Tonkin+Taylor

Memo

To:	Deb Taylor - Ministry of Education	Job No:	53062.3000
From:	Gordon Ashby	Date:	4 October 2016
Subject:	Technical Note: Redcliffs School - site options study, tsunami hazard and Eliot Sinclair comments on TPG report		

Further to your email dated 27 September 2016, our response/advice is as follows:

3. Tsunami Hazard:

   a. What is the tsunami hazard for the Main Road site?
   b. What is tsunami hazard for the Redcliffs Park C site?
   c. What is the difference between the two sites and how does this affect the relative suitability of the sites for a primary school?

The most credible significant hazard to the Canterbury coast is from a distant source tsunami originating off the coast of South America or Alaska, with waves expect to take of the order of 10 to 15 hours to reach New Zealand. A 2,500 year return period event could produce an 84th percentile wave height at the coast within Pegasus Bay of the order of 12 m above quiescent sea levels[1]. The estimated extent of land inundation for Christchurch has been modelled by NIWA[2] based on the 2,500 year return period distant source tsunami hazard (GNS, 2013) occurring coincident with Mean High Water Spring tide level (MHWS). This inundation modelling indicates that ground up to an elevation of approximately 5 mLVD might be flooded within Redcliffs and up to approximately 6 mLVD in the area of Barnett Park. There is expected to be considerable warning time associated with a significant distant tsunami hazard given the potential wave travel time. Given the expected warning time, which is expected to enable evacuation of potentially affected communities, the level of lives risk associated with a significant distant source tsunami is expected to be very low, and almost certainly lower than 10^{-6} (in terms of individual lives risk).

NIWA has also undertaken modelling based on the tsunami that was generated by the 1868 South American earthquake[3], which was experienced at the time in Christchurch. The NIWA (2012) work indicates that wave heights of 3.5 to 4.5 m could be generated at the Christchurch coastline. Their associated inundation modelling indicates that ground up to an elevation of approximately 3.5 mLVD might be flooded within Redcliffs and up to approximately 4.25 mLVD in the area of Barnett Park, if such an event coincided with MHWS.

[1] Power, W. L. (compiler). 2013. Review of Tsunami Hazard in New Zealand (2013 Update), *GNS Science Consultancy Report* 2013/131/222 p.

[2] National Institute of Water & Atmospheric Research Ltd (NIWA) (2014). *Updated inundation modelling in Canterbury from a South American tsunami*. Report prepared for Environment Canterbury, Environment Canterbury report number R14/78, November.

[3] National Institute of Water & Atmospheric Research Ltd (NIWA) (2012). *Modelling coastal inundation in Christchurch and Kaiapoi from a South American tsunami using topography from after the 2011 February earthquake.* Report prepared for Environment Canterbury, Environment Canterbury report number R12/38, June.

Distant source tsunamis also dominate the 500 year return period hazard with an estimated 84th percentile wave height of the order of 8 m (GNS, 2013). Based on a comparison of wave height to inundation depth for the above 2,500 year hazard and the 1868 event, it is estimated that ground below an elevation of approximately 4.25 mLVD and 5.0 mLVD may be flooded at Redcliffs and Barnett Park, respectively, if the 500 year event coincided with MHWS.

The potential wave heights[4] from a local source tsunami hazard (such as from an event below Pegasus Bay or off the coast of Kaikoura), or a regional source tsunami hazard (the most likely source is considered to be the Hikurangi subduction zone off the Wairarapa/Hawke's Bay coastline), is likely to be of the order of 1 - 3 m. Actual land inundation depths will likely be less than this wave height and will depend, amongst other things, on the actual tide level at the time of an event. Detailed inundation modelling at the potential school sites has not been undertaken for local or regional source tsunami. However, based on the studies reported by GNS (2013) and NIWA (2012 & 2014), inundation depths would be expected to be no more than those estimated for the 1868 event coincident with MHWS, as discussed above. In lower lying areas this depth of inundation could present some threat to life. Although this hazard would have considerably shorter warning time, risk treatment measures such as short notice community evacuation procedures would be expected to address the lives risk.

Hazard posed to fixed assets such as buildings and services from distant source tsunami are potentially significant at Redcliffs Park Locations B & C (and possibly at the Main Road site), and more severe at Barnett Park Location D.

