Centre for Infrastructure Performance and Reliability

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TAC meeting Oct 2013
Activity 3 presentation

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Outline

- Progress
- Current and future tasks
- Plan for next 6-12 months

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Progress outline

- Hunter Water field work + analysis
- Analysis of additional pipe corrosion and environment data sets, and comparison to collected HW field work data

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Field work

- Aim: collect field data of corrosion losses and soil conditions for model development and calibration
- Inspections began in Jan. Completed June 2013
- 20 sites inspected
- Results from first 11 sites presented May TAC
- Details of work reported in LESAM 2013 and ACA 2013 conference papers

Field work – Initial analysis

- Looked at maximum corrosion depth
- Data from sites separated into following categories (based on backfill):

- Native clay backfill (11 sites)
- Sand surround (2 sites)
- Native sand backfill (2 sites)
- Other (5 sites)

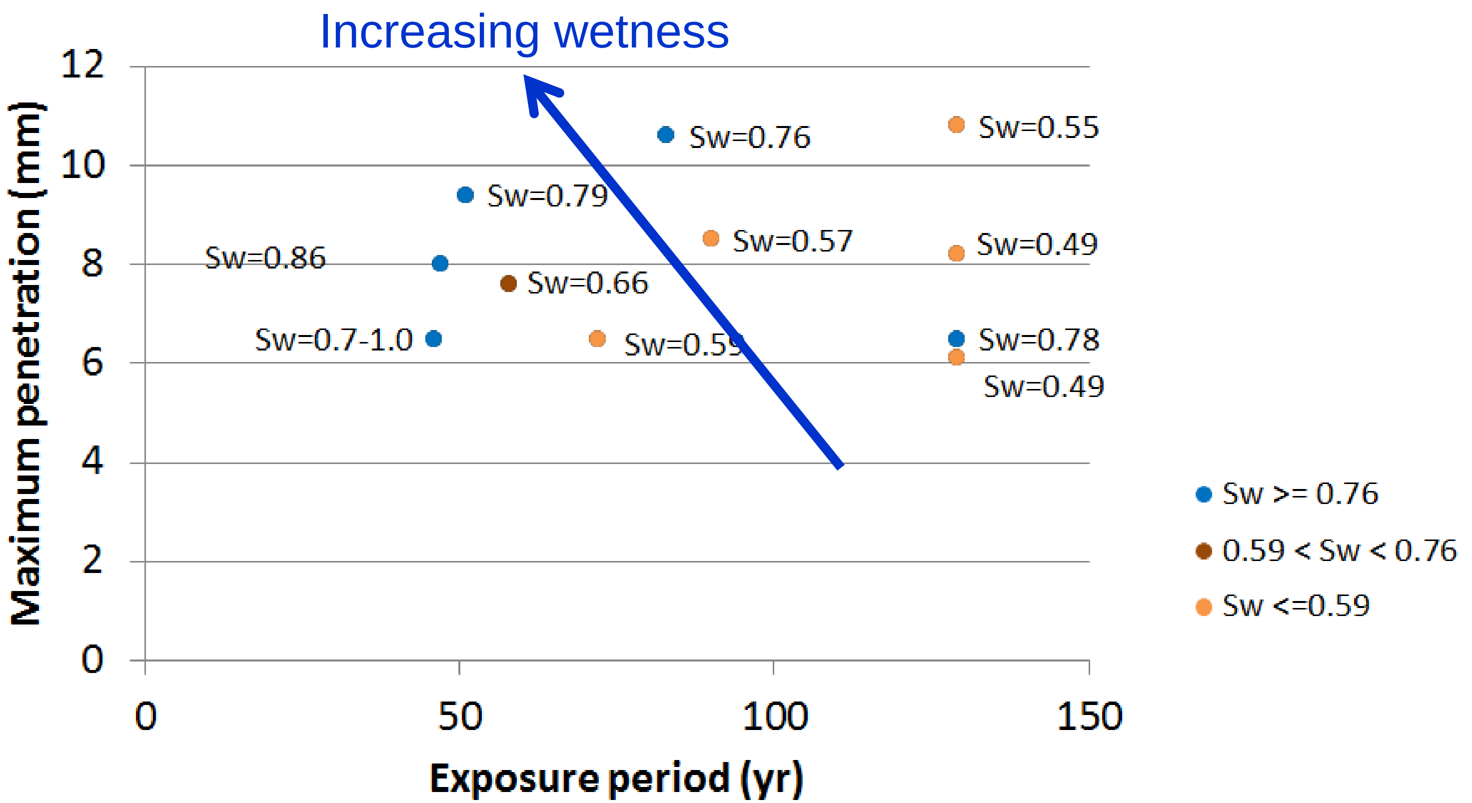
