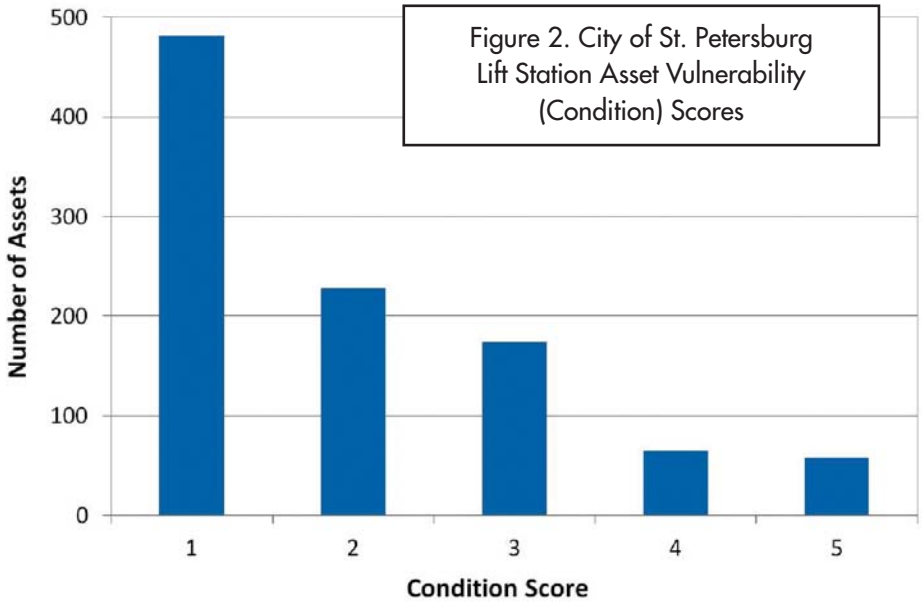
asset fails to meet its intended purpose. Criticality is often addressed in terms of environmental, social, or financial consequences. The criticality and vulnerability scoring criteria used by the City are discussed later. The schematic below illustrates the relationship among criticality, vulnerability, and risk.

Data Configuration

Carollo Engineers worked with the City to configure its WAM Asset Class Condition Assessment Module for each type of asset at the City's lift stations, stormwater stations, and alum feed stations. The project also included identifying which equipment (assets) should be included in the WAM database to ensure a complete asset inventory and to allow for appropriate asset classes, hierarchies, and rollup of information for reporting and management purposes. The system configuration identified specific items to inspect or evaluate during the condition assessments based on the equipment type and discipline (e.g., electrical, mechanical, or structural). The WAM module was programmed to house condition data and the defect scoring system described below, in addition to criticality and risk scores.

Figure 1. Pump Motors and Operating Temperature Gradient



Vulnerability Assessment

Asset failure can occur as the result of many factors, including inefficiency and obsolescence, as well as physical condition. This effort used a detailed condition assessment process to combine those factors into a single score to represent asset vulnerability. Separate condition assessment templates with specific criteria relevant to 18 different asset types (Table 1) were developed to provide a detailed method for inspecting each type of asset. This rigorous inspection method was designed to be thorough, eliminate bias, and improve repeatability and consistency. Although the inspections completed during this project were solely for wastewater lift stations and stormwater stations, the inspection templates for equipment common to other facilities will be used during future inspections at the City's water and wastewater treatment facilities.

A condition assessment was performed at each remote facility by a team that included both engineers and O&M staff. The inspection also was used as a training opportunity for City staff so they could continue to maintain the asset management program in the future. The condition assessment followed the detailed inspection template specific to each asset type. Pump shut-off head tests were completed at all lift stations as a component of the functionality testing of the pump assets. All valves were exercised to ensure operability. Operators started all equipment to check for noise, visually evident vibration, and abnormal heat. In addition to observed heat, infrared photographs of all electrical and electromechanical assets were taken in order to detect excessive operating temperatures.

Infrared thermography is a non-destructive testing method. Non-destructive testing technologies can detect substandard operating conditions prior to failure, such as corrosion, erosion, pitting, cracking and other flaws,

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damage, and degradation. Non-destructive technologies can also be used to confirm the quality of repairs and new installations, such as weld inspections, leak detection, rebar location, and coating inspections.

Although infrared thermography has been used in other industries for many years, this non-destructive testing technique is relatively new to the water and wastewater industry. Infrared thermography relies on temperature sensors to monitor thermal gradients and infrared photographs can identify operating temperatures, pipe leaks, and liquid levels in metal tanks, as well as damaged insulation. This technique was used in the City's condition assessments at lift stations to identify "hot spots" in operating temperatures of control panels, switchgears, generators, pump motors, and other electrical and electromechanical equipment. Figure 1 shows a group of pump motors and range of operating temperatures illustrated by an infrared photograph.

