Risk and Reliability Based Life-Cycle Cost Analysis for Capital Repairs
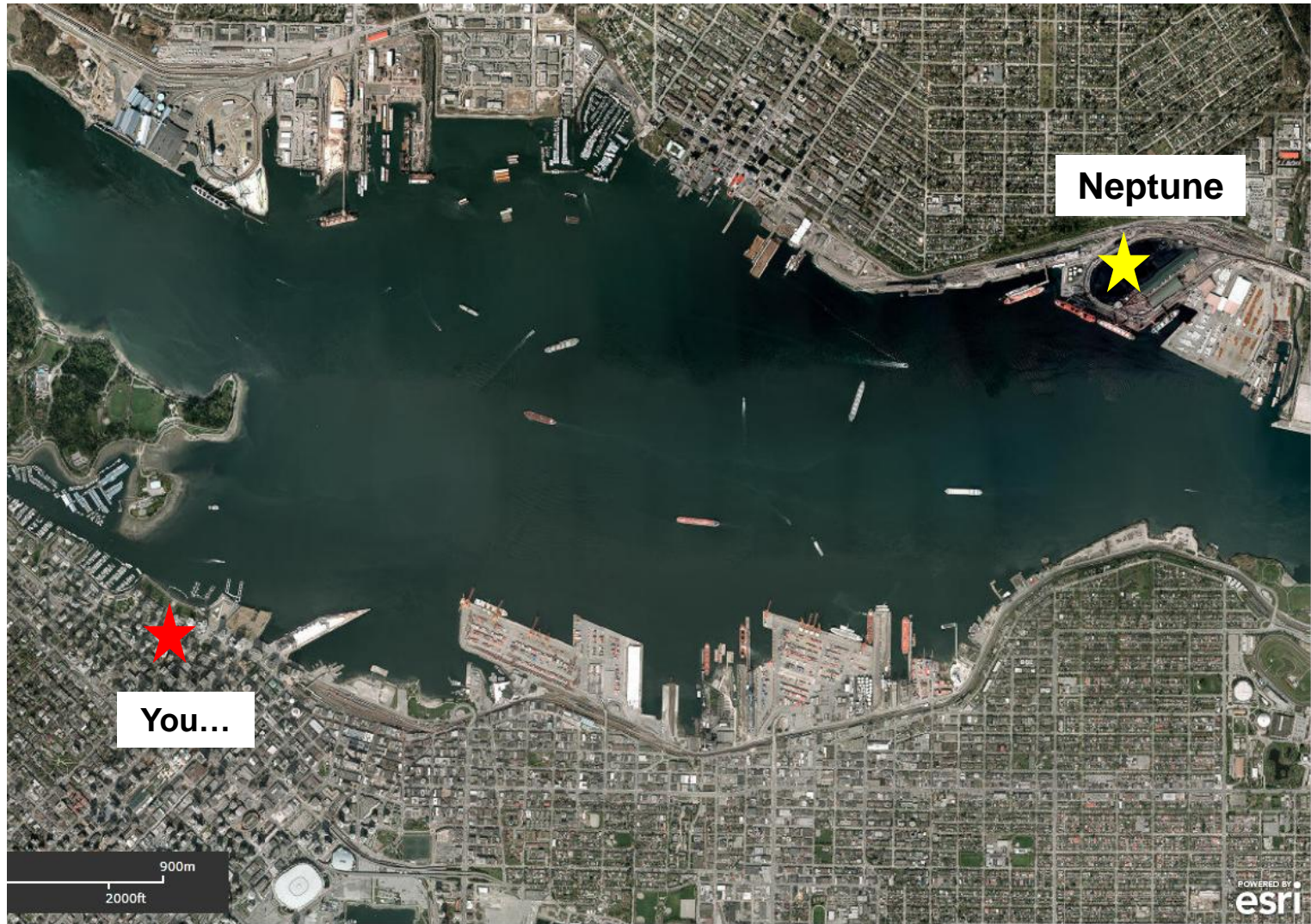
Or...

A case study in getting the most cost effective capital repairs for the next 50 years while minimizing risk and maximizing reliability

Gary Tosh - PMV Engineering

Consultant: Tetratech

Agenda

- Introduction: Neptune Terminal

- Background

- Findings

- Reliability and Risk

- Repair Program

Neptune

You…

900m
2000ft

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# Background: Two Proposals

2013 Original Capital Plan

- 100% epoxy coating loss -> $3.5M for new wall coating
- Others modes of failure? Probability of occurrence?
- How to keep wall operational for another 50 years?

