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Report

Cranford Basin Rezoning - Review of Geotechnical, Hydrogeology and Stormwater Evidence

Prepared for Christchurch City Council

Prepared by Beca Ltd (Beca)

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Contents

1 Introduction

We understand that Christchurch City Council (CCC) wish to consider the suitability of rezoning approximately 50ha of land in parts of the Cranford Basin comprising the Grassmere (submission 3193), Crozier (submission 3268) and Case (submission 3280) blocks as well as areas of land adjacent to Cranford Street and Meadow Street occupied in part by Christchurch Top 10 Holiday Park (referred to here as Area A) and south of Winters Road east of Wiremu Street (referred to here as Area B). This land, which is outside the "urban limits", is being considered for residential zoning. These areas area shown in Figure 1.

Figure 1 - Location plan

CCC had obtained technical evidence in December 2015 in respect of the geotechnical aspects of rezoning which did not oppose the rezoning from a technical perspective. This was presented at a hearing to the proposed District Plan last year and was not disputed by submitters or the hearings panel. CCC are seeking further opinion of the technical evidence for the rezoning as presented here.

2 Scope

2.1 General

The approach adopted for this review, which is not a formal IPENZ Peer Review, is to review the evidence provided and consider at a high level whether the land might be suitable for residential development, and what geotechnical, hydrogeological and stormwater aspects will need to be considered.

2.2 Geotechnical

The scope of work covered by this report comprises a technical review of:

- Geotechnical Report on Proposed 12.5-hectare Residential Subdivision, Grants Road, Papanui, Bell Geoconsulting Ltd [BGL] (April 2013)
- Desktop Geotechnical Review 340 Cranford Street, St Albans, Elliot Sinclair and Partners Ltd (April 2015)
- Cranford Basin Geotechnical Desktop Report GHD (February 2015) (http://resources.ccc.govt.nz/files/policiesreportsstrategies/chapter17-rural-cranfordbasin-s32-appendix1-cranfordbasin-geotechnicaldesktopreport.pdf)
- Cranford Basin Geotechnical Investigation Report GHD (September 2015)
- Technical evidence on the geotechnical conditions provided by Webb (http://www.chchplan.ihp.govt.nz/wp-content/uploads/2015/10/3723-CCC-Samantha-Webb-Evidence-Geotechnical-10-12-2015.pdf)

The approach adopted for this geotechnical review, is to consider whether the land is suitable for residential development at a high level and what geotechnical aspects will need to be considered. Relevant geotechnical aspects are discussed broadly below, and for details it is necessary to refer to the documents listed above. The land that is subject to the rezoning has not been visited as part of this review.

2.3 Hydrogeology

The scope of work covered by this report comprises a technical review of hydrogeological matters covered in:

- Geotechnical Report on Proposed 12.5-hectare Residential Subdivision, Grants Road, Papanui Bell Geoconsulting Ltd [BGL] (April 2013)
- Cranford Basin Geotechnical Investigation Report GHD (September, 2015)
- Technical evidence on the geotechnical conditions provided by Mr Stephen Douglass (http://www.chchplan.ihp.govt.nz/wp-content/uploads/2015/10/3723-CCC-Stephen-Douglass-Evidence-Hydrogeological-10-12-2015.pdf)
- Geotechnical Report on Proposed 12.5-hectare Residential Subdivision, Grants Road, Papanui Bell Geoconsulting Ltd [BGL] (April 2013)

2.4 Stormwater

The scope of stormwater work covered by this report comprises:

- A technical review of evidence on stormwater by Paul Dickson, dated 10 December 2015. This evidence related to the Grassmere (submission 3193), Crozier (submission 3268) and Case (submission 3280).
- A high level review of the suitability of Areas A and B for residential development from a stormwater and flood risk perspective.

The following documents have also been referred to:

- Evidence on planning, by Ivan Thomson, dated 10 December 2015.
- Technical evidence on the geotechnical conditions, by Samantha Webb, dated 10 December 2015.
- Proposed Christchurch District Plan http://proposeddistrictplan.ccc.govt.nz/PropertySearch/DistrictPlanContainer.html
- CCC, Supplementary Agenda, Council Meeting Thursday 11 February 2016, Cranford Basin Optimisation Report.
- CCC, Styx SMP, Part B: Blueprint for Surface Water Management

The land that is subject to the rezoning has not been visited as part of this review.

