Technical Memo

SUBJECT
Bank Stability Procedures
Pipeline Water Crossings

TO
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ExxonMobil Pipeline Company

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Arcadis U.S., Inc. (Arcadis) was asked by ExxonMobil Pipeline Company (EMPCo) to provide input on the bank stability assessment procedures that were updated in 2022. This memo summarizes issues that have been observed while assisting the EMPCo Water Crossing Engineers with engineering assessments and reviews.

Arcadis updated the banks stability procedures in 2022 under direction of Gabi Romano. A high-level summary of procedure updates made in 2022 as described by Gabi is provided below:

- FOS of 1.5 is the threshold for all Risk Assessment Scenarios, so the screening and scorecard templates have been updated such that they do not filter out crossings with FOS < 1.5. Pipes engaged by failure plane with FOS < 1.5 for any load case and which exceed pipeline structural limitations are recommended for Risk Assessment. Factor of Safety of 1.5 is used as the cutoff because the safety factors prescribed by USACE do not account for structures in soil.
- When running SlopeW in future: plot the critical failure surface (call out FOS), the failure surface with FOS = 1.5, and a few additional failure surfaces between FOS 1.5 and Critical FOS depending on the size of difference between them
- For now, while we use soil springs to determine if pipe capacity from soil movement is exceeded, we will consult an ExxonMobil Geotech SME before filtering out a crossing for Bank Stability Concern based on soil spring results.
- Until additional failure planes are drawn in Hazard Assessment Report to show Failure Planes with FOS up to 1.5, preliminary SlopeW will need to be run with conservative soil assumptions to determine if pipeline may be located in failure plane with FOS = 1.5 for steady state and rapid drawdown loading scenarios for all crossings with FOS < 1.5 (i.e. less than Stable).

Crossings with “Light Green,” “Yellow,” or “Red” Scorecards that have “sufficient setback” based on overlaying of survey with critical failure plane from 2017 Slope Stability Report require Slope/W analysis with slope geometry and conservative soil assumptions to determine if pipeline still has sufficient setback (not located within 5 ft of failure plane) for a failure plane with FOS up to 1.5.

Arcadis interprets “slope geometry” to be the survey points from latest survey for better accuracy. Coordinates are provided in an Excel file or interpolated from a profile drawing. Following this protocol requires running stability analyses on 99% of scored crossings – only those rated as “Green” don’t require analysis. Arcadis can submit a proposal to re-run the FOS plates and only show 1.5 FOS failure surfaces upon request. Otherwise, we suggest EMPCo continue to use the existing FOS plates and note the FOS of the failure surface. The SME can determine if a Slope/W analysis is necessary to establish a more precise setback distance.

Another suggestion on the updated procedures is to decrease the amount of “soil springs” analyses required by providing a minimum DOC and length of permanent ground deformation (PGD) along the pipeline to initiate the calculation. A chart of DOC and PGD vs pipeline capacity FOS based on the thinnest wall pipe may be beneficial to the program.

The main concern for elevated pipelines is a sudden increase in unsupported length should the slope fail. The procedure should be updated to require allowable unsupported length (USL) to be submitted with the request for SME review. This allows the SME to evaluate the threat of bank failure to the pipeline. For elevated pipes perpendicular to water crossings, we believe soil spring analyses are not needed due to the reduced DOC at the banks and short length of pipeline in the deformation zone (i.e., pipeline is not following the slope). We can back this up with a “worst case” scenario soil springs analyses on an elevated pipeline.

Arcadis recommends creating another slope stability hazard matrix that addresses elevated or suspended pipelines that takes the shallow DOC and pipe supports into account. Based on our experience, plans with pipeline support embedment depths are not readily available. A setback rule may be established for failure surfaces intersecting or encompassing embedded pipe supports.

Another issue is the Scorecard question #9 regarding “active erosion”. There is always erosion present on a stream bank and the question is heavily weighted and changes the result to “Yellow”. Much time is spent reviewing images and discounting the erosion as not impacting bank stability or only being an “erosion” issue. We believe the Scorecard should be modified to say “extreme erosion including gullies” or including “presence of gullies” in the #6 overland flow scorecard question. The undercutting question #10 addresses erosion impacting stability and question #9 may be redundant.

Elevated Pipelines

US-00169 is an extreme example of a crossing with an elevated pipeline where the pipe support embedment depth can determine whether the pipe support can become dislodged in the event of bank failure. The pipeline and failure surface are shown in Figure 1.