2013 Study

- 730 Port-owned assets: competition for funding
- New thinking: maximize ROI of capital repairs
- **Tetratech** to produce:
  - Future data collection spec and location referencing
  - Condition assessment
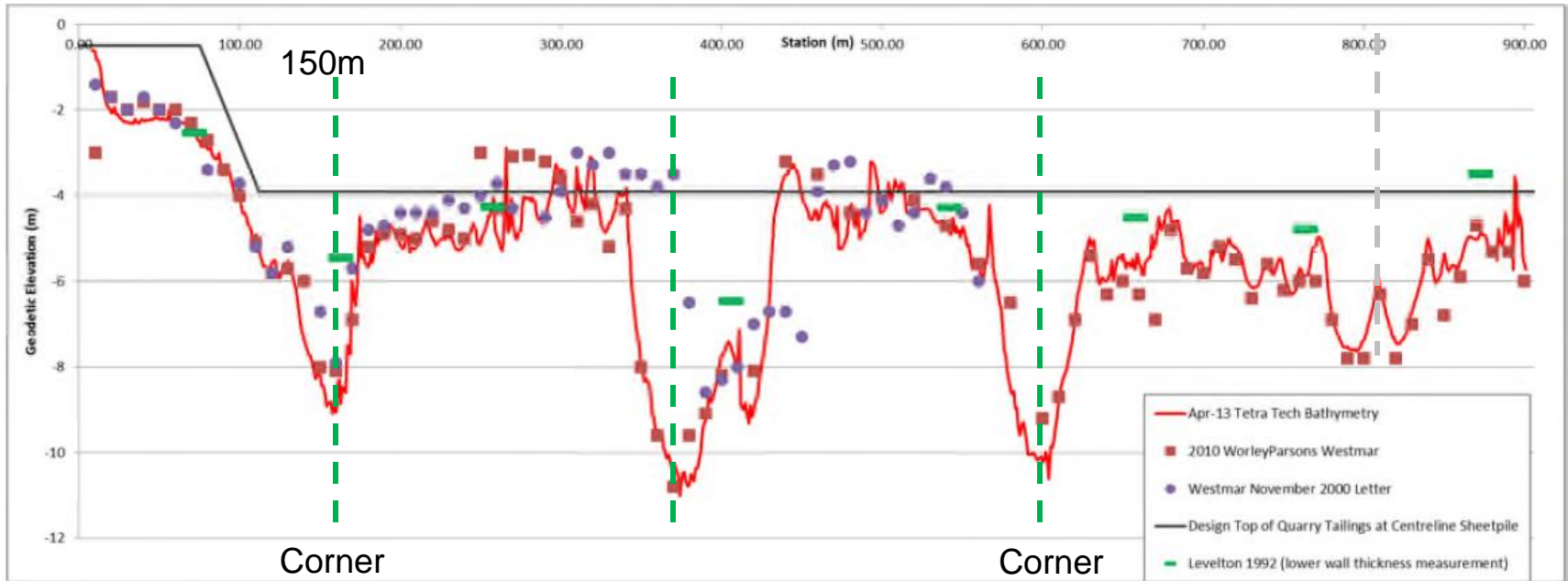 - Determine repairs, upgrades or modifications required

