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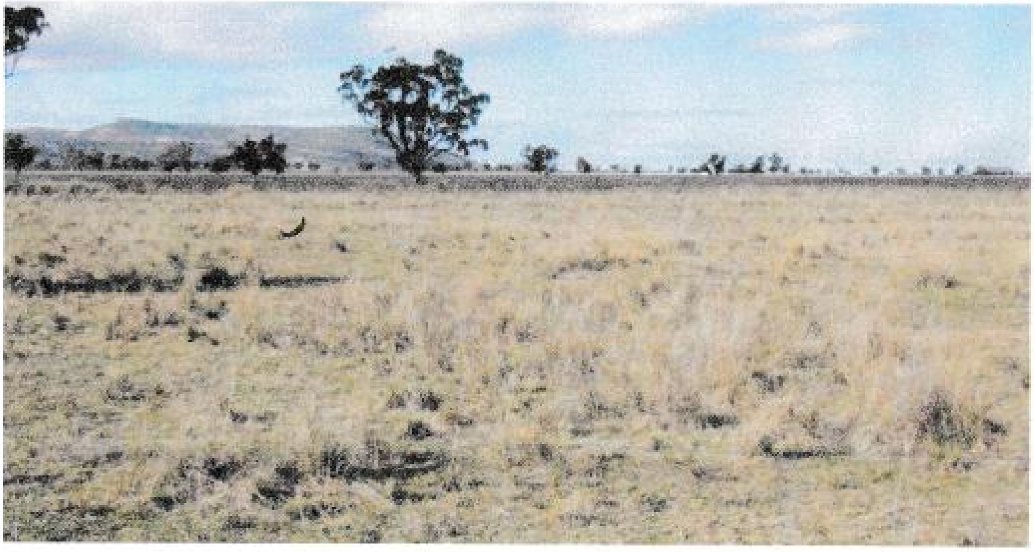

Review of Soil and Drainage Line Constraints for a Buried Gas Pipeline: Western Liverpool Plains

Prepared for:

Hunter Gas Pipeline Pty Ltd

5 November 2020

Strategic Environmental & Engineering Consulting

SEEC

Strategic Environmental and Engineering Consulting

PO Box 1098, Bowral NSW 2576
phone: (02) 4862 1633 • fax: (02) 4862 3088 • email: reception@seec.com.au • www.seec.com.au

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Andrew Macleod B.Sc (Hons) CPESC CPSS
Director and Principal Soil Conservationist
SEEC

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Version Register

Version	Date	Author	Reviewer	Notes
Rev 00	21 Oct 2020	AM	BJ	Issued for review
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1 INTRODUCTION

1.1 Background and Purpose

SEEC was engaged by Hunter Gas Pipeline Pty Ltd to review provided documentation and provide high-level advice and guidance on soil constraints and erosion hazards associated with buried gas pipeline planning, construction and operation across the Vertosols of the Liverpool Plains in NSW.

Vertosols are reactive clay soils and are described in Isbell (2016) as follows:

- *A clay field texture or 35% or more clay throughout the solum except for thin, surface crusty horizons 0.03 m or less thick; and*
- *When dry, open cracks occur at some time in most years. These are at least 5 mm wide and extend upward to the surface or to the base of any plough layer, peaty horizon, self-mulching horizon, or thin, surface crusty horizon; and*
- *Slickensides and/or lenticular peds occur at some depth in the solum.*

This report was prepared by Andrew Macleod from SEEC, a Certified Professional Soil Scientist (CPSS) and Certified Professional in Erosion and Sediment Control (CPESC).

1.2 Limitations

In preparing this report, SEEC staff have not undertaken a site inspection and have not collected or analysed any soil samples. This report comprises a desktop review and high-level guidance only to help with planning the construction and operation of a buried gas pipeline across the Vertosols of the Liverpool Plains in NSW.

This report does not constitute geotechnical advice and has not been prepared nor reviewed by a geotechnical or pipeline engineer. No decisions regarding pipeline routing, construction or operation should be made based on the advice provided herein without first undertaking additional studies or designs as recommended, or seeking further advice from subject-matter experts.

Adoption of any of the recommendations in this report does not guarantee that the pipeline would not be impacted by soil movement in reactive clay soils such as the Vertosols on the Liverpool Plains.

2 REVIEW OF SOILFUTURES REPORT

2.1 Introduction

A review was conducted of a report dated October 2011 prepared by Robert Banks of SoilFutures Consulting Pty Ltd ("the SoilFutures report"), which was appended to a submission to the NSW Independent Planning Commission (IPC) by Peter Wills.

