Maui Pipeline (403Line)
Assessment of Geohazard Features
Huntly Offtake to Huntly Power Station
A02676751-R004-0416
Vector Limited
Maui Pipeline (403Line) Assessment of Geohazard Features
Huntly Offtake to Huntly Power Station

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Limitations:

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With the exception of the geohazard features visited by PDP for field review/assessment, this report has been prepared using information provided by Vector Limited including identification and observations at the geohazard features along the pipeline route assessed by Vector Limited to be relevant for pipeline risk assessment. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

The risk ranking provided in this report is based on visual engineering geological observations and/or desktop assessment of the pipeline route at the selected geohazard features. With the exception of field evaluations at selected features, no subsurface investigation has been carried out to confirm the desktop/visual interpretation of the risk ranking at the features.
Executive Summary

This report is one of a set of six reports that document the geohazard assessment for six of the seven on-shore pipeline sections of the 307 km long Maui Pipeline (400Line and 403Line) running between the Oaonui Production Station and the Huntly Power Station. The geohazard assessment reports for the 400Line and 403Line comprise:

- Oaonui Production Station to Frankley Road Offtake
- Frankley Road Offtake to Mokau Compressor Station
- Mokau Compressor Station to Mahoenui Scraper Station
- Mahoenui Scraper Station to Tihiroa Scraper Station
- Tihiroa Scraper Station to Huntly Offtake
- **Huntly Offtake to Huntly Power Station (403Line).**

The Maui Pipeline section between Oaonui Production Station and Frankley Road Offtake includes the Frankley Road Offtake to New Plymouth Power Station pipeline known as the 404Line. This section of pipeline is not included in the geohazard assessment process because the operational status of the pipeline is suspended at the time of this assessment.

This report documents the geohazard assessment for the Huntly Offtake to Huntly Power Station section of the Maui Pipeline (403Line).

Vector Limited (Vector) requested that Pattle Delamore Partners Limited (PDP) provide geohazard advice in a desktop workshop and at selected locations in the field to assess the geohazard risk at geohazard features identified along this section of the 403Line.

Geohazard features are slope instability (e.g. landsliding and slumping), surface water erosion, sub-surface erosion, trench backfill consolidation and human related hazards (e.g. excess fill).

The Tihiroa Scraper Station to Huntly Offtake and Huntly Offtake to Huntly Power Station (403Line) sections of the pipeline were the first sections to be assessed for geohazard feature risk. As a result, the risk assessment process for these 2 pipeline sections has included additional stages compared to the process for the other 4 pipeline sections, namely:

- Initial assessment of geohazard feature risk was carried out using a precursor version of the Vector Geohazard Feature Risk Ranking Assessment Tool (GFRRAT). Subsequent re-ranking of risk using the updated version of the GFRRAT was therefore required to ensure consistency with the risk assessment carried out for other sections of the pipeline.
A Vector pipeline integrity assessment carried out in April 2014 recommended that field evaluations be carried out at a number of geohazard features as part of pipeline risk treatment actions. Information collected during these field evaluations (June 2014) has been used to provide the most up-to-date risk ranking for the geohazard features in this report.

Key conclusions arising from the desktop workshops and field reviews, assessments and evaluations are:

- There are a total of 25 geohazard features along this section of the pipeline.
- All 25 features have been risk assessed, namely:
  - 21 features assessed for geohazard risk using desktop methods only.
  - 4 features assessed using desktop and field methods.
- The geohazard risk ranking summary for the 25 geohazard features is:
  - 3 High risk
  - 2 Intermediate risk
  - 14 Low risk
  - 6 Negligible risk
- Field assessments indicate that the High risk rankings assigned in the desktop workshop are valid.
- Field review of geohazard features with a range of risk rankings, but with emphasis on the higher risk features is considered appropriate in the wider context of the overall risk assessment process.
- Based on all information available at completion of the field reviews (3 February 2014), no urgent actions were deemed necessary for geohazard features assessed in this report. Vector advised that the geohazard features would be evaluated using the Vector pipeline integrity assessment process and risk treatment actions would be identified and carried out as required, consistent with this process (refer below). In recognition of the potential for changes to geohazard risk with time from natural events such as heavy rainfall and flooding, Vector also advised that the geohazard features would be subject to ongoing monitoring as part of Vector’s routine pipeline surveillance. This monitoring includes special emphasis on High risk geohazard features and site specific monitoring.

The findings from field assessments and monitoring related to slope movement in mid-2015 at geohazard feature F2-2013 are included in this report.
The geohazard features and associated geohazard risk identified in this assessment will be considered along with pipeline related factors in further Vector pipeline integrity assessment processes (based on AS2885.1 2012). The Vector pipeline integrity assessment will determine the need for and scope of any further risk treatment actions at the geohazard features.