Location Referencing

Top of Wall

Vertical Settlement
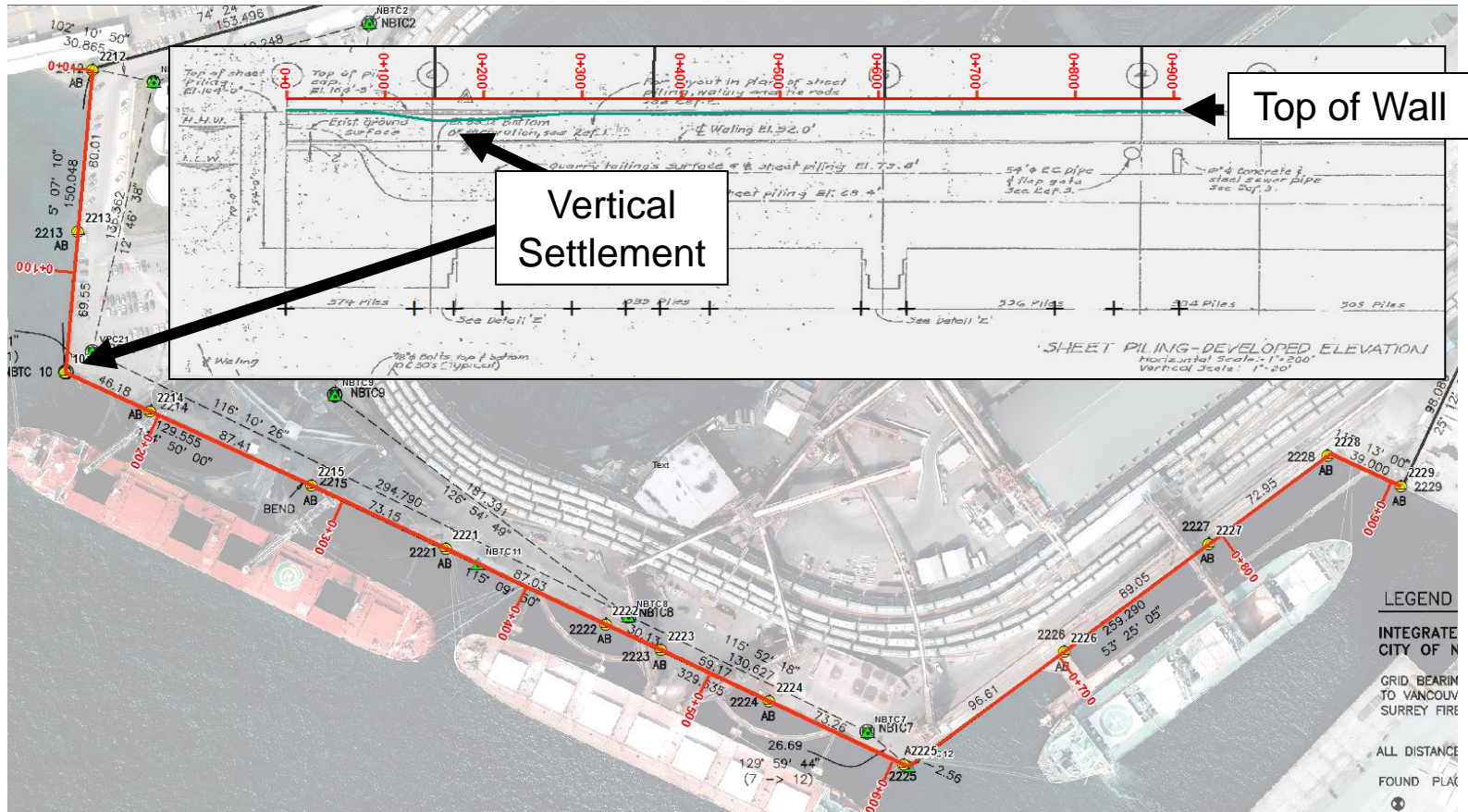
Findings: Bathymetric Study

