10 August 2010 Reference No. 107662007-010-L-Rev1

Mr Jai O'Toole
Department for Water
Level 1, 22 King William Street
ADELAIDE SA 5000

LANDSLIDE RISK MANAGEMENT
MANNUM CARAVAN PARK, SOUTH AUSTRALIA

Dear Jai

Introduction

As requested by the South Australian Department for Water (DfW) Lyndon Sanders, Principal Engineer, visited the Mannum Caravan Park on 17 June 2010 with Jai O'Toole of DWLBC. During the visit we were accompanied by Mr Gavin Pitman, the Manager of the Caravan Park which is owned by Mid-Murray Council. The aim of the site visit was to assess the possibility that landsliding was occurring at the Park, and to provide advice regarding landslide risk management.

Site notes and photographs taken during the visit are retained on our project files. Mr Pitman has subsequently provided copies of his measurements of ground movements since March 2009.

Background Information

Much of Mannum occupies the top or side slopes of the cliffs that bound the River Murray to the northwest. There is an area of lower lying land in the middle of the township, alongside the River. The Mannum Caravan Park is on Purnong Road, towards the northern end of this low-lying land. The cliffs to the west of Purnong Road are composed of Mannum Limestone, the soils of the near-River areas comprise Coonambidgeal Formation - mainly fine grained sand and sandy clay.

We understand from discussions with Mr Pitman that the area in which the Caravan Park stands was probably used for camping from the 1940's.

Aerial photographs of the area taken in 1954, 1963, 1976 and 1979 are presented in Attachment A. The photo's indicate that development of a caravan park from the informal camping area commenced between 1954 and 1963, possibly after this area and most of the lower-lying portions of Mannum were flooded in 1956. Filling to extend the land into the original swamp area towards the northeast is visible in 1976. In the 1979 photograph, the land is close to it present area.

It is possible that fill was placed in the area now known as the 'old park' – the pre-1970's camping area – to raise its level. The ground level in the 'old park' is generally elevated above the newer area.

The layout of the Caravan Park is shown on the map below, reproduced from the Caravan Park's website.

The areas where probable landsliding was thought to have occurred are along the northeastern frontage of the site - along Marion Way adjoining the swampland of the Hermann Gass Bird Sanctuary and along Ariel Street and Bogan Street. All of these were built by the 1970's filling of the swamp.

Site Observations – Marion Way

Sites 26 to 15 along Marion Way are shown in the photographs below, which were taken during our site visit

