21. NATURAL HAZARDS

Overview

The key natural hazards relevant to the Project area relate to seismic activity and flood risk.

Seismic activity, including ground shaking and liquefaction, is a significant geological hazard in the Canterbury area. There are several active and known faults around Canterbury, with the Greendale Fault terminating approximately 1km north of Rolleston. Propagation and extension of this fault eastwards would result in active fault crossing the Project area east of Weedons and trending towards Prebbleton. However, recently generated data and interpretation from GNS is indicating that seismic activity is moving eastwards and north, away from the Project area.

Ground movement associated with the recent earthquake events commencing in September 2010 have recorded horizontal movement up to 900mm and vertical movement of up to 320 mm in the Project area. No liquefaction was recorded in the project area during any of the recent earthquake events, however, geological investigations have proven that liquefiable soils do exist at depth.

In terms of flood risk, the design standard for the highway drainage system is the 100 year Annual Recurrence Interval ("ARI") rainfall event including an allowance for climate change, as recommended by MfE in the local body guidance manual. It has been assessed that disposal to land has the potential to reduce downstream flooding due to the reduction in contributing area (i.e. the area draining to the highway drainage system). This has the potential to have a positive effect on reducing flooding of the existing environment.

Utilisation of total storm detention in the 100 year 24 hour rainfall event will ensure that spilling to Upper Knights Stream in the Halswell River catchment via Montgomery's Drain will only occur in extreme rainfall and/or groundwater events where flood risk can be appropriately managed.

21.1. Introduction

Events such as earthquakes and flooding are natural hazards that can have adverse effects on people, property and other parts of the environment. When designing and constructing roading projects it is important that reasonable steps are undertaken so that the activities do not cause or exacerbate natural hazards while ensuring these events will not become a hazard for people utilising the Project.

The information contained in this chapter is based on the Geotechnical Engineering and Geo-Hazard Report (Technical Report 11) and Assessment of Stormwater Disposal and Water Quality Environmental Effects (Technical Report 3), appended in Volume 3.

The geological and hydrological characteristics of the Project area were assessed to identify elements that require particular recognition at the detailed design stage. The reports also identify measures that will minimise effects of natural hazards on the Project.

21.2. Existing environment

21.2.1. Geological hazards

A geological hazard is an adverse geological condition which is capable of causing damage or loss of property or life. The following geological hazards were assessed:

- Seismicity;
- Liquefaction; and
- Landslips.

Seismicity

Seismicity relates to the frequency or magnitude of an earthquake in a given area. A summary of the seismicity assessment, including ground shaking and ground deformation from the recent earthquake events, of the Project area is provided below. A detailed assessment can be found in Technical Report 11, Section 6.

The route lies within the Canterbury Region south of the Marlborough Fault Zone and to the east of the Alpine Fault. The September 2010 Darfield Earthquake was centred on the previously unmapped Greendale Fault located to the west of the route. The earthquakes that have occurred since September 2010 lie with a localised region centred around Christchurch and to the west of the city. The Greendale Fault has been mapped with its eastern end terminating approximately 1km north of Rolleston. Propagation and extension of this fault eastwards would result in the active fault crossing the Project area east of Weedons and trending towards Prebbleton. However, recently generated data and interpretation from GNS is indicating that seismic activity is moving eastwards and north away from the Project area, becoming centred offshore in near Pegasus Bay. The highest current risk is from a significant aftershock from the current sequence, but both the Marlborough Fault zone and the Alpine Fault are capable of generating large earthquake events which could result in significant ground shaking in the Christchurch area.

The movement on the fault that generated the September 2010 earthquake was accompanied by extensive ground rupture. Subsequent mapping has disclosed subsurface rupture, one extension of which approaches the route immediately north east of Rolleston.

In the Project area, significant ground movement occurred following the September 2010 event. Horizontal displacements of up to 900 mm towards the west occurred on Main South Road near Rolleston with horizontal displacements reducing further east e.g. 300 mm at Berketts Road. To the east of Berketts Road, the vector of displacement changes direction to the north east with displacements of 190 to 230 mm being measured. The vertical displacements measured are all negative (i.e. movements downwards with respect to previous levels). The maximum movements noted were 230 mm west of Weedons Road and 320 mm near the Larcombs Road intersection. Smaller negative displacements of 20 mm to 40 mm were noted around the Main South Road/CSM2 intersection.

