



1 October 2013

BGL Reference 1393/07

Groynes Development (2012) Limited
PO Box 29-432
Christchurch 8540

Attention: The Directors

Dear Sir,

RE: Geotechnical Summary – Groynes Park Development – Johns Road – Christchurch

Introduction

Groynes Park Development is located between Johns Road and a former overflow channel of the Waimakariri River, which was originally part of the South Branch that links to the Styx River. The area was previously developed for apple orchards, and the clayey and peaty soils required drainage measures that involved gravel-filled slot-drains.

The development of a 400-lot (+) subdivision has required sound knowledge of the subsurface geology, and a strategy that addresses the geotechnical issues associated with a layered sequence of clays, silts, peats and some sands to a gravel “base” at about 15m depth. The subdivision layout and infrastructure has been designed by Opus International Consultants Limited (Opus), and the earthworks are being supervised by Bell Geoconsulting Limited (BGL).

Engineering Geology

The generalised subsurface geological model for the Groynes Park site has been derived by a total of 47 cone penetration tests (CPTs), 10 existing borelogs for wells drilled on the site, and four cored boreholes to 10m depth in the north-eastern part of the development (Figure A1; Figure A2). There are also CPT and borelog profiles for the motorway realignment (State Highway One) across the northern part of the site. In summary, the following engineering geology model has been derived for the site:

- Overbank clayey and sandy silts to 2.5m below ground level (bgl) sourced from the Waimakariri.
- Interlayered peats, clays, clayey silts and thin (<0.3m) silty sands of swamp origin to 8-12m bgl.
- Sands and silts in a layer up to 2m thick at around 12m bgl of alluvial or marginal marine origin.
- Presence of Riccarton Gravel of Last Glaciation age at depths between ~13.5m and 17.5m bgl.

Some well logs for the site on the Environment Canterbury (ECan) website record up to 2.5m of shelly sands of the Christchurch Formation deposited at the inland limit of marine transgression ~6,500 years ago. The overlying swamp-related deposits, with periodic influx of mostly fine-grained alluvial sediment sourced from the Waimakariri River, are assigned to the Springston Formation. The topmost 2-2.5m of the soil profile are Waimakariri-sourced overbank sediments overlying former *raupo* swamp deposits.

The site has been subjected to a maximum peak ground acceleration (PGA) of ~0.2g in both the Darfield Earthquake (4 September 2010) and Port Hills earthquake (22 February 2011). No liquefaction occurred in any of the events in the current sequence, and none would be expected given the thick clay-

rich “cap” of minimum thickness 8m and the water table depth typically below 2.5m bgl. However, unlike the eastern parts of Christchurch City the ground has only been tested to the Serviceability Limit State (SLS) 1 in 25-year PGA, and not to (or above) the 1 in 500-year Ultimate Limit State (ULS) event.

Geotechnical Design

Geotechnical analysis conducted for the CPT profiles has confirmed a TC2 land classification based on the estimated vertical settlement that might occur in a future ULS design event. Because of the presence of relatively soft sandy silts near the top of the profile, it has been necessary to provide a suitably engineered gravel base of river-run gravels above the overbank sandy silts and silty sands to act as a raft for residential housing and infrastructure purposes. The underlying peats and organic-rich clayey silts, typically from ~2.5m bgl, have been shown not to be excessively compressible, and to have more than adequate bearing capacity to support the development housing and infrastructure.

A guiding philosophy at Groynes Park has been to provide engineered ground suitable for foundations meeting the TC2 requirements of the Department of Building and Housing (now incorporated into the Ministry of Business, Innovation and Employment). We are firmly of the opinion that the land is suited to an engineered gravel raft base, with a concrete rib-raft or similar to ensure satisfactory performance of foundations in a future large magnitude earthquake. We do not advise piling, because that could potentially breach the clay-rich cap that confines the stratified soils with layered groundwater. Vertical settlements $\leq 100\text{mm}$ are anticipated in TC2 ground under ULS shaking conditions, and the addition of a 0.5-2.0m thick gravel raft reduces that substantially.

It is also noted that the methodology available for analysing earthquake response in stratified ground has not been adequately developed to date, and that the techniques used are better suited to thick sand sequences of the type found in eastern Christchurch. The dominance of clayey soils, and a water table depth $\geq 2.5\text{m}$, together enhance land stability under large magnitude seismic shaking, and that has been confirmed by observation in the northern and south-western parts of the city during the current earthquake sequence. It has been established that the groundwater beneath the Groynes Park site is layered and confined between laterally extensive peat horizons, limiting liquefaction potential.

Infrastructure Design

Sewer and stormwater installation has been designed by Opus for the ground conditions identified in shallow testing by BGL. Specifically, the trunk sewer and laterals are founded on an engineered gravel raft or pad footing, with a gradient and pumpage as required by Christchurch City Council (CCC). The stormwater is gravity-fed to a primary settlement pond to the immediate east of the motorway alignment, with piping to a wetland to be formed with its base on the topmost peat layer. Drilling conducted by BGL has confirmed the integrity of this design, and the presence of low permeability base to the proposed wetland which will operate with low water levels ahead of storm inflows.

Roading alignments are tested by dynamic cone penetration (DCP or Scala penetrometer) to establish any variability of soil bearing capacity, and a 200-300mm thick base layer is used beneath the roadways for conventional sub-grade construction using AP65 and AP40 gravels. Beneath footpaths a thinner gravel layer is being used. Design and construction of all roads is being supervised by Opus to meet current CCC standards, with input and testing by BGL as required. No construction will be undertaken onto or through peat layers, with engineered fill providing final grade to specified alignments.

Motorway construction across the north-western corner of the property will involve pre-loading of the ground, and settlement monitoring by others to document any changes to the ground profile.

Conclusions

- BGL is satisfied that the geotechnical measures being adopted at Groynes Park are appropriate for the ground conditions identified by comprehensive investigation and on-site testing of materials.
- The site is underlain by interlayered peats and organic-rich clayey silts to a depth of ~10m bgl, and groundwater is stratified between peat horizons with locally perched water tables at variable depth.
- The land is classified as Technical Category TC2 based on analysis of CPT data, and appropriate foundation measures are being implemented using an engineered gravel raft and concrete rib-raft.
- There are no geotechnical concerns with the presence of peat at the site, as testing has shown adequate bearing capacity to comply with the definition of 'good ground' in NZS 3604:2011.
- The construction of engineered gravel rafts 0.5-2.0m in thickness ensures compliance with the vertical settlements to meet TC2 (or better) requirements, and no liquefaction is anticipated.
- To date the land has been tested only to SLS (PGA ~0.2g), but the presence of the ~10m thick organic-rich clay cap will enhance land stability under future large magnitude earthquake shaking.
- The use of piling is not advised on this land as that could provide pathways for deep-seated liquefaction ejecta, and the gravel raft/rib-raft is considered the most appropriate design measure.
- All infrastructure elements (sewer; stormwater; roading; etc) are being designed by Opus using test data from BGL, and use of gravel rafts and pads is considered appropriate to limit settlement.

Reference

BELL GEOCONSULTING LIMITED (2012) Engineering Geology Report – The Groynes Residential Subdivision – Johns Road *BGL Report 1393/02 to Opus International Consultants dated 31 October 2012: 10p + Appendices*

We trust that this summary document is sufficient for your immediate needs. Do not hesitate to contact the undersigned if you require additional information at davidbell@bgconsult.co.nz or (027) 249 3896. We suggest that BGL Report 1393/02 is made available to interested parties.

Yours sincerely,



David H Bell
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