QUEENSLAND FLOODS COMMISSION OF INQUIRY

STATEMENT OF ANDREW KROTEWICZ

TABLE OF EXHIBITS

ATK2-1	Wivenhoe Power Station Geological Inspection Report by SunWater	19 January 2011

On 3 November 2011 I, Andrew Krotewicz of c/ Level 2, HQ North Tower, 540 Wickham Street, Fortitude Valley in the State of Queensland, say on oath:

1. I am the former General Manager Generation Operations of Tarong Energy Corporation. I held this position between 1 September 2007 and 30 June 2011.

2. On 1 July 2011, I was appointed the Executive General Manager Asset Strategy of CS Energy at the same time as CS Energy became the successor in law to Tarong Energy Corporation of the Wivenhoe Business Unit as defined in the *Government Owned Corporations Act 1993* (Qld) (*Generator Restructure) Regulation 2011* which includes the Wivenhoe Power Station and rights to move water in and out of Splityard Creek Dam.

3. This statement is supplementary to the two prior statements dated 13 September 2011. For the period 1 October 2010 to 31 March 2011:

4.0 1(a) ***a description of whether and how the communication requirements set out in the following documents were complied with and*** 1(b) ***to the extent that either of these documents were not complied with, and explanation as to why compliance did not occur:***

i. Deed of Practice between Seqwater and Tarong Energy Corporation (**Tarong Energy**) for Wivenhoe Dam and Wivenhoe Power Station.

ii. Wivenhoe Power Station Business Procedure for Wivenhoe – High Rainfall, High Dam Water Levels (WIV-OPS-15).

<u>Deed of Practice</u>

4.1 On 4 October 2010 Seqwater requested under the terms of the *Deed of Practice* that a notification protocol be initiated to allow Seqwater to receive notice of impending water releases to/ extraction from Lake Wivenhoe by Wivenhoe Power Station. Tarong Energy was advised at the time that Lake Wivenhoe was at 100% capacity.

4.2 The Tarong Power Station operators were responsible for the remote dispatch of the Wivenhoe Power Station into the National Electricity Market for either generation or pumping load. Both of these actions result in water movement, namely release into or extraction from Wivenhoe Dam. The Tarong Power Station operators worked on a 24/7 roster to meet the dispatch requirements of the whole Tarong Energy generation portfolio, including Wivenhoe Power Station.

4.3 On 7 October 2010 the draft "communication protocol" (refer Attachment ATK- 2 from statement of 13 September 2011) was adopted and included in the operating instructions of the Tarong Power Station operators, and was to apply for a minimum of three months. The protocol document was emailed to Seqwater on that date to make the flood engineers aware that the notification mechanism within Tarong Energy had been established.

4.4 On 10 October 2010, the first notification was issued by Tarong Energy, advising the flood engineers of an impending water extraction. The protocol was working and the provisions of the Deed of Practice were therefore being observed. SEQWater confirmed the arrangement was satisfactory.

4.5 On 20 October 2010, the protocol was overlooked and Wivenhoe Power Station management issued a notification in arrears.

4.6 During the period 21 October 2010 to 10 January 2011 inclusive, the protocol operated satisfactorily, however some notifications were not issued in late October and early November 2010 by the Tarong Power Station operators.

4.7 On 11 January 2011 the protocol was not followed as no notification of the water release into Lake Wivenhoe was issued to the flood engineers.

4.8 The subsequent request from Seqwater on 11 January 2011 to stop the release was complied with as soon as practicable after the telephone message was retrieved (refer to the detailed communications issues in section 6.0 below).

4.9 To the best of my knowledge, notifications after 11 January 2011 were issued in accordance with the protocol until it effectively ceased on 18 February 2011 when Lake Wivenhoe dropped below 100% FSL.

4.10 The explanation of why the Deed of Practice was not complied with on 11 January 2011 is dealt with in section 5.3 below.

<u>High Rainfall Procedure</u>

4.11 The procedure was not triggered until 10 January 2011 when communication with Seqwater was made as required.

4.12 As explained in section 6.0 below, on 11 January 2011 communication with Seqwater was not initiated by Wivenhoe Power Station personnel between 05:00 and 18:30 when they were taking emergency action to protect the power station machine hall from inundation by runoff from the access road, and attempting to clear debris from and reopen the access road between station and Splityard Creek Dam. It is noted that phone networks into the power station and region were not working after 17:00 that day.

5.0** 1(c) **an explanation of how the 'other demands' and 'lack of personnel' referred to in paragraph 6(b)(i) of my statement of 13 September 2011 prevented Wivenhoe Power Station staff from making any attempt to inform Seqwater of the release from Splityard Creek Dam on 11 January 2011.

Responsibility for Notification

5.1 Firstly I note that as the power station was remotely operated by the operators from the Tarong Power Station, the notification on 11 January 2011 was initially their responsibility, and not the responsibility of Wivenhoe Power Station personnel.

5.2 The personnel at Wivenhoe Power Station were concerned to ensure that the notifications occurred, however unavailability of communication networks affecting the power station from 17:00 meant that it was not possible for them to check.

5.3 The operators at Tarong Power Station were managing the company's generation portfolio at the time in the context of the Brisbane based Corporate Office having been evacuated and the Wivenhoe Power Station being cut off, and as I recall, on a skeleton staff.

Actions of Wivenhoe Power Station personnel

5.4 For most of 11 Jan 2011 the WPS hydro personnel priority line of thinking was concentrated on

5.4.1 counteracting the threat that the incoming rivers of mud generated by the slopes surrounding the station would penetrate the power station machine hall and contaminate the generators;

5.4.2 controlling water leaks through the walls of the silos housing the hydro machines and their associated electrical, mechanical, hydraulic and pneumatic equipment; and

5.4.3 maintaining the safety of Splityard Creek Dam in the absence of reliable data.

6.0 For the period from 8 to 13 January 2011, a detailed account, presented in narrative form, of:

(a)The loss of communication suffered at the Wivenhoe Power Station, its causes and effects;

(b)The extent to which staff were prevented from accessing the Wivenhoe Power Station;

(c)Whether and how the decrease in staff levels associated with such access problems caused difficulties in the operation of the power station or communications with Seqwater and the Department of Environment and Resource Management.

Communications

6.1 Communications between Wivenhoe Power Station and Seqwater were maintained over the period including on 8, 9 and 10 January 2011 by either phone or email, as required as telephone networks were still available.

6.2 The loss of communication at Wivenhoe Power Station was observed at around 17:00 on 11 January 2011 when the Bureau of Meteorology weather radar, on a dedicated permanent display in the office disappeared from the screen indicating that Internet access was no longer available. Without an ability to see the incoming weather, read the warnings, it became increasingly difficult to optimise the spread of effort of the skeleton crew towards the site works. The crew had no means of watching the news and understanding the magnitude of the flood event elsewhere in the region. Weather and news updates were supplied in the coming days by family members or Seqwater on the satellite phone (refer below).

6.3 At around the same time, it was noted that email was no longer functional. Both internal email communication with the Tarong Energy Crisis Management Team and external email communications ceased.

6.4 The Cisco phone LCD screens blanked out also around 17:00 on 11 January 2011 indicating interruption of service. This was expected considering the system also ran on the corporate network.