Vector has advised that the geohazard features for the entire pipeline will be maintained and documented within the Vector GIS (Geographic Information System) framework.
Table of Contents

<table>
<thead>
<tr>
<th>SECTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Executive Summary</td>
<td>ii</td>
</tr>
<tr>
<td>1.0 Introduction</td>
<td>1</td>
</tr>
<tr>
<td>2.0 Scope and Objectives</td>
<td>2</td>
</tr>
<tr>
<td>2.1 Initial Desktop Workshop and Field Reviews</td>
<td>3</td>
</tr>
<tr>
<td>2.2 GFRRAT Re-Ranking Assessment</td>
<td>4</td>
</tr>
<tr>
<td>2.3 Vector Pipeline Integrity Assessment Field</td>
<td></td>
</tr>
<tr>
<td>Evaluations</td>
<td>4</td>
</tr>
<tr>
<td>3.0 Geohazard Risk Ranking System</td>
<td>4</td>
</tr>
<tr>
<td>4.0 Pipeline Route Characteristics</td>
<td>6</td>
</tr>
<tr>
<td>4.1 Section Alignment and Geology</td>
<td>6</td>
</tr>
<tr>
<td>4.2 Slope Instability Overview</td>
<td>6</td>
</tr>
<tr>
<td>5.0 Initial Desktop Workshop Assessment</td>
<td>7</td>
</tr>
<tr>
<td>5.1 Methodology and Inputs</td>
<td>7</td>
</tr>
<tr>
<td>5.2 Outcomes</td>
<td>8</td>
</tr>
<tr>
<td>5.3 Recommendations</td>
<td>9</td>
</tr>
<tr>
<td>6.0 Initial Field Review and Assessment</td>
<td>9</td>
</tr>
<tr>
<td>6.1 Strategy</td>
<td>9</td>
</tr>
<tr>
<td>6.2 Methodology</td>
<td>9</td>
</tr>
<tr>
<td>6.3 Outcomes and Recommendations</td>
<td>10</td>
</tr>
<tr>
<td>7.0 GFRRAT Risk Re-Ranking Assessment</td>
<td>10</td>
</tr>
<tr>
<td>7.1 Methodology</td>
<td>10</td>
</tr>
<tr>
<td>7.2 Re-Ranking Workshop Outcomes</td>
<td>11</td>
</tr>
<tr>
<td>8.0 Vector Pipeline Integrity Assessment Actions</td>
<td>11</td>
</tr>
<tr>
<td>8.1 Vector Pipeline Integrity Assessment</td>
<td>11</td>
</tr>
<tr>
<td>8.2 VPIA Field Evaluations and Outcomes</td>
<td>12</td>
</tr>
<tr>
<td>8.3 Comparison of GFRRAT Workshop and VPIA Field</td>
<td>12</td>
</tr>
<tr>
<td>Evaluation Risk Rankings</td>
<td></td>
</tr>
<tr>
<td>9.0 Recent Field Investigations and Monitoring</td>
<td>13</td>
</tr>
<tr>
<td>10.0 Overall Conclusions</td>
<td>13</td>
</tr>
<tr>
<td>11.0 References</td>
<td>14</td>
</tr>
</tbody>
</table>

Table of Figures

Figure 1: Overview of Geohazard Feature Risk          15
Table of Tables

Table 1: Geohazard Risk Ranking after GFRRAT Desktop Workshop Assessment

Table 2: Comparison of Desktop and VPIA Field Evaluated Geohazard Risk Rankings

Table 3: Geohazard Risk Ranking after Workshop and Field Review/Evaluation

Appendices

Appendix A: Geohazard Feature Risk Ranking Assessment Tool (Vector)

Appendix B: Geohazard Feature Risk Ranking Assessment Record
1.0 Introduction

This report is one of a set of six reports that document the geohazard assessment for six of the seven on-shore pipeline sections of the 307 km long Maui Pipeline (400Line and 403Line) running between the Oaonui Production Station and the Huntly Power Station. The geohazard assessment reports for the 400Line and 403Line comprise:

- Oaonui Production Station to Frankley Road Offtake
- Frankley Road Offtake to Mokau Compressor Station
- Mokau Compressor Station to Mahoenui Scraper Station
- Mahoenui Scraper Station to Tihiroa Scraper Station
- Tihiroa Scraper Station to Huntly Offtake
- Huntly Offtake to Huntly Power Station (403Line).

The Maui Pipeline section between Oaonui Production Station and Frankley Road Offtake includes the Frankley Road Offtake to New Plymouth Power Station pipeline known as the 404Line. This section of pipeline is not included in the geohazard assessment process because the operational status of the pipeline is suspended at the time of this assessment.

This report documents the geohazard assessment for the Huntly Offtake to Huntly Power Station section of the Maui Pipeline (403Line).

Vector Limited (Vector) requested that Pattle Delamore Partners Limited (PDP) provide advice in a desktop workshop and at selected locations in the field to assess the geohazard risk to the Maui Pipeline (403Line) at geohazard features identified between the Huntly Offtake and Huntly Power Station. For purposes of clarity, the pipeline outlined above will be referred to as “the pipeline” or “pipeline” in the remainder of the report.

For the purposes of the assessment, geohazard features are slope instability (e.g. landsliding and slumping), surface water erosion, sub-surface erosion, trench backfill consolidation and human related hazards (e.g. excess fill). Other geohazards such as seismic hazards (e.g. fault rupture and liquefaction) are outside the scope of the assessment.

A total of 25 geohazard features have been identified and considered along the pipeline section. All features were identified in a foot assessment undertaken by Derek Coombe (Senior Pipeline Integrity Specialist, Vector). Geohazard features identified during the walkover included small (slumping) and large (landslide) scale slope instability, pipeline trench consolidation, stream erosion and human related features such as fill areas.
The geohazard identification and assessment process has comprised:

- Identification of geohazard features by foot assessment which was undertaken by Derek Coombe (Senior Pipeline Integrity Specialist) from Vector in September/October 2013.
- An initial desktop workshop assessment carried out by Derek Coombe and Neil Crampton (Technical Director Engineering Geology) and Chris Foote (Engineering Geologist) from PDP in October/November 2013.
- Field review of selected geohazard features by Derek Coombe and Neil Crampton in February 2014.
- GFRRAT re-ranking workshop assessment carried out by Derek Coombe, Neil Crampton and Chris Foote in March 2014.
- Field evaluations recommended by the Vector pipeline integrity assessment.
- Recent field assessment and monitoring at 1 geohazard feature due to fresh slope movement in mid-2015.