Unusually high levels of ground shaking were noted in the 22 February 2011 and 13 June 2011 earthquakes with maximum peak ground accelerations of 2.2 g recorded in the Heathcote Valley and 1.6 g in parts of the Eastern suburbs. In the Project area, peak ground acceleration values were in the order 0.2 g arising from both the 4 September and 22 February events. The interaction of the subsurface strata is significant with respect to the Project area. In the Heathcote Valley and Eastern Suburb's soft alluvial sediments overlying harder basement rock (the subsurface extension of the Lyttelton Volcano) has resulted in the amplification of the arriving earthquake waves i.e. they refract and "bunch up". The subsurface conditions underlying the Project area are somewhat different, with stiff soils to some considerable depth. There are unlikely to be any amplification effects within the Project area.

Liquefaction

ECan had previously (to 2010) carried out liquefaction susceptibility studies in Christchurch to identify areas of particular risk. The Project area was identified as having a low risk of liquefaction. The earthquakes of 4 September 2010, 22 February 2011, 13 June 2011 and 23 December 2011 generated liquefaction in the Christchurch area. The effects included extensive "sand boils", discharge of groundwater, lateral spreading of liquefied soils and associated cracking of overlying soils and settlement of ground and structures founded on surficial soils. Little or no liquefaction was observed in the Project area. This was due to:

- lower Peak Ground Accelerations in the Project area;
- lower ground water levels (4-5m below surface); and
- dominant soils e.g. gravels which are not particularly susceptible to liquefaction.

Based on the site investigation data obtained, and the observed effects, and data from the recent earthquakes, the susceptibility of the soils within the Project area to liquefaction is low and limited to particular horizons of more silt and fine sand rich material.

Slope Stability

With the relatively flat topographical relief of the Project area and natural slope stability, general land instability issues do not pose a significant constraint to construction or long term serviceability of the motorway.

21.2.2. Climatic Hazards

The majority of the catchment crossed by the proposed MSRFL and CSM2 route does not directly contribute to any natural watercourse. This conclusion was reached in discussion with staff of ECan and SDC and is illustrated by the absence of natural watercourses in the vicinity of the Project. Surface water in the Project area typically ponds in local depressions on the catchment surface and soaks to land or evaporates. In larger events overland flows have the potential to flow along surface flow paths. These overland flow paths are often intercepted by field drains, irrigation channels and the existing stockwater race network, which either eventually discharge to the Halswell River or discharge to land via engineered soak pits.

The SDC advises that stockwater races perform a land drainage function during heavy rainfall events. During or prior to such events, the upstream stockwater race intakes are closed or shut off. SDC advises that runoff can exceed water race capacity and some localised flooding does occur.

The natural catchment upstream of the proposed MSRFL alignment is intercepted by SH1 and the railway embankment. Both of these structures form impediments to overland flows, particularly the railway embankment, and there is little existing stormwater infrastructure in place to allow for the passage of flood flows through or under Jones Road and the rail embankments. There is significant capacity for ponding upstream of these embankments.

The section of CSM2 about Halswell Junction Road is part of the Halswell River Catchment. This area drains to the Halswell River via Montgomery's Drain and Upper Knights Stream. Upper Knights Stream is permanently dry at the upstream end. ECan has stated that the Halswell River is sensitive to any increases in peak discharge rate or volume as there is a history of flooding. The Project alignment cuts diagonally across the flood plain and has the potential to divert surplus overland flow back to the Upper Knights Stream and hence into the upper reaches of the Halswell River. There is a history of flooding in the Halswell catchment where the critical duration storm is up to 60 hours in length.

21.3. Assessment of natural hazard effects

21.3.1. Geological hazards

From a geological perspective, the design and construction of the Project is relatively straight forward with few inherent risks associated with geological hazards.

The change in seismic activity and setting for the Canterbury region as a consequence of the earthquake events from September 2010 onwards does pose an element of risk in terms of elevated peak ground accelerations, ground shaking, ground rupture and liquefaction (at depth in the soil horizon).