6.5 The Tarong Energy corporate network servers were located in the corporate office. This office had been shut down in anticipation of the approaching flood in the central business district.

6.6 Mobile phone reception is poor at any time on the Wivenhoe Power Station site given its location and distance from reception towers, however on 11 January 2011, mobile phone communication difficulties were exacerbated by apparent congestion on the Telstra network and its reduced overall performance.

6.7 The wall-mounted satellite phone in the Wivenhoe Power Station manager's office was the only means of communicating as road access to the power station was cut.

6.8 The NEM trading pre-dispatch screen and the live Electricity Market data froze on the screen with the loss of the intranet connection. Personnel could no longer stay informed of the state of the electricity market or be aware of any proposed operation of the power station.

6.9 The electronic maintenance management and plant isolation system was affected by the Corporate Office power outage commencing 11 January 2011. Plant isolations and maintenance was severely limited as a result.

6.10 The electronic drawing and documentation management system was also out of commission as a result of the Corporate Office power outage commencing 11 January 2011. Hard copies of drawings and manuals associated with critical functions were available onsite.

6.11 None of the systems referenced above were restored by 13 January 2011.

6.12 One hydromachine had been compromised by an earlier lightning strike and the unit would not have run even if dispatched by the Tarong Power Station operators.

6.13 The SCADA data system remained in service, meaning the protection and control equipment continued to oversee the operational security of the generators, including their remote despatch capability from Tarong Power Station could continue (subject to the outage on unit 1).

6.14 As far as I am aware, the causes of the telecommunications and power outages were outside of the control of Tarong Energy.

6.15 A phone call was initiated by Seqwater as a result of the water release by Wivenhoe Power Station on 11 January 2011, however lack of mobile phone reception meant that the message could not be retrieved until 45 minutes later.

6.16 Via the satellite phone, Seqwater began supplying Wivenhoe Power Station with regular updates of the flood situation and weather forecasts on 12 and 13 January 2011.

6.17 Additional requests were made by Wivenhoe Power Station management of Seqwater for landing boats at the Wivenhoe Dam Visitor Centre and a helicopter at Mt Crosby Water Treatment Plant in order to effect Wivenhoe Power Station personnel shift changes via 2-way radio. All of these requests were granted.

6.18 In subsequent weeks, other communications took place, for example about locating lost cattle for common neighbours and the like.

6.19 Communication requirements with DERM were complied with. Dam Safety was contacted via phone on both 10 and 11 January 2011 and advised of the situation, in accordance with the high rainfall procedure.

6.20 SunWater's engineers were unable to be contacted at the time as required by the procedure. In lieu, DERM Dam Safety was used as an advisory service by power station personnel.

Access to the power station

6.21 On 10 January 2011 at approx 06:20 the first of the Wivenhoe Power Station personnel en route to the station, northbound on Brisbane Valley Highway was heading for the Fernvale bridge and on towards the Junction. It immediately became apparent that the bridge had been submerged. Consultation with the Wivenhoe Power Station duty officer who was attempting to reach the station from a different direction revealed that the back roads were also impassable.

6.22 Consequently the only two Wivenhoe Power Station staff residing on the Northern side of the river were recalled from annual leave. They were able to access the station travelling in a southerly direction towards the Brisbane Valley Highway/ Wivenhoe-Somerset Rd junction.

6.23 Another four Wivenhoe Power Station personnel travelled by helicopter later that day to relieve the initial two. The rest of the Wivenhoe Power Station crew were placed on standby.

6.24 On 11 January 2011 the crew of four lost the ability to move between the station and Splityard Creek Dam due to rock falls and landslides on the station access road. When they cleared a way up the station access road they found Wivenhoe-Somerset road completely cut-off at the Brisbane Valley Highway/Wivenhoe-Somerset Rd junction to the South and at the Kipper Creek Bridge to the North.

6.25 Accordingly, the Pryde Creek community downstream of Splityard Creek Dam on Wivenhoe-Somerset Rd as well as Wivenhoe Power Station were islanded. For the period, this area was only accessible by helicopter. The situation continued until the morning of 13 January 2011, when the floodwater at Brisbane Valley Highway/ Wivenhoe-Somerset Rd junction receded enabling 4WD access via the northern section of Brisbane Valley Hwy.

6.26 On 11 January 2011, many helicopters were grounded, including the Wivenhoe Power Station chartered unit. Once the extreme weather conditions cleared, on 12 and 13 January 2011, rotating shifts of Wivenhoe Power Station personnel (2 shifts x 4 personnel each) resumed access by helicopter.

6.27 On 14 January 2011, access to the station became possible via Lowood whilst still avoiding the submerged Fernvale Bridge.

Effect on operation of the power station or Communication with DERM and Seqwater

6.28 During the period 8 – 13 January 2011 Wivenhoe Power Station was manned by a skeleton crew.

6.29 WPS #1 Hydromachine control was rendered unserviceable by a lightning strike early on 11 January 2011. Hydro personnel experienced in diagnostics and repair of the control system only arrived on site by helicopter a day later, on 12 January 2011.

6.30 On 11 January 2011, due to the access road between the power station and Splityard Creek Dam becoming impassable, the hydro personnel on site were temporarily prevented from performing the necessary dam safety monitoring tasks at Splityard Creek Dam as per the High Rainfall procedure. The 18 hours gap in the dam surveillance and leakage monitoring combined with the dam instrumentation failure (identified in my statement of 13 September 2011 section 5(b)) led to the decision to initiate the water release detailed in my earlier statement.

6.31 Communications with Seqwater and DERM Dam Safety were primarily affected by the unavailability of the Tarong Energy corporate network, based in the Brisbane central business district which had been evacuated and had no power, starting 11 January 2011 rather than the limited number of personnel on site.

7.0 How best to ensure the maintenance of the communications contemplated in the Deed of Practice and High Rainfall Business Procedure during flood events.

7.1 An additional set of two-way radios, independent of any corporate telecommunications network would add another layer of contingency in a repeat flood event.

8.0 The water level at Splityard Creek Dam at the time releases began on 11 January 2011.

8.1 At the time the water release via to the power station began, the operational 'Level Indicator 2' at Splityard Creek Dam was reading EL163.3m.

9.0 Whether the transmitters and other instrumentation that failed to provide accurate dam level readings on 11 January 2011 have been replaced or repaired as contemplated in paragraph 8(iii) of my statement of 13 September 2011 and, if not, when the 'system upgrade' referred to therein is likely to take place.

9.1 As identified in section 5(b) of my statement of 13 September 2011, the transmitters operated to design in that the failure of one meant that readings could still be taken albeit with less confidence.

9.2 The transmitter that failed was repaired in late January 2011, and both transmitters are in use at all times to support operation of the power station as the Splityard Creek Dam is maintained in a state of almost constant readiness for discharge to Wivenhoe Dam via the power station when dispatched into the National Electricity Market.

9.3 There are no immediate plans to upgrade the transmitters with the new control system as they are functional and operated as designed.

10.0 ***Any reports produced following the inspection by SunWater dam safety engineers and SunWater Geotechnical engineers on 19 January 2011.***

10.1 My statement of 13 September 2011 contains the Dam Safety Inspection Report following the inspection 19 January 2011 in Attachment CSE-2.