This report outlines the methodology and presents the findings from the assessment of geohazard features along this section of the pipeline including the geohazard feature risk ranking assessment record, the number of features in each risk category, conclusions and recommendations.

The geohazard features and associated geohazard risk identified in this assessment will be considered along with pipeline related factors in further Vector pipeline integrity assessment processes. The Vector pipeline integrity assessment will determine the need for and scope of any further risk treatment actions at the geohazard features.

Vector has advised that the geohazard features for the entire pipeline will be maintained and documented within the Vector GIS (Geographic Information System) framework.

### 2.0 Scope and Objectives

The Tihiroa Scraper Station to Huntly Offtake and Huntly Offtake to Huntly Power Station (403Line) sections of the pipeline were the first sections to be assessed for geohazard feature risk. As a result, the risk assessment process for these 2 pipeline sections has included additional stages compared to the process for the other 4 pipeline sections. The additional stages, which are described in the following sections, are:
Initial assessment of geohazard feature risk was carried out using a precursor version of the Geohazard Feature Risk Ranking Assessment Tool (GFRRAT). Subsequent risk re-ranking with the updated version of the GFRRAT was therefore required to ensure consistency with the risk assessment carried out for other sections of the pipeline.

A Vector pipeline integrity assessment carried out in April 2014 recommended that field assessments be carried out at a number of geohazard features as part of pipeline risk treatment actions. Information collected during these field assessments (June 2014) has been used to provide the most up-to-date risk ranking for the geohazard features in this report.

2.1 Initial Desktop Workshop and Field Reviews

2.1.1 Initial Desktop Workshop

The initial workshop had the objective of using the available information to assess and rank risk to the pipeline at each geohazard feature identified during the foot assessment (and any additional geohazard feature identified during the workshop), where this was possible based on the available information.

2.1.2 Field Reviews

The objectives of the field reviews were to:

- Provide a degree of calibration for the desktop risk assessment process.
- Based on all information available, determine whether any geohazard features require urgent action at the time of completion of the field reviews. Vector advised that the geohazard features would subsequently be evaluated using the Vector pipeline integrity assessment process and that the features would be subject to ongoing monitoring as part of Vector’s routine pipeline surveillance in recognition that geohazard risk can change over time.

The scope of the field reviews involved locating and determining the depth to the pipeline (using electronic locator) and carrying out a brief (up to 1hr duration) engineering geological site assessment (walkover) at each geohazard feature. In addition, engineering geology evaluation was used to infer geohazard mechanisms and the likelihood of geohazard effects on the pipeline at each feature for risk assessment purposes.

The field reviews were based on visual appraisal of the geohazard feature only and have not been confirmed by a detailed geohazard assessment (e.g. subsurface investigations) which may modify the allocated risk ranking.
2.1.3 Initial Risk Assessment

The initial assessment of geohazard feature risk was based on the initial desktop workshop and field reviews and was carried out using a precursor version of the Geohazard Feature Risk Ranking Assessment Tool (GFRRAT). The precursor risk assessment was superseded by the risk assessment subsequently carried out (refer below) which used the Vector GFRRAT current at the time of writing (Vector Document #3208429, Appendix A). Information from the foot assessment, initial desktop workshop and field reviews were used for both the initial and updated risk assessment.

2.2 GFRRAT Re-Ranking Assessment

The purpose of the GFRRAT re-ranking assessment was to apply the updated GFRRAT and obtain a risk ranking for each geohazard feature, utilising information from the foot assessment, initial desktop workshop and field reviews.

The GFRRAT re-ranking assessment was based solely on desktop methods and essentially involved determining a feature mechanism, severity category, frequency class and risk rank for each geohazard feature.

2.3 Vector Pipeline Integrity Assessment Field Evaluations

The Vector pipeline integrity assessment (VPIA) carried out in April 2014 recommended field evaluations be carried out at a number of geohazard features as part of pipeline risk treatment actions. Two types of field evaluation were recommended, namely:

- A Site Condition Assessment (SCA) at all High risk geohazard features. An SCA comprises desktop assessment and site investigation, including pipeline location/depth information, surface engineering geological evaluation and limited shallow sub-surface investigations.
- A Site Visit (SV) at a selection of Intermediate risk geohazard features. A SV involves a preliminary surface engineering geological evaluation (walkover) and a check on pipeline location/depth.

Information collected during the field evaluations has been used to provide the most up-to-date risk ranking for geohazard features in this report.

3.0 Geohazard Risk Ranking System

Vector has developed a Geohazard Feature Risk Ranking Assessment Tool (GFRRAT) for assigning a qualitative risk to geohazard features along the pipeline route (Appendix A).

The GFRRAT has the general framework contained in Appendix F of the AS2885.1 2012, risk matrix i.e. severity categories and frequency classes which are inputs
for a matrix that determines risk. The GFRRAT has however been tailored for geohazard features and, as such is intended as one of a number of inputs into the Vector pipeline integrity assessment process which is based on AS2885.1 2012 (i.e. the GFRRAT is not intended to be correlated directly with the AS2885.1 2012 pipeline risk assessment categories).

