

Existing Steel Reservoirs – Retrofit or Build New?

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Overview

- Typical Scenario
- Comprehensive Reservoir Evaluation
- Recoating Considerations
- Seismic Considerations
- Other Considerations
- Compare to New Reservoir Alternative
- Examples
- Final Thoughts



Typical Scenario

- Steel reservoir built 20-30+ years ago
- Ground supported or elevated
- Coating system due for recoating

How to proceed?



Comprehensive Reservoir Evaluation

- Coating Evaluation
- Seismic Evaluation
- Safety and access
- Other Improvements

How much will it cost?

How does that cost compare to a new reservoir?



Reservoir Evaluations

Goals:

- Define required and desired improvements
- Collect information as needed to develop an accurate cost estimate for improvements



Reservoir Evaluations - Coatings

Failure Types



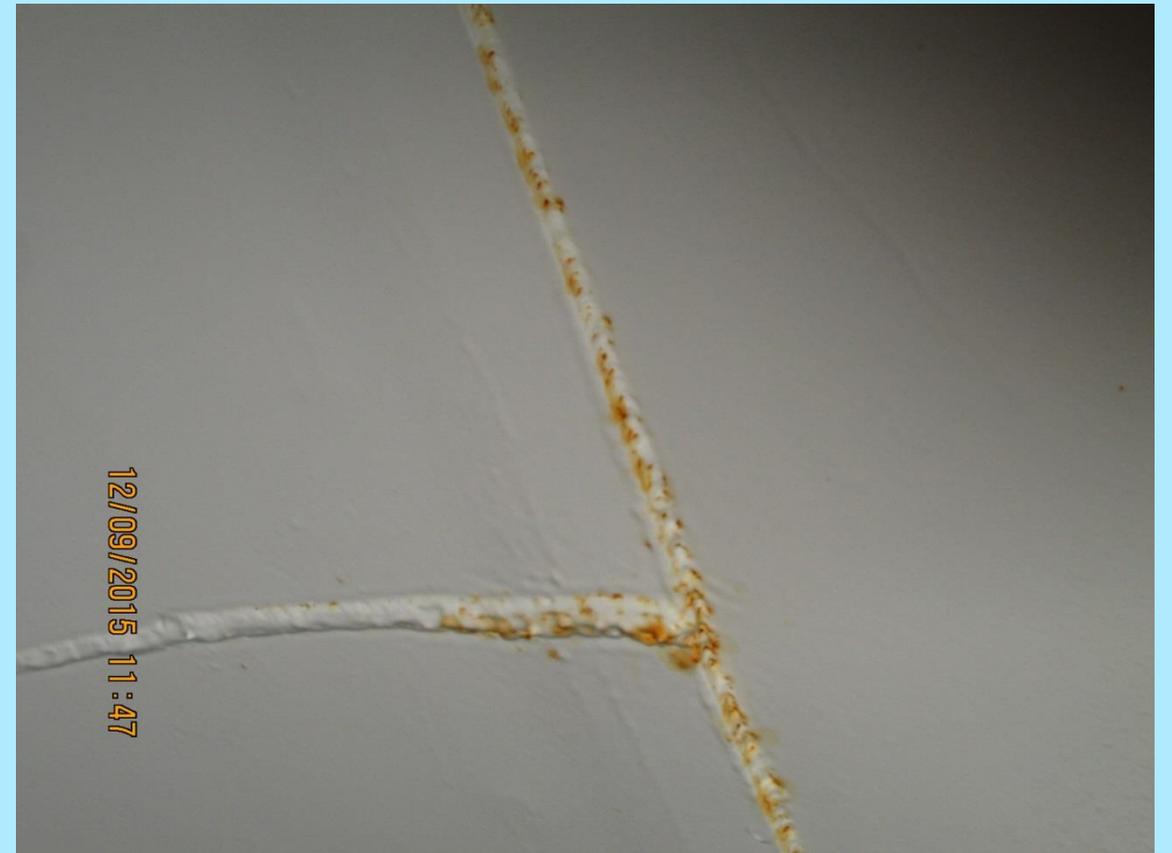
Reservoir Evaluations - Coatings

Failure Types



Reservoir Evaluations - Coatings

Failure Types

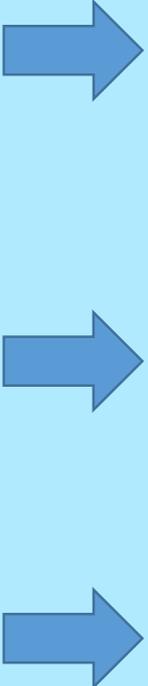


Reservoir Evaluations - Coatings

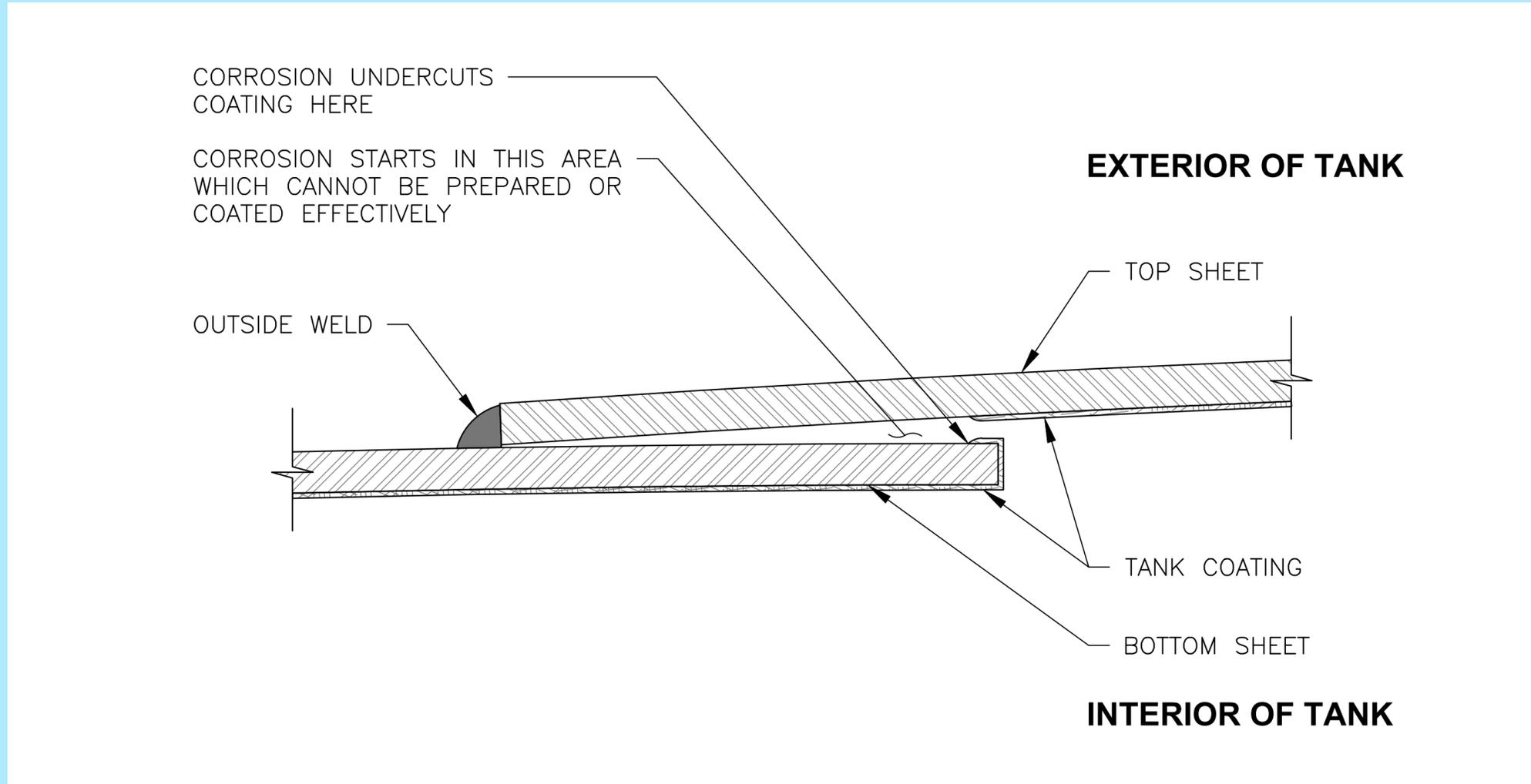
Failure Types



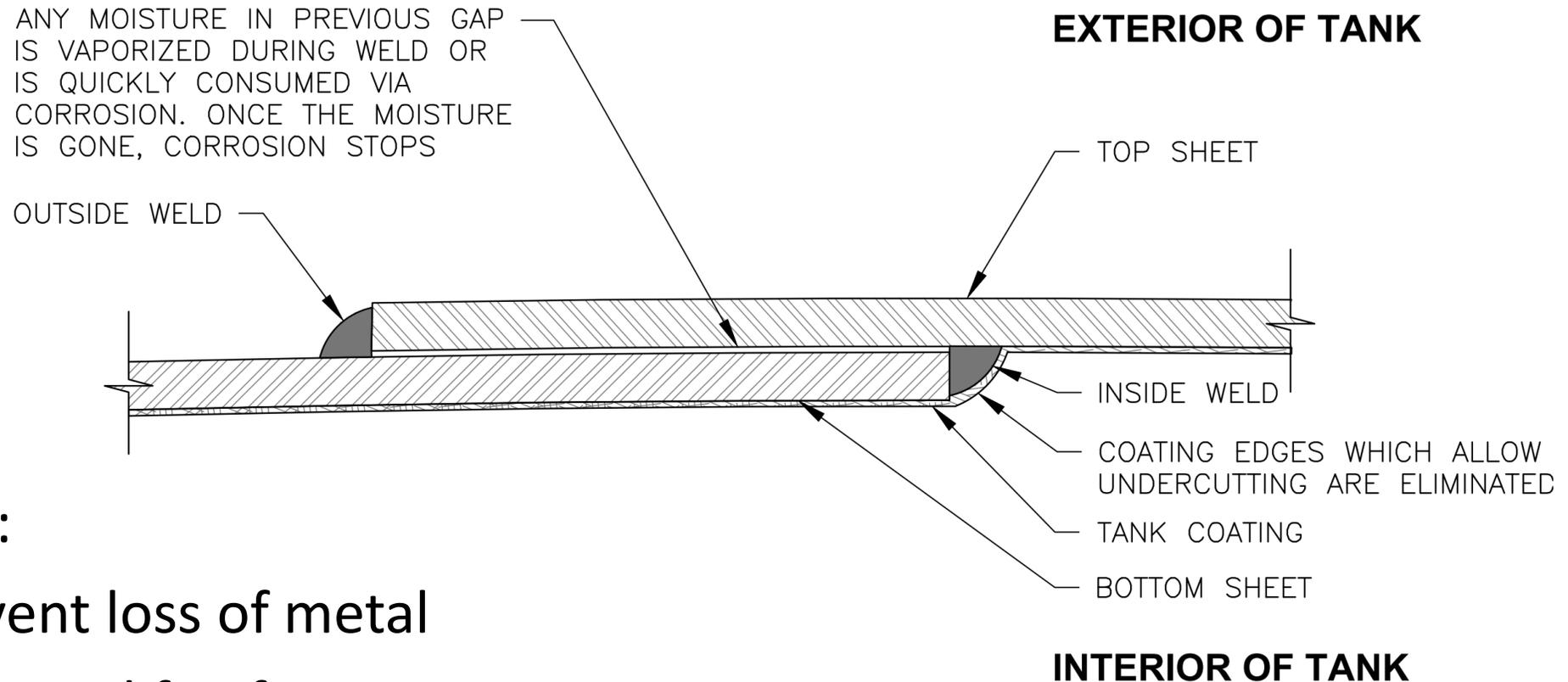
Reservoir Evaluations - Coatings

- Pull-off adhesion tests
 - Visual inspection by NACE certified personnel