Field work – Native clay backfill sites

Field work – Native clay backfill sites

- Soils predominantly clay
- Reasonably uniform/homogenous
- First investigated the influence of moisture on maximum corrosion depth
- Assumed moisture content measured at time of inspection a reasonable approximation of long-term moisture content

Field work – Native clay backfill sites

- Sw = degree of saturation



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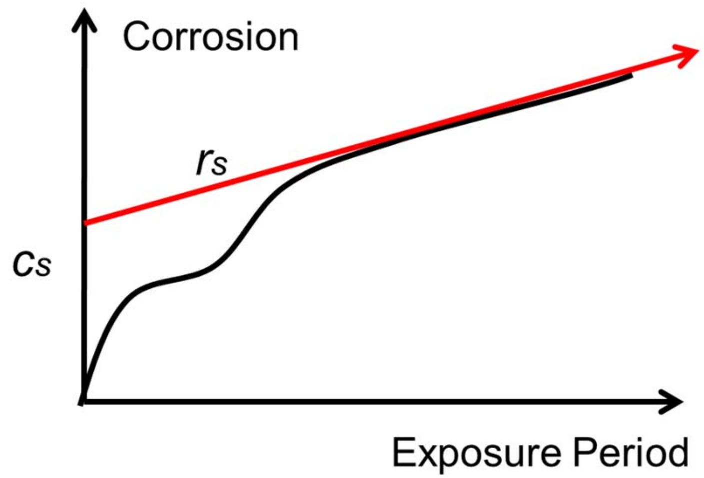
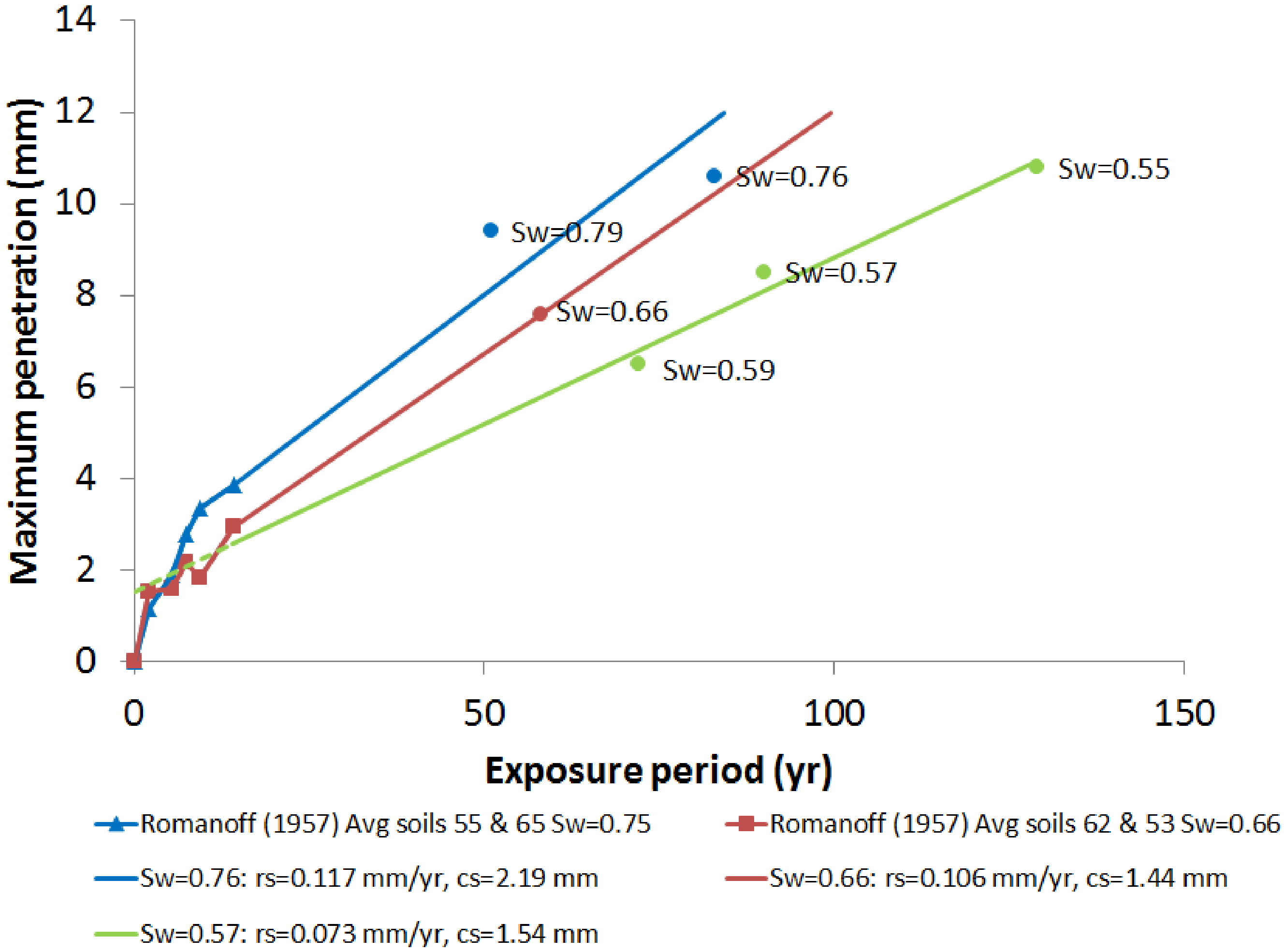
Initial model calibration – clay sites