The major effects from liquefaction, if it were to occur on site, would be concentrated on the structures. It is unlikely given the site soils of sands and gravels that liquefaction would disrupt either the pavement or buried services such as occurred in the eastern suburbs of Christchurch. Based on this analysis it is concluded that there is little risk from liquefaction to major structures at the site, and therefore adverse effects on the public using the State highway, that prudent design would not mitigate.

21.3.2. Climatic hazards

The Halswell River has a history of flooding. The South West Area Plan (SWAP)[97] and its associated Stormwater Management Plan (SMP)[98] have considered limiting the effects of flooding through a series of stormwater storage facilities. These include ponding and detention basins and a recommendation to encourage discharge to land.

Events below the design storm event should be completely contained within the Project corridor reducing potential flooding effects downstream. The stormwater design will reduce the contributing area to any existing flooding locations (through re-contouring land and the creation of embankments and bunds), thereby reducing flooding to adjacent landowners. It is considered there will be a slight increase in total volume to land but a negligible change during and immediately after a large storm event (by taking into consideration the time to soak away following that storm event).

Events in exceedance of the ARI event have the potential to cause flooding upstream of the Project and of the Project itself. These events will also result in the spilling of flood water into Montgomery's Drain. These flows will eventually reach the Halswell River (via Upper Knights Stream)

It is anticipated that there will be an increase in base and flood flows in Upper Knights Stream and Halswell River. The increase in flows in these water bodies will be a result of the new highway impervious area increasing, and as such, there will be more runoff water that would otherwise be soaking directly to land (ignoring the effects of evaporation and evapotranspiration).

During future periods of high groundwater, the expected base flow and flood flows are likely to increase. The time of elevated flow in the Halswell River is currently expected to occur over a period up to 60 hours in length following a storm. However, during the recession curve, the River and Upper Knights Drain are expected to have some surplus capacity.Overland flows in excess of the notional full capacity of the stockwater race have the potential to arrive upstream of the Project alignment. The extent of development immediately adjacent to the proposed alignment is currently limited; therefore effects on flooding of habitable floors are likely to be less than minor. However, the current extent and frequency of inundation of pasture upstream of the alignment is not known.

On the downstream side of the Project alignment, the siphons will discharge stormwater. This is also aided by distance between the Project alignment and the downstream properties. Natural dispersion of flows is likely to occur in the distance between the siphon outlets and the downstream properties.

There may be overland flood flow exceedance events at Halswell Junction Road. The Owaka Basin has been designed to accommodate overflows from Halswell Road detention basin (which collects

[97] South West Christchurch Area Plan, Christchurch City Council, April 2009.
[98] Stormwater Management Plan for South West Christchurch, Christchurch City Council, 2011.

flows from the Hornby Industrial Area). The outlet from the Owaka Basin is to the old quarry pit on Wilmers Road. However, when this is full or there is insufficient hydraulic gradient, an overflow discharge from the basin will discharge to Montgomery's Drain and on to Upper Knights Stream via a pipe and open channel system. It will be necessary to maintain the connectivity and capacity of this overflow through the construction sequence of CSM2.

More detail on the effects of geological and climatic hazards is provided in Chapter 19 and Technical Reports 3 and 11, Volume 3.

21.4. Measures to avoid, remedy or mitigate actual or potential effects on or from natural hazards

21.4.1. Geological hazards

Mitigation of risks associated with geological hazards will be largely addressed through detailed and commensurate investigation for the detailed design of the structures and implementation of the appropriate geotechnical parameters which will ensure the risk is 'designed out'. It is considered that the Project will not affect the rate or likelihood of a geological hazard, however while an earthquake event may affect the proposed State highway it will be designed in such a way so there are minimal effects on the highway and users of the highway.