3 Geotechnical

3.1 Site Conditions

The ground level generally falls slightly from and across the subject blocks towards the centre of the Cranford Basin, with elevations above mean sea level varying between:

- 5m to 11m Grassmere (submission 3193) and Area A
- 4.5m to 7.5m Crozier (submission 3268), Case (submission 3280) and Area B.

The geotechnical investigation data indicates that the geological ground conditions are broadly consistent, comprising:

- an upper horizon of silt
- sands/silts interbedded with organic silt and peat (and locally un-engineered fill) beneath the upper silt and extending to 5m to 10m depth or so
- sands/gravel/silt to approximately 18m to 19m depth, underlain by
- Riccarton Gravel

Whilst the geological conditions are fairly consistent, the shallow ground conditions (upper 5m to 10m or so), and their expected characteristics are variable, with notable changes over short distances in the amount and distribution of silt, sand and peat. Additionally *in situ* and laboratory testing indicates:

- Low strength of near surface horizons
- Highly compressible organic layers (with a significant variation in compressibility of the samples tested)
- Soils with liquefaction potential

Groundwater is shallow, reported[1] as varying between 0-1m and 1-2m depth, with evidence of springs noted[2], particularly in the Grassmere block (submission 3193). A borehole drilled for the New Zealand Transport Agency (NZTA) Northern Arterial specimen design at the intersection with QEII drive (approximately 200m

[1] van Ballegooy, S.; Cox, S. C.; Thurlow, C.; Rutter, H. K.; Reynolds, T.; Harrington, G.; Fraser, J.; Smith, T. (2014) Median water table elevation in Christchurch and surrounding area after the 4 September 2010 Darfield Earthquake: Version 2, GNS Science Report 2014/18, April 2014. ISBN 978-1-927278-41-3. 79 p and 8 Appendices.

[2] Statement of evidence of Stephen John Douglass on behalf of Christchurch City Council, Hydrogeology, 10 December 2015

north of the study area) encountered 0.7m artesian groundwater head in the first sand layer at 6m depth, which increased to over 4m of artesian head in the Riccarton Gravel at 21m depth.

3.2 Geotechnical Investigation

On the Grassmere block BGL undertook 12 Cone Penetration Tests (CPTs) to between depths of between 3.8m and 8.1m below ground level (stating the termination depth was "effective refusal on dense sand and/or gravel at all locations"). BGL also had access to seven machine auger boreholes drilled to between 4m to 7m depth and undertook two additional boreholes to 15.5m depth with associated Standard Penetration Testing (SPT).

On the Case block Elliot Sinclair undertook three shallow hand auger and Scala penetrometer tests.

GHD undertook four sonic boreholes with associated SPTs to depths of between 11m and 17m and four CPTs to depths of between 17m and 18m in the Grassmere block.

Both BGL and GHD refer to Ministry of Business, Innovation and Employment (MBIE) guidance, BGL to September 2012 information[3] and GHD to December 2012 (v3) information. The current reference for 'Part D: Subdivisions[4]' given on the MBIE website is Version 2 of December 2012, which states:-

- a recommended density between 0.2 to 0.5 exploratory holes per hectare (ha), with the higher density appropriate for variable ground conditions.
- a minimum of five exploratory holes for sites greater than 1 ha
- that appropriate geotechnical investigations shall be carried out to at least 15 m depth, unless the ground is known to be of acceptable quality from lesser depths.

BGL refer to the Grassmere block as being 12.5 ha in area, on which they undertook two sonic boreholes and GHD undertook six exploratory holes, to greater than 15m depth.

The evidence of Dickson states that the property area of the Case block (#3280) is 2.27 ha and the Crozier block (#3268) is 2.56 ha. According to the New Zealand Geotechnical Database[5] the Crozier block has two exploratory holes to ~10m depth and the Case block two to between ~7.5m and 15m depth. The shallow Scala penetrometer testing undertaken by Elliot Sinclair is not considered appropriate by MBIE as the primary ground characterisation method for liquefaction purposes.