- Data used for to fit long-term corrosion model
- Fit straight line to field data
- Construct corrosion vs. time data using short and long-term data from similar environments
- Preliminary calibration – corrosion a function of soil moisture



Initial model calibration – clay sites



Field work – Sand surround backfill (1)

- Imported sand backfill surrounding pipe
- Typically 100 mm thick
- Introduced in 1960
- Design function: separate pipe from natural environment with less corrosive sand layer
- Construction quality of sand backfill varied at inspected sites.
- Observations from previous HW CA: correlation between quality of sand surround backfill installation and amount of corrosion

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Field work – Sand surround backfill (2)

- Site BE7
- Example of good quality sand surround.
- Pipe in excellent condition
- Corrosion less than expected were pipe in native soil

Field work – Sand surround backfill (3)

- Site BE5
- Poor quality sand surround.
- Native clay soil interspersed. Touching pipe.
- Corrosion similar to native clay sites

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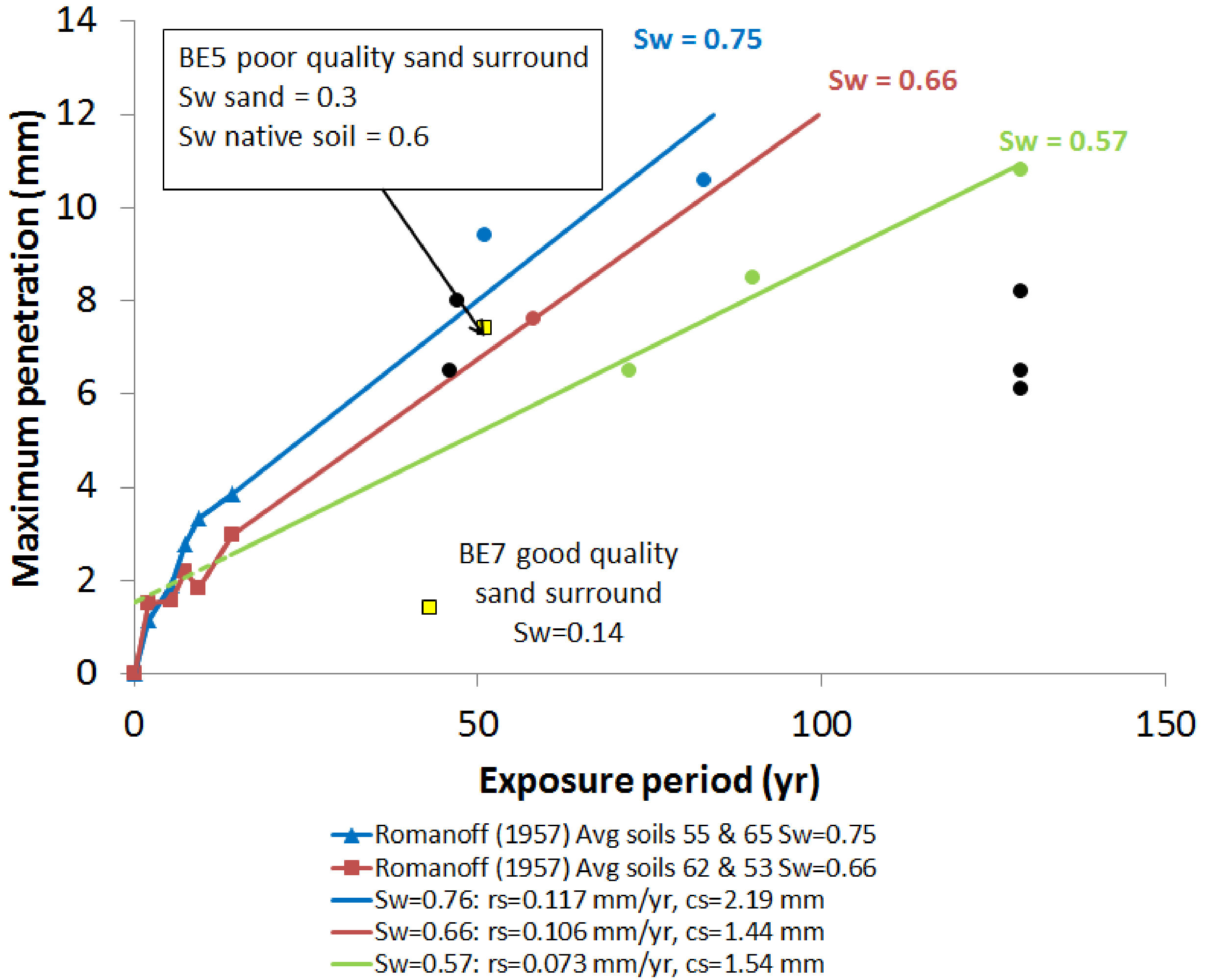
Field work – Sand surround backfill (4)



Field work – Native sand backfill + other

- Left out of original analysis
- Native sand backfill sites:
- Low confidence on long-term average moisture content.
- Other sites –site specific factors or incomplete inspections made difficult to analyse
- Noteworthy "other" site: CE2 - rocks in fill > higher then expected corrosion

HW CA 2013 CE2 site photos

Re-creation of backfill condition – rock on pipe in native clay

- (photos courtesy M Dafter)