We also note that the tsunami hazard discussed in our earlier report (*2106.09.13 T+T redcliffs options rpt3 final.pdf)* listed information labelled as "indicative tsunami inundation" in Table B1 (refer Appendix B). The tabulated values reflect the potential tsunami wave heights, which would be expected to over-estimate the potential tsunami-related inundation depths at the various sites, potentially by a factor of 2 to 3.

The various levels and elevations discussed above are shown diagrammatically on the attached Figure 1.

We also note that the response to the tsunami hazard is somewhat similar to the coastal inundation and coastal erosion hazards in that it is a community-wide issue and not restricted to an individual school site.

We also note that the ground surface elevation at the Main Road site appears to range from approximately 3.5 mLDV at the Main Road frontage to approximately 6.5 mLVD at the back of the old Hall. The ground contours show an elevation change between about 4.5 mLVD and 5.5 mLVD across the footprint of the existing teaching/admin buildings. We understand from the Ministry that any future rebuilding on the site would be closer to the Main Road, at a slightly lower ground surface elevation that is comparable to Redcliffs Park Locations B and C.

[4] http://ecan.govt.nz/advice/emergencies-and-hazard/tsunami/pages/tsunami-info-chch.aspx

1 Eliot Sinclair comments on TPG report

We have reviewed the document "Redcliffs School Draft Report 25082016_NH comments 15 Sept 2016.pdf". We understand that the comments were made by Mr Nick Harwood of Eliot Sinclair Ltd following his review of the TPG report[5] , and parts of the TPG report were based on the T+T report[6]. Our response to the comments relevant to T+T are provided below:

Comment

I would have expected tsunami hazard to be a Red Light under major geotech hazards in current land use at all sites; and also for sea inundation for McC Bay Reserve and Redcliffs Pk?

T+T response

In our opinion, tsunami hazard is more of a flooding/inundation hazard, than a geotechnical hazard and therefore the evaluation of tsunami-related hazard is best incorporated into the Flooding aspect of the Ministry's evaluation methodology for new school sites.

Comment

and suitability of the site for school use(e.g. in relation to tsunami hazard).

T+T response

We do not believe that it is appropriate to include this specific text, at the location indicated by the reviewer. All of the attributes covered by the Ministry's evaluation methodology for new school sites may influence the suitability of a site for school use. Therefore, it is not appropriate to include this particular comment in relation to this particular aspect of the site selection methodology.

Comment

All the sites are likely to be NZS1170.5 subsoil class C. The Bradley & Hughes contours on the CGD are based on attenuation in Class D (deep soil) conditions, so not strictly applicable to the sites of interest. The contours cannot be directly referenced and compared to Class C design levels.

T+T response

Given the timeframes involved in this study and the relatively high-level "desk top" nature of the site selection methodology, the evaluations and assessments necessarily rely on information that is typically readily obtainable from publically available sources such as the Canterbury Geotechnical Database (now often referred to as the New Zealand Geotechnical Database, NZGD). Also, given that information on the NZGD, supplemented by guidance from the Ministry of Business, Innovation and Employment (MBIE), has been extensively used in Christchurch over the past few years, there is

[5] The Property Group (2016). Alternative Site Selection Assessment Redcliffs School, Christchurch. Report prepared for Ministry of Education, August 2016.
[6] Tonkin & Taylor Ltd (2016). Redcliffs School Site Options Study. Report prepared for the Ministry of Education, reference 53062.3000.v3 dated September 2016.

generally a high-level of familiarity amongst the technical and non-technical population with the information and what it means.

An example is the information on peak ground acceleration (PGA) that may have been experienced at a particular site die to specific events within the Canterbury Earthquake Sequence. There are several areas of uncertainty associated with calculating the PGA (whether in a vertical motion sense or horizontal sense). These uncertainties are associated with:

- The characteristics of the fault rupture source such as the type of fault, the length of the fault that ruptures, the sense and direction of fault rupture, etc.
- The nature of the ground conditions between the source of rupture and the site, such as geological units, soil/rock stiffness, etc.
- Site-specific influences such as basin effects, potential occurrence and extent of liquefaction and/or cyclic soil softening, distance of the site from a ground motion recoding station, etc.

