



# Condition Assessment and Rehabilitation of Pumps, Valves, and Meters

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# Agenda

- Asset Management Strategies (Risk Based)
- Condition Assessment
  - Approaches
  - Field Investigation Technologies
    - Thermography
    - Vibration
    - Ultrasonic
- Rehabilitation Approaches

# Safety Moment



Greenwood Neighborhood (Seattle, WA)  
March 14<sup>th</sup> Heavy Windstorm

+250K without power

Felled trees and powerlines can start a fire quickly in a windstorm.

Emergency services may be delayed in such a widespread event.

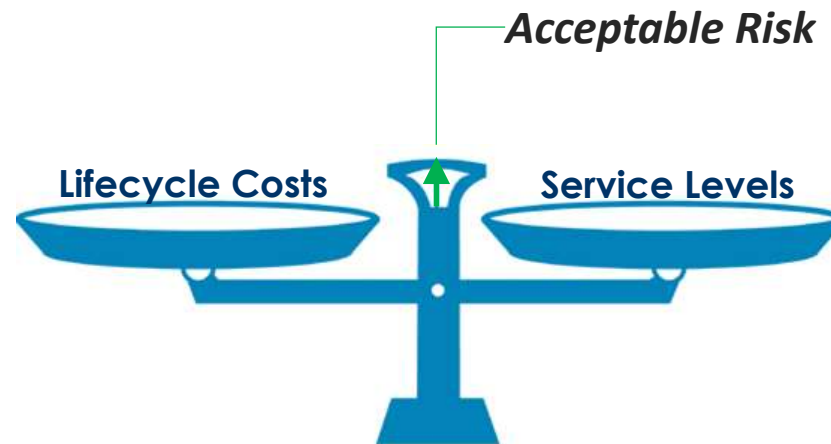
Proper maintenances of urban canopy trees by certified arborists can greatly reduce the likelihood of accidental tree falls.

## **Effective Asset Management is:**

*An integrated set of processes to minimize the life-cycle costs of owning, operating and maintaining assets, at an acceptable level of risk, while continuously delivering established levels of service*

# Balancing Act...

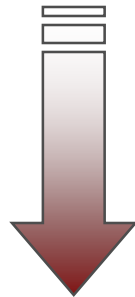
*An integrated set of processes to minimize the lifecycle costs of infrastructure assets, at an acceptable level of risk, while continuously delivering established levels of service.*



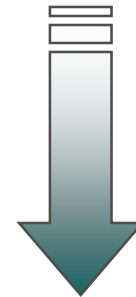
**Balance conflicting goals by managing risk**

Risk is quantified by the classic equation.