Photo 1
Marion Road
looking North West

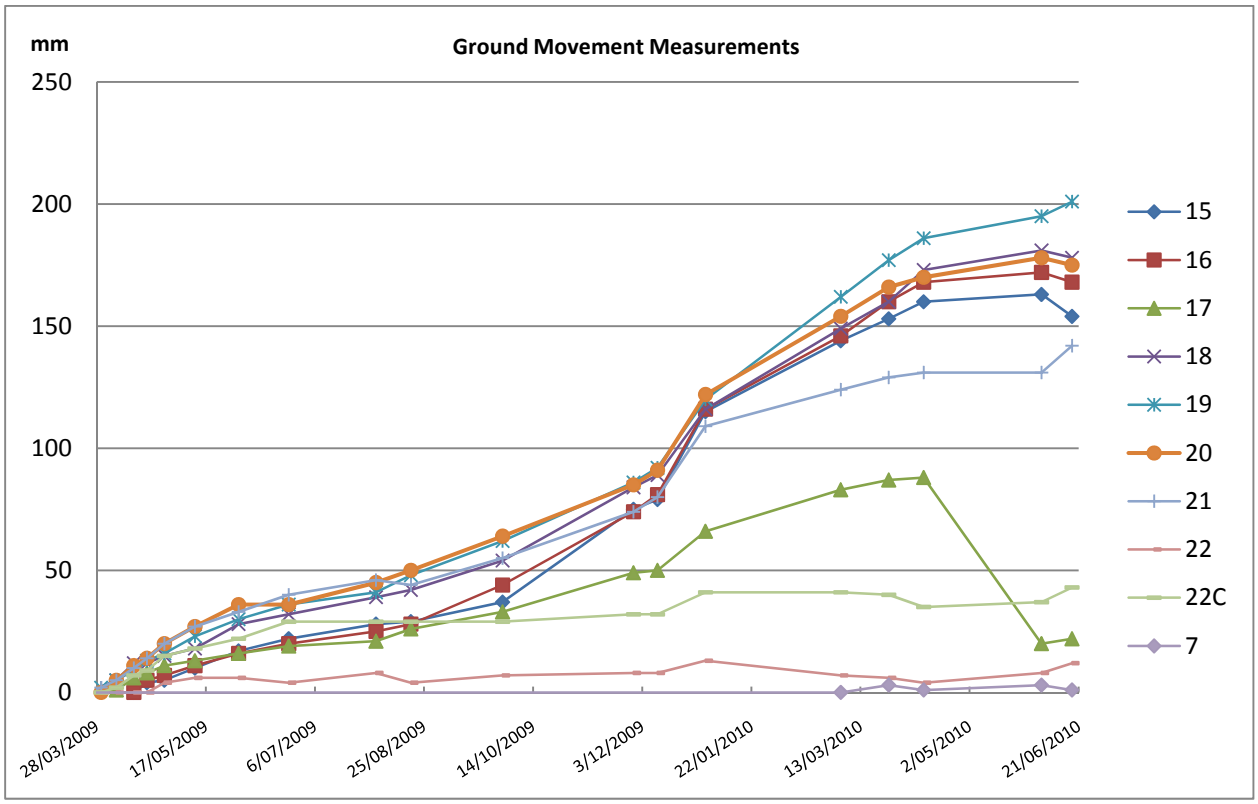
Photo 2
Marion Road
looking south east

The photographs show that the ground is cracked with the cracks generally orientated approximately parallel with the crest of the slope that falls towards the Bird Sanctuary. The slope is between about 2 m and 3 m high – it was impractical to measure it – and has a face angle generally around 25° (about 2 horizontal to 1 vertical).

The cracks coincide generally with service trenches, and service conduits are exposed in the base of some cracks. At the Purnong Road end, the cracks bend towards the Bird Sanctuary and apparently peter out a few metres beyond the temporary fence shown in the photo.

The openings in the ground are up to about 200 mm wide, but this may be somewhat misleading as we understand that some trenching and other earthworks have been performed in the area since cracking was originally observed which has probably affected the crack width.

Gavin Pitman has been measuring the lengths of the block paving hard stands on some of the camping sites since March 2009. A graph of the increase in measured length over time is presented below.



The graph indicates ongoing horizontal movement of the ground surface, with the majority of sites experiencing at least 140 mm horizontal extension over approximately 6 m measurement length.

The limited extent of ground movement at site 22 may be associated with the tree near the measuring sites, which could potentially be buttressing the slope locally. Site 7 is relatively far from the slope compared with the other sites. The measured movements may provide an indication of the repeatability and reliability of these measurements, which might on that basis be inferred to be accurate to about ±5 mm.

We judge that landsliding is occurring in this area. The sharp increase in the measured rate of movement during December 2009 may be associated with the corresponding sharp increase in measured water level during that time. Although the measured ground movements subsequently slowed during a period when the River level rise also slowed, they have not ceased.

The latest rounds of movement measurements show more scatter than previous rounds, and some apparent reversal of movement. This is likely to imply that horizontal movement is being redistributed in the ground as

landsliding behaviour extends further from the crest of the slope – that at least some movement is now occurring behind the present reference points.

Site Observations – Ariel Street and Bogan Street

Photo 3 Ariel Street, looking north

Photo 4 Ariel Street looking south

The photographs above show Ariel Street and the ground falling towards the River. The left one is from the Caravan Park website, the other was taken during our site visit and shows significant distortion of the roadway surface since the first photograph was taken.

We understand that this distortion has occurred since about late December 2009, and that some cracking in the roadway has been repaired during that period. We judge that there is about 0.3 m difference in level across the roadway. We understand that movement is ongoing and represents the development of landsliding of this area, although this has not yet led to full rupture of the soil.

Photo 5: Bogan Street, looking North West

Cracking in the ground near Bogan Street is shown on the photograph above. This is similar to, although not as severe as, the cracking near Marion Way and is oriented diagonally across the slope (the crack runs approximately east-west).

The slope along the Ariel Street and Bogan Street frontages is similar to that at Marion Way – between about 2 m and 3 m high with a slope angle around 2 horizontal to 1 vertical.

DISCUSSION AND RECOMMENDATIONS

Our site observations indicate ongoing ground movement along practically the whole extent of the ground between Marion Way, Ariel Street and Bogan Street and the swamp along the Caravan Park boundary. That is, the movement is occurring along practically the entire water boundary of the area filled in the 1970's.

Observations by Caravan Park staff suggest that the movements started in early 2009. It may be no coincidence that this was when the water levels in this part of the River were the lowest ever recorded, as generally lowered water levels are associated with reduced stability in bank slopes.

The measurements provided by Mr Gavin Pitman suggest that the movements near Marion Way may have slowed recently, but they have not stopped and there is every reason to think that they could accelerate in the future. The latest measurements suggest that the area affected by landsliding may have recently extended further from the water along the Marion Way frontage.

The monitoring suggests that increased horizontal ground movement near Marion Way is associated with rises in the River water level, which are predicted to continue over the next few months. That might not appear to be consistent with a lowered water level having been the trigger for landsliding, but it should be recognised that once landsliding has occurred the soil's properties are fundamentally changed and post-landsliding behaviour may be quite different from the pre-landslide situation.

