Dear Reza

Parks Victoria Flood Damage Sites - The Blow Hole, Hepburn

1 Introduction
Tonkin & Taylor Pty Ltd (T+T) has carried out a preliminary geotechnical assessment of damage to Parks Victoria assets, caused by the July 2016 storm and flood events. T+T was engaged by Kellogg Brown Root Pty Ltd (KBR) to undertake the works.

This letter report presents the findings of a geotechnical assessment for the site known as The Blow Hole.

2 Asset details
The site is situated within Hepburn Regional Park, approximately 1.3 km west of Hepburn (Figure 2.1). The site is an artificial diversion tunnel on Sailors Creek known as The Blow Hole, a short walk from the official car park.

The site is accessed via a walking track from the car park, and is a popular place of interest particularly when creek flows through the tunnel are high. Currently, the walking track to the site is closed, which in turn prevents access to the wider network of walking tracks in the local area.

The asset at the site is the network of walking tracks and viewing platforms. The tracks have been affected by the recent flooding as a result of rockfalls and erosion. Three distinct areas were noted during the inspection;

- Area 1 - tunnel entrance (upstream)
- Area 2 - tunnel exit (downstream)
- Area 3 - creek bank opposite tunnel exit (downstream)

Based on the online geological map of the area provided by the Department of Economic Development, Jobs, Transport and Resources (DEDJTR)\(^1\), the site is shown to be underlain by sandstone of the Castlemaine Group. Some un-named alluvium is also shown to outcrop along the

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creek alignment. While not shown on the maps, some colluvium associated with the downslope movement of the weathered rock is also anticipated.

![Site location map](image)

Figure 2.1: Site location (source; Google). Not to scale

3 Pre-event condition

3.1 Area 1 – tunnel entrance

The footpath was a gravel surfaced track approximately 1.5 m wide that runs along an elevated spur, with slopes on either side. A timber post and wire fence ran along the south side of the path, where it runs along the crest of the cliff.

Prior to the July 2016, the rock face was a short distance from the footpath and fence (Photograph 1). It is understood that a previous flood event had caused a rockfall which had undermined part of a footpath which provided access from the main path to the viewing platform on the upstream side of The Blow Hole (conversation between David Glover and Kyra Winduss on 2 December 2016). The footpath was subsequently closed by Parks Victoria, and remains closed. The main footpath was unaffected by the previous flood and remained open.
3.2 Area 2 – tunnel exit

The footpath down to the viewing platform comprised both gravel surfaced track and timber boardwalk. The boardwalk and viewing platform supports were founded on small concrete pad footings on sandstone. Photograph 2 shows part of the viewing platform.
3.3 Area 3 – creek bank

There are two footpaths on the opposite side of the creek to the tunnel exit; one that follows the creek bank at a low level, and one that heads diagonally up the slope. No images or notes were available on the pre-event condition. The footpaths are unsurfaced and do not have any formal construction.

4 Damage incurred from July 2016 Storm and flood event

4.1 Area 1 – tunnel entrance

A complex landslide has occurred adjacent to the footpath. The mechanisms include rock slide along adverse bedding planes, and toppling failure caused by root jacking. Joints and bedding planes are now opening up, which may result in regression of the landslide (Photographs 3, 4 & 5).

There is currently no damage to the footpath surface or timber post and rail fence. However, the landslide has removed support to the footpath and therefore there is considered to be damage to the integrity of the asset. The stability of the slope has been reduced by the event and it is likely that the landslide will continue to regress.
Photograph 3: View east of footpath showing extent of landslide above tunnel entrance.
Photograph 4: View west of tunnel entrance showing extent of rockfall.

Photograph 5: View north of rock face.

- Sandstone block has slipped from here.
- Colluvium.
- Adverse bedding allowing toppling failure.
- Roots (root jacking).
- Joints and bedding planes opening up.
- Soil along joints.
4.2 Area 2 – tunnel exit

A planar rockslide has occurred, which has removed support from the viewing platform. The sandstone block which supports the viewing platform is now overhanging (Photograph 6).

The bedding planes have an adverse orientation which allows blocks to become dislodged from the face. Joints and bedding planes were observed to be open, which will allow water and vegetation to penetrate and potentially destabilise the blocks further.