$$\text{Risk} = (\text{consequence} \times \text{likelihood})$$

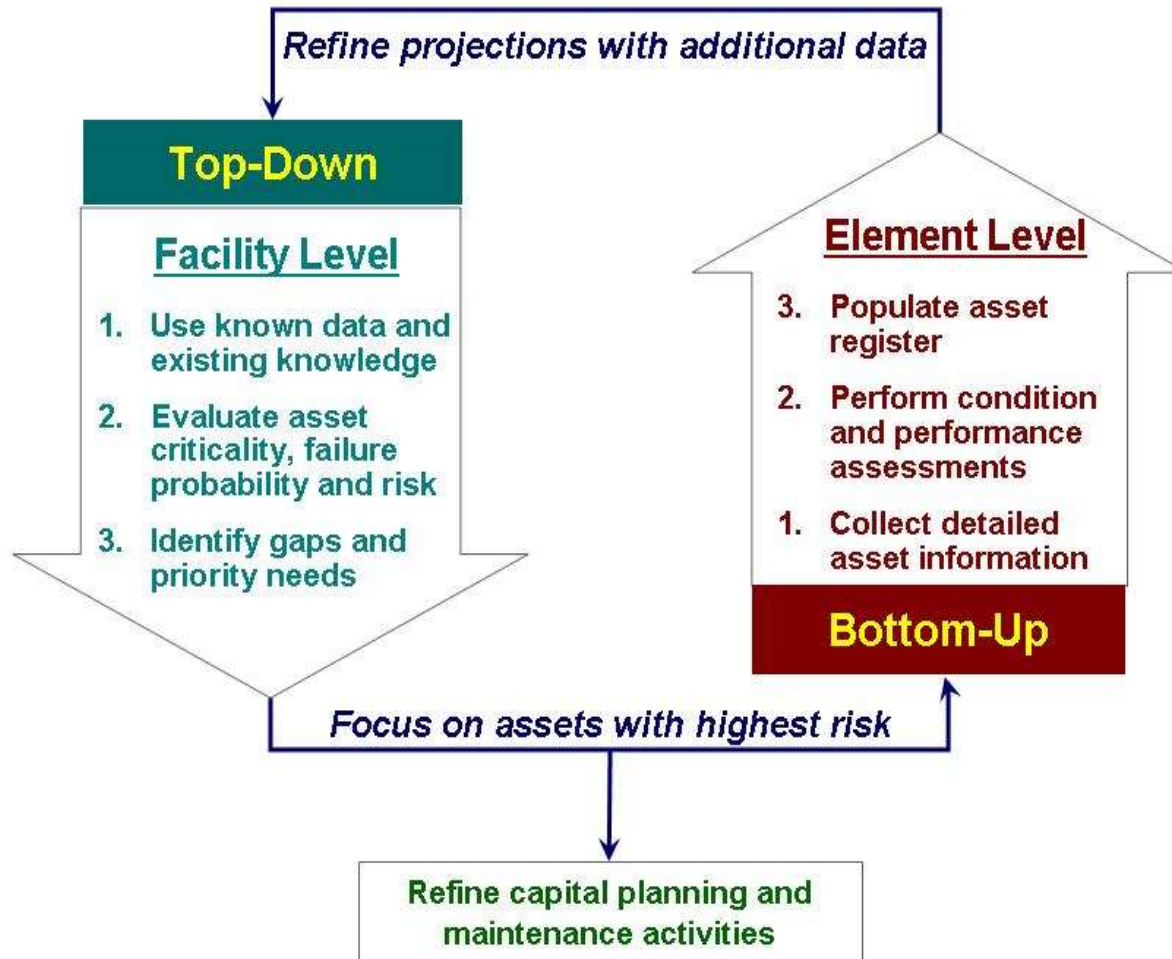


***How severe are the consequences of asset failure?***



***How likely is it for the asset to fail?***

# Top Down Bottom Up Approach



# Understanding the risk of asset failure provides...

- The basis prioritizing capital investments for R&R
- The basis for optimizing O&M
- The basis for investing in condition assessments
- A uniform and rigorous manner that results in defensible decisions





# Risk Based Approach

## Quantified by using the classic risk equation

$$\text{Risk} = (\text{consequence} \times \text{likelihood})$$



*How severe are the consequences of asset failure?*

- Levels of Service*
- Health & Safety implications
  - Financial impact
  - Regulatory compliance
  - Public confidence
  - Service delivery