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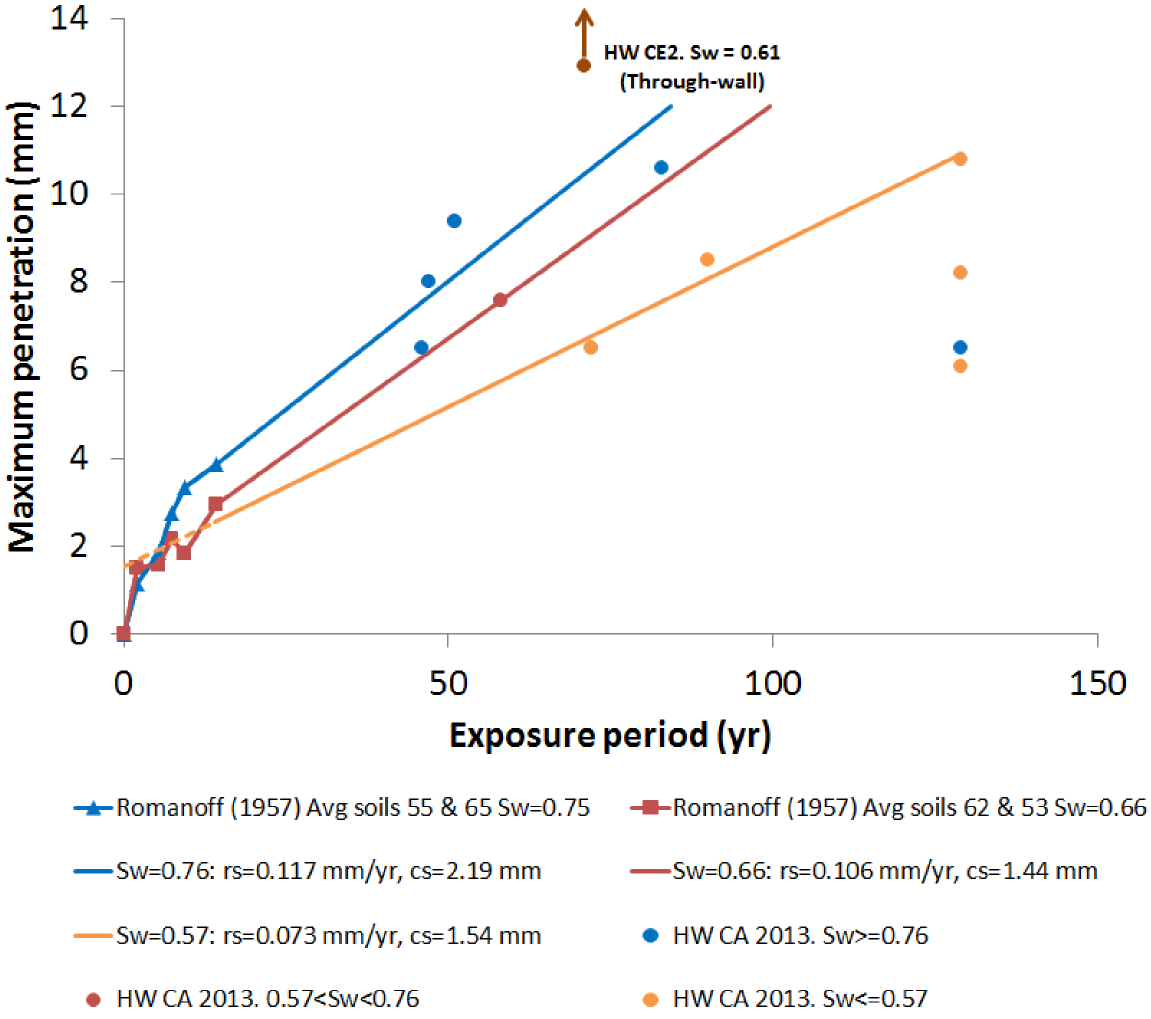
Field work – Site CE2



Field work – Conclusions (1)

- Native clay sites – long-term corrosion increases with soil wetness (for the inspected sites)
- Sand surround sites - quality of installation and amount of moisture significantly affect the observed corrosion

Field work – Conclusions (2)

- The approach to model calibration produced rational results
- Short + long-term data sets under similar moisture conditions appeared consistent
- The effect of moisture on the short and long-term corrosion of these sites was consistent with expected behaviour

Field work - Outcomes

- Information collected from 20 condition assessment sites
- Initial model calibration: CI pipe pit depth in native clayey soils for a range of moisture conditions ($0.57 < S_w < 0.76$)

Field work - Future work

- For the data collected in the field study:
- So far only looked at the maximum corrosion depth on the pipe.
- Still need to look at average corrosion loss and pit area for all sites.
- Look at native sand sites/ other sites
- Looking at moisture models to:
  - Check assumption of constant moisture content at clay sites
  - Estimate average moisture content at sand sites

Analysis of Additional pipe corrosion – environment data sets

- Data sets
  - HW condition assessments (2007-2012)
  - Hay (1984)
- Deepest pit + environmental data
- Data analysis: Sorted sites by moisture condition and backfill type (as done for HW field work data)
- Compared results with HW field work data

HW CA (2007-2012) - overview

- Previous condition assessments 2007-2012
- Similar process as current field work
- (pipes exhumed/blasted/inspected on site)
- 21 additional site investigations
- Deepest pits measured
- Notes made on soil type, backfill type, water table, and soil moisture (among others)
- In some cases some soil properties including moisture content determined