There is currently no damage to the timber structure of the boardwalk or viewing platform. However, the rockslide has removed support from the structure and there is considered to be damage to the integrity of the asset. The stability of the slope has been reduced by the event and it is likely that the overhanging block, on which the viewing platform is founded, will fall during the next significant storm event.

The footpath down to the viewing platform has been affected by a small (<1m\(^3\)) debris slide within the overlying colluvium, which has then deposited the debris onto the track (Photograph 7). The track has not been damaged by the debris slide.
4.3 Area 3 - creek bank

A small (<2m³) rotational-translational landslide has occurred within the soil slopes of the creek bank (Photograph 8). Evidence of previous landslides were observed, and are now partially overgrown. The soil slopes have formed within colluvium and further landslides will occur as the river continues to erode the toe of the slope. As the landslides regress, there is potential for them to undermine the footpath above.

The footpaths have not been damaged but there is a risk of undermining and debris being deposited on the footpaths, as the landslides continue to regress.
5 Remedial Works

5.1 General

The landslides that have occurred have resulted in damage to the integrity of the assets. The landslides present a hazard to site users and remedial works are recommended to mitigate the risk of further instability.

The remedial works discussed below have been developed based on the principal hazards at each of the sites. Most landslides tend to occur during or immediately after significant storm events. People tend to seek shelter during these events and so are unlikely to be in areas that may be affected by landslides (i.e. the temporal risk is low). However, the Blow Hole is a unique site which tends to attract a significant number of visitors during or immediately after storm or flood events with the specific intent to view the high water flow through the tunnel. Therefore the visitor temporal risk is higher and additional preventative measures are recommended beyond simply reconstructing the asset following damage, as there is considered to be a risk of failure while the asset may be in use. These are discussed further below.

5.2 Area 1 – tunnel entrance

5.2.1 Reinstate asset to pre-event condition

In order to return the footpath to its pre-event condition, it will be necessary to reinstate the ground supporting the footpath, or to provide equivalent lateral restraint. Reinstating the hillside is not considered to be feasible therefore support should be provided by:

- Scaling of loose material and removal of vegetation from the rock face.
- Rock bolting, including mesh in areas where joints are more closely spaced.

Photograph 9 below shows where the rock bolting and mesh should be installed.

![Photograph 9: Potential stabilisation works (image source: Parks Victoria)](image-source)
5.2.2 Alternative measures to reduce the risk to site users

The principal hazard to the footpath is considered to be undermining by landslide. There are considered to be a number of options available to protect site users. These include;

- Close the footpath to prevent access to the affected areas.
- Move the footpath to a more stable area.
- Trim the slope on the right hand side of the tunnel entrance (looking downstream) to a flatter angle (Advised area, Photograph 9).

Scaling of loose material and removal of vegetation from the rock face should be included in all options. Vegetation should not be removed from soil slopes unless necessary as part of the rectification works, and erosion protection is then included.

It is recommended that the footpath along the top of the rock face remains closed until the rectification works have been carried out. Works should be carried out within three months.

Further geotechnical assessments will be required to determine the optimum bolt spacing and length.

5.3 Area 2 - tunnel exit

5.3.1 Reinstate asset to pre-event condition

In order to return the viewing platform to its pre-event condition, it will be necessary to reinstate the ground supporting the platform, or to provide equivalent lateral restraint. Reinstating the fallen sandstone block is not considered to be feasible therefore support should be provided by:

- Scaling of loose material and removal of vegetation from the rock face.
- Rock bolting to anchor the overhanging block in place.

Photograph 10 below shows where the rock bolting should be installed.

5.3.2 Alternative measures to reduce the risk to site users

The principal hazard to the boardwalk is considered to be sandstone blocks toppling out of the face due to adverse bedding and joint orientations. As identified in Section 5.1, there are two areas of the boardwalk which were not damaged during the event but would benefit from stabilisation works to prevent failure in future storm or flood events (Photograph 10).

While the small landslide that has occurred in the soil slope has not resulted in damage to the footpath, consideration should be given to trimming back the surrounding slope and construction of a low height retaining wall along the edge of the footpath. The trimmed slope should be protected with erosion protection matting while vegetation re-establishes.
The rock bolting work should be carried out within three to six months. Access to the viewing platforms can be maintained during this time but reviewed after any significant storm or flooding event.

As identified above, it is recommended that the footpath along the top of the rock face remains closed until the rectification works have been carried out. This will prevent access to the tunnel exit, therefore consideration should be given to a temporary realignment of the footpath to maintain access.