Hence for the Grassmere block the density of exploratory holes is slightly above those recommended by MBIE for 'plan change stage' for variable ground conditions. The number and depth of exploratory holes for the Case and Crozier blocks do not meet the requirements of MBIE. A preliminary assessment suggests that there is sufficient data for Area A, but not for Area B.

Hence in relation to making a decision on re-zoning of the Grassmere block and Area A, it is considered that there is sufficient investigation information. For the other areas there are a number of exploratory holes

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[3] Ministry of Business, Innovation and Employment, September 2012. Guidelines for the investigation and assessment of subdivisions on the flat in Canterbury (Appendix B2 to the November 2011 guidance document)

[4] Ministry of Business, Innovation and Employment (MBIE) requirements for Repairing and rebuilding houses affected by the Canterbury earthquakes, Part D: Guidelines for the geotechnical investigation and assessment of subdivisions in the Canterbury region,

[5] https://www.nzgd.org.nz/default.aspx accessed 8 August 2016

which can provide an indication on which the re-zoning could be based, although undertaking further investigation would reduce the risk.

3.3 Seismic Performance

The study areas have been subjected to shaking estimated to be between a Serviceability Limit State (SLS) and Ultimate Limit State (ULS) earthquake during the Canterbury Earthquake Sequence (CES)[6]. Ms Webb's evidence noted that published aerial photography in the Canterbury Geotechnical Database (CGD) taken after each major seismic event of the CES shows minimal surface liquefaction ejecta. Other studies[7] noted more evidence, as follows:-

- September 2010
  - 'flooding – water' possibly related to liquefaction on the Grassmere block (submission 3193)
- February 2011
  - certain liquefaction locally on the Grassmere block (submission 3193) and Area A as well as throughout the Crozier block (submission 3268) and locally on Area B.
  - 'flooding – water' and 'unknown features' possibly related to liquefaction were noted locally on the Grassmere block (submission 3193), Area A and Area B.

As a result of all the events in the CES the reported[8] total vertical ground subsidence varied between 100mm and 500mm throughout the study areas, except locally on the Grassmere block (submission 3193) where both greater and lesser subsidence was noted. Of this subsidence, 50mm to 100mm was attributed to tectonic movement, the remainder is inferred to be due to soil densification / liquefaction (and subsequent re-consolidation).

3.4 Suitability of Land for Residential Development

Static Characteristics

As identified by others, the presence of variable near surface weak, compressible soils will impose constraints on any development. Additionally artesian water pressures at relatively shallow depth has the potential to influence the performance and constructability of any development, including deeper foundations and buried infrastructure/utilities.

Based on the readily available investigation data the dependable bearing capacities will be low. We concur with the BGL and GHD reports that the ground cannot be classified as 'good ground' as defined in NZS 3604:2011[9].

Initial (elastic) and consolidation settlement will occur as a result of stress changes in the ground. Such stress changes can result from imposed loading, for example earthworks to raise the land and/or loads imposed by shallow foundations. Additionally they can occur due to an increase in effective stress, for example as a result of groundwater lowering.

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[6] Canterbury Geotechnical Database (2015) "Conditional PGA for Liquefaction Assessment", Map Layer CGD5110 - 20 July 2015, retrieved 20 July 2016 from https://canterburygeotechnicaldatabase.projectorbit.com/

[7] Review of liquefaction hazard information in eastern Canterbury, including Christchurch City and parts of Selwyn, Waimakariri and Hurunui Districts. Environment Canterbury Report R12/83. December 2012. Accessed 19 Feb 2013 from http://ecan.govt.nz/advice/emergencies-and-hazard/earthquakes/Pages/liquefaction-information.aspx#review

[8] Canterbury Geotechnical Database (2012) "Vertical Ground Surface Movements", Map Layer CGD0600 - 23 July 2012, retrieved 20 July 2016 from https://canterburygeotechnicaldatabase.projectorbit.com/

[9] New Zealand Standard 3604 Timber Framed Buildings 2011

In addition secondary (or creep) settlement of organic soils will occur over time, irrespective of any stress change in the ground. Such settlement could be significant - Ms Webb's evidence refers to CCC data showing settlement of 400mm over a 24 year period. The variable thicknesses of the near surface peat, organic silt and sand are likely to result in a proportion of this settlement occurring as differential settlement, which could be expected to develop over relatively short distances.