The GFRRAT retains the AS2885.1 2012 severity category titles but contains qualitative or semi-qualitative descriptions for each category (refer to Appendix A). The frequency classes and descriptions, and the risk matrix used in the GFRRAT are as per AS2885.1 2012.

The first step in assessing the risk for a geohazard feature is to assign a mechanism of failure/process based on desktop and field assessment and engineering geological judgement. The current range of geohazard feature mechanisms to choose from is:

- **Landslide** (slope instability > approximately 10m x 10m in footprint area)
- **Slump** (slope instability < approximately 10m x 10m in footprint area)
- **Erosion** (either surface erosion e.g. stream or river bank, surface water rilling or sub-surface erosion e.g. tomo and piping)
- **Ground Consolidation** (e.g. trench backfill consolidation, weak ground consolidation)
- **Human** - human activity (e.g. pond excavation, fill stockpile).

The second step of the GFRRAT is to select an appropriate severity category for the geohazard feature based on the failure mechanism/process and the consequences to the pipeline/pipeline cover of this mode of failure. Some examples are (refer also to Appendix A):

- The pipeline crosses a landslide and the inferred failure surface is below the depth of the pipeline. The mechanism is Landslide and the appropriate severity category is Major because the geohazard feature (landslide) could result in pipeline deformation.
- Slope instability on the slopes of a ridge where the pipeline is located on the ridge shoulder. The mechanism would be Landslide and the appropriate severity category is likely to be Severe i.e. landslide failure would remove cover to less than minimum, result in exposure of the pipeline or result in loss of support over less than the self-supporting length.
- Slope instability on the bank of a shallow drain would be classed as Slumping and the appropriate severity category would be Minor (loss of cover but minimum cover retained).
The Catastrophic severity category has been retained for the GFRRAT but this category is only likely to apply to extreme consequences to the pipeline e.g. exposed pipeline in a river crossing subject to impact by rocks or an actively moving landslide with loss of containment.

The third step of the GFRRAT is to select the appropriate frequency class for the geohazard feature mechanism/severity category i.e. the frequency (likelihood) of the mechanism occurring such that the pipeline is subjected to the severity category consequences. For both the Landslide examples above, the frequency class may be judged to be Unlikely (unlikely to occur in the life of the pipeline but possible). For the Slumping example above, the frequency class may be judged to be Occasional (may occur occasionally in the life of the pipeline).

The fourth step of the GFRRAT is to determine the risk for the geohazard feature using the risk matrix. For the first landslide example, the severity category is Major and the frequency class is Unlikely – the resulting risk ranking is High. For the second landslide example, the severity category is Severe and the frequency class is Unlikely – the resulting risk ranking is Intermediate. For the slumping example, Minor and Occasional result in a Low risk ranking.

Along with site details and foot/geohazard assessment comments, the table in Appendix B contains the geohazard feature mechanism, severity category, frequency class and Risk Rank for each geohazard feature for the pipeline section.

### 4.0 Pipeline Route Characteristics

Summary information on the topography and geology along the pipeline route is provided below to set the scene for the geohazard assessment that follows (refer to Figure 1 for pipeline route overview).

#### 4.1 Section Alignment and Geology

Between the Huntly Offtake (located at the Rotowaro Compressor Station) and the Huntly Power Station, the pipeline heads east towards the Waikato River. In this section, the pipeline crossing rolling farmland on generally east and south facing slopes as well as low lying swampy areas associated with Lake Waahi.

The geology throughout this pipeline section is a mixture of predominantly sandy Tauranga Group alluvium and softer Holocene alluvial materials such as peat and mud. The underlying Tertiary bedrock is typically Glen Massey Formation sandstone and siltstone.

#### 4.2 Slope Instability Overview

Slope instability occurs on some slopes underlain by Tauranga Group alluvium and Tertiary bedrock along the pipeline alignment. These typically comprise
large relic landslides which in some locations have more active internal lobes (e.g. F2-2013).

The relic landslides generally become more infrequent and eroded as the pipeline alignment heads eastward towards the Huntly Power Station.

5.0 Initial Desktop Workshop Assessment

The information inputs, methodology, outcome and recommendations from the initial desktop workshop phase of the geohazard assessment are outlined below.

5.1 Methodology and Inputs

Inputs and assessment methodology for the geohazard feature risk assessment carried out in the initial desktop workshop are outlined below.

5.1.1 Vector Foot Assessment Input

The pipeline foot assessment was undertaken by the Vector Senior Pipeline Integrity Specialist (Derek Coombe) during October 2013.

The following information was collected at each geohazard feature during the walkover:

- A GPS location point.
- Pipeline alignment located (electronic locator) and described.
- Geohazard feature described.
- Photographs taken of the geohazard feature and the general area.

5.1.2 Desktop Information Inputs

Desktop information inputs for the workshop include published geology, Google aerial photos, Vector line flight photos and historical reports. Key data sources used for the assessment of each geohazard feature in the workshop include:

- Geology Map
  - 1:250,000 QMAP Geology of the Auckland Region (Edbrooke, S.W. 2001).
- Aerial and Oblique Aerial Imagery
  - Line flight photographs.
  - Google Earth aerial imagery taken between 2001 and present day.
  - Vector in-house GIS layers.
5.1.3 Desktop Geohazard Feature Assessment Methodology

An assessment of each geohazard feature was carried out at the initial desktop workshop using the various inputs outlined above. The assessment typically included:

- Determine the instability mechanism at each geohazard feature based primarily on observed landforms (geomorphology) e.g. landslide, slump, erosion and ground consolidation.
- Consideration of the geology (e.g. rock/soil type, bedding orientation).
- Interpret the boundaries of each geohazard feature including depth (where relevant) and location within a larger geohazard feature (e.g. large relic landslide).
- Allocate a length of pipeline associated with each geohazard feature.
- Characteristics of each geohazard feature including:
  - Inferred mechanism of formation and contributing factors (e.g. groundwater, geology).
  - Inferred activeness and potential for future movement (reactivation).
  - Location of the pipeline with respect to the geohazard feature (including inferred depth relationship).
- A general assessment of likelihood and consequence of geohazard feature affecting the pipeline integrity.