Further geotechnical assessments will be required to determine the optimum bolt spacing and length.

5.4 Area 3 – creek bank

The footpaths have not been damaged by the storm event. However, due to the high temporal risk to site users, it is recommended that the over steepened slopes with soil exposed are trimmed back to a shallower angle to match the adjacent slopes which have not been affected by landslide. Rock armour should be placed along the toe of the slope to prevent scour and erosion during flood events.

Further geotechnical assessments will be required to determine the optimum size of rock armour and geotextile separator requirements.

6 Applicability

This report has been prepared for the exclusive use of our client Kellogg Brown and Root Pty Ltd, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.
Tonkin & Taylor Pty Ltd

Environmental and Engineering Consultants

Report prepared by:  Authorised for Tonkin & Taylor Pty Ltd by:

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David Glover  Tim Vass

Senior Geotechnical Engineer  Project Director

DRG
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Capital Cost Estimate

ESTIMATE PURPOSE
The purpose of this estimate is to establish a capital cost for each identified storm event damaged assets that require repairs or replacement, the pre-feasibility report is to assist the owner in the decision making process of proceeding with the repairs or replacement of the assets.

ESTIMATING METHOD
In support of the purpose, KBR have developed an estimate to a class 3 standard with a nominal accuracy of ±30%. The estimate has been developed in accordance with KBR Business Procedures System P4-1 Estimating Standards.

CURRENCY
The estimate has been developed in Australian Dollars (AUD).

ESTIMATE STRUCTURE
The estimate was compiled using Excel spreadsheet. Estimate summaries and detail printouts are available on request.

Each estimated item has been identified both by the physical facility and trade commodity to which it belongs in order to provide meaningful summary reports and estimate analysis.

Scope of works represented in the work breakdown structure (WBS) is outlined below.

WORK BREAKDOWN STRUCTURE or ASSETS
For the purpose of production and review, the estimate has been developed within a structured work breakdown structure (WBS) with an associated coding structure for each facility. Within each facility, works are represented by estimate details with various trade commodity codes (for example earthworks, structures, mechanical, piping, electrical etc.).

The general areas (for this project also known as asset) covered by this estimate in the WBS are described below:

A. The Blow Hole

ESTIMATE BASE DATE
The estimate is presented at market conditions as at December 2016. No allowance for escalation to actual time of expenditure has been made.
Estimate Basis

Scope Brief:

1. Area 1 – Tunnel Entrance
   a) Scaling of loose material at all rock face using rope abseiling method - 15m x 7m
   b) Relocate footpath and fence 1m x 8m long away from landslide edge
   c) Re-profile rock face using rope abseiling method - 5m x 6m
   d) Drill and fix 260 each 12mm diameter x 1m long anchor rods in chemical-sets
   e) Fix heavy duty wire mesh across rock face - 15m x 7m
   f) Clear rocks at blow hole opening, dispose evenly in water pond

2. Area 2 – Tunnel Exit
   a) Scaling of loose material at rock face using rope abseiling method 3 places - 6m2
   b) Drill and fix 20 each 12mm diameter x 1m long anchor rods in chemical-sets
   c) Construct 600mm high x 400mm deep retaining rock wall x 3m long two places

3. Area 3 – Creek Bank
   a) Trim back to a shallower angle to match adjacent slopes - 8m x 6m x 0.20m deep
   b) Install geo-fabric liner at toe of slope - 8m x 1m wide
   c) Lay new topsoil - 8m x 6m wide x 100mm thick
   d) Spray hydro-seeding - 8m x 6m wide
   e) Install rock armour along toe - 8m x 1m wide x 300mm deep

Quantities:
The estimate has been developed using quantities derived from drawings, sketches or photos taken during the site visits for each location.

Where quantities were not available, historical similar projects have been used and extrapolated to align with this scope of work.