*How likely is it for the asset to fail?*

- **Condition**
- O&M Protocols
- Performance

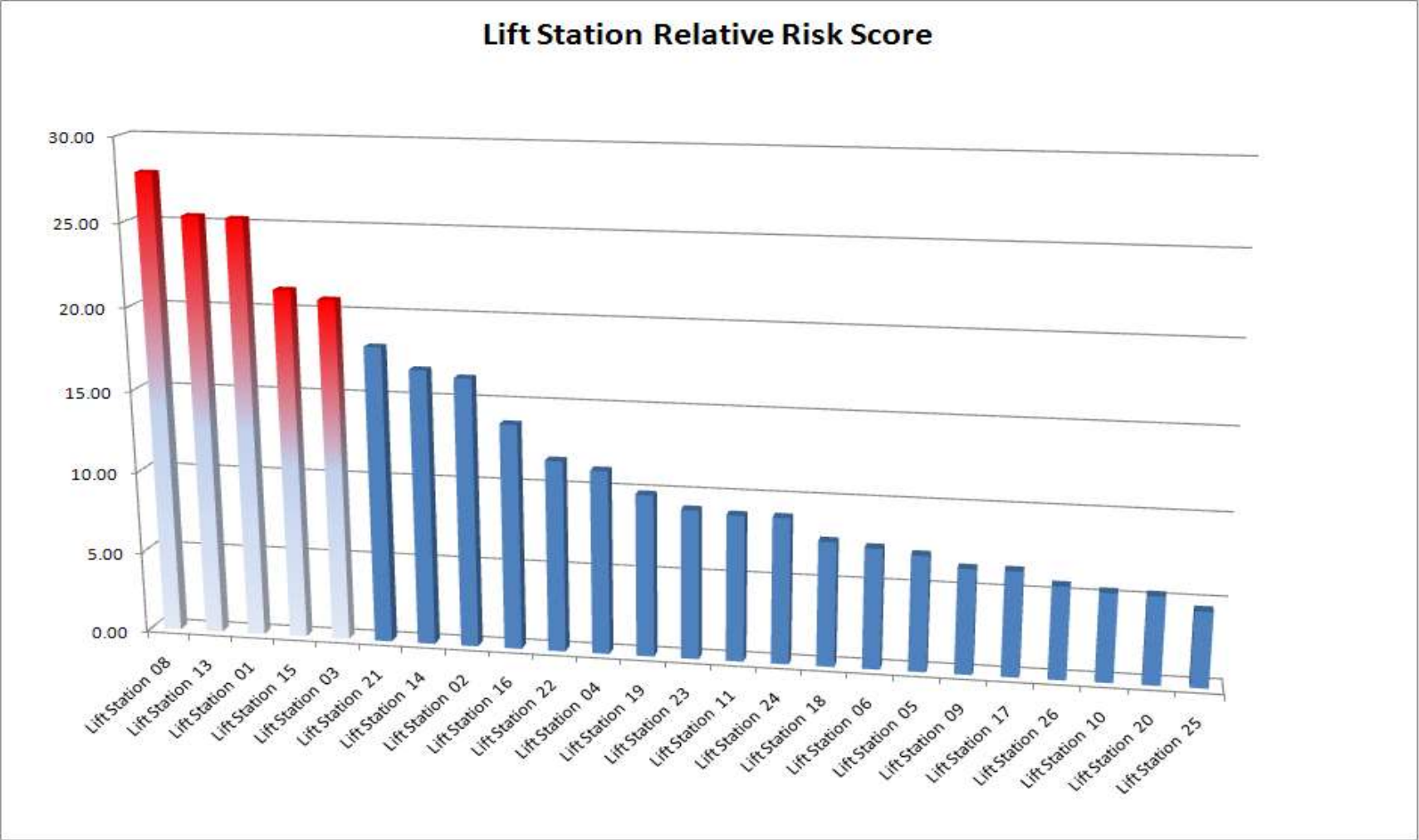
# Consequence of Failure Matrix

Consequence by Level of Service Category					
LOS Category	Wt.	Negligible = 1	Low = 4	Moderate = 7	Severe = 10
Safety of public and employees	30%	No injuries or adverse health effects	No lost-time injuries or medical attention required	Lost-time injury or medical attention required	Loss of life or widespread outbreak of illness
Financial impact	15%	Can be repaired within Utility budget (<\$2,500)	Can be repaired between \$2500 and \$9,999	Can be repaired between \$10,000 to \$29,000.	Greater than \$30,000. Sealed bids and City Council approval required
Public confidence	10%	No social or economic impact on the community. No reactive media coverage. Any media coverage is a result of proactive announcements by Utility. No complaints.	Minor disruption (e.g., traffic, dust, noise, water pressure). No adverse media coverage. Some complaints.	Substantial but short-term disruption. Adverse media coverage due to public impact. Localized media coverage.	Long-term impact. Area-wide disruption. Regional media coverage.
Regulatory compliance	25%	No State or local permit violations . No SSO's	Possible technical violation	Probable enforcement action, but fines or surcharge unlikely	Enforcement action with fines or surcharge
Service Delivery	20%	No impact	Minor impact to process or out of service less than 24 hours. No SSO's or loss of service	Major impact to process, out of service <24 hours. Potential SSO or loss of service	Major impact to process, out of service >24 hours, outside services required, SSO' or loss of service