5.1.4 Assessment of Geohazard Feature Risk

The assessment of geohazard feature risk during the initial desktop workshop was carried out using a precursor system of the current Geohazard Feature Risk Ranking Assessment Tool (GFRRAT) and therefore has not been included in this report. Geohazard feature risk for features along this section of the pipeline alignment is outlined in Section 7.

5.2 Outcomes

A total of 25 geohazard features were considered for assessment in the initial desktop workshop. These comprise:

- 22 geohazard features identified during the foot assessments.
- 3 geohazard features identified as part of the desktop workshop. These features comprised subdivision of whole slopes/large scale features into separate features to facilitate geohazard risk assessment.

The assessment summary for each geohazard feature from the initial desktop is presented in the geohazard feature risk ranking assessment record in Appendix
B. Note that the desktop assessment summaries in Appendix B combine the findings from the initial desktop workshop and the GFRRAT re-ranking assessment workshop (refer below).

5.3 Recommendations

Following the initial desktop workshop, it was recommended that field reviews be carried out at all higher risk geohazard features and selected lower risk features.

6.0 Initial Field Review and Assessment

The strategy, methodology, outcomes and recommendations for the field review and assessments phase of this geohazard assessment are outlined below.

6.1 Strategy

The strategy adopted for field review of geohazard features assessed in the desktop workshop was to review all High risk features (not previously assessed in the field) and a selection of lower risk features. The aim of the field review strategy was to provide a degree of calibration for the desktop risk assessment process with a greater emphasis on the higher risk geohazard features.

The strategy also involved carrying out a field assessment at any new geohazard features identified during the field review work. The same methodology (refer below) was adopted for field reviews and field assessments.

No new geohazard feature was identified during the field review work for this section of the pipeline and hence no field assessments were carried out.

6.2 Methodology

Field review was carried out at two geohazard features (F1-2013 and F2-2013) during February 2014.

The field review typically included the following at each geohazard feature:

- Locating and determining the depth to the pipeline (electronic locator).
- Carrying out a brief (up to 1hr duration) engineering geological site assessment (walkover) and using engineering geological evaluation and judgement to infer the extent, geometry, type, activity status and likelihood of effects on the pipeline from slope instability and other geohazard mechanisms.
- Determining if any urgent action was required.
6.3 Outcomes and Recommendations

The assessment summary for the two geohazard features reviewed in the field is presented in the geohazard feature risk ranking assessment record in Appendix B.

Based on all information available at completion of the field reviews (3 February 2014), no urgent actions were deemed necessary for geohazard features assessed in this report. Vector advised that the geohazard features would be evaluated using the Vector pipeline integrity assessment process and risk treatment actions would be identified and carried out as required, consistent with this process (refer below). In recognition of the potential for changes to geohazard risk with time from natural events such as heavy rainfall and flooding, Vector also advised that the geohazard features would be subject to ongoing monitoring as part of Vector’s routine pipeline surveillance. This monitoring includes special emphasis on High risk geohazard features and site specific monitoring.

7.0 GFRRAT Risk Re-Ranking Assessment

7.1 Methodology

7.1.1 Re-ranking of Initial Geohazard Risk

The geohazard feature risk rankings assigned during the initial desktop workshop (using a precursor system of the current GFRRAT) were re-ranked using the updated GFRRAT in a desktop workshop in March 2014.

7.1.2 GFRRAT Risk Re-Ranking Methodology

The updated risk ranking was based on information from the geohazard feature descriptions and assessments determined during the initial phases of the assessment i.e. foot assessment, initial desktop workshop and field reviews.

The assessment also included confirming/defining the following attributes for each geohazard feature to inform the GFRRAT risk re-ranking:

- The instability mechanism.
- The consequence of the geohazard feature affecting the pipeline integrity (e.g. loss of cover, exposure of pipeline, deformation of pipeline).
- The likelihood of the pipeline being affected by the geohazard feature – currently or in the future.
Re-Ranking Workshop Outcomes

The geohazard risk ranking statistics for the 25 geohazard features on this section of the pipeline after the desktop workshops and field reviews are presented in Table 1.

<table>
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<tr>
<th>Risk Ranking</th>
<th>Number of Geohazard Features (~% of total geohazard features (25))</th>
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<tbody>
<tr>
<td>High</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Intermediate</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>Low</td>
<td>14 (56%)</td>
</tr>
<tr>
<td>Negligible</td>
<td>6 (24%)</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
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Vector Pipeline Integrity Assessment Actions

Vector Pipeline Integrity Assessment

In April 2014, the geohazard features and associated geohazard risk identified in the above assessment were considered along with pipeline related factors in a Vector pipeline integrity assessment (VPIA) process based on AS2885.1 2012. The VPIA determined the need for and scope of any risk treatment actions at the geohazard features.