The groundwater regime is likely to be characterised by a general upward flow of water from the underlying aquifers. The near surface silt layers act as aquitards, restricting the upward flow due to their lower permeability. Puncturing these aquitards could release the artesian water pressures, resulting in water flowing out at ground level or into excavations.

Seismic Characteristics

Plastic silts and clay soils do not have liquefaction potential, however low plasticity or non-plastic silts do. There is insufficient data to reliably assess the plastic characteristics of the near surface silts and hence assess whether they have liquefaction potential. Based on a preliminary assessment of the readily available data for the sand horizons, the sand is likely to have liquefaction potential.

Whilst the study area does not appear to be as susceptible to seismically induced ground effects compared to other areas in Christchurch e.g. the Residential Red Zone, the soils do have liquefaction potential. The MBIE Residential Technical Categories (TC) map defines the subject sites as 'Urban Non-residential', with adjacent residential properties mapped as TC2, with zones of TC3 land to the south.

MBIE guidance[4] suggests that where:-

- SLS settlement is greater than 50mm (for the upper 10m of soil) the land be classified as TC3
- ULS settlement is greater than 100mm (for the upper 10m of soil) the land be classified as TC3
- Investigations have shown that a mix of land classifications might apply across a site, the site should either be classified as a whole according to the most conservative result on the site, or micro-zoned into multiple classifications on a conservative basis (this might require further investigations to more tightly define these areas).

We note that the evidence of Ms Webb states that evaluation of deep Cone Penetration Testing (CPTs) indicate that the ground performance across the investigated parts of the Cranford Basin are consistent with Technical Category 2. However, the GHD report (December 2015) indicates that greater than 50mm of SLS liquefaction settlement and greater than 100mm of ULS liquefaction settlement is predicted. The latter is consistent with the CPT data[10] from the Top 10 Holiday Park adjacent to the Grassmere block.

Hence, without micro-zoning, the MBIE guidance indicates that the land would be classified as TC3. This should be reviewed, with further work/assessment carried out to assess whether the land is equivalent to TC 2 or TC3. This would logically include an assessment of whether the CES has tested the site to an SLS level of shaking. Also such an assessment should consider whether liquefaction is not predicted in the upper soil layers and whether this is consistent with there being limited surface manifestations of liquefaction and lateral spread.

We do note that up to 400mm of inferred densification / liquefaction (and re-consolidation) subsidence has been recorded across the study area as a result of the CES, which suggests that there is a seismic risk which warrants consideration. In addition to foundation design, this risk will need to be considered in relation

[10] Canterbury Geotechnical Database ([enter year]) "Liquefaction Evaluation of CPT Investigations", Map Layer CGD0050 - 20 July 2015, retrieved [enter date] from https://canterburygeotechnicaldatabase.projectorbit.com/

to how any subdivision is serviced e.g. can infrastructure/utilities and drainage accommodate seismic movements and will such movements increase the subdivision's vulnerability to flooding.

Development Effects

Foundations on compressible soils will need to be designed to accommodate settlement. Whilst piles will transfer loads to more competent strata, settlement of the adjacent soils will induce negative skin friction on the piles increasing the pile loading and hence the required number/capacity of piles. Piles that penetrate the aquitard layers may create pathways for increased seepage and groundwater flow and, if they are founded in layers with high water pressures, may have reduced end bearing capacity. Hence, while piles could feasibly provide a suitable foundation option they may have to have a greater load capacity than that required to resist just super-structure loading and their construction may be complicated by the need for additional drainage measures.