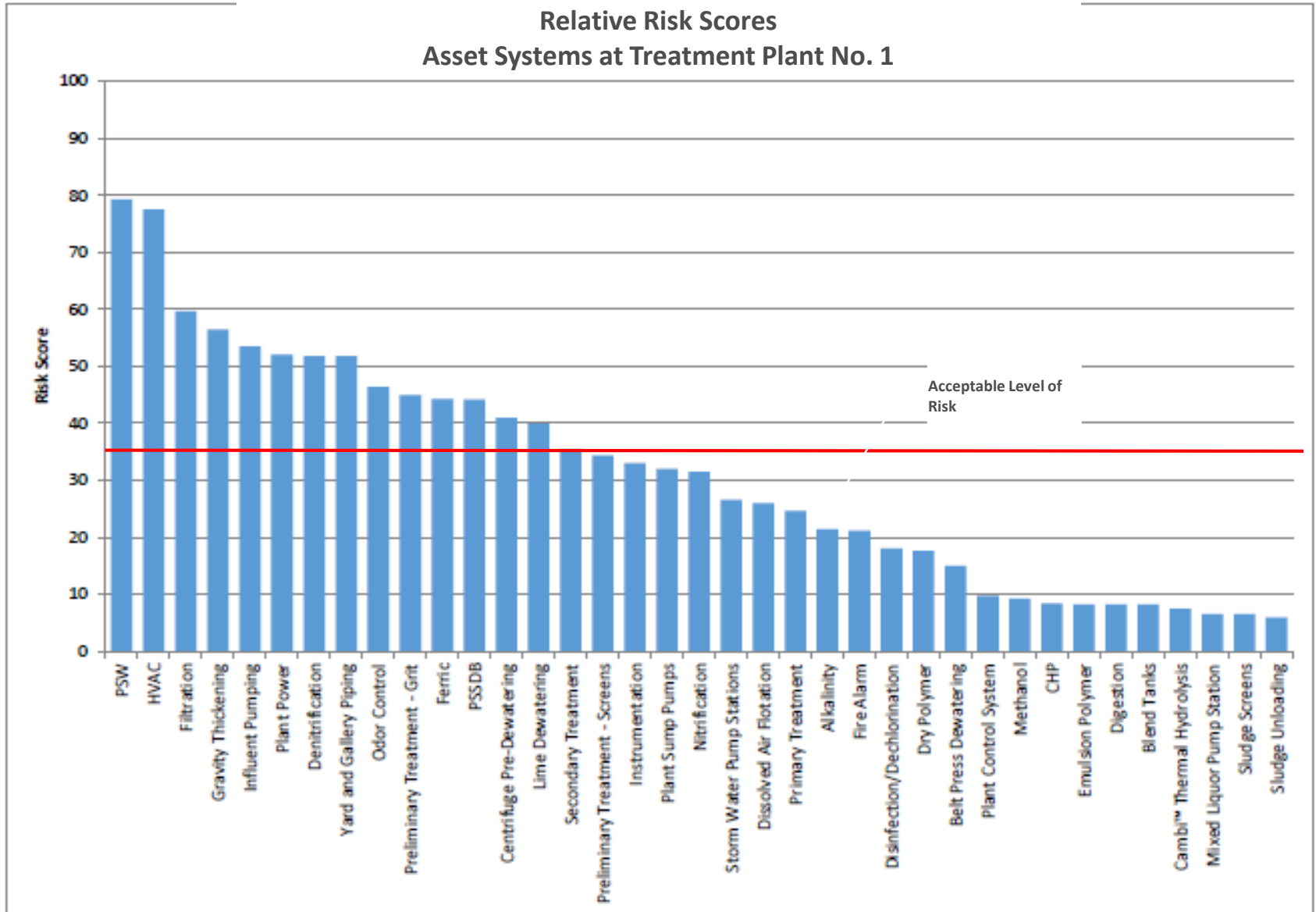
# Likelihood Matrix

Likelihood by Category						
Likelihood Category	Wt	Negligible = 1	Unlikely = 3	Possible = 5	Likely = 7	Very Likely = 10
Physical Condition	65%	Very good. Condition Grade 1. New or nearly new. Only normal maintenance required.	Good. Condition Grade 2. Minor wear.	Fair. Condition Grade 3. Major wear impacting level of service.	Poor. Condition Grade 4. Unable to meet level of service life. Failure imminent.	Very poor. Grade 5. Requires complete rehabilitation or replacement. Failed.
O&M Protocols (i.e., PMs, SOPs, JSAs) staffing skill level	5%	Complete, up-to-date, written, easily accessible and is being used.	Complete, written, up-to-date, being used but not easily accessible.	Partially developed	Written, but out-date and not used.	No written protocols.
Performance	20%	Sufficient capacity to meet average and peak flow requirements. Appropriate utilization and function.	Under-utilized or oversized, causing O&M issues.	Sufficient capacity, but does not meet functional requirements, or over-utilized.	Able to meet current average capacity demand, but not peak demands.	Unable to meet current average capacity needs.
Reliability	10%	No corrective work order events within 12 months	<2 corrective work order events within 12 months	2-5 corrective work order events within 12 months	6-8 corrective work order events within 12 months	>8 corrective work order events within 12 months