Table 2. Selected Matrix for Assigning Criticality Scores

Level of Service / Criticality Category	Weight	Negligible = 1	Low = 4	Moderate = 7	Severe = 10
Health and Safety for Public and Employees	30 percent	No injuries or adverse health effects	No lost-time injuries or medical attention	Lost-time injury or medical attention	Loss of life or widespread outbreak of illnesses
Financial Impact	15 percent	Absorbed within budget line item < $10,000	Absorbed within current budget with manager signature $10,000 to $100,000	Requires Council approval $100,000 to $250,000	May require transfer between departments, new borrowing, or impact rates > $250,000
Impact on Environment or Regulatory Compliance	25 percent	100% compliance with permits & no impact on environment	Violation but no enforcement action &/or minor impact on environment	Violation with minor enforcement action &/or moderate impact on environment	Enforcement action with fines &/or major impact on environment
Effect to Service and on Customers	20 perecent	No breaks, outages. or T&O complaints; No impacts on customers	Minor disruption, no breaks or outages, infrequent T&O complaints	Substantial disruption; short duration of breaks or outages; occasional T&O complaints	Long-term impact; area-wide disruption. Numerous breaks, outages; widespread T&O complaints
Ability to Respond and Return Asset to Service	10 percent	Redundant asset available or service restored in < 4 hours	Service restored in 4 to 24 hours	Service restored in 24 to 48 hours	Not able to restore service for > 48 hours

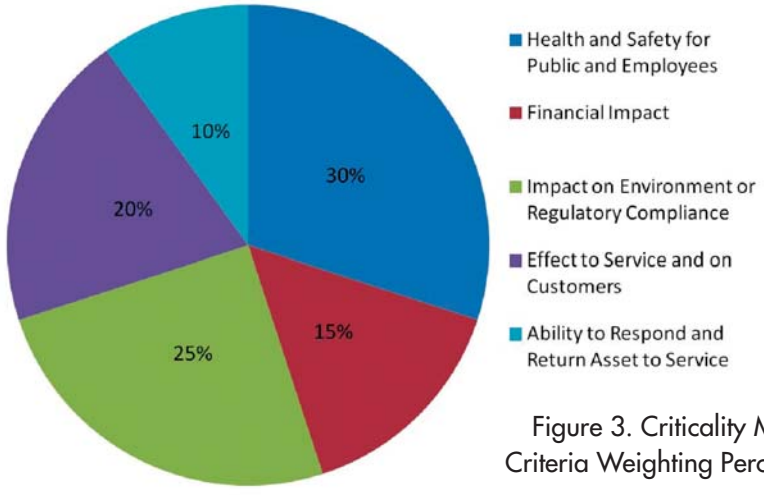

Figure 3. Criticality Matrix Criteria Weighting Percentages

Condition inspection data from the template for each asset were entered into WAM. The Condition Assessment Module included a system for weighting the type of defect, as well as severity of the defect, to determine an overall condition, or vulnerability, score for each asset. Calculations within WAM converted inspection results into industry standard condition scores adapted from the International Infrastructure Management Manual (IIMM). The IIMM classifies asset condition into one of five rankings: 1 – very good, 2 – good, 3 – fair, 4 – poor, and 5- very poor. Combining these scoring systems allowed the City to benefit from industry standard gradations as well as a detailed defect rating system customized to the City's assets.

The City's resulting vulnerability scores for lift station assets are illustrated in Figure 2. Although the City's lift station assets are primarily in very good or good condition (condition scores of 1 and 2, respectively), approximately 10 percent of their assets are classified as being in poor or very poor condition. The City will be taking appropriate steps to rehabilitate or replace these assets.

Criticality Assessment

Understanding the importance of criticality in overall risk score calculations, the City hosted a workshop with WRD staff at multiple levels to develop a scoring matrix for criticality. The WRD selected criticality categories based on typical industry standards and input from WRD staff to reflect relative importance to the agency. WRD selected five criticality categories including:

- Health and safety for public and employees
- Financial impact
- Impact on environment or regulatory compliance
- Effect on service and customers
- Ability to respond and return asset to service

Scores and weighting factors were established for each of the five categories listed. The scoring for each category ranged from 10 (severely critical) to 1 (not critical). Each category was assigned a weighting factor based on its relative importance. The selected matrix used for assigning criticality scores is summarized in Table 2 and shown in Figure 3. This criticality matrix will be used for all WRD assets as the asset management program continues to move forward.