I am familiar with Mr Banks' work and his experience working with the soils on the Liverpool Plains of NSW. I largely concur with the findings and recommendations within the SoilFutures report and find it to be a relatively comprehensive summary of potential issues relating to construction of a buried gas pipeline across the Vertosols of the Liverpool Plains. In short, I concur that movement associated with highly reactive clay soils (such as the Vertosols of the Liverpool Plains) presents a significant risk for a buried pipeline.

2.2 Additional Considerations

Although I broadly concur with the findings and recommendations within the SoilFutures report, I note the following points:

- With regard to the gully washout at "Barana":
  - The SoilFutures report suggests that the excessive width of the gully erosion at the pipe location was caused by turbulent flow associated with the pipeline. Whilst there might be some truth in this statement, this is only speculation by the author. In making this conclusion, consideration hasn't been given to some other potential causal factors such as:
    - Trenching activities for pipe construction, which can create preferential pathways for subsurface water movement; and
    - Potential issues associated with compaction (or lack thereof) when the pipe trench was backfilled. Poor compaction of backfill material could have created a natural propensity for erosion of that material that might have been a contributing factor to the excessive gully width observed.
  - Following on from the above, it's not just the presence of the pipeline that causes or exacerbates the potential for erosion at a watercourse crossing such as that on the "Barana" property. The construction methodologies are also significant potential contributing factors. If construction methodologies could be modified to address the risks identified above, this could help reduce the risk of a buried pipeline causing or exacerbating gully erosion at a watercourse crossing.

- With regard to the presence of highly reactive soils, gully erosion and potential for high run-on:
  - The maps in Figures 1 to 3 of the SoilFutures report identify both "widespread" and "localised" hazards for each soil and landscape limitation. These maps are based on the NSW Government Soil Landscape mapping, typically conducted at a scale of 1:100,000. While I do not question the quality of the Soil Landscape mapping and acknowledge that it is an excellent resource, site-specific soil testing along the proposed pipeline route would be worthwhile to further refine these data and to determine:
    - The location and extent of reactive soils;
    - The degree of reactivity within those soils;
    - Those locations along the pipeline route where high run-on might be a significant concern for pipe stability and erosion hazard.
  - An assessment of the fluvial geomorphology of each proposed pipeline watercourse crossing would be worthwhile to determine:
    - Existing erosion issues, including the depth, width and bank condition of any existing eroded gullies;
    - The potential for future erosion issues, caused by both external factors (non-pipeline-related, such as runoff from surrounding lands) and by pipeline-related (e.g. trenching across a natural watercourse);
    - Watercourse conditions that might influence decision-making regarding construction methodology or timing (e.g. depth of alluvial material, flow patterns, natural vegetation etc.).

In noting the above points, this does not alter my concurrence with the most significant findings of the SoilFutures report, especially with regard to the inherent risks posed to a buried gas pipeline from highly reactive clay soils.

2.3 Other References

I have not conducted a literature review of potential impacts on buried pipelines in highly reactive soils as this is well summarised in the SoilFutures report and I concur with the conclusions therein. However, I note that there are a number of examples where high-pressure gas transmission pipelines have been sited within areas of reactive clay soils, including:

- Near Oakey, in the Darling Downs region of Queensland.
- The southern end of the Amadeus Gas Pipeline in the Northern Territory.

In discussions with an environmental specialist from the asset owner of both pipelines (APA Group), they were not aware of any significant ongoing pipeline stability issues caused by those soils.

I acknowledge that the shrink/swell characteristics of the soils at those sites might very well differ from the soil conditions experienced in the Liverpool Plains Vertosols. As such, I consider site-specific soil testing would be very worthwhile prior to pipeline construction, to determine the soil conditions (especially with regard to shrink/swell potential), allow comparison with other locations/projects, and employ appropriate application of proven soil management and pipe construction techniques to this project.

I note that Australian Standard AS 2885 includes the following:

"Environmental matters are of importance in the construction and operation of pipelines and must be considered fully in the design stage. In view of the wide range of conditions that occur and the wide variations in available information, specific requirements cannot be incorporated in the Standard. The extent of the investigations that are necessary in a particular location will depend on the amount and reliability of the environmental information already available, and the sensitivity of the location to environmental damage.