Quantity information has been categorised to reflect the accuracy of scope definition as follows:

A. Take-off from engineered detail design, e.g. detail drawings, equip lists, schedules.
B. Take-off from engineered conceptual design, e.g. engineer’s sketches or photos taken during site visits.
C. Estimated from plot plans, GAs, PFDs, previous experience.
D. Factored from previous project based on capacity.
E. Order of magnitude allowance

Below is the estimate quantities basis distribution table:

<table>
<thead>
<tr>
<th>Description</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Development/Set-up</td>
<td>0%</td>
<td>13%</td>
<td>0%</td>
<td>16%</td>
<td>1%</td>
</tr>
<tr>
<td>Earthworks</td>
<td>0%</td>
<td>70%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>Concrete</td>
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<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>Structural</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>% Weighted Total:</td>
<td>0%</td>
<td>83%</td>
<td>0%</td>
<td>16%</td>
<td>1%</td>
</tr>
</tbody>
</table>

Pricing:
The unit prices that have been applied to the above quantities have been derived from a combination of the following sources:

A. Firm quotation - project specific.
B. Budget quotation - project specific.
C. Estimated from historical data of similar project.
D. Factored from previous project based on capacity / relationship.
E. Order of magnitude allowance.

Pricing by these categories is weighted by value of the cost of works including engineering and contingency. This information has been used in determining the level of contingency applied to the overall capital cost estimate described below as percentages for the cost pricing sources.

**PRICING BASIS – TABLE 2**

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (AUD)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
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<td>0%</td>
<td>96%</td>
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<td>Equipment</td>
<td>0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Labour &amp; Indirect</td>
<td>171,560</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>96%</td>
<td>4%</td>
</tr>
<tr>
<td>% Weighted Total Cost:</td>
<td>199,800</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>96%</td>
<td>4%</td>
</tr>
</tbody>
</table>

**Job-Hours:**
The estimate has been developed using man-hours derived from hours provided by vendors, KBR or industries standards, crew-up by the estimator, KBR historical in-house rates for similar projects or allowance.

Man-hours information has been categorised to reflect the accuracy of scope definition as follows:

A. Vendor Estimate.
B. Estimated with Standard
C. Estimated with Crew-Up
D. Historical In-House.
E. Allowance

Below is the table showing Man-hours distribution % by the above categories. This information has been used in determining the level of contingency applied to the overall capital cost estimate.

**JOB-HOURS BASIS – TABLE 4**

<table>
<thead>
<tr>
<th>Description</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Job-Hours</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>424</td>
<td>16</td>
</tr>
<tr>
<td>% Job-Hours Total</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>94%</td>
<td>4%</td>
</tr>
</tbody>
</table>

**Engineering:**
An amount of engineering cost has been allowed in the estimate to cover anticipated engineering drawing, technical support for assets that most likely are made redundant or are no longer available or made, hence will require design input for correct product selection.

An Engineering amount has been included at the rate of 9%. or $12,500

**Insurance/Taxes/Duty:**
An Insurance/Taxes/Duty amount has been included at the rate of 1%.

**D&C or PMC Fee:**
A D&C or PMC fee amount has been included at the rate of 6%.
This amount is contingent on the basis of project execution methodology; hence this estimate has been based on executing this work using a local qualified registered Design & Construct (D&C) Contractor.

**Contingency:**
An amount of contingency has been provided in the estimate to cover the anticipated variances between the specific values given in the base estimate and the final actual project cost in order for the total estimated value to represent the most likely outcome.

It is expected that, should the project proceed, all contingency monies will be spent in the execution of the project. It is noted that contingency is not intended to cover changes from design performance, nor is it intended to cover the qualifications and exclusions listed.

A contingency amount has been included at the rate of 25% due to the unknown issues such as inclement weather, estimate errors, site access, pricing formation, site productivity, project execution methodology, etc.

### Estimate Cost by Assets

<table>
<thead>
<tr>
<th>ASSET DESCRIPTION</th>
<th>ASSET COST (AUD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Bolw Hole</td>
<td>$199,800</td>
</tr>
</tbody>
</table>

### Qualification and Assumptions

The estimate has been based on the following underlying assumptions:

- The project is to be delivered using a single D&C contractor;
- Design cost has been included at 9% of all direct cost enabling to identify actual repair or replacement cost for potential insurance claim;
- No allowance has been made for encountering rock while constructing the above ground infrastructure support foundations;

### Exclusions

- Owners costs as described above;
- Project Management;
- Cultural heritage and environmental, cost and schedule related issues;
- Rehabilitation of the site;
- Geotechnical and surveying;
- Provisions for extended periods of industrial unrest or inclement weather;
- Escalation of costs from the estimate base date;
- Goods and Services Tax (GST);
- Current and ongoing future cost of studies, asset reviews, site visits, estimate preparation etc.