HW CA (2007-2012) – site types

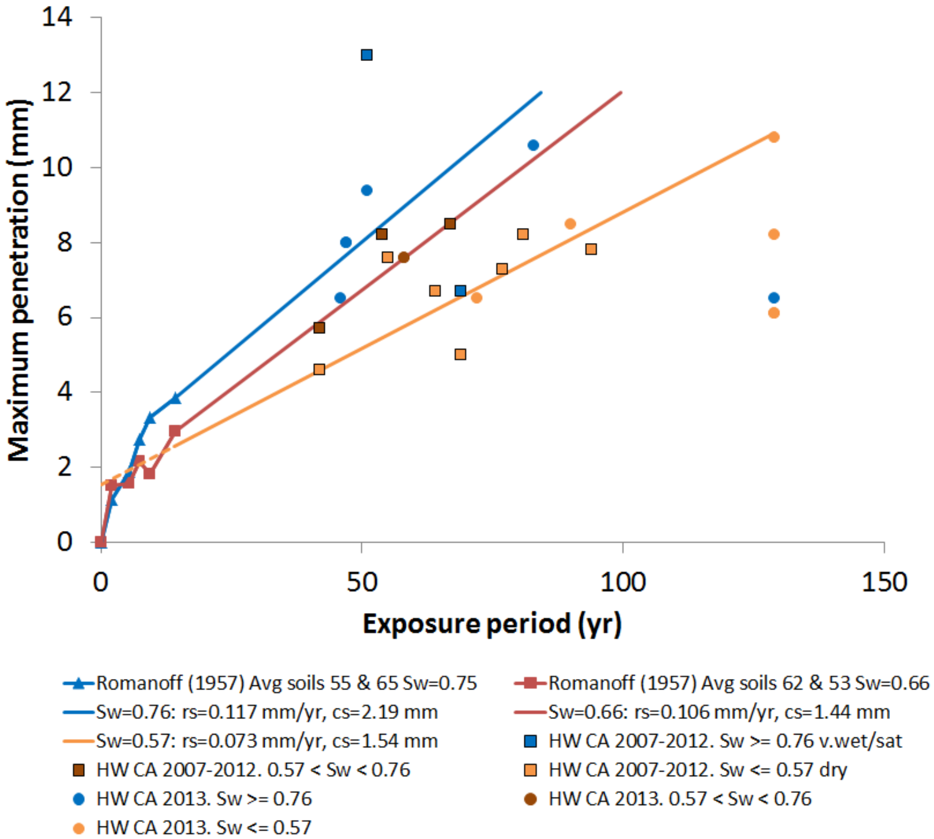
- Sites separated into following categories:
  - Native clay backfill (11 sites)
  - Sand surround (6 sites)
  - Native sand backfill (not analysed)

HW CA (2007-2012) – clay sites

- For native clay backfill sites:
- Roughly estimated degree of saturation using information in reports
- Used measured moisture contents
- Used comments on soil wetness from reports such as “dry”, “moist”, “very wet”, “saturated”…
- Put each site into broad buckets:
  - $Sw > 0.76$ (dry)
  - $0.57 < Sw < 0.76$ (moist)
  - $Sw < 0.57$ (very wet/saturated)

HW CA (2007-2012) – clay sites

- Native clay soil data from previous and current Hunter Water Condition Assessment studies