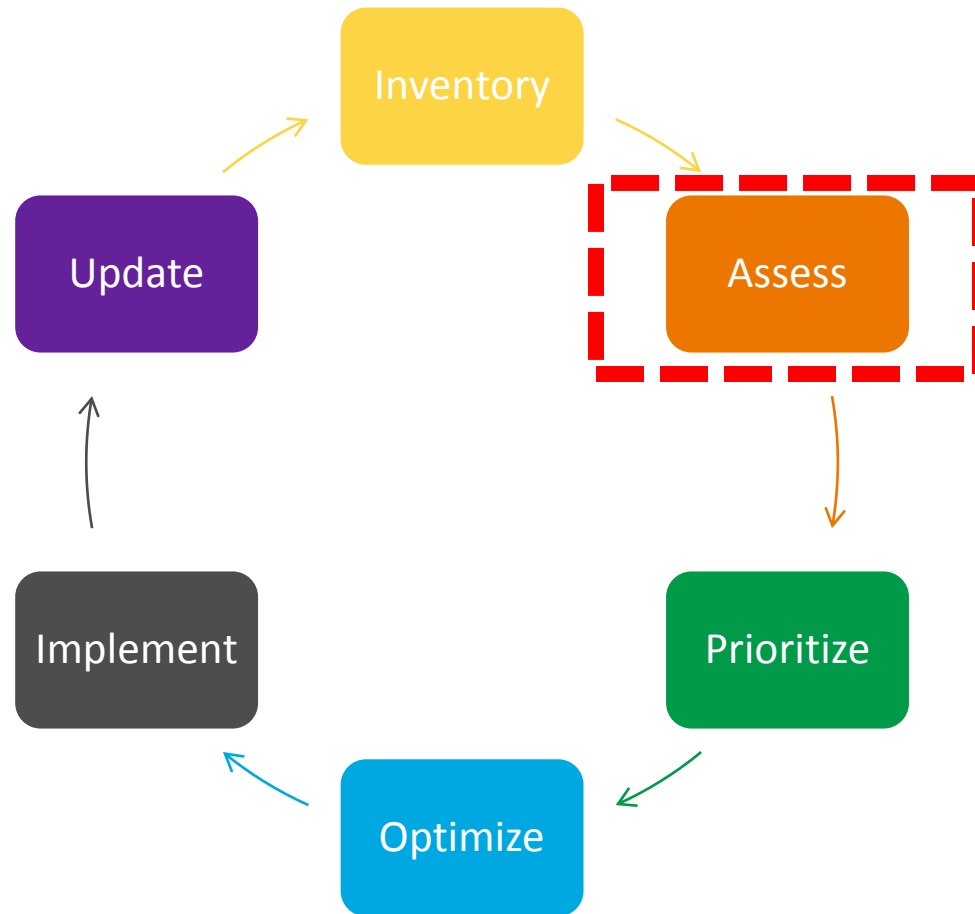
# Example Risk Profile by area



# Example Risk Profile by asset



# The Role of Condition Assessment in Asset Management



# Use risk levels to prioritize detailed assessments

**Pump Condition Assessment Form**

Date \_\_\_\_\_ Assessor \_\_\_\_\_  
 Entity ID \_\_\_\_\_ Entity Class \_\_\_\_\_  
 Entity Description \_\_\_\_\_  
 Site \_\_\_\_\_ Facility \_\_\_\_\_  
 Picture Number \_\_\_\_\_

	Yes	No	NA	Yes	No	NA
Timing of Inspection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Oil OK at Inspection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
All Safety Guards Present	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Acceptable Sound or Heat	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Oil Level within Range	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Absence of Pump Cavitation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Note: Check the box of the parameter that apply.

	Rating 1	Rating 2	Rating 3	Rating 4	Rating 5	Rating 6
<input type="checkbox"/> (1) Corrosion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> (2) Packing Seal/Leak	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> (3) Bearing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> (4) Oil Seal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> (5) Pul	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**FIRST STAGE PUMPING STATION**

Equipment \_\_\_\_\_  
 Condition Assessment Group Rating: 1.8



Overall Condition:  
 Generally the pumps in this facility are in good condition with the exception of the comments noted in this section.

Exceptions:  
 Isolation valves on the following pumps could not be closed as part of the assessment to see if they still function the pumps connected to them relative to their operation:

- 12830 HORIZONTAL SPLIT CASE PUMP P3E
- 12845 HORIZONTAL SPLIT CASE PUMP P3E
- 12846 HORIZONTAL SPLIT CASE PUMP P3E
- 12844 HORIZONTAL SPLIT CASE PUMP P3E

Safety:  
 The following pumps had exposed shaft between the seal and bearing:

- 12830 HORIZONTAL SPLIT CASE PUMP P3E
- 12845 HORIZONTAL SPLIT CASE PUMP P3E
- 12846 HORIZONTAL SPLIT CASE PUMP P3E
- 12844 HORIZONTAL SPLIT CASE PUMP P3E

AND the following pumps had no upper shaft guards installed:

- 12876 VERTICAL TURBINE PUMP (P3A)
- 12880 VERTICAL TURBINE PUMP (P3B)
- 12886 VERTICAL TURBINE PUMP (P3E)
- 12888 VERTICAL TURBINE PUMP (P3E)