For the purposes of this study, the information available on the NZGD relating to the level of PGA that may have been felt at a specific site is adequate to inform a comparative assessment of the level of shaking likely to have been experienced at the subject sites. At this stage, the subtleties associated with whether a specific site is Class C or Class D is not considered material to the outcome of the comparative site evaluation methodology.

Another example is the MBIE residential foundation technical categories (TCs). Evaluating the TCs (which are strictly speaking only relevant to residential properties in Christchurch) generally provide a useful means to compare typical liquefaction-related ground performance (either historical or future). This sort of information is considered useful when informing the site comparison process contemplated by the Ministry's evaluation methodology for new school sites.

In this context, the difference between Class C ground conditions and Class D ground conditions is not considered material to comparing the level of PGA likely to have been experienced at the sites and not influence the outcomes of the site evaluation process. Obviously, and as set out in the T+T 2016 report, the appropriate ground condition Class should (and would) be used for any site-specific building design work.

Comment

These are for Class D subsoil sites. The sites of interest are likely Class C being so close to hills and therefore not "deep soil" cover to bedrock. Ref NZS1170.5. Without better guidance and as an approximation I have previously taken the ratio of Class C / Class D for T=0, which indicates Class C design PGA is approx 20% higher than for Class D. By stating this assumption it at least gives a rationale for recognition that Class C sites have higher site response.

T+T response

Further to our response to the previous comment, the need to account for potential differences between a Class C and a Class D site, for the purposes of this comparative site evaluation study, are not considered material nor warranted.

Comment

Median may be appropriate for liquefaction hazard analysis, but highest possible should be taken account of in 50-year design of foundations with respect to bearing capacity assessment, where elevated GWL in cohesionless soils can significantly reduce capacity.

T+T response

With regards to assessing bearing capacity under static loading conditions (i.e. non-earthquake related), we do not disagree with this statement. However, it is unclear what relevance this has to the current comparative site evaluation study, since it relates to site-specific foundation design. Site-specific foundation design is beyond the scope of the T+T 2016 report.

Comment

In addition to life-risk comments, a multi-million dollar school asset will be impacted / destroyed, at high economic loss and preventing return to school. No feasible mitigation.

T+T response

This particular comment appears to consider the potential economic consequences of a distant source tsunami hazard. Comments relating to economic aspects are best made by the Ministry and therefore we have not provided a response on this topic. However, similar to lives risk aspects, to appropriately inform decision-making, we suggest that such considerations also take into account the likelihood of the hazard/consequence occurring, rather than simply commenting on the magnitude of potential consequences.

With regards to "feasible mitigation" – a feasible mitigation to the Redcliffs School (whether in its current location or at some other nearby location) being rendered unusable (i.e. prevented from students returning to the school), could be to temporarily re-locate the students to other serviceable facilities. This has proven to be a feasible mitigation as demonstrated by experience from the CES.

Comment

tsunami comments? hazard and mitigation?

T+T response

Further comment could be provided and the report re-issued, if desired by the Ministry.

Comment

Tsunami hazard maps absent? e.g. at http://ecan.govt.nz/publications/Plans/modelling-coastal-inundation-chch-kaiapoi.pdf

T+T response

Such maps can be provided, if desired by the Ministry, although in our opinion spending further time and resource to do so is not considered necessary nor warranted, at this stage.

Comment

Reassess using Class C PGA. See comments in main text

T+T response

Further time and resource spent to reassess the liquefaction-related assessments is not considered necessary nor warranted, at this stage.

Comment

tsunami, storm surge, sea level rise as distinct from overland flooding?

T+T response

It is not quite clear what these comments are referring to, but, given that the Ministry's evaluation methodology includes an overall "Flooding" attribute, it is considered appropriate to include the evaluation/scoring of all inundation-related issues/hazards under this attribute, as set out in the T+T 2016 report.