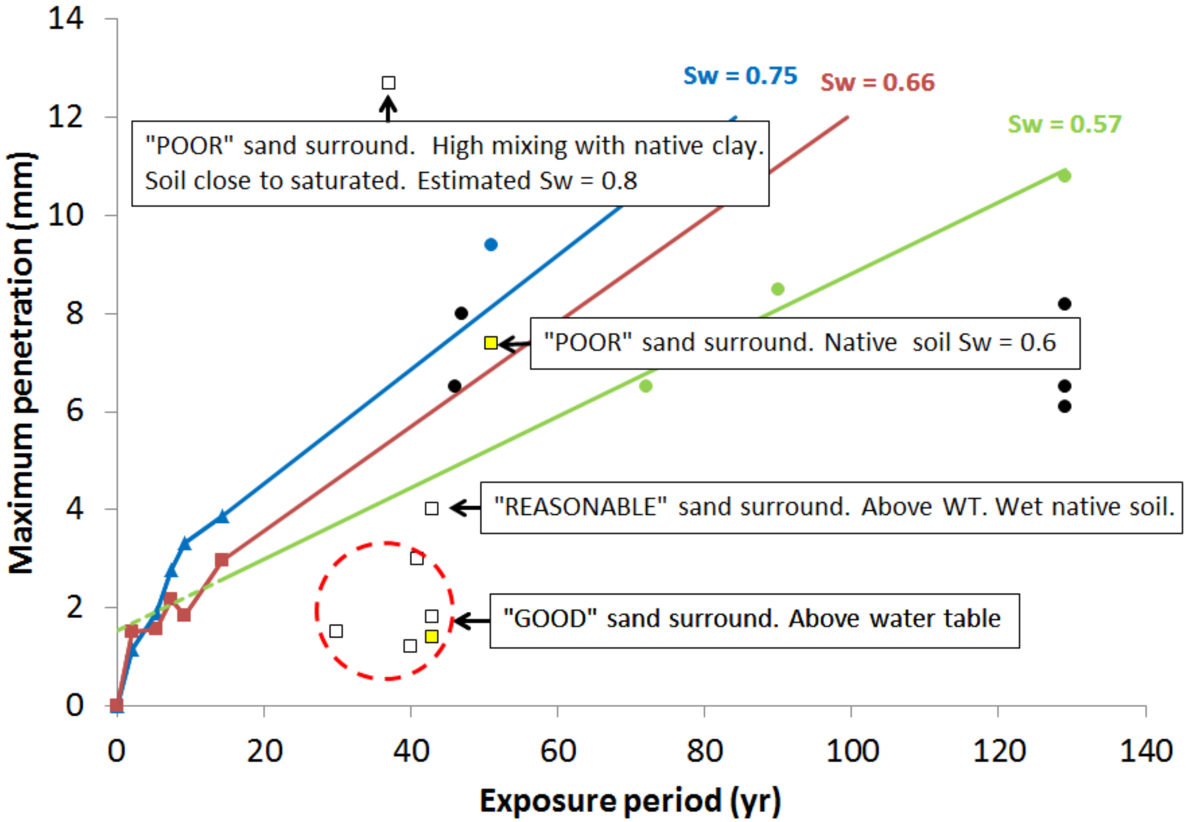


HW CA (2007-2012) – clay sites

- Data consistent with 2013 data
- (dry sites low corrosion, worst corrosion wetter sites)
- To make data useful for model calibration –
- Propose additional work to sample soils at sites to determine soil properties:
  - Texture
  - Moisture content
  - Density

HW CA (2007-2012) – sand surround

- Data points sand surround superimposed on native clay soil data (2013 data)



HW CA sand surround sites

- Findings
- Sites with good quality sand surround above water table: relatively low corrosion
- Poor quality sand surround in very wet conditions (native soil = clay): relatively high corrosion
- Corrosion likely to be a function of:
  - Degree of intermixing with native soil
  - Native soil type
  - Soil moisture next to pipe

HW CA sand surround sites

- Findings
- Initial estimate for poor quality – observed corrosion appears to lie in range expected for native soil without surround (maybe even higher)
- All cases of good sand surround above WT, expect to be reasonably well drained and dry.
- No cases of good sand surround under WT or partially submerged

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Implications for site investigating

- The quality of sand surround appears to be important
- Issues inspecting
  – Determine backfill type/quality properly with drilling alone? Unlikely
  – Open trench required for accurate inspection
- How to quantify?
  – Qualitative so far ("good", "poor", inspector's judgement)
  – Possible solution: Analyse particle size distribution

HW CA (2007-2012) - outcomes

- Consistency between data sets adds confidence to modelling approach and expected influence of moisture on corrosion
- Data potentially useful for model calibration with additional work.
- Issues raised about inspecting and quantifying quality of sand surround backfills for model calibration and future predictions
- Factors influencing corrosion in sand surround backfills identified

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Hay (1984) data - overview

- Cast iron pipes 100 – 300 mm diameter
- Sampled from sites in Newcastle & Sydney
- Corrosion measured on removed pipe sections
- Site details recorded + multiple soil properties determined
- Soils: predominantly loams and sands
- Some cases rubbish, bricks & rocks in backfill

Hay (1984) data – preliminary analysis

- Sites sorted into categories based on moisture content (like previous analysis)
- Degree of saturation (Sw) determined from in-situ moisture contents and remoulded soil bulk densities
- Broad moisture buckets for first pass trend analysis
- Applied to both sand and loam data