10.2 Since that statement, it has come to my attention that there was a Geological Report dated February 2011, for inspections performed on 19 January 2011. This report is in Attachment ATK2-1.

~~Sworn~~/ Affirmed at Brisbane in the State of Queensland

Before me:

[redacted]

[redacted]

Solicitor

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SunWater

Prepared for: Tarong Energy

FINAL REPORT

Wivenhoe Power Station Geological Inspection

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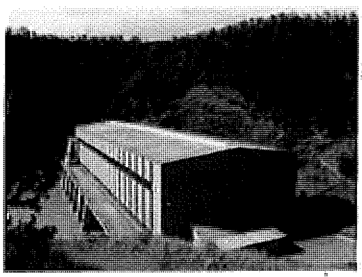
Reviewed: [redacted]
Senior Geologist
Infrastructure Development

Approved: [redacted]
Manager, Engineering South
Infrastructure Development

Date: February 2011

Project: P-AEXP-1900-AC-12-03 **File No:** 05-013001/009



EXECUTIVE SUMMARY

During a severe weather event on Tuesday 11 January, 2011, during which between 450 mm and 584 mm of precipitation (anecdotal (pers comm. Berthelsen 2011)) was recorded, numerous minor to major landslips and erosion events occurred along the Wivenhoe Power Station (WPS) access road and the slopes adjacent to the power station building.

SunWater preformed a non-routine [emergency] geological inspection of the Splityard Creek Dam and the slopes surrounding WPS on 19 January 2011. The WPS site inspection identified several significant soil/rock falls and slides in addition to significant/major erosion. Observations were made of conditions that require attention and recommendations were made.

The following is concluded from the geological inspection performed Tuesday 11 January 2011.

- No new significant geological or geotechnical issues were identified at the Splityard Creek Dam, WPS car park or its north-eastern slopes.
- Pre-existing risk mitigation measures such as benches, berms, rock bolts and shotcrete worked effectively to reduce damage at several inspected locations.
- Numerous new slips/failures, predominantly within non-bedrock (soil) horizons, were identified along the WPS southern, south-eastern, north-western slopes that surround the WPS, as well as along the WPS access road.

Recommendations are made with respect to the above mentioned specifically observed areas of concern. However, more detailed site inspection and evaluation is recommended in order to formulate appropriate site-specific engineered solutions. Recommendations include:

- Benching of unstable slopes, with a drain possibly installed at the crest of the slip, in addition to formed drainage on each bench to prevent ponding, and installation of shotcreting or conventional reinforced concrete to protect susceptible erosion areas.
- Removal of material which has suffered failure or disturbance to prevent further future failure.
- Revegetation of unstable slopes as soon as practicable to increase slope stability.
- In areas where rock fall has occurred, removal of material located in the main scarp at risk of future failure by barring down.

- The construction of appropriate barrier fence/walls to protect existing infrastructure from potential damage.
- Discontinue use of the access road in storm events or following prolonged precipitation until inspected and declared safe by a nominated individual, and the erection of international standard "No Stopping" signs along the access road.
- The isolation of tension cracks using barricade fencing, the sealing of tension cracks using asphalt or tar to prevent water ingress, the protection of tension cracks from overland flow via the construction of a low cold mix asphalt bund, fortnightly monitoring of tension cracks using elongate rectangular stencilled markings, the education of all personnel and heavy vehicle drivers of the risk associated with tension cracks, and adding load to areas with tension cracks should be avoided.
- The removal of boulders at risk of failure via controlled blasts. A licensed blasting contractor should be consulted to discuss removal options.

The following detailed investigations are recommended to allow properly engineered stability solutions to be designed to improve safety and stability in the power station area.

- Failures in slopes around the power station.
- Gully erosion: rehabilitation and control of drainage
- Access road monitoring and remediation

Note that this report provides preliminary advice only and further, more detailed site inspection and evaluation is recommended.

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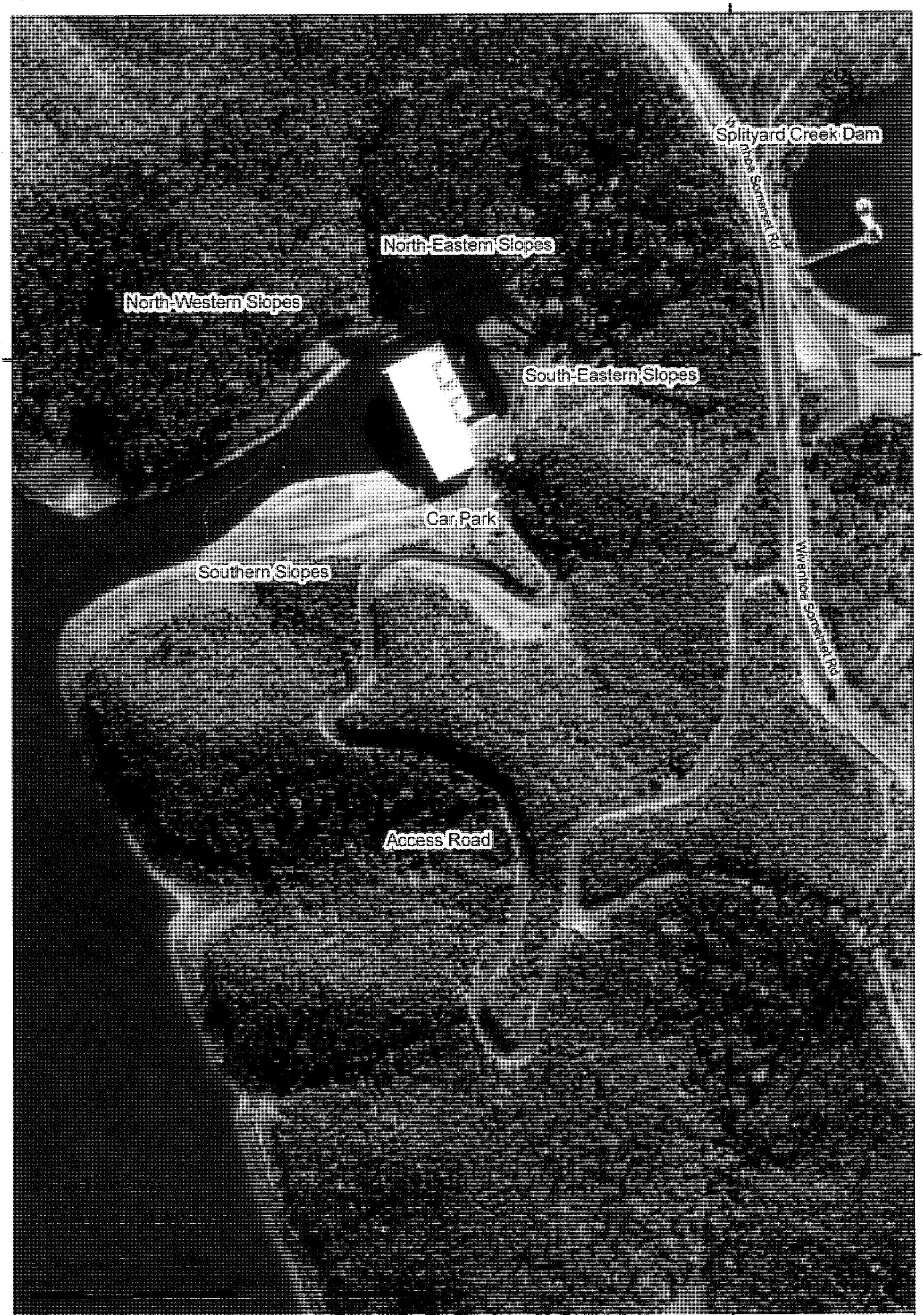