Preloading or surcharging the ground is a recognised method for reducing the effects of settlement, including for organic soils, and if suitable it may then allow robust shallow foundations to be adopted instead of piles. Whether it is feasible on the study sites would require an assessment of the amount of surcharge and its duration along with an assessment of the effects on:-

- neighbours
- the development services/infrastructure/utilities
- long term development levels.

Differential settlements are expected to develop across the study areas where compressible soils are present, with such settlements particularly pronounced between structures supported on piles and the surrounding ground. Remedial filling to raise any subsided ground will increase the amount and rate of settlement.

Differential settlement will affect the infrastructure of any development, including driveways / accesses into and out of structures, and utilities servicing the structures. We understand that the existing CCC main sewer pipeline and associated manholes in Grassmere Street are supported on piles.

The ground conditions will affect the design, construction and maintenance of the infrastructure supporting any residential sub-divisions on the study area, including:-

- settlement effects on surface assets, such as roading and open ditches
- settlement effects on buried services, such as drainage / stormwater, sewerage and other utilities
- how stormwater can be dealt with e.g. by retention and then through the surrounding drainage network (as it is not expected that it will be able to be discharged to ground due to the high groundwater level and upward groundwater flow)
- draining surface seepage or springs (where present).
- the relative levels of development services/infrastructure/utilities (including sewers) how these may vary over time, including whether gravity systems are feasible and how any new infrastructure can reliably tie into existing infrastructure.

Excavations are likely to encounter groundwater and may well have to be dewatered. As well as influencing construction options, dewatering will induce settlement in organic soils, both locally and away from the excavation, the effects of which will need to be considered as part of any development.

3.5 Summary

Whilst there is no evidence of geotechnical aspects which cannot be overcome by engineering for the Grassmere, Case and Crozier blocks, the consequential effects of the ground conditions on development need to be considered.

We are of the opinion that the seismic geotechnical performance, including the ‘global’ subsidence, poses a greater risk to the residential re-zoning than that inferred by Ms Webb’s evidence. Seismic subsidence needs to be considered in addition to static ground settlement.

It would be prudent to confirm that the effects of potential ground subsidence on the other aspects of re-zoning, including services/infrastructure/utilities and long term development levels are acceptable, before determining whether the land is suitable for re-zoning.

4 Hydrogeology

4.1 Hydrogeology of Cranford Basin

The main hydrogeological feature of the Cranford Basin area comprises the transition of the fluvial Springston Formation to the marine Christchurch Formation. Groundwater exhibits flowing artesian conditions (a condition whereby groundwater pressure heads are higher than ground level) which is due to a combination of geological structure, surface topography and drainage and a ready source of groundwater recharge from the Waimakariri River via transmissive gravel aquifers. Nearby older wells to the west also show very high artesian levels in the Riccarton Gravel Aquifer and deeper strata (Well Nos M35/1360, M35/1470).

An Opus investigation bore hole (BH501) located next to Cranford Street encountered ~4 m flowing artesian head when it reached the Riccarton Gravel at ~18 depth. Other shallow boreholes and piezometers (BH180, BH181, BH182) extended into the Christchurch Formation sands experienced significant heave during drilling and encountered flowing artesian pressures of up to 2.5 m above ground (BH180). Piezometers installed over a response zone of 2-4 m depth (PZ501, PZ502, PZ503) also show groundwater levels of up to ~0.5 m above ground level although we expect the land elevation to be higher and groundwater level lower towards the sides of the basin.

Whilst we generally agree with Mr Douglass’s and the BGL and GHD (2015) characterisation of the hydrogeology, the flowing artesian pressures are likely to be a bigger risk than seems to have been acknowledged. It may be of assistance to CCC if the more recent data collected during 2015 by Opus as part of the Northern Arterial Extension Specimen Design phase were taken into account. A more comprehensive analyses of groundwater elevation (including seasonality) over several response zones (depths) compared to the land elevation would assist in determining if groundwater in the areas under consideration for rezoning can be feasibly managed for residential purposes.