The outcome of the VPIA for this section of the pipeline was for field evaluations to be carried out as follows:

- Carry out a Site Condition Assessment (SCA) at all (2) High risk geohazard features. A SCA comprises desktop assessment and field investigation including pipeline location/depth information, surface engineering geological evaluation and limited shallow sub-surface investigations. The aim of a SCA is to collect surface and subsurface data to better define the risk to the pipeline at the geohazard feature.

- Carry out a Site Visit (SV) at a selection (1) of Intermediate risk geohazard features. A SV involves a preliminary surface engineering geological evaluation (walkover) and a check on pipeline location/depth. The aim of a SV is to evaluate surface data to better define the risk to the pipeline at the geohazard feature.
8.2 VPIA Field Evaluations and Outcomes

The VPIA field evaluations outlined above were carried out at three sites during June 2014, namely:

- A SCA was carried out at High risk geohazard features F2-2013 and F4-2013.
- A SV was carried out at Intermediate geohazard feature F7-2013.

A summary of findings from the field evaluations are presented in the geohazard feature risk ranking assessment record in Appendix B.

On completion of the field evaluations, the risk ranking for each of the geohazard features was reassessed and updated as required (refer below).

8.3 Comparison of GFRRAT Workshop and VPIA Field Evaluation Risk Rankings

Table 2 presents the risk ranking comparison for the three geohazard features that were allocated a risk ranking in the GFRRAT desktop workshop and also during the VPIA field evaluations.

<table>
<thead>
<tr>
<th>Geohazard Risk Ranking</th>
<th>GFRRAT Desktop Workshop (No. of geohazard features)</th>
<th>Following VPIA Field Evaluation (No. of geohazard features)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Intermediate</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

The field evaluations resulted in the following changes to the risk rankings assigned in the desktop workshop:

- The 2 High risk features retained their risk ranking.
- The risk ranking for the one Intermediate risk feature was increased by one ranking category to High.

These risk ranking comparisons indicate that the High risk rankings assigned in the desktop workshop are valid. The increase in geohazard risk (Intermediate to High) for feature F7-2013 was the result of clarifying the nature of the surface instability features and confirming the location and depth of the pipeline within the feature.
9.0 Recent Field Investigations and Monitoring

Additional field investigations and site monitoring have been carried out at geohazard feature F2-2013 since completing of the VPIA field evaluation in June 2014. The investigations and monitoring relate to slope movement events that were first detected in June 2015 and are inferred to have been triggered by a prolonged wet period in the preceding 6 weeks.

The findings from the field investigations and monitoring are presented in the geohazard feature risk ranking assessment record in Appendix B.

10.0 Overall Conclusions

There are a total of 25 geohazard features along this section of the pipeline. All 25 features have been assessed for geohazard risk as follows:

- 21 features assessed for geohazard risk using desktop methods only.
- 4 features assessed using desktop and field methods.

The geohazard risk ranking totals for the geohazard features on this section of the pipeline after both desktop workshop and field review/evaluation are presented in Table 3.

<table>
<thead>
<tr>
<th>Risk Ranking</th>
<th>Number of Geohazard Features (~% of total geohazard features (25))</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>3 (12%)</td>
</tr>
<tr>
<td>Intermediate</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Low</td>
<td>14 (56%)</td>
</tr>
<tr>
<td>Negligible</td>
<td>6 (24%)</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
</tbody>
</table>

Figure 1 illustrates the location and geohazard risk ranking for the geohazard features on the pipeline section.

Other key conclusions arising from the desktop workshop and field review/evaluation are:

- Field assessments indicate that the High risk rankings assigned in the desktop workshop are valid.
- The risk ranking for the one Intermediate risk feature was increased by one ranking category to High as a result of clarifying the nature of the
surface instability features and confirming the location and depth of the pipeline within the feature.

Based on all information available at completion of the field reviews (3 February 2014), no urgent actions were deemed necessary for geohazard features assessed in this report. Vector advised that the geohazard features would be evaluated using the Vector pipeline integrity assessment process and risk treatment actions would be identified and carried out as required, consistent with this process. In recognition of the potential for changes to geohazard risk with time from natural events such as heavy rainfall and flooding, Vector also advised that the geohazard features would be subject to ongoing monitoring as part of Vector’s routine pipeline surveillance. This monitoring includes special emphasis on High risk geohazard features and site specific monitoring.

The findings from field assessments and monitoring related to slope movement in mid-2015 at geohazard feature F2-2013 are included in this report.

The geohazard features and associated geohazard risk identified in this assessment will be considered along with pipeline related factors in further Vector pipeline integrity assessment processes (based on AS2885.1 2012). The Vector pipeline integrity assessment will determine the need for and scope of any further risk treatment actions at the geohazard features.

Vector has advised that the geohazard features for the entire pipeline will be maintained and documented within the Vector GIS (Geographic Information System) framework.

11.0 References


Vector Limited; Geohazard Feature Risk Ranking Assessment Tool, Vector Document #3208429, Rev 2.

SOURCE:
1. GEOHAZARD FEATURE LABELS SPACED APPROXIMATELY 5 FEATURES.
2. FEATURE RANKING AS PER VECTOR GEOHAZARD FEATURE RISK RANKING TOOL.
3. PIPELINE LOCATION PROVIDED BY VECTOR LTD 0800 734 567.
4. AERIAL IMAGES SOURCED FROM THE LINZ DATA SERVICE (FLOWN WRC 2012-2013) AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 3.0 NEW ZEALAND LICENSE.