Each asset was scored using the criticality matrix selected by the City. The City's resulting criticality scores for lift station assets are illustrated in Figure 4. The majority of individual

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Table 3. Lift Station #1 Risk Report

CONDITION ASSESSMENT ASSET TYPE	ASSET ID	DEFECT TYPE (INSPECTION CRITERIA)	DEFECT SEVERITY	COND RATING	COND SCORE	CRITICALITY	RISK
ELECTRIC	6269	JUNCTION BOX/CONDUIT	SEVERE CORROSION ON INTERNAL COMPONENTS	POOR	4	5	20
		JUNCTION BOX/CONDUIT	MINOR CORROSION ON CONDUIT				
		ELECTRICAL ENCLOSURE-CRTL PNL	CONTROL PANEL DOOR OPEN /CLOSE WITH NO OBSTRUCTIONS				
		ELECTRICAL ENCLOSURE-CRTL PNL	NO VISIBLE CORROSION				
		COMPONENTS-BREAKERS,RELAYS,WIR	DISPLAYS, HMIS, INDICATORS, OR METERS NOT FUNCTIONING				
		FUNCTIONALITY	FULLY OPERATIONAL				
GENERATOR	6528	OVERALL APPEARANCE	POOR	GOOD	2	6	12
		GENERATOR ENCLOSURE	SOME CORROSION				
		FUNCTIONALITY	FULLY OPERATIONAL				
		FASTERNS,BLTS,CAPS,WASHERS,ETC	SOME CORROSION				
		GENERATOR/ENGINE	SOME CORROSION ON FUEL TANK				
		GENERATOR ENCLOSURE	SOUND ATTENUATION INSULATION DAMAGED				
		GENERATOR ENCLOSURE	SOME CORROSION				
		GENERATOR ENCLOSURE	DOOR HARDWARE OR LOCKS IN POOR CONDITION				
PUMP	5881	PAINTING/COATING	SHOWING WEAR	POOR	4	4	16
		PUMP BODY	EXCESSIVE CORROSION				
		PUMP OVERALL	POWER CORDS CUT, CRACKED, OR DAMAGED-SUBMERSIBLE PUMPS ONLY				
		FASTERNS,BLTS,CAPS,WASHERS,ETC	EXCESSIVE CORROSION				
		FUNCTIONALITY	FULLY FUNCTIONAL				
SWITCHGEAR	6151	SWITCHGEAR CABINETS	EXCESSIVE CORROSION	POOR	4	5	20
		SWITCHGEAR CABINETS	ENCLOSURE INTERIOR DIRTY				
		SWITCHGEAR CABINETS	ARC FLASH SAFETY LABELS NOT PRESENT				
		SWITCHGEAR	LAMPS OUT				
		SWITCHGEAR CABINETS	CONTROL PANEL DOOR OPEN/CLOSE WITH NO OBSTRUCTIONS				
		FUNCTIONALITY	FULLY OPERABLE				
VALVE	4205	PAINT/COATING	SHOWING WEAR	AVERAGE	3	2	6
		VALVE BODY	SOME CORROSION				
		VALVE OPERATOR	SOME CORROSION				
		FUNCTIONALITY	FULLY OPERABLE				
		FASTERNS,BLTS,CAPS,WASHERS,ETC	SOME CORROSION				
	4730	FUNCTIONALITY	LIMITED ROTATION OR DIFFICULT TO OPERATE	POOR	4	2	8
		FASTERNS,BLTS,CAPS,WASHERS,ETC	SOME CORROSION				
		VALVE OPERATOR	SOME CORROSION				
		PAINT/COATING	SHOWING WEAR				
		VALVE BODY	SOME CORROSION				
WELL	620247	PIPING INSIDE WETWELL	EXCESSIVE CORROSION	POOR	4	5	20
		WET/DRY WELL	SPALLING CONCRETE				
		INTERIOR COATING/PAINT	GOOD				
		HATCH	SOME CORROSION				
		PIPING INSIDE WETWELL	PAINT EXCESSIVELY WORN OR NOT PRESENT				