DRAWN EA	DESIGNED	SunWater ©SunWater Limited ACN 131 034 985	Wivenhoe Power Station Geological Inspection	CONTRACT NUMBER
CHECKED	CHECKED			DRAWING NUMBER 238169
APPROVED			Figure 1 Location Overview and Areas Inspected	DATE 02 02 2011

Map Produced By:
SunWater
Level 9, 179 Turbot St
Brisbane Qld 4000
Tel: (07) 3120 0000

1.0 INTRODUCTION

SunWater's geologists, Mr [redacted] (Senior Geologist) and Ms [redacted] (Geologist), completed a non-routine geological inspection of the Splityard Creek Dam and the slopes surrounding the Wivenhoe Power Station (WPS) on Tuesday 19 January 2011 at the request of Mr [redacted] of Tarong Energy. SunWater staff were escorted across the site by representatives of Tarong Energy.

The request for the inspection was made following a significant weather event that occurred on Tuesday 11 January 2011, which caused significant mass wasting on the slopes surrounding the WPS. To ensure the short [and long] term safety of the power station facility and site personnel, Tarong Energy sought advice for temporary and permanent engineering solutions and the revision of site procedures.

This report provides a summary of the areas observed during the site inspection completed on Tuesday 19 January 2011. The solutions provided herein are suggested as possible remedial options. Any option which may be employed to improve stability or safety or to protect an asset will require proper geotechnical investigation, design and engineering and installation. The solutions provided herein are provided as conceptual remedial options only.

SunWater completes inspections of the slopes around the power station on an annual basis, monitoring movement and risk areas for Tarong Energy.

Figure 1 shows the location of the sites previously labelled slopes, which are all subject to regular geological inspection.

1.1 TERMINOLOGY

- Overslips are defined as those slumps occurring above a roadway or asset.
- Dropouts describe where slumping or failure has occurred below a roadway or berm.

The above defined terms are not standard nomenclature, and should only be referenced within the context of this report.

2.0 GEOLOGY

The Splityard Creek Dam and Wivenhoe Power Station have been constructed within an area underlain by rocks of the Neranleigh-Fernvale Beds, a Devonian-Carboniferous aged unit comprising mudstone, shale, arenite, chert, jasper, basic meta-volcanics, pillow lava and conglomerate (GSQ, 2008).

The Northbrook Beds are mapped to the north of the site, occurring to the west of a north-south striking faulted contact with the Neranleigh-Fernvale Beds (GSQ, 2008), occurring approximately coincident with the eastern shore of Lake Wivenhoe. This unit is of Early to Late Permain age, comprising intermediate to acid volcanics, mudstone, siltstone, shale, sandstone and conglomerate (GSQ, 2008). Rocks of similar composition were noted in the hills to the east of the power station, suggesting a faulted contact may exist in this area.

Whilst the majority of rock exposed in outcrop represented meta-sedimentary rocks consistent with those of the Neranleigh-Fernvale Beds, localised instrusives (olivine basalts) were identified in outcrop along limited sections of the access road.

3.0 INSPECTION AREAS

3.1 SPLITYARD CREEK DAM

Both Mr Forster and Ms Anania accompanied Mr Peter Richardson (SunWater) and Mr Brendan Trebilco (SunWater) during an engineering inspection of Splityard Creek Dam.

No significant geological or geotechnical issues were identified in the following areas:

- Main [dam] embankment,
- Saddle dam,
- Spillway,
- Seepage collection areas and drainage lines.

Minor spalling was noted along the approaches to the left wall of the spillway. Three (3) small slumps were noted in the steep banks of the reservoir and were estimated to be of less than 5 m^3 in volume[1].

Several slumps were observed along the banks of the gullies draining the area downstream of the main embankment. The areas most prone to slumping were noted to occur along the bank adjacent to the thalweg[2] of the stream/gully.

3.2 WIVENHOE POWER STATION

3.2.1 Car Park

A comparison was made to the previous geological inspection of the carpark area. No new significant rock falls or slides were observed during this inspection.

[1] Observation made from opposite bank of reservoir.

[2] A line connecting the deepest parts of a river channel (Lapidus, 1990)

A temporary earth levee had been constructed to control overland flow, and to prevent overland flow from entering the power station or control room.

A temporary solution was discussed on-site, which involved a portable system of water filled traffic/crash barriers, covered with tarpaulin/plastic to improve water proofing. A series of removable pins could be installed into the underlining tarmac to further reduce instability/resist sliding caused by overland flow.

3.2.2 Southern Slopes

A comparison was made to the previous geological inspection of the southern slope area. Generally, the southern slopes were intact, however a new rock fall was noted to have developed, in addition to two (2) small areas of soil slumping.

An inspection of the above ground sewerage pipe was made. No direct impact damage was observed, however numerous small (10 - 15 cm ∅) rocks were observed to be scattered within one metre of the pipeline suggesting impact damage may be possible.

An over slip was observed up-slope of the sewerage pipe near the evaporation trench (Figure 2). It is recommended that the affected area be benched to increase slope stability, with a drain possibly installed at the crest of the slip, in addition to formed drainage on each bench to prevent ponding.

Figure 3 shows a rock fall which occurred on the southern slopes, immediately adjacent to the boat ramp launch area. This site was inspected from both below and above.

Figure 2: Slump above and below sewer line (upper centre of image).

Figure 3: Rockfall (pale yellow-brown area) in southern wall of inlet area.

Weathered rock material, failed from the area immediately below the bench along which the sewer line runs and adjacent to a shotcreted section of the wall, was deposited on and above the boat ramp. No damage was noted to have occurred to the boat ramp, however a large amount of sediment had accumulated [in a delta like feature] along a section of the ramp interpreted to be coincident with the water level in the reservoir at the time of the rain event.

The material was observed to have released along a clay filled joint plane (Figure 4), which was likely weakened to the point of failure due to over-saturation during the rain event. Material remaining in-situ was also observed to have dilated and initiation of toppling and sliding failure was observed (Figure 5), and as such it was recommended that the at risk material be removed (barred down), and that the site should be monitored using an extensometer.

Figure 4: View of clay coated jointed (shaded area at base of image) and weathered rock.