The basis of the design is that a pipeline is required to have sufficient strength to withstand all forces to which it will be subjected during construction, testing, and operation. Before a pipeline is placed in operation, it is to be inspected and tested to prove its integrity by tests to verify its pressure strength and leaktightness."

As such, compliance with Australian Standard AS 2885 during pipeline planning, construction and operation should inherently include addressing any risks posed to the operational stability of the pipeline from reactive clay soils.

3 RECOMMENDATIONS

Table 1 details a series of recommendations for the planning, construction and operation of the new pipeline. Note that the construction and operational phase recommendations would ultimately be informed by the investigations recommended in the planning phase, and these should not be considered definitive or exhaustive.

Table 1: Options and recommendations

No.	Recommendation	Details
		Planning Phase
1	Detailed soil survey	Conduct a detailed soil survey along the route of the proposed pipeline in areas where Vertosols are mapped (based on the Namoi Catchment Management Authority (NCMA, 2009) Soil Landscape mapping) to determine soil conditions. This survey should include an assessment of soil conditions at multiple depths within the soil profile, including below the proposed pipe elevation. Soil assessments should include (but not be limited to): • Describing the soil type; • Particle size analysis; • Observed shrink/swell properties; • Optimum moisture content to aid compaction and settlement; • Volume expansion. Any soil survey program must be designed in consultation with a geotechnical engineer specialising in pipelines, as well as a soil conservationist. It is also recommended that detailed soil surveys include consultation with landholders along the proposed survey corridor, as they have extensive experience and knowledge of the inherent soil conditions.
2	Detailed fluvial geomorphology survey of all watercourses to be crossed.	An expert fluvial geomorphologist should conduct a detailed investigation of all watercourse crossings along the route of the proposed pipeline. This survey should include (but not be limited to): • Existing erosion issues, including the depth, width and bank condition of any existing eroded gullies; • The potential for future erosion issues, caused by both external factors (non-pipeline-related, such as runoff from surrounding lands) and by pipeline-related (e.g. trenching across a natural watercourse); • Watercourse conditions that might influence decision-making regarding construction methodology or timing (e.g. depth of alluvial material, flow patterns, natural vegetation etc.).
3	Locally relocate the pipe to avoid high-risk areas	Following on from the detailed survey of soils and watercourses (Items 1 and 2 in this table), determine where the pipeline route might be locally relocated to avoid high-risk areas (if possible). Note that any areas identified for local relocation would also need to be subject to soil and watercourse assessment as per Items 1 and 2, above.

No.	Recommendation	Details
4	Locally position the pipe in road reserves	In addition to the recommendations in Item 3, to avoid the most productive agricultural land, consider the potential to position the pipeline within road reserves if possible. Road reserves tend to have a more constant moisture content in the soils than surrounding agricultural lands, because ground cover conditions (especially vegetation) don't change as frequently, soils are often compacted, and batter slopes encourage runoff, rather then infiltration. A more constant moisture content in soils will help reduce shrinking and swelling within reactive clay soils.
5	Training for construction staff	While training and induction are typically undertaken on any construction project, it is recommended that training be provided to construction staff specifically related to potential issues associated with highly reactive clay soils. This training should include (but not be limited to): • Erosion issues associated with subsidence along backfilled trench lines; how to recognise potential problems and address them; • Erosion issues associated with mounding of spoil over trench lines; how to recognise potential problems and address them; • Erosion issues associated with open trenching through watercourses and gullies, and how to avoid common problems; • Constructing access tracks, cross banks and drainage features for stability and to replicate the natural movement of water in the landscape.
Construction Phase		
6	Use trenchless construction techniques across higher-risk watercourses	The detailed fluvial geomorphological survey of all watercourses to be crossed (Item 2) will identify where there is a significant risk of erosion that might impact on or be exacerbated by pipeline construction. In those locations, consideration should be given to trenchless construction techniques such as Horizontal Directional Drilling (HDD). This is particularly relevant where: • Open trenching across an actively eroding watercourse or gully line would create a permanent weak spot in the bed and banks of that watercourse; and/or • Compaction issues in the backfilled trench could act as a subsurface pathway for water movement that might cause or exacerbate erosion. Adoption of any trenchless techniques for pipe construction must be in consultation with a geotechnical engineer specialising in pipelines.