4.2 Springs

No comprehensive mapping and description of springs has been completed across Cranford Basin. Some desktop review and targeted mapping for the adjacent Northern Arterial Project has been completed. The report from GHD would have benefited from more site investigations and comprehensive mapping in forming views on the appropriateness of land zoning. We note that the BGL report shows some localised ponding in Figure 2, however this pond looks very similar to springs mapped elsewhere in Cranford Basin. On inspection of aerial photos of the south-western part of the basin, there appears to be some very large springs connected to drains in the area which have not been mapped or acknowledged by the BGL report.

4.3 Groundwater level control & land drainage

The approach taken for the Northern Arterial Developed Design was to provide ample drainage blankets beneath pavements and other structures to divert any groundwater and springs encountered which effectively maintain lowered groundwater levels, particularly during times of seasonally high groundwater. Provision for consolidation (volume reduction of founding soils due to removal of excess pore water), together with accidental interception of artesian pressure conditions during deeper excavation and piling were important considerations with respect to geotechnical design approaches.

Implementing shallow drainage in the near surface may also be challenging to achieve due to the low permeability materials and artesian head beneath the surficial capping materials. This may involve relatively closely spaced surface drains and/or subsoil drains whereby the underlying groundwater is intercepted and diverted to a drainage outlet. It would be helpful to better understand the outcome required under the Infrastructure Design Standards (IDS) in terms of groundwater management i.e. how deep should groundwater be managed from surface when designing drainage (surface and subsoil) systems.

The evidence and conclusions of Mr Douglass seem to rely on there being no further dewatering of the basin or its surrounds including using subsoil drainage, or positioning infrastructure above the water table.(para 4.20 of evidence). If developed for residential use, the area is very likely to require some form of sub-surface drainage and/or deeply set surface water drains to protect properties from groundwater seepage or inflow. There are likely to be several if not many springs that will also need to be diverted to drainage outlets or avoided. CCC may even need to provide outlets for private subsurface drainage from each lot.

The CCC Waterways Wetlands and Drainage Guideline states that low lying areas with high groundwater be returned to wetlands. None of the evidence by Mr Douglass addresses the issue of how much of the rezoned land may only be suitable for wetland regeneration and the potential interplay with the CCC Cranford Basin Optimisation Project has not been addressed. The design and operation of the Cranford Basin flood management area could change the permanent land drainage levels and flood levels and could have implications for surrounding groundwater levels. Although the land is presently drained and managed for cultivation, the water levels could rise once wetlands and flow paths are established by CCC.

Any excavations and drainage pathways are likely to increase the upward movement of groundwater and disturbance of land could create new springs or divert groundwater in unexpected ways. Whilst there may be engineering approaches that can be employed to minimise the volume and consequent effects of groundwater flow reporting to the surface, it would be prudent to assume that residential development of this area will divert and potentially increase groundwater outflow, although by how much and where is uncertain.

The implications of land drainage for ground subsidence should be considered by a suitably qualified geotechnical engineer prior to development. If rezoning to residential does occur, foundations to deal with subsidence caused by drainage will need to be designed accordingly.

4.4 Summary

From a hydrogeological perspective, it appears only parts of the proposed rezoned area in Cranford Basin are likely to be suitable for rezoning. We believe that further investigations are required prior to development. The objective of further investigations should be to clearly identify which parts of the land are suitable for residential development, identify a feasible land drainage regime to manage high groundwater and where this would be implemented, and those areas which should be set aside for spring protection and wetland restoration or utilised as part of the Cranford Basin Optimisation Project.

5 Stormwater

5.1 Site levels

From the LiDAR levels (September 2011) in Canterbury Geotechnical Database, the approximate site levels are:

- Grassmere – RL15.0m - RL18.5m
- Case – RL14.0m – RL15.5m
- Crozier – RL14.0m – RL15.5m
- Area A – RL16.0m - RL17.5m
- Area B – RL14.5m – 15.5m

5.2 Flooding

The Cranford basin is low-lying area which is subject to regular flooding. A large part of the Cranford Basin is designated for stormwater management and as part of its Styx SMP CCC proposes to convert this area into planted or forested stormwater facilities. CCC has carried out extensive modelling of flooding of the Cranford Basin as part of its Styx Stormwater Management Plan (SMP) and further work. This modelling has been used to inform the flood hazard overlays in the District Plan process.