 - Test for RCRA 8 metals
 - Visual inspection by structural engineer
- 
- Integrity of existing coatings
 - Containment and disposal requirements
 - Corrosion damage

Coating Considerations – Not Seal Welded



Coating Considerations – Seal Welded



Goals:

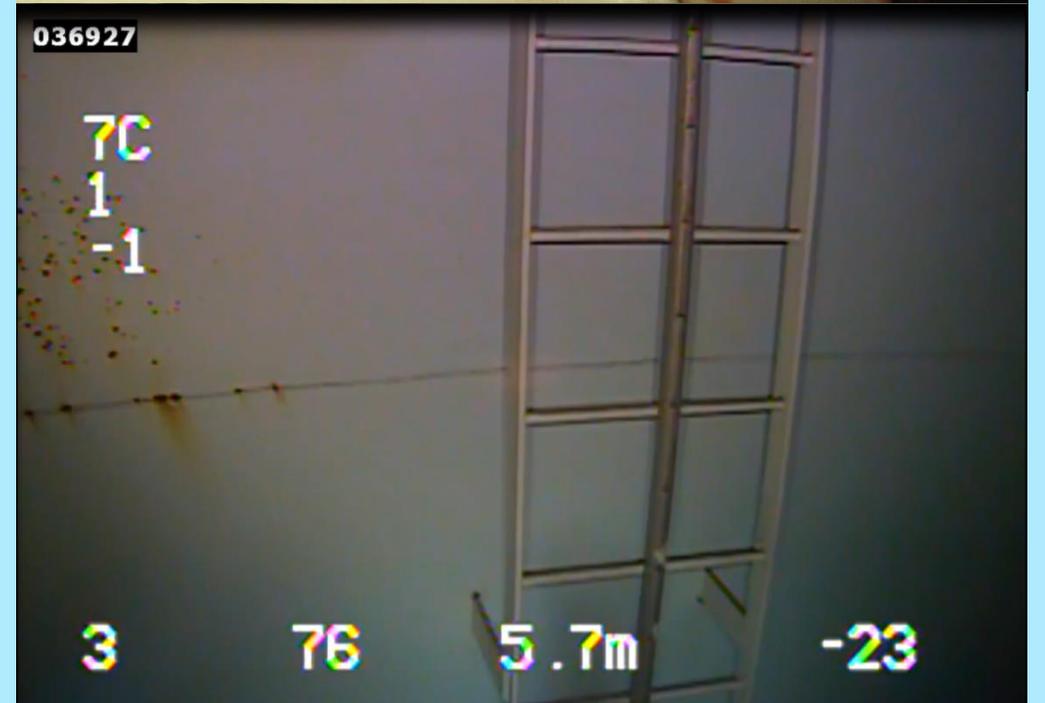
- Prevent loss of metal
- Increase life of coating system

Coating Considerations

How to evaluate areas that are difficult to access?

Examples:

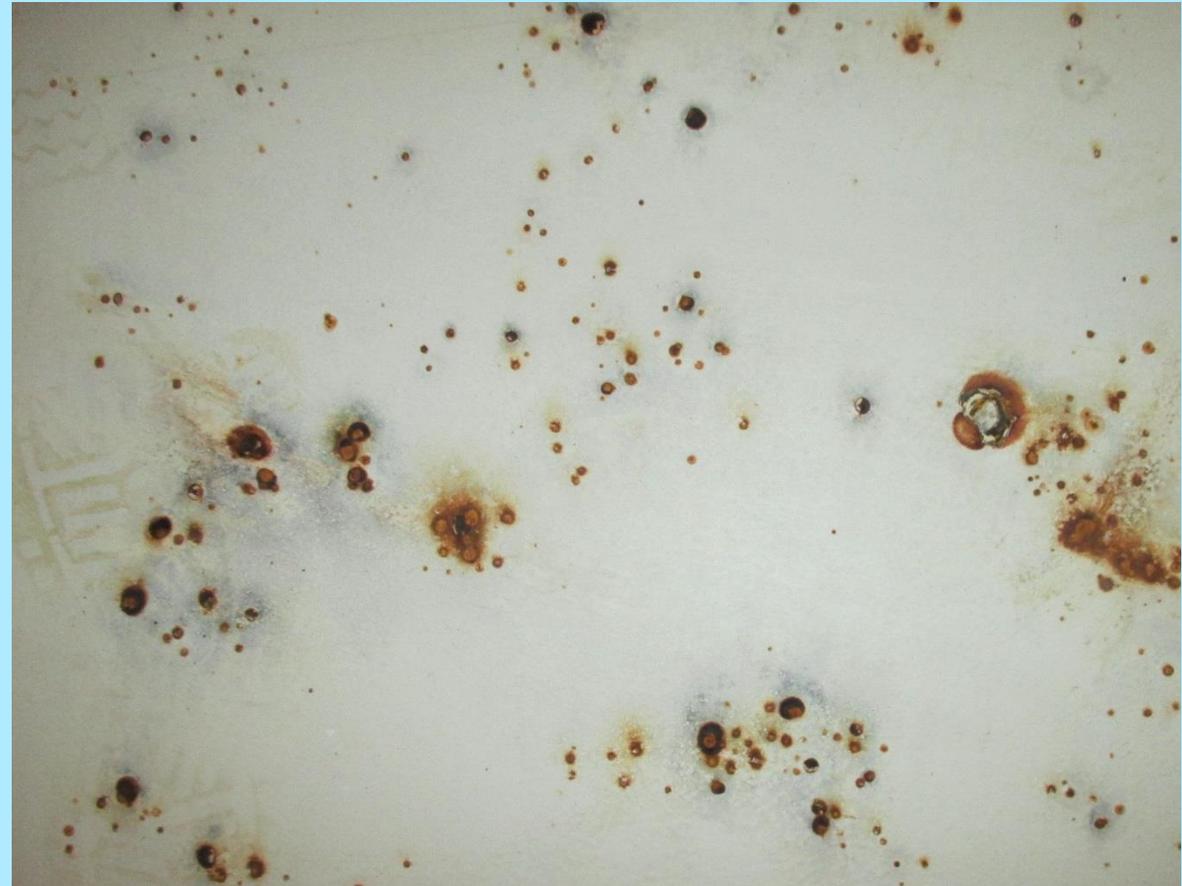
- Gap between underside of roof plate and top of roof rafter
- Interior walls at midheight of reservoir
- Floating inspection of underside of roof
- Remote Operated Vehicle (ROV)



Coating Considerations

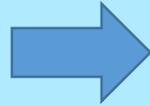
Important to perform regular coating inspections

- More corrosion damage results in
 - repair cost increases
 - Increased risk of change orders
- Rate of metal loss can be non-linear
- Exact extent of corrosion damage will not be known until sandblasting is performed



Reservoir Evaluations - Seismic

- Verify existing reservoir geometry
- Perform seismic evaluation in accordance with ASCE 41 and AWWA D100.