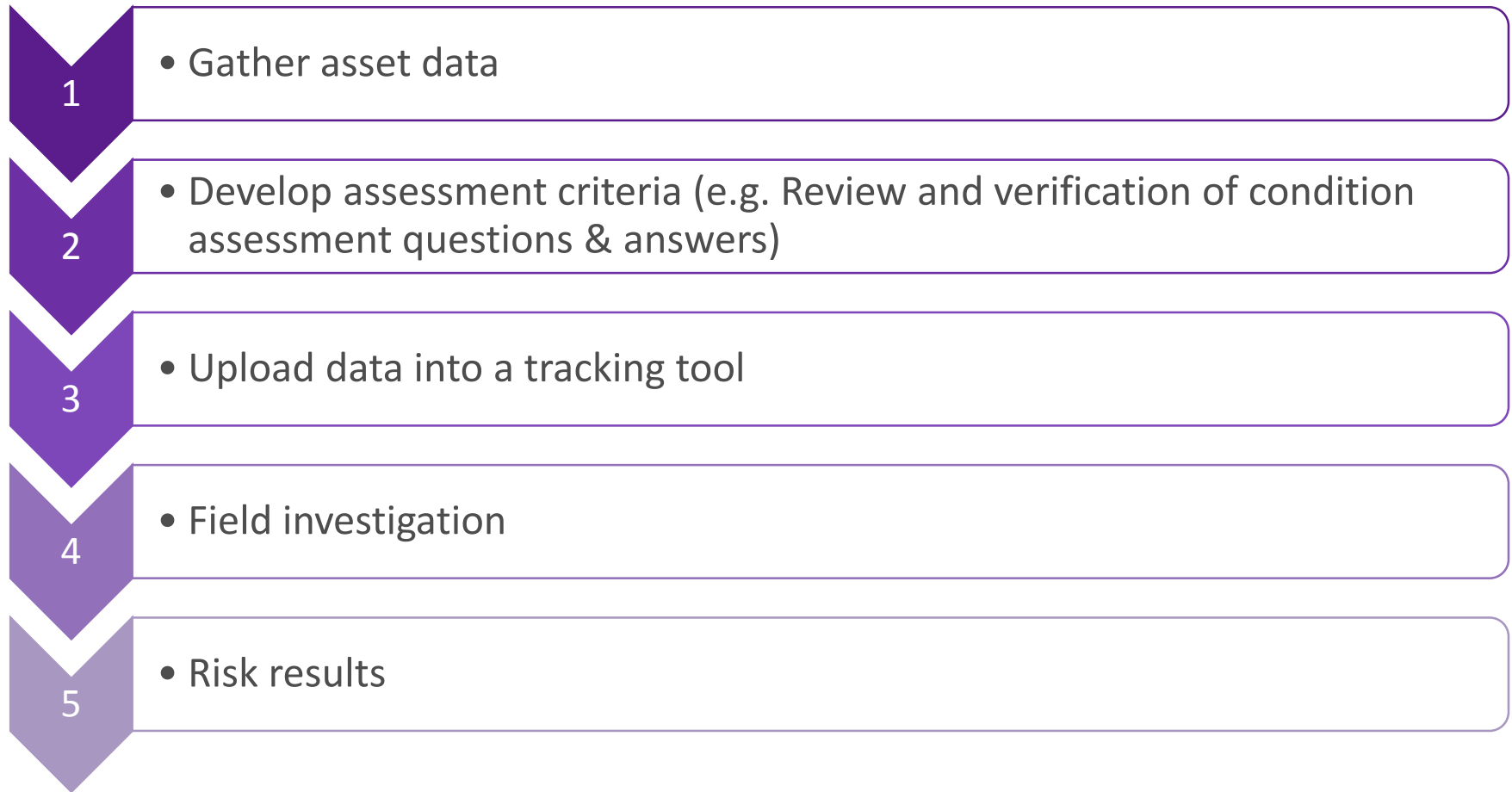


COMMENTS



- Re-score likelihood of failure based on updated field information
- Recalculate risk

# Condition Assessment is step-by-step process





# Asset Data Gathering

- Assets and their characteristics need to be captured
- Easiest method is to obtain from EAM/CMMS database
- “Walking down” assets is a critical step

# Criteria development

- We must ask and answer some predefined questions that relate to the equipment condition.
- Questions are grouped by asset type. (e.g. All *pumps* will have the same question and answer group.)
- Each answer is rated from 1 to 5 with 1 being excellent and 5 being un-serviceable.
- Predictive Maintenance (PdM) Technologies

Asset Type	UPS		
	Question	Condition Weight	Overriding?
	Absence of Burn Marks	1	
			1
			5
	Acceptable Noise	1	
			1
			5
	Acceptable Smell or Heat	1	
			1
			5
	All Components	1	
			1
			5
	All Safety Features Present	1	
			1
			5
	Control Switches	1	
			1
			3
			5
	Good Housekeeping	1	
			1
			5
	Monitoring Panel	1	
			1
			2
			3
			4
			5
	Obsolescence	1	
			1
			3
			5

# Asset and Risk Upload

- Data gathered is entered into a tool for tracking.
- Once the data is uploaded, field devices are shipped to the job site.



# Assessment data is captured in the field

CONTROL PANEL, Pump Control Panel

General Condition Questions Risk Questions Photos and Documents

Save Changes Cancel

Question	Answer	N/A	Flag	Comment
Absence of Burn Marks	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Acceptable Noise	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Acceptable Smell or Heat	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
All Components	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
All Safety Features Present	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Good House Keeping	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Good Wire Labeling	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Grounding	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Operating at Inspection	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Proper Drawings Accessible	<input type="radio"/> yes <input type="radio"/> no	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Appearance (Carbon Dust)	<input type="text"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Control Gauges (Hour Meters Volts & Amps)	<input type="text"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Control Lamps	<input type="text"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Control Switches	<input type="text"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Corrosion - Structural Metals	<input type="text"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Infrared	<input type="text"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Installation	<input type="text"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>
Main Breaker	<input type="text"/>	<input type="checkbox"/>	<input type="text"/>	<input type="text"/>

Internet

# Condition Assessment Technologies

## Visual/Audio

- SOP Checklists

## Mechanical

- Torque wrench
- Calipers
- Pit-depth gauge, etc.