Ultrasonic Testing: Thickness Loss
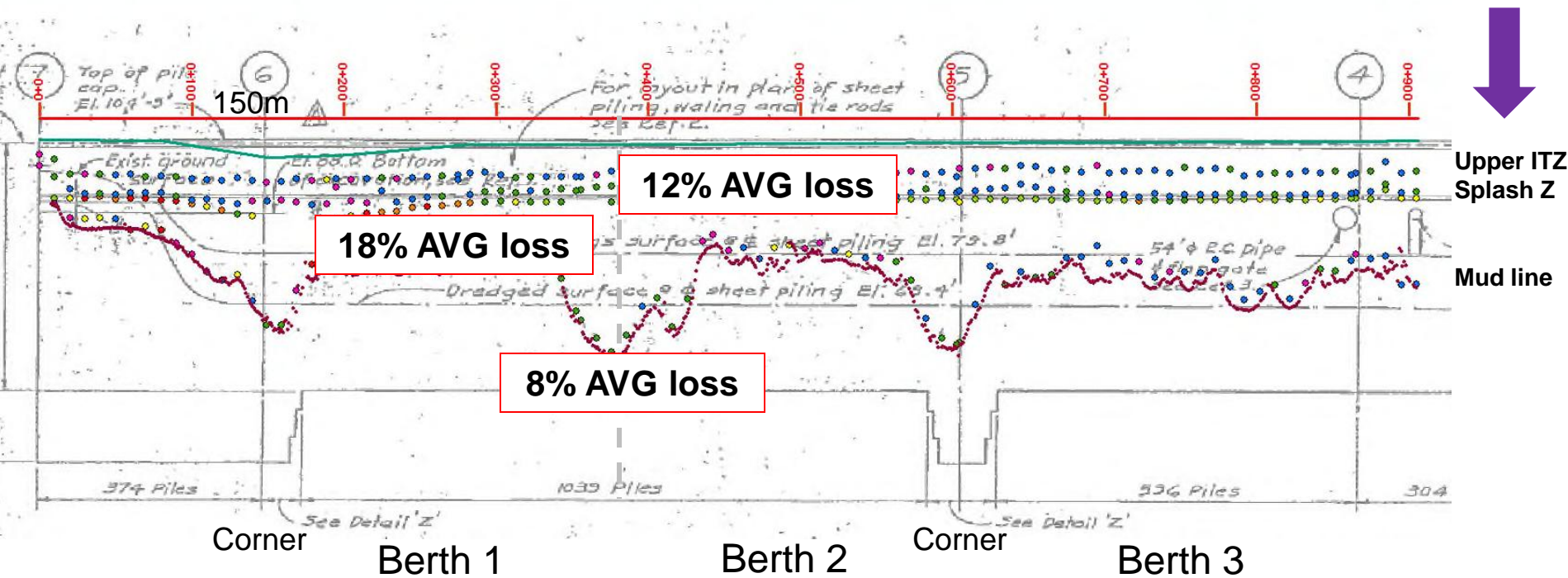
Cathodic Protection
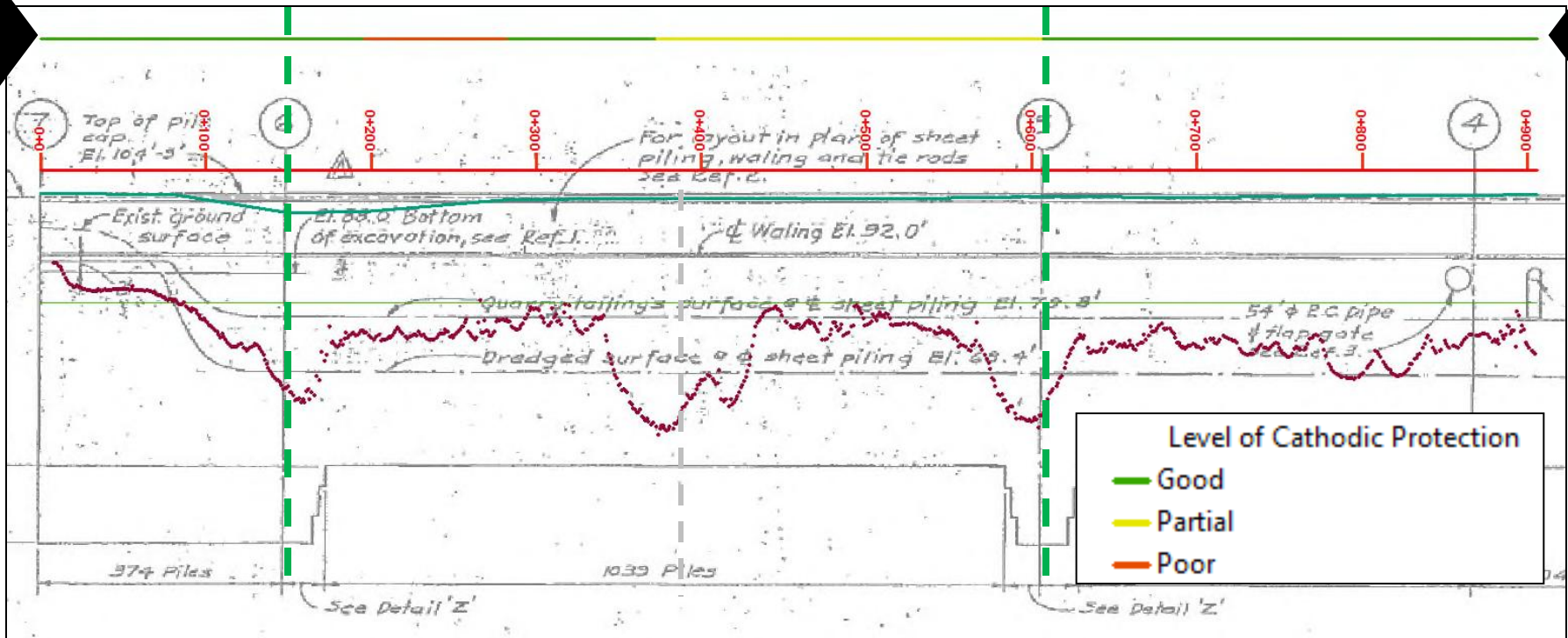
Berth 1   Berth 2   Berth 3