5.2.1 Grassmere, Case & Crozier sites

Over half of the Case land and part of the Crozier land are within the Flood Ponding Management Area (FPMA) notified as part of Stage 3 of the District Plan. Part of the Case site is also within the High Flood Hazard Management Area (HFHMA) notified as part of Stage 3 of the District Plan. The land within these areas is not suitable for residential development. However the remainder of these sites could still be developed. For Area B, the irregular shape of the FPMA at the eastern end of the site would likely make only the western end of the site suitable for development.

Part of the Grassmere land and part of the Case land are within the Floor Level and Fill Management Area (FLFMA) which was included in Stage 1 of the District Plan. Residential development of these areas would need to comply with the District Plan requirements regarding floor levels and filling.

5.2.2 Areas A & B

Area A is outside all the flood overlays in the District Plan.

Area B has flooding issues which need to be carefully considered. The District Plan Stage 3 FPMA covers much of the eastern end of the site, and the majority of the site is within the FLFMA from Stage 1 and Stage 3 additions. The land within the FPMA is not suitable for residential development. Any residential development within the FLFMA would need to comply with the District Plan requirements regarding floor levels and filling.

5.3 Proposed Cranford Basin Optimisation

CCC has carried out a Cranford Basin Optimisation project considering options for increasing the flood storage within the Cranford Basin and modifying operation of its stormwater system to increase storage within the Cranford Basin and reduce flooding in the adjoining suburbs. This work was reported to Council in February 2016, which was after the completion of Mr Dickson's evidence (dated December 2015).

The preferred option in the report to Council, Option 1, includes bunding along the low edges of Cranford Basin east of Cranford St up to RL14.9m CDD datum, based on an increased predicted 2% AEP flood level of RL14.5m.

It is not clear whether this would include bunding adjacent to the Case and Crozier blocks and Area B. Bunding could interrupt secondary (overland) flow paths to the Basin. The Grassmere block and Area A are adjacent to Cranford Basin west and would therefore not be affected by the proposed bunding in the east. Although the Grassmere block could be affected by changes in flood levels.

It is understood that the Cranford Basin Optimisation project has developed since the modelling for the District Plan, and therefore the increased flood levels are not reflected in the District Plan maps. It is not clear what effect this increase in flood level would have on the floodplain, and how much further this would extend into the Grassmere, Case and Crozier blocks and Area B. The revised ponding areas with the Cranford Basin Optimisation Option 1 in place, including freeboard, should be mapped within the Grassmere, Case and Crozier blocks, and Area B.

5.4 Primary and Secondary Stormwater Discharge

The Grassmere block (and Area A if developed in conjunction with it), Case block, Crozier blocks and Area B are adjacent to the proposed CCC Cranford Basin stormwater management area and should be able to be developed so that they discharge primary flow (via a piped system) and secondary flow (via overland flow) to the Cranford Basin. However this needs to be confirmed based on the details of the proposed Cranford Basin Optimisation and Cranford Basin stormwater facilities.

The site stormwater could be managed under CCC's existing consents for the Styx Area, by complying with the Styx SMP. The Styx SMP would require the stormwater to be treated and attenuated on site before being discharged to the CCC system (Cranford Basin). This should be able to be achieved within the sites. However Cranford Basin has a catchment of approximately 644 ha, while the combined area of the Case and Crozier blocks is only 4.66 ha. This means that the additional runoff from development of these blocks would be very minor compared to the wider catchment and would be unlikely to affect water levels in 48 ha Cranford Basin ponding area, and therefore attenuation may not be required. Area B and the combined area of Area A and the Grassmere block are much larger, but still minor compared to the Cranford Basin catchment.

5.5 Land Drainage

Groundwater levels in the Cranford Basin area are high and springs are common. (Refer to section 4 for further information on hydrogeology of the area). In addition to stormwater management, groundwater at the sites would need to be managed for residential development. Very high groundwater levels and springs are not desirable within residential areas as they can cause issues with construction of buildings and services, and maintenance of landscaped areas.