## Electrical

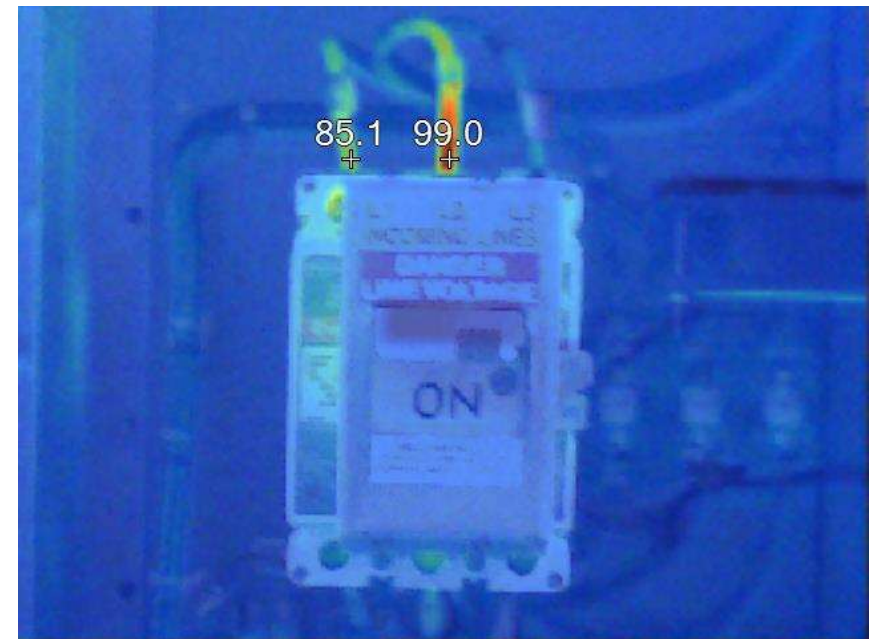
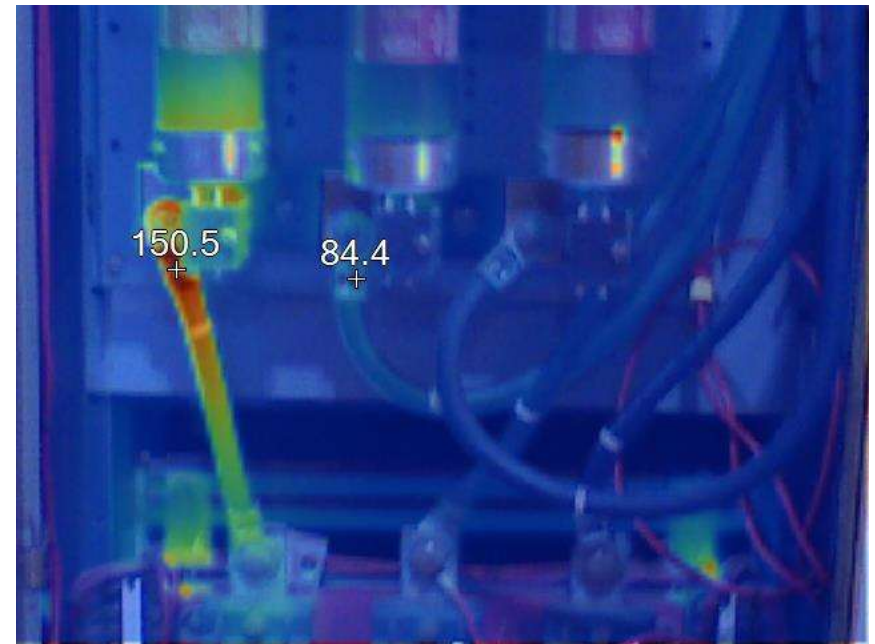
- Multi-meter
- “Meggar”, etc.

## Specialty...



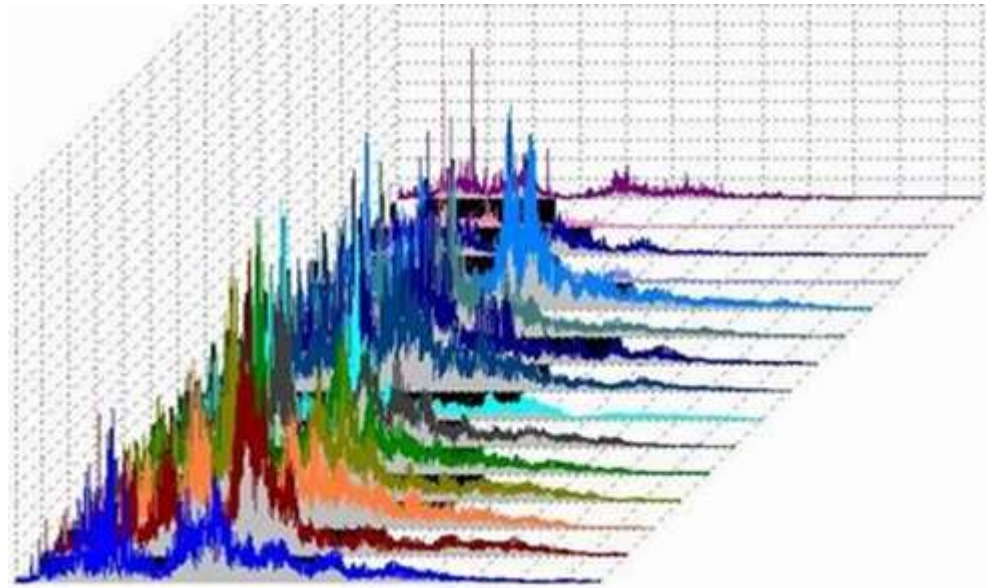
# Thermography

- Versatile technology
- Low cost for equipment
- Training is significant
- Most common uses
  - Electrical
  - Mechanical
  - Structural
  - Security
  - Health