We judge that the situation near Ariel and Bogan Streets is similar even though the manifestations of landsliding might appear different. The relatively rapid development of vertical movement in the roadway of Ariel Street and the size of that movement is cause for concern.

We expect that sooner or later there will be landsliding in a proportion of the land that is showing signs of distress – the ground will rupture and parts of it will slide towards the water. At the basis of the signs we observed during the site visit, we expect that most of the frontage of Marion Way and Ariel Street is likely to slide over time although this is unlikely to occur all at once. Monitoring is likely to assist in predicting how far the ground will distort before this occurs.

That being said, such predictions are not always accurate and based on the reported speed with which the landslide occurred at Long Island Marina in February 2009, we consider that it would be prudent to allow access to the areas at risk only to those actually monitoring the movements. The area should be assessed only after analysis of the previous monitoring round confirms that the associated risks are acceptable each time monitoring is performed.

Public access to much of the area potentially at risk of landslide is already controlled by fencing. We recommend that the fence be realigned to the north western side of Ariel Street – that Ariel Street be closed – to include all areas in which landsliding is presently apparent. It would also be prudent to close Marion Way along the Bird Sanctuary frontage. Although there are no clear signs to date that landsliding has progressed this far behind the slope crest, the possibility cannot be ruled out.

We recommend that the measurement of ground movements currently undertaken along Marion Way should be extended to include the whole of the Caravan Park swamp and river frontage along Marion Way, Ariel Street and Bogan Street. We recommend that measuring points (pegs or similar) should be placed in pairs, one well away from the slope crest – the land side of the various streets would appear to be appropriate at present – and the other close to the slope crest (subject to appropriate risk management).

We recommend monitoring of at least each caravan/camping site. Measurements should be taken between these pairs weekly or more frequently. These measurements should be checked for signs of any acceleration of movement after each reading. At the same time, the ground outside of the fenced area should be monitored for any signs that the present cracking or vertical ground movements are extending. If this does occur, it will be necessary to extent the quarantined and monitored area.

We could not rule out the necessity, as a matter of prudence, to quarantine a significant proportion of the 'new' park area over time.

We recommend that as far as is reasonably practicable, stormwater runoff should be directed away from the areas at risk of landslide. Water entry into cracks in the ground is likely to destabilise the slopes. It would be prudent to decommission any services in these areas also as these are likely to be affected by landsliding when it occurs.

We have considered and discussed with DfW and Mr Pitman possible earthworks to close the cracks that are present in the ground in the landslide areas. We recommend against these in the current situation, even though it is likely to reduce the possibility of stormwater triggering a landslide event, because the risk to the workers is unquantified and it would require significantly more data than is currently available to demonstrate that the OH&S risks would be acceptable.

We recommend monitoring of the remainder of the River frontage of the Caravan Park. As far as we can tell, the present distress is confined to the 'new' park – the roughly 30 year old section of filling over swamp – and not the bank areas shown above water in the pre-1976 aerial photographs. However, we cannot rule out the possibility of landsliding occurring around the water frontage of the 'old' park.

POTENTIAL FOR REMEDIATION

We have previously provided DWLBC with discussion of various possible means of improving the stability of an area of incipiently unstable ground at East Front Road, about 4 km up- and cross-River from the Caravan Park and in geologically similar conditions. We see little benefit in reiterating that discussion in this document. It may suffice to observe that any remediation is likely to be costly and difficult, with more reliable solutions being more difficult and more costly than less reliable ones. It may prove impractical or uneconomic to remediate landsliding at the Caravan Park, or to bring the risk to acceptable levels.

It must be borne in mind that investigations at East Front Road have been performed to gain some understanding of the subsurface conditions, allowing analysis and some predictions of the soil behaviour. Such an understanding of the subsurface conditions would be necessary to allow assessment and costing of any remedial activities at the Caravan Park.

Based on discussions with Golder Associates OH&S managers, geotechnical investigations within the present area of landsliding at Mannum Caravan Park are likely to be possible only under stringent OH&S management, and may prove impractical. Investigations outside of that area may not be representative of conditions in the area.

The scope of investigations will be affected by the expected outcomes. We suggest that these should be assessed before a scope can be devised.

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CLOSURE

Thank you for the opportunity to contribute to this project. The work has been interesting and presented some challenges. Should you have any queries regarding this letter, or if we can be of further assistance, please do not hesitate to contact this office.

GOLDER ASSOCIATES PTY LTD

Lyndon Sanders
Principal Geotechnical Engineer

LJS/AOM/ljs:ed

Attachments: Limitations (LEG04, RL1)

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1954 aerial photograph

1963 aerial photograph

1976 aerial photograph

1979 aerial photograph

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