21.4.2. Climatic hazards

The design standard for the highway drainage system is the 100 year ARI rainfall event including an allowance for climate change. This includes the conveyance capacity of swales and pipes and the required storage within the disposal system. Disposal to land has the potential to reduce downstream flooding due to the reduction in contributing area (i.e. the area draining to the highway drainage system) and reduced flows to Montgomery's Drain and Upper Knights Stream. This has the potential to have a positive effect on reducing flooding of the existing environment. Events in exceedance of the ARI event have the potential to cause flooding upstream of the Project and of the Project itself. These are explained in detail below:

MSRFL

Flooding may occur upstream of the existing SH1 alignment. The highway drainage system has not been designed to dispose of the flows generated in the catchment between the State highway and the railway. In order to mitigate the effects of overland flows on the disposal system, bunds will separate the 'engineered' and 'natural' systems. The effect on the 'natural' system is that the 'engineered' system will occupy flood volume, but the effect of this is partially mitigated by a reduction in runoff volume contributing to the 'natural' system (i.e. discharges from the existing highway will be diverted to the disposal system). The effect of the reduction in flood plain volume will be minor.

There are two locations where overland flows may exceed the runoff from the local catchment downstream of the large railway embankment culvert and the Digga-link site. In both these instances, specific infrastructure is proposed to mitigate any potential flooding effects by providing conveyance beneath the Project. More specifically:

- a culvert with a high level entry at a level near the existing road crest is proposed downstream of large diameter railway crossing culvert; and
- extension and/or replacement of the existing Digga-link culvert is proposed.

CSM2

There is significant uncertainty with the occurrence and size of the overland flows generated in the catchments upstream of the Project. In order to mitigate this uncertainty, bunds have been included upstream of the Project drainage system. As CSM2 is a greenfield development without any existing restriction to overland flows, siphons have been included to pass flows beneath the Project. Key aspects of their design to mitigate environmental effects are listed below:

- the overland flow siphons have been included in locations where the natural overland flows occur;
- consideration has been given to all topographic data presently available to minimise the effects of any concentration of overland flows on downstream properties;
- increases in flood level upstream of the siphons is intended to be limited 250 mm in events up to the 50 Year ARI event and with no increases in habitable floor level flooding;
- the land adjacent to the siphon is slightly dropped to minimise sedimentation of the siphon (reducing the chance of blockage and upstream flooding); and
- soakage at the base of the inlet and outlet manholes has been included to allow the siphon to drain and remain dry between events, thus easing maintenance and reducing flood volumes.

In addition to the siphons the overland flow paths have influenced the highway drainage disposal system. As described above, the disposal points in the highway drainage system have been located and sized with consideration given to overland flow path locations. Further to the additional soakage devices and their location, cross drains have been included in the design to permit two functions:

- activation of the disposal systems on both sides of the Project; and,
- facilitate pumping down of the system (using temporary pumps) to downstream overland flow paths after exceedance events.

In locations where overland flow siphons will be impractical (given length or geometric constraints) surface water soakage areas have been proposed.

A network of drainage measures under the Ponds that discharge to Upper Knights Stream will operate when groundwater rises above RL 17.5m. This will create a new groundwater equilibrium and maintain current flow rates to Upper Knights Stream and Halswell River.

In order to manage the effects on the drainage system, a period of monitoring of the discretionary discharge from the stormwater pond is recommended under controlled conditions. A process for the controlled release of water from the Maize Maze Pond to the Halswell River system is recommended.

Potential for blockage or partial blockage of the siphons is a risk, but one which can be managed by:

- raising the upstream inlet above the immediate adjacent ground in order to allow settlement of solid particles and gravels from entering the siphon;
- installing scruffy dome type devices to limit larger floatables and branches from entering siphon;
- oversizing the capacity of the siphon in order to cater for limited over design events;
- attending to good engineering practice on the downstream end of the siphon to ensure effects of concentrated flow discharge are mitigated against on a case by case basis; and
- ensuring there is an adequate and functioning maintenance programme.

Stockwater races

The design of the secondary pipe system at each of the stockwater race crossings will provide sufficient conveyance to pass flood flows. This will mitigate any potential upstream flooding effects arising from the proposed alterations to the stockwater races.

21.5. Conclusion

Overall, it is considered that the Project has appropriately considered natural hazard effects. A number of mitigation measures are proposed and natural hazards will be further considered at the detailed design stage of the Project.