Prepared by

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Reviewed by

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4-Oct-16
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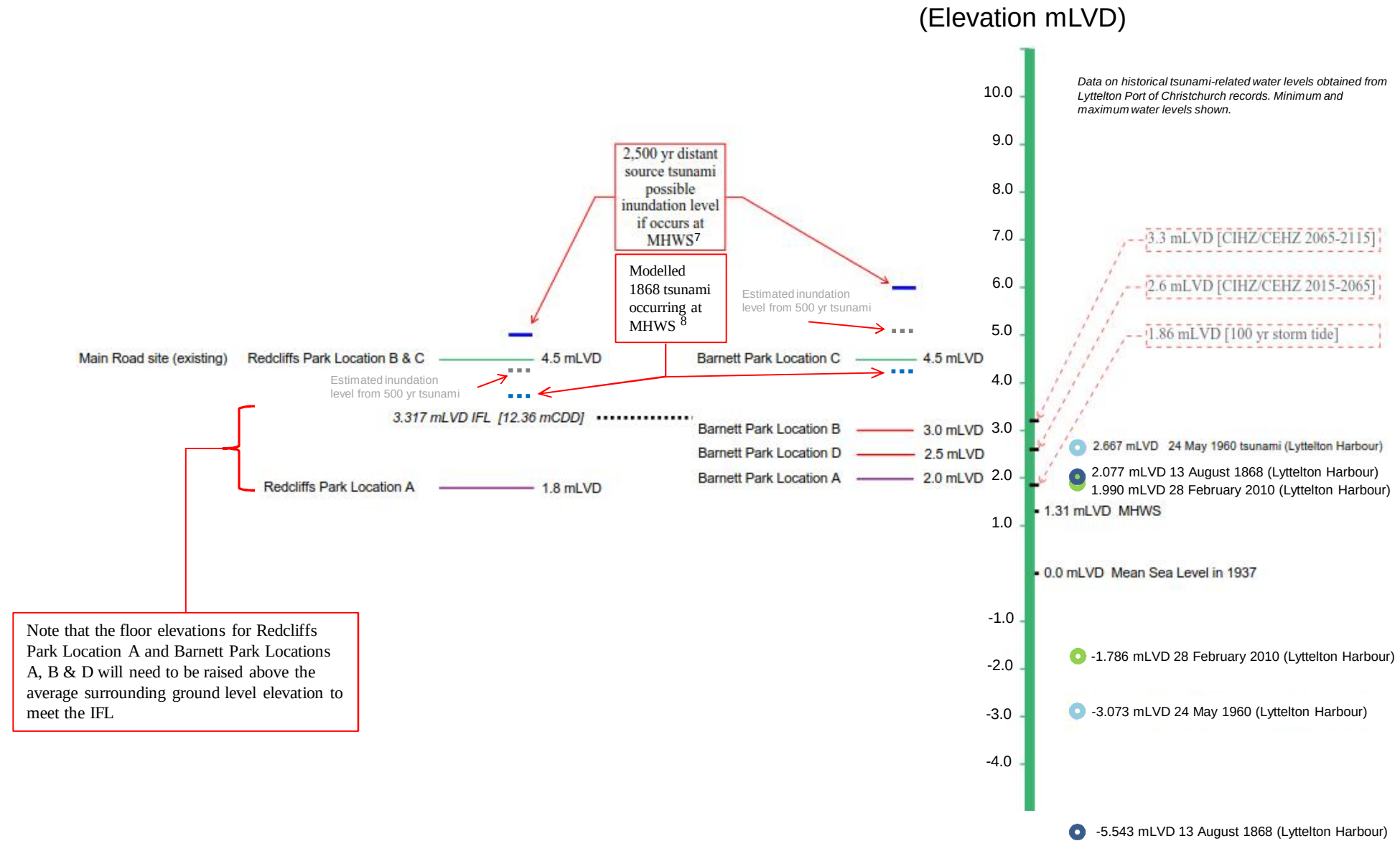

Notes:

1. LVD = Lyttelton Vertical Datum 1937
2. MHWS = Mean High Water Spring
3. IFL = Interim Floor Level
4. CDD = Christchurch Drainage Datum = LVD + 9.043 m
5. CIHZ = Coastal Inundation hazard Zone
6. CEHZ = Coastal Erosion Hazard Zone
7. Source: NIWA, 2014
8. Source: NIWA, 2012

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MINISTRY OF EDUCATION
REDCLIFFS SCHOOL SITE OPTIONS STUDY
ELEVATIONS DIAGRAM

FIG. No. Figure 1

REV. 0