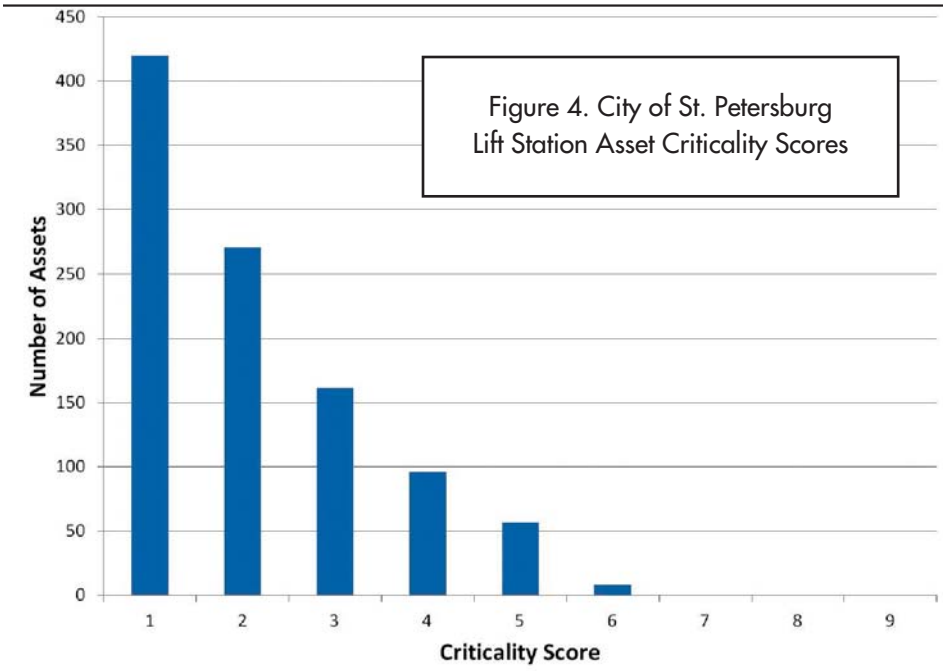

Figure 4. City of St. Petersburg Lift Station Asset Criticality Scores

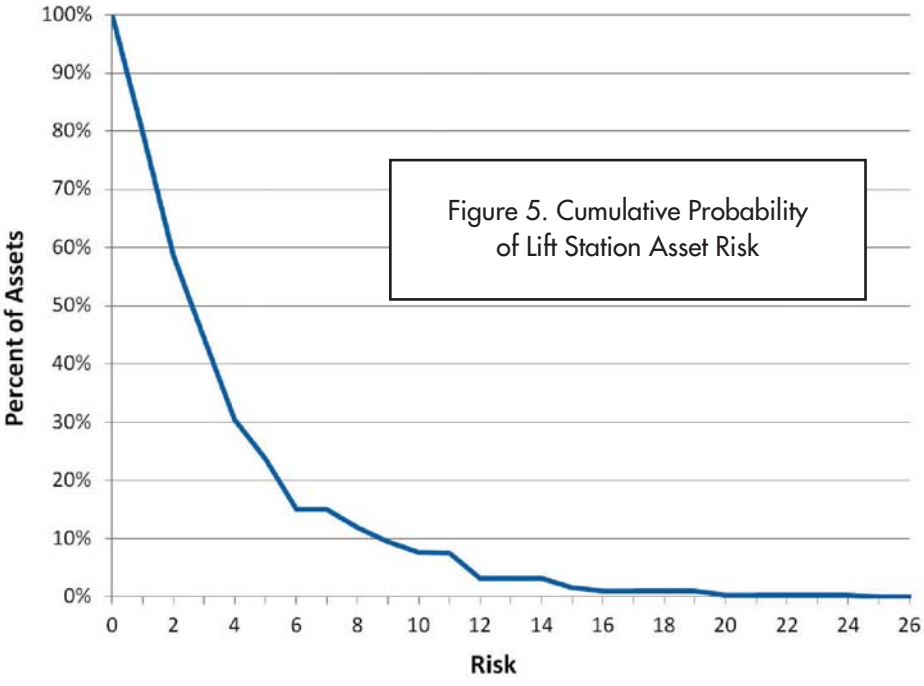

Figure 5. Cumulative Probability of Lift Station Asset Risk

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lift station assets are considered to have negligible to low criticality, with only 6 percent of assets having low to moderate criticality (scores of 5 to 6).

Risk Assessment

After completion of the criticality and condition assessment process, the inspection findings were loaded into the WAM Condition Assessment Module. An inspection report providing a listing of each inspection criteria (defect type), inspection results (defect severity), and scores was created in WAM. The report included each asset's criticality rating and overall risk score. Table 3 provides an example of an inspection report for a number of assets in varying condition at one of the City's lift stations.

The assets were sorted based on their risk scores to provide a prioritized list for further evaluation and development into R&R projects. Assets with the highest risk will be addressed first by the City's planning, engineering, and O&M staff. The cumulative probability of risk scores for the City's lift station assets is illustrated in Figure 5.

Next Steps

The City plans to use the asset risk scores developed during this project to prioritize R&R projects at the City's wastewater lift stations and stormwater stations. Operations and maintenance staff will also monitor performance and condition of high-risk assets and implement aggressive preventative maintenance until R&R projects can be completed.

The next major step in the City's asset management program is to perform condition and criticality assessments at its water and wastewater treatment facilities. The City plans to initiate these assessments during 2013.