Currently Cranford Basin has a system of farm drains through it and parts of the Basin are operated as market gardens. In other areas market gardening has been abandoned due to high groundwater levels. It is proposed to convert the Basin to a forested basin for stormwater management. This may increase groundwater levels in the Basin and adjacent areas.

The issue of land drainage for the Case, Crozier and Grassmere blocks and Areas A and B requires further investigation prior to residential development. Options for improving land drainage include filling and subsoil drainage (either individual piped or aggregate drains or wider drainage blankets). These options, their effects and advantages and disadvantages need to be carefully considered taking a multi-disciplinary approach. For example, filling may improve land drainage, but filling within the floodplain would increase flood levels, and may require compensatory (offset) storage. Drainage of groundwater to a suitable outfall may be possible, but may be technically difficult and may increase settlement.

6 Recommendations

6.1 Introduction

The preceding commentary identifies geotechnical, hydrogeological and stormwater aspects that are not straightforward and will affect the development and ongoing maintenance of residential sub-division(s). Particularly careful consideration needs to be given to development elevations and how utilities can be constructed and operated effectively in low lying areas underlain by compressible and liquefaction prone soils with high groundwater.

If further work were to be undertaken it could provide information to better inform CCC's decision. This could include incorporation of readily available data from NZTA's Northern Arterial project, CCC's Cranford Basin Optimisation Project and CCC's Cranford Basin flood management plans. As the conditions are variable, there may be some benefit in refining the study area into development areas (i.e. micro-zoning), if some are better suited to rezoning than others.

We have identified a number of recommendations (below) which CCC may wish to consider implementing prior to reaching a decision on whether the land is suitable for re-zoning.

6.2 Geotechnical

1. Where the amount of existing geotechnical investigation data is less than the 0.5 exploratory holes per hectare (minimum of 5) recommended by MBIE[1] for complex and variable sites at plan change, further investigation be undertaken to meet the MBIE recommendations.

2. Carry out a liquefaction assessment of the site in accordance with the recommendation given by MBIE[1]. If laboratory testing for fines content and plasticity index is not available, obtain representative soil samples and have them tested in a soils laboratory to obtain this data and use it in the liquefaction assessment.

3. Make a preliminary estimate of the 'non-development' ground subsidence due to i) seismic effects and ii) secondary (creep) settlement, which could be expected over the design life of the sub-division(s), including an assessment of differential settlement.

4. Classify the study area according to the liquefaction and secondary settlement assessments either i) as a whole or ii) as micro-zones if variable subsidence is predicted.

5. If ground levels need to be raised by filling (based on minimum development elevations) make a preliminary estimate of the induced settlements both in the study area and on neighbours over the design life of the sub-division(s), including an assessment of differential settlement.

6. Have a suitably qualified and experienced Civil Engineer carry out an assessment of the effects of the cumulative settlements determined in 3 and 5 on the development infrastructure for the area(s) determined in 4 and any 'downstream' effects. Development infrastructure includes, but is not limited to: utilities, potable water, sewerage, stormwater, drainage, roading and structures.

6.3 Hydrogeological

1. Comprehensively map and describe springs across the areas under consideration for rezoning and consider appropriate restoration and protection and/or appropriate drainage measures.

2. Compile a robust and more detailed account of groundwater levels across the area including flowing artesian conditions compared to land elevation and consider the implications for development.

3. Consider options and potential effects of managing shallow groundwater for the purposes of residential zoning and infrastructure development.

6.4 Stormwater

1. Consider the effects of Cranford Basin Optimisation project on the areas under consideration for residential development, including changes in flood levels and extents and the effects of bunding on primary and secondary drainage.

2. Comprehensively map the latest information on flood prone areas (including updates with Cranford Basin Optimisation in place) to more clearly define footprints that are flood prone and whether they can be filled or not.

3. Further investigate the issue of land drainage for the areas under consideration for residential development. This should include: consideration of the effects on groundwater levels at the sites when the Cranford Basin is converted to a forested stormwater management area; appropriate levels of service; options for reducing groundwater levels; and the effects of these options.