FIGURE 1: OVERVIEW OF GEOHAZARD FEATURE RISK
# GeoHazard Feature Risk Ranking Assessment Tool

## Severity Category

<table>
<thead>
<tr>
<th>Trivial</th>
<th>Minor</th>
<th>Severe</th>
<th>Major</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Impact on easement or pipeline integrity. E.g. Land feature identified but pipeline within vicinity or feature considered not to be active.</td>
<td>Minimal Impact or effect to the easement and/or pipeline integrity, effects noted outside of the easement. E.g. Pipeline crosses or is in close proximity to a relic landslide (considered not active), erosion outside easement, pipeline slide down or within crest of a ridge, loss of cover (but minimum retain) due to erosion, slumping, ditch backfill migration or land modification.</td>
<td>Significant Impact to easement and/or pipeline integrity, effects within easement. E.g. Pipeline is in close proximity (&lt;6m) to an active land feature or shallow feature extends or encompasses the easement, regression is within the easement, loss of cover (less than minimum) due to landsliding, erosion, slumping or land modification (or the impact to the instability of a feature).</td>
<td>Major Impact to pipeline integrity, significant effects within easement. E.g. Pipeline is within an active land feature, potential for pipeline deflection, pipeline at risk to be exposed (but under self-supported length), feature is associated with other data (i.e. ILI, coatings, ground monitoring, etc.), land modification (has meant impact to the instability of a feature).</td>
<td>Extreme and/or Current Impact on the pipeline. E.g. Pipeline exposed (subject to impact, i.e. river, rock fall), pipeline alignment within an actively moving landslide feature.</td>
</tr>
</tbody>
</table>

## Frequency Classes

<table>
<thead>
<tr>
<th>Transmission Pipeline Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected to occur once per year or more</td>
</tr>
<tr>
<td>May occur occasionally in the life of the pipeline</td>
</tr>
<tr>
<td>Unlikely to occur within the life of the pipeline but possible.</td>
</tr>
<tr>
<td>Not anticipated for this pipeline at this location</td>
</tr>
<tr>
<td>Theoretically possible but has never occurred on a similar pipeline</td>
</tr>
</tbody>
</table>

## Risk Matrix

<table>
<thead>
<tr>
<th>Catastrophic</th>
<th>Major</th>
<th>Severe</th>
<th>Minor</th>
<th>Trivial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme</td>
<td>Extreme</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Occasional</td>
<td>Extreme</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Unlikely</td>
<td>High</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
<tr>
<td>Remote</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
<td>Negligible</td>
</tr>
<tr>
<td>Hypothetical</td>
<td>Intermediate</td>
<td>Low</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

## Notes

1. Field Observation Notes
2. Proximity of Pipeline(s) to the Feature
3. Site Images
4. Published Geology
5. Aerial Imagery

If further detail is made available such as detailed mapping, In Line Inspection data or sub-surface data (hand augers, test pits, core drilling), a review of the assumptions made during the first ranking will be carried out. Those observations ranked as Intermediate or higher shall be reviewed through the Safety Management Study (SMS), those ranked Low or Negligible would be continued to be monitored for change through routine surveillance.
<p>| Feature ID | Pipeline Section | Pipeline Description | Start NAD83 | End NAD83 | Observation Images | Areal Assessment | Geological | Feature Length | Inferred Mechanism | Frequency Class | Risk Ranking |
|-----------|------------------|----------------------|-------------|-----------|--------------------|----------------|-----------|--------------|------------------|-----------------|--------------|-------------|
| F001-2013 | Huntly Offtake to Huntly Power Station - Assessment of Geohazard Features - Appendix B Geohazard Feature Risk Ranking Assessment Record | | | | | Hypothetical | | | | | |
| F002-2013 | Huntly PS to Rotowaro CS to Waikokowai Road to Coal Haulage Road | | | | | Major | F002-2013 | | | | |
| F003-2013 | Huntly PS to Rotowaro CS | | | | | Major | F003-2013 | | | | |
| F004-2013 | Rotowaro CS to Waikokowai Road to Coal Haulage Road | | | | | Major | F004-2013 | | | | |
| F005-2013 | Waikokowai Road to Coal Haulage Road | | | | | Major | F005-2013 | | | | |</p>
<table>
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<th>Site ID</th>
<th>Pipeline</th>
<th>Pipeline Section</th>
<th>Subsection Description</th>
<th>Start N90E, m</th>
<th>Start N90E, m</th>
<th>Observation Images</th>
<th>Comment</th>
<th>Geohazard Feature ID</th>
<th>Subgroup</th>
<th>Geology</th>
<th>Feature Length</th>
<th>Likelihood Feature</th>
<th>Blockout Length</th>
<th>Severity Category</th>
<th>Frequency Class</th>
<th>Risk Ranking</th>
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<tbody>
<tr>
<td>9001-2013</td>
<td>Maui 403</td>
<td>McDonald Road - Coal Fadage Road</td>
<td>6023260.7</td>
<td>2692701.7</td>
<td></td>
<td></td>
<td>This is a landslide caused by an unexpected rise in the river above the pipeline, due to heavy rain and flooding. The pipeline is at risk of damage from the increased water flow.</td>
<td></td>
<td>Tauranga Group - Sand [Walton Subgroup]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9001-2013</td>
<td>Maui 403</td>
<td>McDonald Road - Coal Fadage Road</td>
<td>6023260.7</td>
<td>2692701.7</td>
<td></td>
<td></td>
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<td></td>
<td>Tauranga Group - Sand [Walton Subgroup]</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>9001-2013</td>
<td>Maui 403</td>
<td>McDonald Road - Coal Fadage Road</td>
<td>6023260.7</td>
<td>2692701.7</td>
<td></td>
<td></td>
<td>This is a landslide caused by an unexpected rise in the river above the pipeline, due to heavy rain and flooding. The pipeline is at risk of damage from the increased water flow.</td>
<td></td>
<td>Tauranga Group - Sand [Walton Subgroup]</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Comment:**
- Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment.