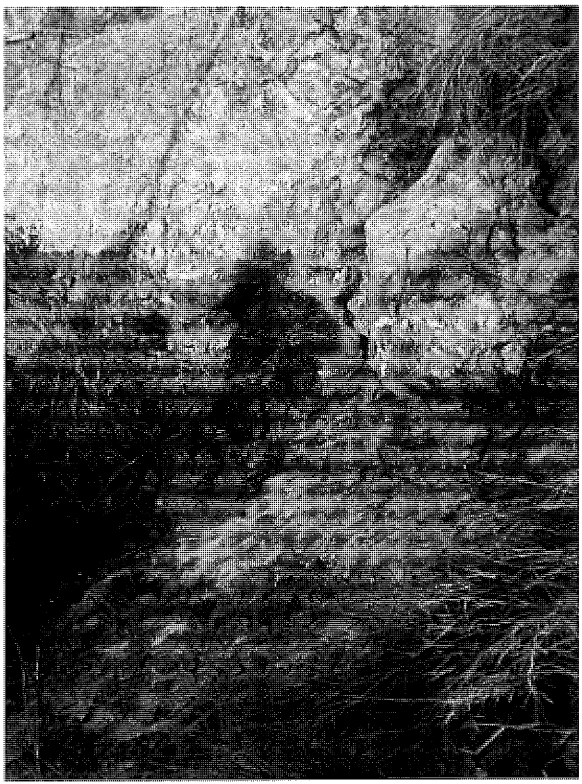


Figure 5: Weathered rock toppling from slope below sewer-line bench.

3.2.3 South-Eastern Slopes

This area was identified as an area of high priority by [redacted] due to its proximity to WPS structures.

Material (rock and soil) was observed on the access track below the south-eastern slopes (Figure 6). Several rock falls and slips were observed above (see Figures 7 and 8). No damage to the road was observed and the slope below the road was observed to be intact.

At those locations where there is a high likelihood of further rock fall (i.e. loose or overhanging rock), it is recommended that such material be removed via barring down as soon as practicable to safely do so.

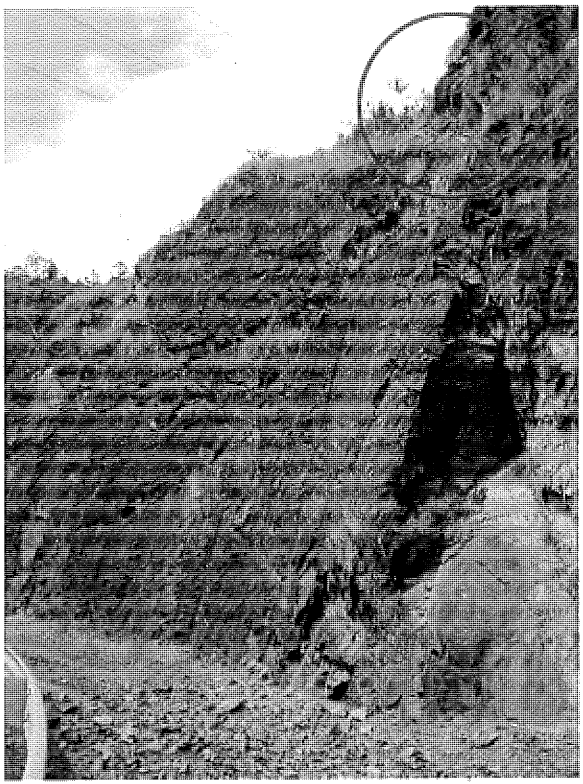
Where benches or berms exist, it is recommended that these features are cleared of displaced material as soon as possible to allow these structures to accommodate future failures. It is suggested that a crest drain is installed to divert water away from the slopes.

Figure 6: Access track to south-eastern slopes (looking towards power station).

Figure 7: Over slip in soil in access track area.

It is noted that in those areas where the failures have occurred within the soil profile, the failure appears to be limited to the vegetated horizon, with the base of the vegetated mat approximating the release surface.

Figure 8: Minor rock fall associated with unfavourable jointing, south-eastern access track area. Note that wedge failure in foreground occurred some years ago.

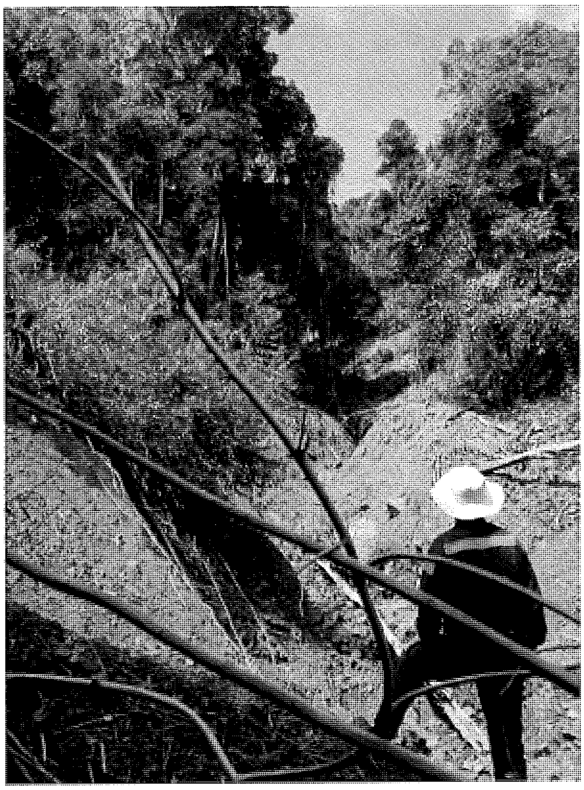


The slope directly behind the power station was observed to have suffered major degradation, and wasting as shown in Figure 9. The damage to this area was enhanced by a large quantity of additional material from multiple significant upper slope failures and erosion moving down gradient along existing gullies and communication and power service corridors. Several concrete pipes were exposed along the southern edge of the corridor. Where erosion had occurred in the existing gullies, the soil profile was estimated to range between 2 to 4 m (Figure 10).

To improve slope stability it is recommended the areas that were denuded during the rainfall event are revegetated as soon as practicable to assist in stabilising the slope, reducing overland flow velocities, ultimately reducing the potential for further erosion. This may be achieved by planting a series of parallel rows of vetiver grass orientated normal to the flow direction, at regular intervals along the gullies.

Figure 9: Benched slope behind the power station illustrating degradation and wasting due to overland flow.

Figure 10: Eroded gully illustrating thickness of soil profile.



With the future aim of slowing the velocity of material moving down the adjacent slope and then impacting on those areas in close proximity to WPS infrastructure, it is suggested that the flow path be altered, to route material around and away from the WPS, toward the shotcrete protected north-eastern slopes, where flow may be released with less impact on the power station facility.

It is possible that an anchored, reinforced concrete training wall may be suitable to re-route any debris flows. A mesh screen may be required atop the wall to reduce debris flow over the wall.

3.2.4 North-Eastern Slopes

No significant rock falls or slides were observed.

3.2.5 North-Western Slopes

Due to time restrictions it was not possible to access this site; however observations were made from the deck of the power station, adjacent to the gantry crane.