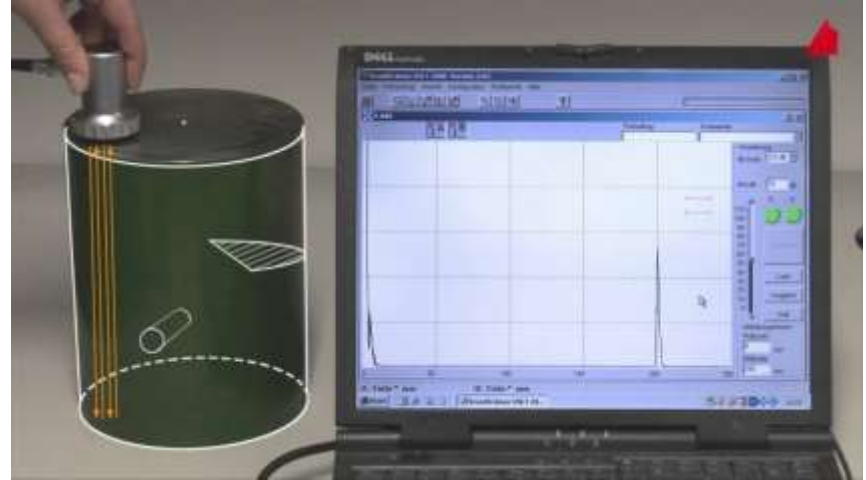
# Vibration

- Most common PdM tool in use
- Significant investment for training/certification
- Must trend data for effective use



# Ultrasonic

- Common uses
  - Electrical corona, tracking, arcing
  - Compressed gas leaks
  - Vessel integrity
  - Pipe wall thickness
  - Material defects





# Condition Data Updates the Risk Register and is Used to Identify Risk Reduction Measures

## Reduce Likelihood

- Rehabilitation
- Replacement
- Operating procedures
- Maintenance procedures

## Reduce Consequence

- Demand management
- Reduce LOS & educate
- Improve response & recovery
- Add redundancy

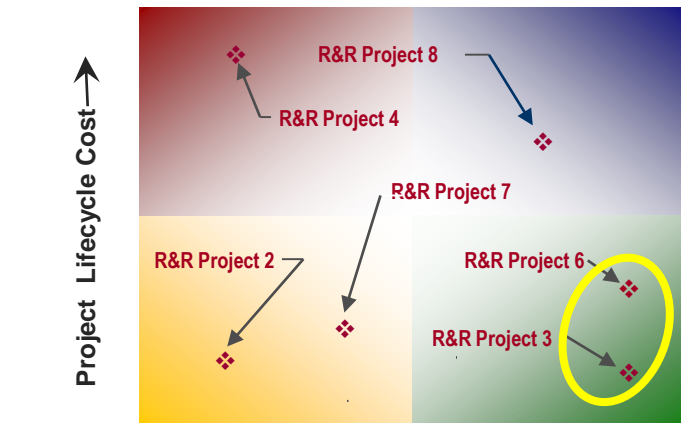
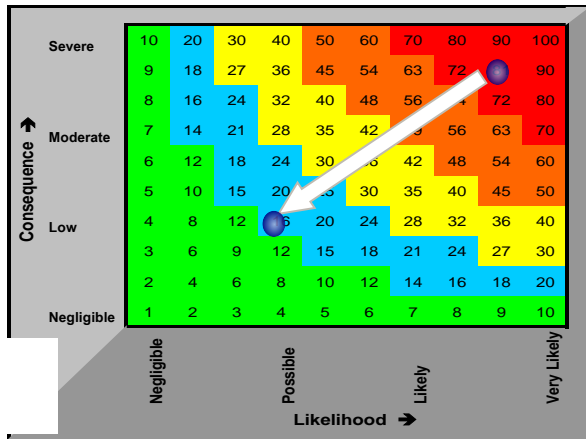
# Approaches to Rehabilitation/Maintenance

- Corrective Rehab/Maintenance
  - Repair work conducted after a failure or breakdown.
- Preventive Rehab/Maintenance
  - A specified list of inspections, cleaning, testing, and part replacement during a pre-defined, time-based schedule.
- Predictive Rehab/Maintenance
  - Schedule based on diagnostic evaluations. Also factors in equipment age, environmental stresses, criticality of equipment, (etc.) in order to decide on schedule.



# Options are ranked and optimum is chosen

Assess risk reduction for identified options



Rank options by:  
Risk Reduction  
Cost

# In a nut shell.....

- Define your levels of service
- Characterize your risk exposure
- Optimize your rehab/maintenance strategy

Call a certified arborist and trim your trees. Today.