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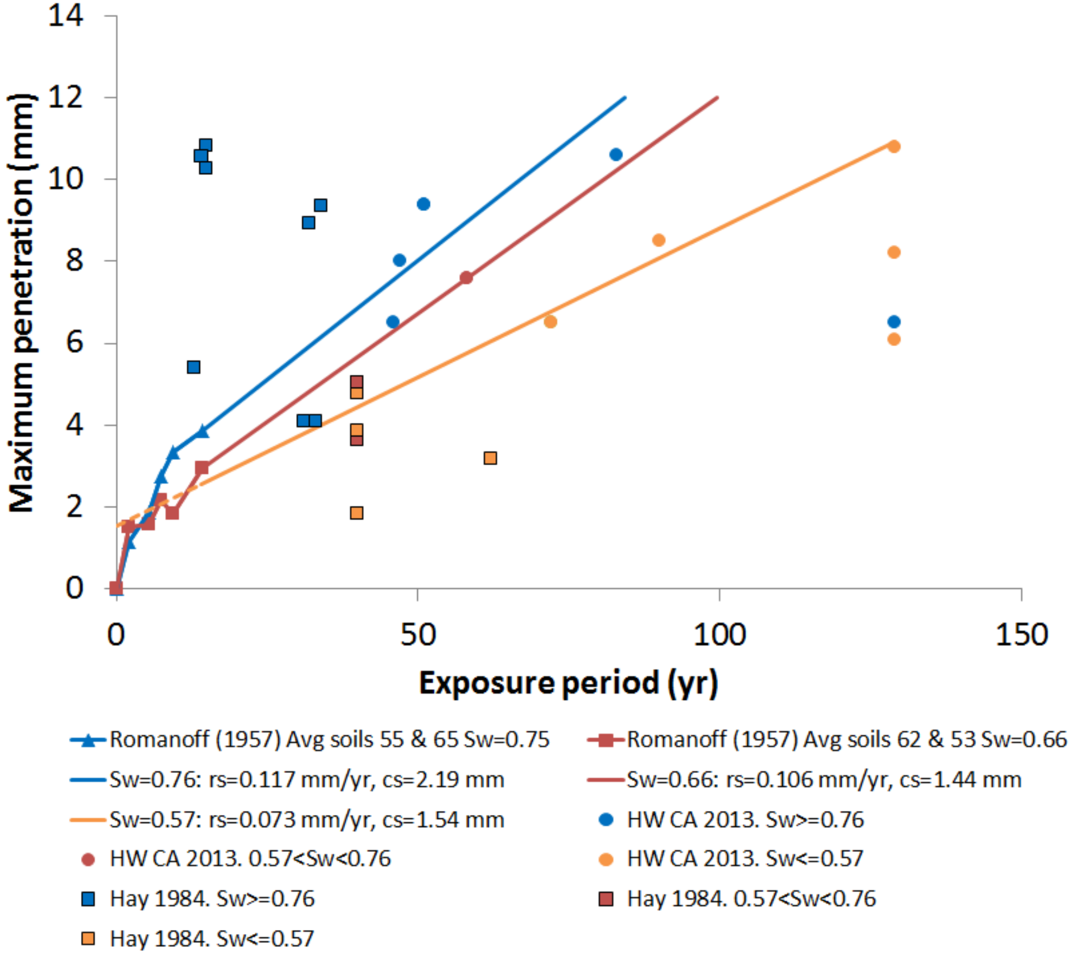
Hay (1984) data – deepest pit vs time

Loam and sand data superimposed over HW CA (2013) clay data



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Hay (1984) data – general findings

- General trend: corrosion (deepest pit) increases with wetness
- Can data be used for model calibration?
- 1^{st} step: Need to improve confidence in long-term average moisture content.
- Consider model

Analysis of Hay (1984) data

- Consistency between data sets adds confidence to modelling approach and expected influence of moisture on corrosion
- Data potentially useful for model calibration with additional work.

Current and future tasks (1)

- Corrosion measurement + environmental data collection
  - Sydney Water pipe failure specimens
  - Pipes at Newcastle
  - + any others
  - Soil sample collection at previous HW CA sites
  - Propose moisture monitoring at selected sites

Current and future tasks (2)

- Environmental data estimation
  - To gain more information of the variation of moisture next to the pipe, and *improve estimate of the long-term moisture content/degree of saturation*:
  - Develop simple model to estimate long-term average moisture content in soil next to pipe as a function of soil type and climate
  - Apply to data sets (HW CA 2013, HW CA 2007-2012, Hay 1984, Romanoff 1957)

Current and future tasks (3)

- Data analysis + model development
  - Continue to analyse new data and develop models for:
  - Max pit depth
  - Average loss
  - Corrosion pit/ pit cluster area

Timeline (1 year)

- Corrosion measurement + environmental data collection (Oct – Jan)
- Environmental data estimation (Feb/March)
- Data Analysis + model development (April – June)
- Additional work (resulting from additional failure + condition assessment sites) (July/August)