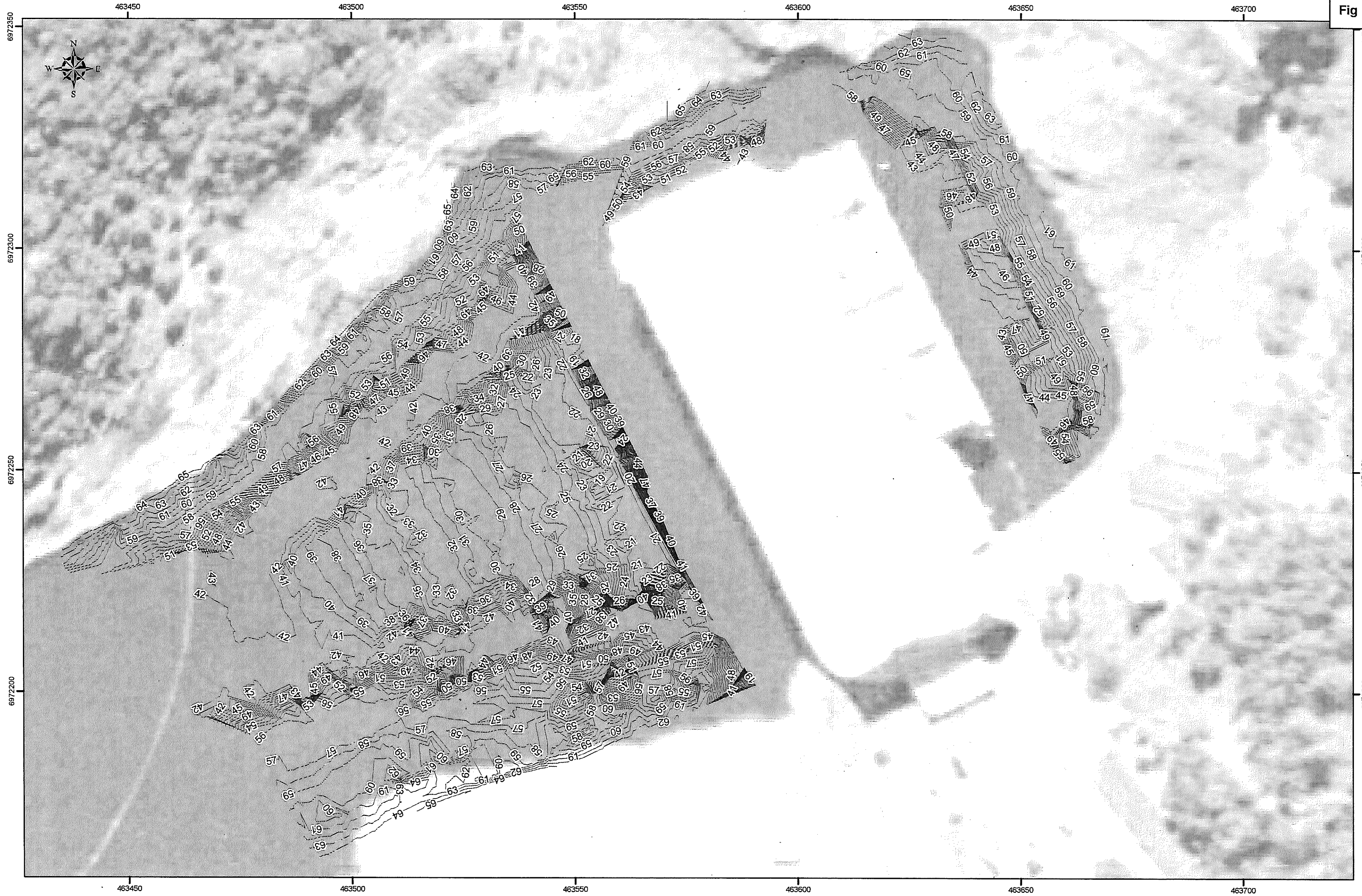
A land slip was observed on the north-western slopes, with the release surface interpreted to approximate the base of the vegetated root mat. This interpretation is based on the limited escarpment adjacent to the slip and the observed root mat thickness below the vegetated areas (Figure 11). Generally, some of the soil profile appears to remain intact within the failure area, with rock exposed along the base of the slope in the area where engineered works appear to have been completed as part of the construction of the inlet pool.

Figure 11: Slip located to the north of the pump intake area.

Engineering surveying of the inlet pool was carried out by [redacted] (SunWater) 20 to 21 January 2011. Depth contours are shown on Figure 12. From the survey, it is interpreted that no significant quantity of land slip debris was introduced to the inlet pool as a result of the failure. Therefore, the topography and pre-existing structures at the base of the slope appear to have assisted in dissipating much of the wasted material, diverting it to the right and left of the failure plane.

It was suggested that to prevent fouling of the inlets as a result of future failures in this area, that an appropriate barrier fence/wall be constructed along the toe of the slope. Ideally the slope should be benched and drained, and re-vegetated with vetiver grass or a similar deep rooting species.

Fig 12



DATE		REMARKS	CKD	PSD

REVISION

MAP INFORMATION

Coordinate System: MGA94 Zone 56

SCALES (A3 SIZE)

0 10 20 30 40 m

1:800

DRAWN KFP	DESIGNED
CHECKED	CHECKED
APPROVED	

SunWater

©SunWater Limited ACN 131 034 985

TARONG ENERGY
WIVENHOE POWER STATION
SURVEY 20-21 JAN 2011
CONTOUR PLAN

CONTRACT NUMBER

DRAWING NUMBER 238118

DATE JAN 2011

Map Produced By:
SUNWATER
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3.2.6 Access Road

The access road stability is interpreted to be controlled by a variety of factors including:

- Soil characteristics/properties,
- Catchment size and drainage characteristics,
- Geometry, and
- Existing stability issues.

Interpretation of an oblique aerial photograph identified a large section of the catchment may be mobile, with a distinctive change in vegetation about a feature with geometry similar to that of a landslide. This area has an area of approximately 22,000 m^2. The head scarp of this feature appears to coincide with tension cracks present within the roadway, approximately 200 m north of the security hut (Figure 13).

Consequently, stereo pair aerial photographs from 1982 and 2002 were borrowed from DERM to examine the suspect feature. Examination revealed a feature which requires further investigation.

The 1982 aerial photos show a "construction" track co-incident with the southern upper boundary of the feature. It may be that remnants of the track may present as a feature with similar visual characteristics to a mobile land surface.

This is, however, an interpretation only, based on aerial imagery only and requires investigation and mapping to confirm if this area does, in fact, present a risk.

Both rock falls and slips (typically over slips) were observed along the length of the access road. The majority of the failures are interpreted to be due to a combination of intensive overland flow, soil saturation and a lack of support at the base of slopes (slope over steepening resulting from construction of the roadway). A well defined escarpment (approximate height 400 mm) was consistently observed at the top of failure slopes (Figure 14). Therefore, the slips are interpreted to have a minimum depth of 400 mm. Soil creep was also observed on slopes.

REVISION			
07/02/11	Revised location of crack marker (Location 2)		
DATE	REMARKS	CKD	PSD

MAP INFORMATION

Coordinate System: MGA94 Zone 56

Aerial Imagery sourced from Microsoft Bingmaps.
Inset Imagery sourced from Google Earth.

SCALES (A3 SIZE)

0 20 40 60 80 100 m

1:2,000

DRAWN	DESIGNED
DJF	DJF
CHECKED GAD	CHECKED
APPROVED	

SunWater

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WIVENHOE POWER STATION
GEOLOGICAL INSPECTION

Figure 13
Location of possible unstable area & tension cracks.

CONTRACT NUMBER

DRAWING NUMBER
238170

DATE 03 Feb 2011

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Figure 14: Over slip present in the upper section of the access road.

Longitudinal tension cracks, in excess of 2 m in length, were observed along the outer side of the access road at two locations, as marked on Figure 13.

Tension cracks indicate the likelihood of failure in a particular area is elevated and it is recommended that an exclusion zone be immediately established around the cracked area to reduce loading which may lead to failure. To reinstate these areas, the affected area will require engineered stabilisation solutions.

