Programmatic Approaches to Assessing and Mitigating Risk to Pipelines from Natural Forces

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Introduction

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Arcadis Statistics

- Global design, engineering and management consulting company
- 350 offices in 40 countries
- 28,000 professionals worldwide
- >6,000 professionals in North America

*Arcadis has been providing services to the oil & gas industry for more than SIX decades*
Agenda

- Pipeline Integrity and Natural Forces
- Assessment of Potential Risks
- Management of Risks
- Q&A
Historical Perspective

All Reported Incident Property Damage
National, All Pipeline Systems, 1993-2012
Source: PHMSA Significant Incidents Files, February 28, 2013

- Corrosion: 33.3%
- Excavation Damage: 10.3%
- Incorrect Operation: 10.3%
- Material/Weld/Equipment Failure: 7.7%
- Natural Forces Damage: 5.7%
- Other Outside Force Damage: 2.4%
- All Other Causes: 10.3%
- Heavy Rains and Floods: 30.4% (17.3%)

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Pipeline Integrity

Heightened awareness!

- Perceived aging infrastructure
- Increased regulatory scrutiny
- Increased pipeline usage

- Management AND operations recognize unknown risk
- Business continuity vital
- Reputational risk unquantifiable
Pipeline Integrity – Natural Forces

Riverine
- Hydrologic and hydraulic phenomenon

Coastal
- Storm surge erosion and land loss

Land Movement
- Stability, subsidence, seismic

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Riverine

- Scour
- Erosion
- Migration / Avulsion
Riverine

Risks take into account:
• Changes in watersheds
• Changes in land use
• Increased development
• Long-term channel degradation and movement
• Increase in periodic larger storm events
Coastal Drivers:

- Water flow direction not constrained by channel slope
- Not confined to localized channel crossing
- Flow is driven by tides, winds, waves
- Storm surge, currents, and waves can induce episodic erosion
- Riverine empirical relationships not applicable
- Probability cannot be derived from real data (hurricanes sparse in space and time) – need for computer simulations
Combined effects of:
- Urbanization
- Industrial canals and river channelization
- Widening and dredging projects
- Subsidence
- Sea level rise
- Ship wake
Land Movement

The pipeline risk factors associated with potential geotechnical impacts include:

- Ground shaking in seismically active regions
- Damage due to blasting operations at mines and quarries
- Ground subsidence and settlement
- Landsliding and deep seated slope failures
- Displacements across geologically active faults
- Freeze-thaw displacements
- Erosion and upheavalal displacement
- Geochemical – including karst, acid rock drainage, and corrosive soils
Need for Assessment Prioritization

Segments NEVER removed – just prioritized

- Site inspection and/or modeling where needed at each crossing
- Response planning to minimize potential damage and costs
- Design and permitting support of upgrades at river crossings to further reduce risk of failure
Phased Assessment Approach

- **Phase I**
  - 100% (10,000) All Identified Pipeline Water Crossings
  - **Inventory** Desktop

- **Phase II**
  - 15-25% (2,000) Crossings of Concern
  - **Screening** Desktop

- **Phase III**
  - 5% (500) Critical Crossings
  - **Assessment Refinement** Desktop and Field
  - 1-2% (150) 'High' or 'Medium'
  - **Classification Risk Ranking** Client Specific Algorithm

- **Action**
  - **Additional Planning and Mitigation**
Management – Planning

Options:

• Operational controls – visual inspection, pressure reduction, shutdown, HWAP, etc.
• Engineering controls – armoring beds and banks, pipe sleeves, HDD, etc.

Process:

• Stakeholder involvement
• Data gap assessment
• Feasibility
• Decision implementation
## Operational Controls Example

The table outlines scenarios and corresponding actions for increasing flood levels, monitoring activities, criteria/considerations, and communications and action plans. The table progresses from increasing flood levels to progressively more aggressive responses.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>River Condition</th>
<th>Monitoring Activities</th>
<th>Criteria/Considerations</th>
<th>Communications and Action Plan</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>INCREASING FLOOD LEVELS</td>
<td>INCREASING MONITORING ACTIVITIES</td>
<td>LOOKING FOR CHANGES IN CHANNEL CONDITIONS</td>
<td>AGGRESSIVELY RESPONSES</td>
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Engineering Controls Example

Alternatives

• River training structures
• Channel armoring
• Line lowering
• Supports (inc. horizontal)
• Casing
• VIV Mitigation / Reduction
• Interim measures
• Bank stabilization
• Drilling
Engineering Controls – Considerations

Permitting:
• Assessments and Requirements
  ▪ Ecological
  ▪ Cultural
  ▪ Species-related

Design:
• Perform feasibility reviews
• Consider existing, as-constructed, and post-scour conditions
• Work hand in hand with permitting team
• Build in site access, staging and work areas
• Perform a constructability review
• Decide on procurement and management processes
Take-A-Ways

1. Among all the pipeline integrity risks – natural forces can be very disruptive…and costly

2. Need to understand where and what the risk are for effective management

3. When management required, recommended to assess feasibility and utilize a ‘tool-box’ approach