---

**Observation:**
- Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment.

---

**Risk:**
- Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment. Pipeline integrity excavation as per previous assessments. Pipe locator readings every 40 m across the feature indicate typical pipe depths are 1.4 m - 2.3 m through the feature. No significant change since foot assessment.
<table>
<thead>
<tr>
<th>Site ID</th>
<th>Pipeline</th>
<th>Pipeline Section</th>
<th>Section Description</th>
<th>Start NODE_X</th>
<th>Start NODE_Y</th>
<th>Observation Image</th>
<th>Assessment</th>
<th>Comment</th>
<th>Heliographic Feature ID</th>
<th>Geology</th>
<th>Feature Length</th>
<th>Seismic Category</th>
<th>Frequency Class</th>
<th>Risk Ranking</th>
</tr>
</thead>
<tbody>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403866.4</td>
<td>6403912.5</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Low</td>
<td>Pipeline cover from migration of the seepage area upslope towards the pipeline.</td>
<td>hypothetical</td>
<td>100 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline traverses below the crest and on the top boundary of a relic landslide.</td>
<td>hypothetical</td>
<td>200 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404085.5</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 130m in length.</td>
<td>hypothetical</td>
<td>130 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404085.5</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses a relic landslide feature approximately 80m in length.</td>
<td>hypothetical</td>
<td>80 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 130m in length.</td>
<td>hypothetical</td>
<td>130 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 200m in length.</td>
<td>hypothetical</td>
<td>200 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 260m in length.</td>
<td>hypothetical</td>
<td>260 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 330m in length.</td>
<td>hypothetical</td>
<td>330 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 400m in length.</td>
<td>hypothetical</td>
<td>400 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 470m in length.</td>
<td>hypothetical</td>
<td>470 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 540m in length.</td>
<td>hypothetical</td>
<td>540 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
</tr>
<tr>
<td>010F-001</td>
<td>Maui 403</td>
<td>Chief Range Road to Huntly Road</td>
<td>150 m</td>
<td>6403978.3</td>
<td>6404042.8</td>
<td>September/October 2013 - Foot</td>
<td>Remote</td>
<td>Major</td>
<td>Pipeline crosses the eroded headscarp slope of a relic landslide feature approximately 610m in length.</td>
<td>hypothetical</td>
<td>610 m</td>
<td>Severe</td>
<td>Major</td>
<td>Maui 403</td>
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### Geohazard Feature Risk Ranking Assessment Record

<table>
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<tr>
<th>Site ID</th>
<th>Pipeline</th>
<th>Pipeline Section</th>
<th>Section Description</th>
<th>Start X/Y</th>
<th>Observation Images</th>
<th>Assessment</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>F024-2013</td>
<td>Maui 403</td>
<td>Rotowaro CS to Huntly PS</td>
<td>Coal Haulage Road to Hetherington Road</td>
<td>6403685.8 2699250.2</td>
<td>September/October 2013 - Foot Assessment</td>
<td></td>
<td>The pipeline traverses around the mid-point of a slope of which is facing to the true left of the pipeline. At the toe of this face a wet drainage line flows with the pipeline, on this face there are visible soil creep lines, in the middle of this feature the pipeline completes a right hand IP change.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tauranga Group - Sand [Walton Subgroup]</td>
<td>160 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>October/November 2013 - Desktop Workshop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pipeline side slopes across gently right to dipping left slope. Slope is uniform, some soil creep in mid section of slope. No seepage in slope, stream gully in base of slope. No signs of slope instability. Mechanism is possible loss of pipeline cover from the shallow landsliding off the slope.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Landslide</td>
<td>Severe</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Remote</td>
<td>Low</td>
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<th>Site ID</th>
<th>Pipeline</th>
<th>Pipeline Section</th>
<th>Section Description</th>
<th>Start X/Y</th>
<th>Observation Images</th>
<th>Assessment</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>F025-2013</td>
<td>Maui 403</td>
<td>Rotowaro CS to Huntly PS</td>
<td>Coal Haulage Road to Hetherington Road</td>
<td>6403756.4 2699618.3</td>
<td>September/October 2013 - Foot Assessment</td>
<td></td>
<td>The pipeline traverses downslope on the right hand side of a narrow spur, there are visible soil creep lines across the faces, water seepage is visible either side of the easement area, downstream of the feature start (approx 50m) on the true left side of the pipeline is a wet swamp/pond, on the face between this pond and the pipeline are visible soil creep lines.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tauranga Group - Sand [Walton Subgroup]</td>
<td>480 m</td>
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<td>October/November 2013 - Desktop Workshop</td>
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<td>Pipeline drops obliquely down through relic landslide feature approximately 480m in length. Relic features are indistinct and include a number of lobes in the lower part of the slide downslope of pipe. Pipeline follows internal spur for some distance in central part of landslide with some side slopes (left to right) in places (ranked feature). Number of major seepages greater than 40m from pipe. Non-constant seepage along the pipeline was evident during construction. Movement direction is parallel to oblique to the pipeline. Mechanism’s manifestation of the relic landslide causing pipeline deformation.</td>
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