Cracks at Location 1 appeared to be recently dilated, and it is recommended that they are sealed with tar or grout slurry (with care) to prevent water penetration and hydraulic jacking along the crack (Figure 15).

Figure 15: Tension crack and tilted guard rail located approximately 100 m north of the security building (Location 1).

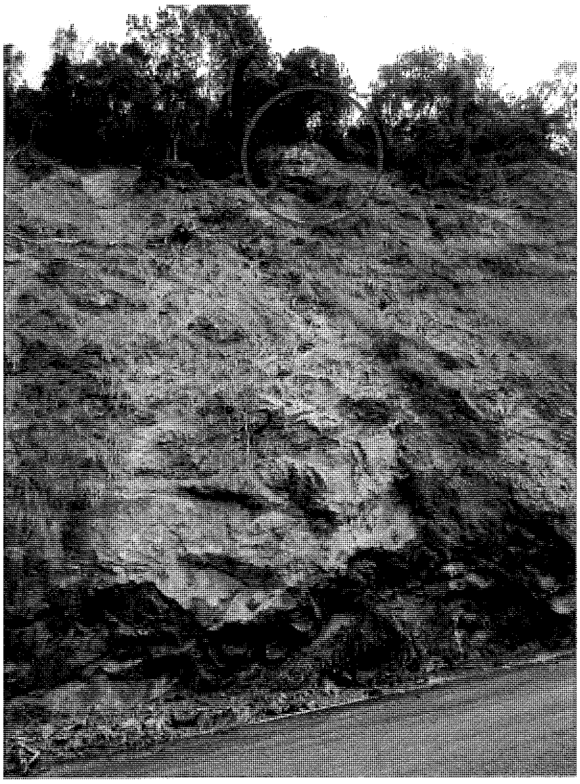
Cracks at Location 2 were dilated approximately 10 mm and as they were in filled with soil and debris it was difficult to determine their age (Figure 16).

Figure 16: In filled tension crack at Location 2

All tension cracks should be monitored using crack indicators such as paint. An elongate rectangular stencil is recommended.

A number of large boulders (2.0 x 1.5 x 1.0 m and 0.5 x 1.0 x 1.5 m) were observed to have fallen onto the access road and at least one other large boulder (inaccessible during the site inspection) appeared to be at risk of future failure (Figure 17). Mitigation options to remove this threat are limited and the best solution may be to remove the boulder using a controlled blast, possibly using detonation cord to first reduce the size of the bolder so it can then be barred down or removed. A licensed blasting contractor should be consulted to discuss removal options.

Figure 17: Large boulder located upslope of the access road.



Along the access road it is generally recommended to re-instate pre-existing benches and berms as soon as possible as these features mitigate some of the impacts of upslope failures by acting as catch benches. It is possible, however, that accumulated material, deposited during the last extreme weather event, will be transported to the roadway during subsequent weather events unless removed (Figure 18). The accumulated material also loads the slope below, affecting stability.

A cement/concrete lined crest drain should be constructed along the crest of the slope to divert surface flow around the excavated area.

Figure 18: Accumulated material present on bench.

Culverts and blocked drains should be cleared (Figure 19).

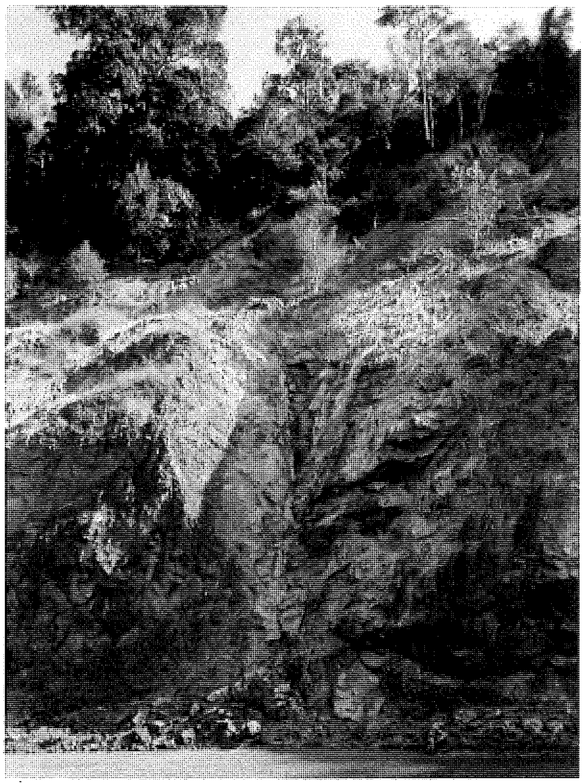
Figure 19: Partially blocked cross drain, located along access road.

It is recommended that large drains cross-cutting the access road be considered at key points. Such drains would reduce the flow that would otherwise be discharged in the area of the power station car park.

International standard 'No Stopping' signs should be erected at regular intervals (e.g. 100 m) along the access road.

Shotcrete or conventional reinforced concrete should be considered to protect susceptible erosion areas such as those shown in Figure 20.

Figure 20: Preferred discharge zone, eroding weak rock along intersecting joints.



4.0 ENGINEERING SOLUTIONS

4.1 BEHAVIOUR

It is recommended that workers be briefed as to the geotechnical risks present at the Wivenhoe Power Station site. All workers should be trained to identify tension cracks or spalling rock and encouraged to report the same to a nominated person.

Workers should be made aware of the dangers of landslides and instructed to never cross a tension crack 'to see what is happening downslope'. There are documented occurrences of persons who have stepped onto unstable ground (i.e. across a crack) and the addition of their mass has resulted in failures causing death.

The access road should not be traversed during storm events or during prolonged periods of precipitation. A nominated person should undertake an inspection of the roadway following any of the aforementioned events, paying specific attention to the slopes above the roadway and identifying any new cracks in the pavement.

Heavy vehicle drivers should be made aware of the presence of weak areas of pavement (i.e. those that contain tension cracks) and instructed to avoid the same. Ideally, all heavy vehicles should traverse the inner lane of the roadway both up and down hill, avoiding the outer section of the roadway closest to the guard rail.

4.2 TENSION CRACKS

Regular inspections (fortnightly) are recommended to identify new areas of tension cracks that may develop along the roadway. When identified, the location of the cracks should be recorded and the width measured. Each area should be photographed and marked with survey paint so heavy vehicles can avoid traversing these areas.

These areas should be isolated with barricade mesh or similar (refer Figure 21).

Figure 21: Example of isolation using barricade mesh (New Zealand).

Tension cracks should be isolated from overland flow by way of the construction of a low, cold mix asphalt bund, which will direct water away from the open crack. Ideally, the crack should be sealed using asphalt or tar to prevent surface water ingress. Grout should not be used as the addition of significant volumes of grout may promote additional movement.

4.3 DRAINAGE

Existing drainage systems should be reviewed to ensure that they:

- Are in operating condition and are not blocked or fouled,
- Do not discharge water to a susceptible slope areas, and
- Do not increase the catchment of any particular area (e.g. import water from an adjacent catchment).