No.	Recommendation	Details
7	Ensure adequate pipe depths	The soil and watercourse surveys (Items 1 and 2 in this table) will identify (among other things): • The depths to which highly reactive clay soils extend down to; and • The depth of any alluvial material in watercourses that would be prone to re-entrainment in future large flow events. When planning and constructing the pipe, consideration must be given to the pipe elevation in the ground. If possible this would include: • Placing the pipe at an elevation deep enough to avoid the most highly reactive layer(s) in the soil profile; and • When crossing watercourses, placing the pipe at an elevation below any transient alluvial material that would be expected to be mobilised in a flow event (and which could expose the pipe). Note that the above requirements would also apply to any pipe scour protection measures, which should also be finished flush with the solid watercourse bed materials. They should not extend into the watercourse bed load material that is expected to migrate during high flows. Ultimately, pipe depth will be determined based on a number of factors and advice should be sought from a geotechnical engineer specialising in pipelines.
8	Lime treatment of reactive soils above, around and below the pipe.	Lime stabilisation of subgrades is frequently used to minimise the risk of damage to road pavements from reactive clay soils. This technique might be feasibly used to chemically alter the soil conditions and reduce the amount of potential soil movement around the pipe. Note that specialist geotechnical advice must be sought on this issue.
9	Design and construct the pipeline to cope with soil movement.	If possible, the pipeline (or the material surrounding it) should be constructed to allow for expected soil shrinking and swelling. Note that specialist advice must be sought on this issue from engineers specialising in pipe construction and soil movement.
10	Minimise potential for subsurface water movement along the pipe	To reduce the risk of the pipe trench providing a preferential pathway for subsurface water movement, scour protection measures (e.g. trench breaks) should be included at regular intervals. The positioning and design of these should be determined in consultation with a specialist pipeline engineer.
11	Compaction during trench backfill operations	Advice should be sought from a geotechnical engineer regarding the optimum moisture conditions for backfill material, as cracking clay soils such as Vertosols can be more readily compacted when moist. During construction, water might need to be applied to windrowed trench spoil to attain optimum moisture content in the material prior to returning it to the trench.
12	Stockpile excess trench spoil for rapid use to fill any subsidence over the pipe.	If possible, create stockpiles of excess trench spoil as a resource to use for rapid repair (filling) of any subsidence along the trench line.

No.	Recommendation	Details
13	Construct access tracks to avoid concentrating water or modifying existing drainage patterns	Access tracks along the pipeline easement should be well-formed and shaped in a manner that avoids them causing artificial concentrations of runoff. Access tracks should include drainage features such as cross banks, table drains, mitre drains (turn-outs) etc as required so that they replicate the existing drainage pattern of the surrounding landscape as much as possible. Note that this is also a planning issue, and guidance on access tracks should be developed by a suitably qualified soil conservationist and drainage engineer during the project design phase.
		Operation Phase
14	Maintain relatively constant soil moisture	Soil movement at pipe depth is influenced by changing moisture content. Therefore, if soil moisture content can be maintained relatively constant, this will help to reduce the amount of soil movement. While this is very difficult to achieve in practice, consideration should be given to the role that vegetation cover and land management practices play in controlling runoff, infiltration and soil moisture content. If possible, the pipeline should not be sited adjacent to lands where management practices rapidly alter the soil moisture content (e.g. heavily irrigated lands).
15	Ongoing monitoring and maintenance	Ongoing monitoring and maintenance is standard practice for a pipe asset owner/operator. However, in the case of highly reactive clay soils, conditions can change relatively rapidly and pipe damage or erosion could also occur relatively rapidly. As such, the asset owner/operator must have a highly responsive management framework to quickly respond to issues as they arise. This includes having ready access to: • In-house expertise to assess erosion problems and develop solutions/plans; • Appropriate machinery and equipment to access and address potential problem areas. I recommend an Operational Management Plan (OMP) be prepared that details how this would be addressed. This OMP should also address ongoing maintenance of access tracks (refer to Item 12 in this table), as tracks are a frequent source of erosion problems along pipeline easements.

Note that the above recommendations do not provide a comprehensive suite of recommendations for the construction of buried pipelines. Extensive guidance is also available in other documents such as Appendix P of IECA (2008), and the APGA (2017) Environmental Code of Practice. Planning and construction should reference those documents to guide best-practice erosion and sediment control.

Further, adoption of the above recommendations does not guarantee that the pipeline would not be impacted by soil movement in reactive clay soils such as the Vertosols on the Liverpool Plains. The above recommendations are put forward as potential methods to help reduce risk, but further investigations and detailed design are required before commencing construction.

4 REFERENCES

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