Scour Rates

Berth 1   Berth 2   Berth 3
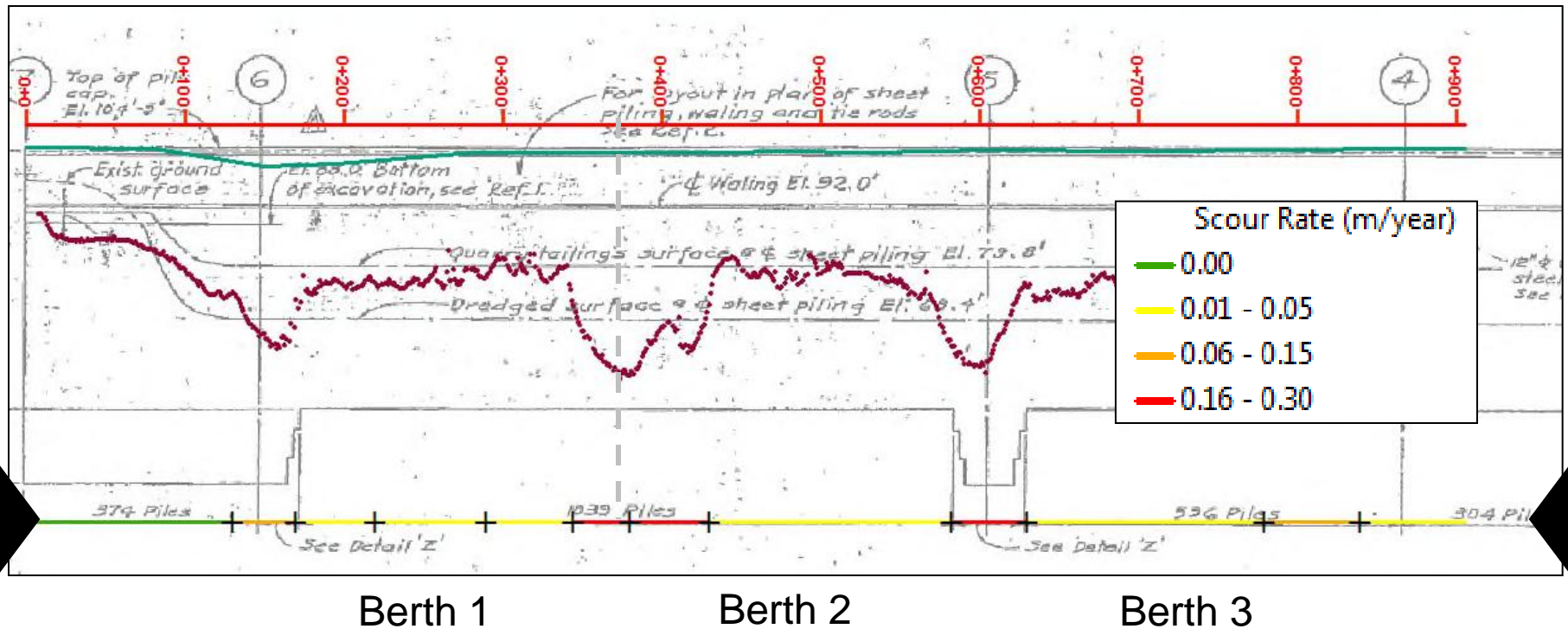
Predicting Reliability

- Risk Modeling Approach: USACE EC 1110-2-6062
- An engineering reliability analysis determining the **P**robability of **U**nsatisfactory **P**erformance (**PUP**)