4.4 OVER SLIPS

Over slips may be successfully managed by implementing the following:

- Remove the material that has suffered failure or disturbance.
- Provide a benched geometry.
- Divert surface flow from upslope using crest drains.
- Install appropriate drainage (e.g. berm drains and subsoil drains).
- Provide support as required.
- Re-vegetate the slope using appropriate species (e.g. vetiver grass).

Depending on the geometry of the slope up-gradient, buttressing of the toe may also be required and may be achieved using large diameter stone or gabions.

4.5 DROPOUTS

A remedial option to improve stability at dropout locations may comprise the following:

- Remove the material that has suffered failure or disturbance.
- Provide a benched foundation.
- Install geofabric and appropriate drainage.
- Reinstate the slope using a combination of gabions and free draining earth materials.

An example of such a repair is provided below (Figure 22).

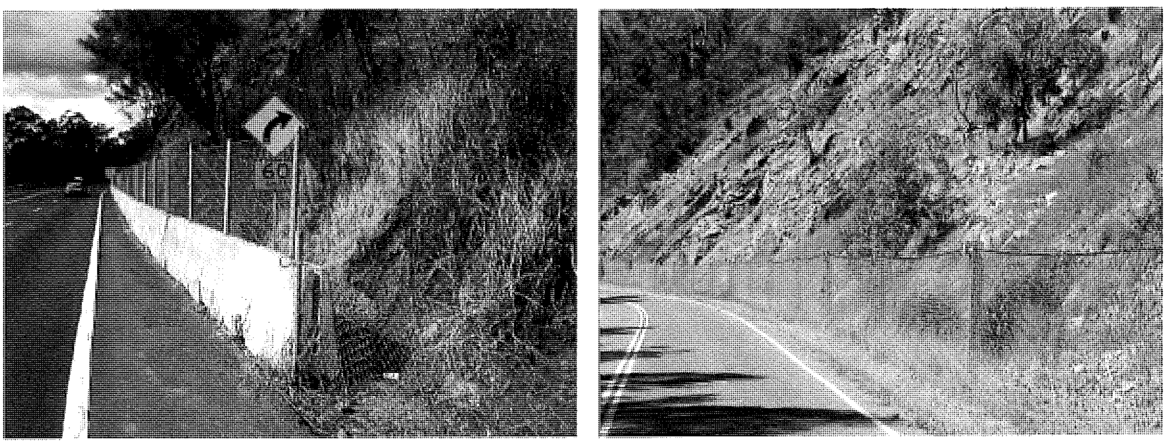
Figure 22: Example of gabions used to stabilise road cutting near Fernvale, Brisbane Valley.

To ensure the ongoing stability of the area, geotechnical data will need to be acquired by way of intrusive investigation prior to the design process.

4.6 ROCK FALL PROTECTION

Where rock falls have and are expected to occur and the adjacent slope is not able to be re-profiled, a system of rock fall protection barriers, similar to those shown in Figure 23 may be suitable. These are engineered systems designed to absorb/protect against specific energy loads.

Figure 23: Rock fall protection systems at Left) Cunningham's Gap, and Right) Mount Tamborine.



5.0 CONCLUSIONS

The following is concluded from the geological inspection performed Wednesday 19 January 2011.

- No new significant geological or geotechnical issues were identified at the Splityard Creek Dam, WPS car park or its north-eastern slopes.
- Pre-existing risk mitigation measures such as benches, berms, rock bolts and shotcrete worked effectively to reduce damage at several inspected locations.
- Numerous new slips/failures, predominantly within non-bedrock (soil) horizons, were identified along the WPS southern, south-eastern, north-western slopes that surround the WPS, as well as along the WPS access road.

  The areas of most concern include:

Southern Slopes

(a) An overslip was observed up-slope of the sewerage pipe near the evaporation trench.

(b) A rock fall was observed immediately adjacent to the boat ramp area.

South-Eastern Slopes

(a) Several rock falls and slips were noted above the access track.

(b) Major degradation and mass wasting was observed directly behind the WPS.

North-Western Slopes

(a) A land slip was observed above the WPS inlet pool.

Access Road

(a) Several rock falls and land slips were observed along the length of the access road.

(b) Tension cracks were observed at two locations along the access road.

(c) Large boulders were observed to have fallen onto the access road.

6.0 RECOMMENDATIONS

The following recommendations are made specifically with respect to observed areas of concern. However, more detailed site inspection and evaluation is recommended in order to formulate appropriate site-specific engineered solutions.

Southern Slopes

(a) Benching is recommended in areas of observed slope instability, with a drain possibly installed at the crest of the slip, in addition to formed drainage on each bench to prevent ponding.

(b) In areas where rock fall has occurred, removal of material at risk of future failure by barring down is recommended, as is the installation of an extensometer to monitor any possible future material movements.

South-Eastern Slopes

(a) In areas where rock fall has occurred, removal of material at risk of future failure by barring down is recommended.

(b) It is recommended that the area subjected to major degradation and mass wasting be revegetated as soon as practicable to increase slope stability. Planting a series of parallel rows of vetiver grass orientated normal to the flow direct at regular intervals along the gullies is suggested.

It is also suggested that in order to decrease the velocity of material moving down the south-eastern slopes, the flow path be altered to re-route any failed material around towards the north-eastern slopes and away from WPS infrastructure. An anchored, reinforced concrete training wall topped by a mesh screen may be a suitable structure.

North-Western Slopes

(a) The observed failed slope should be benched, drained, and revegetated with vetiver grass. To prevent fouling of the inlet pool, it is suggested that an appropriate barrier fence/wall be constructed along the toe of the slope.

Access Road

(a) The following is recommended in areas where rock fall or land slips were observed to have occurred along the access road:

- That material which has suffered failure or disturbance be removed to prevent further future failure.
- To not use the access road in storm events or following prolonged precipitation until inspected and declared safe by a nominated individual.
- That berms be re-instated at failure locations, and crest drains be installed to divert water away from slopes.
- That international standard "No Stopping" signs should be erected along the access road.
- That drains are regularly cleared of debris.
- That large drains cross-cutting the access road be installed to reduce the flow that presently reaches the car park area via the access road drain.
- That shotcreting or conventional reinforced concrete be installed to protect susceptible erosion areas.

(b) The following is recommended in locations were tension cracks were observed:

- That expansion of tension cracks should be monitored by paint markings across the cracks using elongate rectangular stencils. The monitoring should initially be preformed fortnightly.
- That personnel and heavy vehicle drivers be made aware of the risk associated with tension cracks. Adding load to areas with tension cracks should be avoided.
- That areas containing tension cracks be isolated using barricade fencing.
- That tension cracks be protected from overland flow via the construction of a low cold mix asphalt bund
- That tension cracks be sealed using asphalt or tar to prevent surface water ingress.

(c) It is recommended to remove boulders at risk of failure via controlled blasts. A licensed blasting contractor should be consulted to discuss removal options.

The following detailed investigations are recommended to allow properly engineered stability solutions to be designed to improve safety and stability in the power station area.

- Failures in slopes around the power station.
- Gully erosion: rehabilitation and control of drainage.
- Access road monitoring and remediation.

7.0 REFERENCES

GSQ Geological Survey of Queensland, 2008, *1:100,000 Scale Digital Geological Map: Caboolture*, Geological Survey of Queensland, Brisbane

Lapidus, D F (1990) Collins Dictionary of Geology. HarperCollins Publishers, Galsgow.