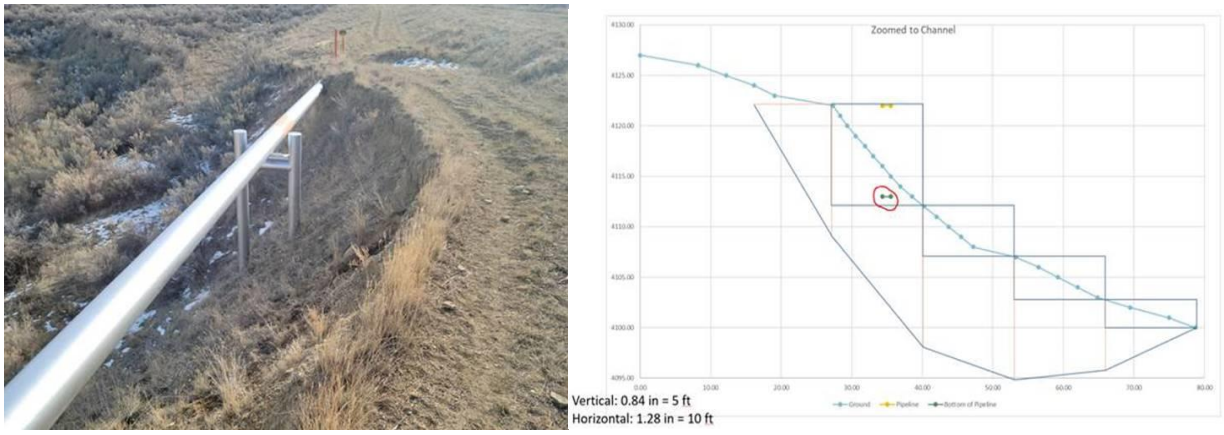

Figure 1. Crossing US-00169 with Intermediate Support Structure

The Professional Survey Water Crossing Inspection Report (PL-2388) form has a section with the support bearing depth (which typically is unknown) but it is unclear how this information is usually found in the EMPCo database. In this case, an embedment depth of only 2 feet does not extend past the projected failure plane and the support

may become dislodged if the bank fails. We need to verify embedment depths in these cases but currently do not know how.

5) External Infrastructure Inspection

5A: Pipe Supports

This guidance should be used for collecting data of a pipeline water crossing that contains supports installed to carry the weight of the pipe and the material in the pipe over a defined span.

1. Identify if supports exist in the water crossing. If any, describe the material(s) the pipe supports are made of (ex. I-beam, wooden timbers, bridge support.) H-BRACE OUT OF 8" Pipe

2. Identify the type of support (augered/jacked, sheeting, anchored to footing/base, etc.)

3. Document the number of pipe supports and if possible, survey the location of each pipe support using a GPS. Inspector should assign a number for each pipe support. Looking downstream, numbering of supports from left bank to right bank should be in numerical order as shown on the Support Numbering Figure on Page 9. Complete the table below, marking the units used when necessary. Please also include photos.

Pipe Support #	Depth of Bottom of Support (Support Bearing Depth) (in or ft)	Description of Measurement (ex: bottom of H brace to channel, pipe to channel, etc.)	Height of Pipe Support from Channel Bed to Top of the Support (in or ft)	Cross-Section Dimension of Pipe Support (ex: 2" x 4" I-beam)	Cradling, Clamping, or Insulating Material Between the Pipe and the Support	Stability Rating (Based on guidance in Table 2 on page 9)
1	2'			8" Pipe	NYLON HALF MOON	
2	2'			8" Pipe	"	

Figure 2. PL-2388 Form with Embedment Depth

Figure 3 shows US-00145 as an example of a crossing with an elevated pipeline where soil spring analysis is not needed due to minimal soil load. The length of pipeline effected by the failure plane used in the bank stability assessment is small and it would be better to use the bank erosion rate from the hydrotechnical assessment to evaluate the expected amount of time before the allowable USL may be reached.

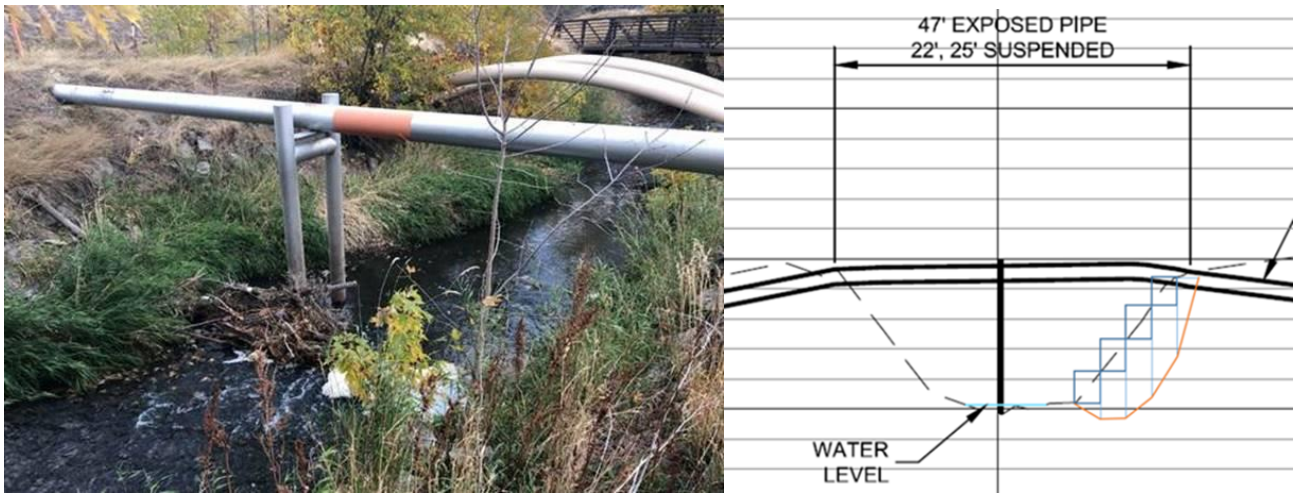

Figure 3. Crossing US-00145 is an Elevated Pipeline

Arcadis looks forward to discussing these issues and working towards solutions to improve the bank stability assessment procedures.