Reliability and Probability of Unsatisfactory Performance

Legend: Reliability, R (solid line); Probability of Unsatisfactory Performance, P(u) (dashed line)
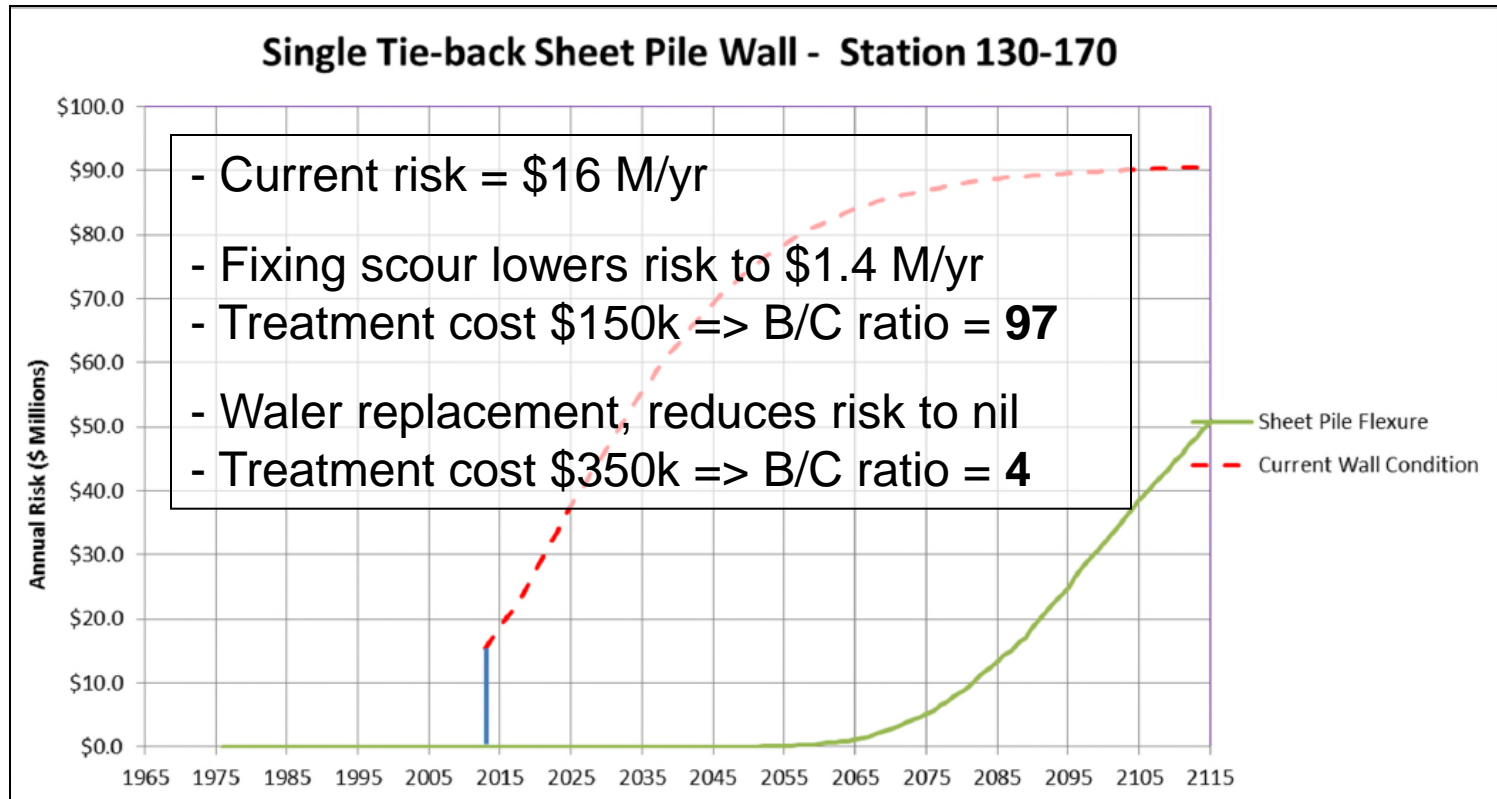
x-axis: Time, t (years)
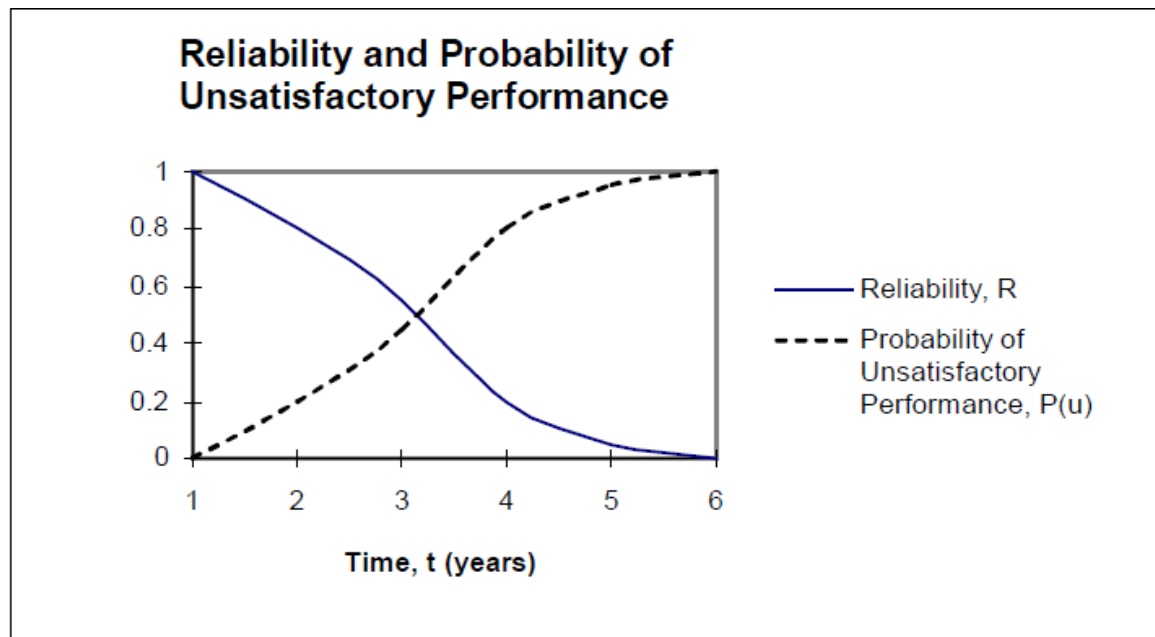
PUP Modelling Results
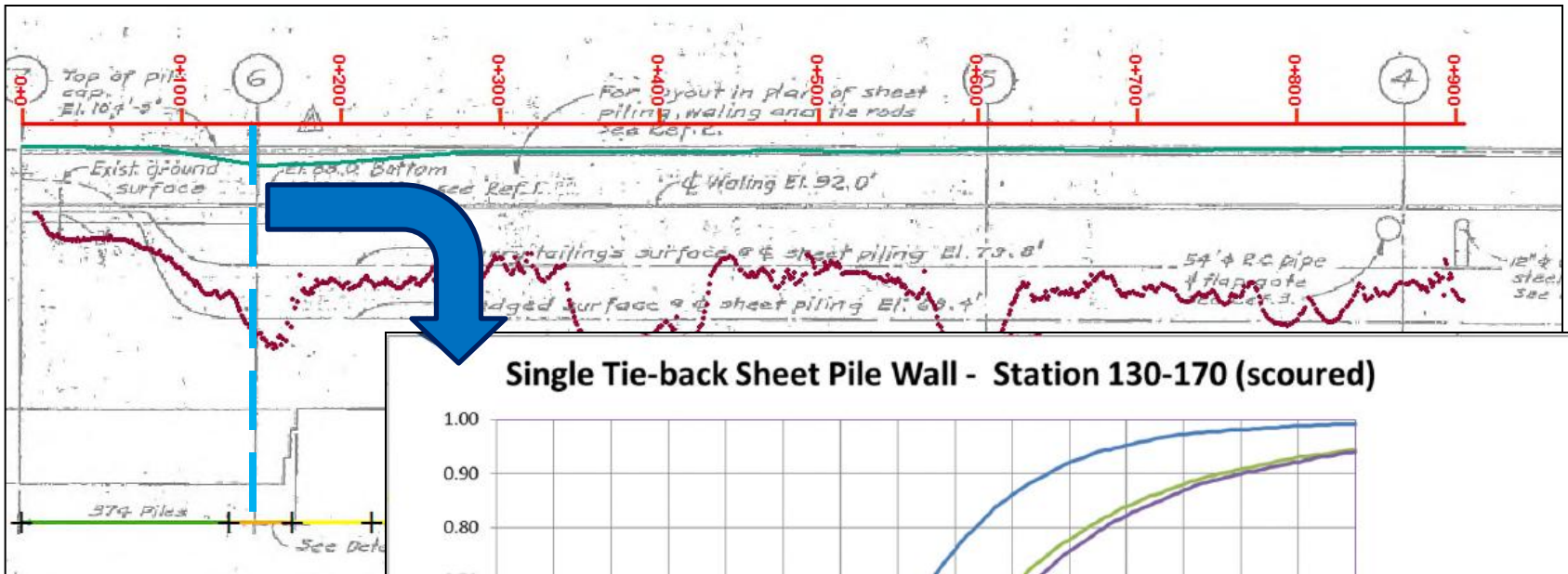
Single Tie-back Sheet Pile Wall - Station 130-170 (scoured)
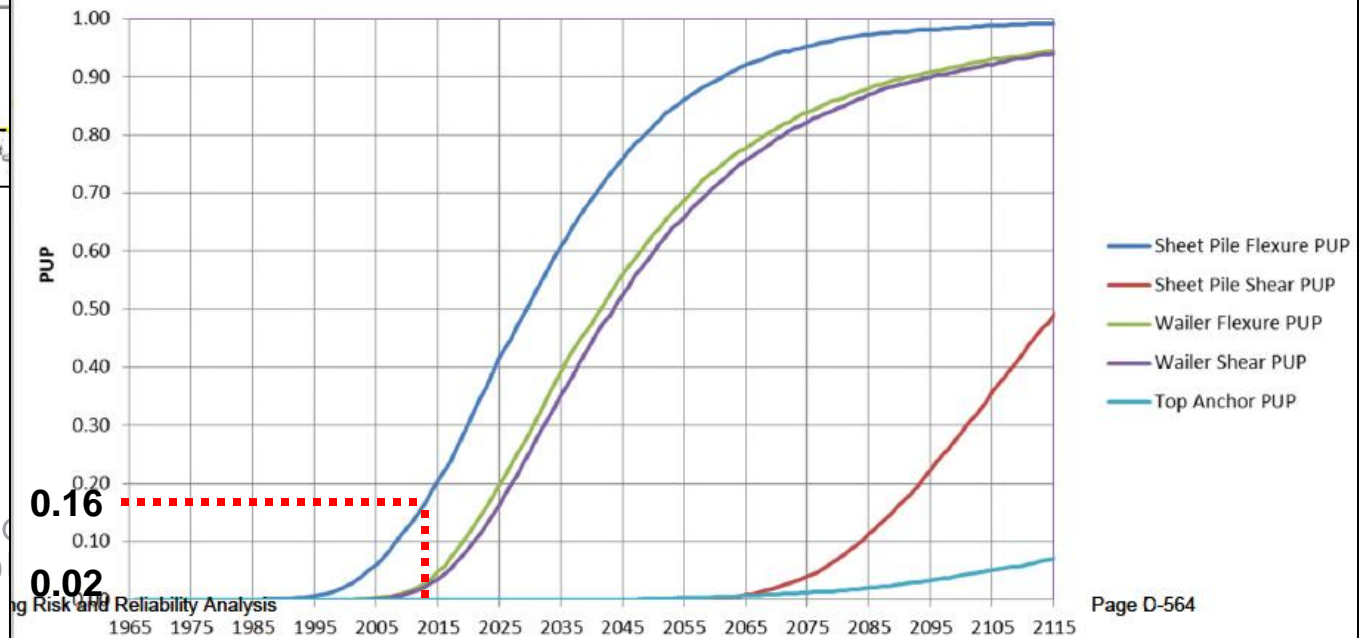
Quantifying Risk in $

- **Risk/yr($) = Consequences ($) X PUP**

Single Tie-back Sheet Pile Wall - Station 130-170

- Current risk = $16 M/yr

- Fixing scour lowers risk to $1.4 M/yr
- Treatment cost $150k => B/C ratio = **97**

- Waler replacement, reduces risk to nil
- Treatment cost $350k => B/C ratio = **4**

Legend:
— Sheet Pile Flexure
– – Current Wall Condition

Y-axis: Annual Risk ($ Millions)

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Full Repair Program

1. Remediate scour
   - 2013 = $150k (est'd)

2. Staged waler replacement – buckling failure predicted
   - 0 – 290 m (2013) = $350k (est'd)

3. Repair cathodic protection system issues
   - 2013 = $150k (est'd)

4. ~135 m of sheet piling reinforcement in 30-40 years
   - Berth 1

2013 Revised Repairs: $650,000, PUP = nil
Original Repairs: $3,500,000, PUP = 0.16

Thank you

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