- Foundation
- Anchorage
- Shell Buckling (ground-supported reservoirs)
- Bracing (elevated reservoirs)
- Freeboard
- Flexible connections

Seismic Considerations

- Seismic parameters have increased over the years based on increased understanding of earthquakes
- Older reservoirs likely to be deficient for current seismic parameters
- 1984-1996 reservoirs likely to have slight deficiencies
- Pre-1984 reservoirs likely to have significant deficiencies
- In some cases a reservoir may have been designed to a more stringent standard
- Seismic analysis can show deficiencies but also can show the seismic event level for which the structure is adequate

Seismic Considerations

- Taller reservoirs more likely to have significant deficiencies
- Seismic retrofit options are different for elevated reservoirs versus ground supported reservoirs



Seismic Considerations

Basin Amplification Effect

- Affects central Puget Sound region
- Seismic parameters in current building code do not fully account for the effect
- Seismic parameters will increase in central Puget Sound region in upcoming versions of building code



Seismic Considerations

Performance Objectives

- Seismic retrofit is voluntary, and the design level may be selected by the Owner
- ASCE 41 provides framework for defining performance objectives. They consist of:
 - Seismic Hazard Level
 - Structural Performance Level
- May be more or less stringent than the requirements of current building code for new structure
- Can be coordinated with the relative importance of the reservoir in the water system

Seismic Considerations

Consider consequence of failure

- Loss of storage / impact to water system
- Potential damage to adjacent properties



Reservoir Evaluations – Safety/Access

Regulatory Compliance

- Ladders
- Fall arrest systems
- Manways/hatches
- Guardrails

Potential Improvements

- Spiral stair
- Catwalks and platforms
- Lifting equipment



Reservoir Evaluations – Other Improvements

- Security Cameras
- Intrusion Switches
- Cellular Equipment
- Cathodic Protection
- Roof Vent
- Water Quality Features
- Tank Operation Appurtenances



Compare to New Reservoir Alternative

- For some cases, significant corrosion damage and/or seismic retrofit can make project cost comparable to a new reservoir
- New reservoir becomes an alternative to consider

Compare to New Reservoir Alternative

Consider Life Cycle Costs

- Remaining life of reservoir should be considered by evaluation
- Many factors to consider
- Example: replacing two existing reservoirs with one larger reservoir can reduce overall long term cost, but limit operational flexibility for future cleaning and recoating

Compare to New Reservoir Alternative

The “Do Nothing Option”

- May be an interim option to consider if new reservoir alternative has been selected
- Saves money today
- Accepts interim risk of seismic failure
- Accepts interim risk of significant corrosion damage

Example

Steel reservoir built in 1987-126' Dia. X 65' Tall

Coating evaluation

- Full blast and recoat – interior
- Full blast and recoat – exterior

Seismic evaluation

- No deficiencies found

Other safety and access improvements

Estimated retrofit cost << New reservoir cost

Recommendation –

Upgrade/Recoat Reservoir



Example

Steel reservoir built in 2001 - 66' Dia. X 100' Tall

Coating evaluation

- Full blast and recoat – interior
- Full blast and recoat – exterior

Seismic evaluation – minor deficiencies

- Shell stiffening
- More anchor bolts and chairs
- Foundation augmentation

Other safety and access improvements

Estimated retrofit/recoat cost \$2.0-2.5 million

New reservoir cost \$3.5-4.0 million

Recommendation –

Upgrade/Recoat Reservoir



Example

Steel reservoir built in 1973 - 46' Dia. X 86' Tall

Coating evaluation

- Full blast and recoat – interior
- Full blast and recoat – exterior

Seismic evaluation – significant deficiencies

- Shell stiffening
- More anchor bolts and chairs
- Foundation augmentation

Other safety and access improvements

Owner contemplating increasing zone pressure

Estimated retrofit cost \$2.0-2.5 million

New reservoir cost \$2.5 million

Recommendation – New Reservoir



Final Thoughts

- Importance of a **comprehensive reservoir evaluation** and **accurate cost estimate**.
- Perform detailed evaluation to minimize risk of surprise cost increases during bid and/or via change orders.
- If retrofit cost is approaching the cost of a new reservoir, consider uncertainty of retrofit costs versus the relative certainty of new construction.
- The project starts with recoating, but should involve all reservoir components.

Questions?

