02 December 2020

R.J. Hall & Associates Ltd

PO Box 534, Timaru

File: FRA 015 / 042

Memorandum: The relevance of increased runoff from potential new development on Pinehaven hills to the Pinehaven Stream Improvements project because of incorrect baseline (pre-development) hydrology rendering hydraulic neutrality provisions of UHCC Plan Change 42 ineffective.

To: Save Our Hills (Upper Hutt) Inc

Pinehaven, Upper Hutt

From: Bob Hall

R.J. Hall & Associates Ltd., Timaru.

This memorandum has been compiled to record how increased runoff from potential new development on the Pinehaven hills is relevant to the Pinehaven Stream Improvements project.

At the time of the hearing (3 – 5 August 2020) of the Application for the Pinehaven Stream Improvements, the development on the hills surrounding Pinehaven was ruled out of scope by the Commissioners as no applications for development on the hills had been received by Upper Hutt City Council. However, since the hearing a new Plan Change (PC50) has been proposed by Council involving development on the hills surrounding Pinehaven by the Guildford Timber Company. At the time, the Upper Hutt City Council planners were well aware of this proposed Plan Change however they did not raise it at the hearing.

Work undertaken to date by Greater Wellington Regional Council (GWRC), the Upper Hutt City Council (UHCC) and their various consultants (see References

below) does not adequately reflect the rainfall – runoff processes nor the flood frequency characteristics of the steep forested Pinehaven Stream catchment.

R.J. Hall & Associates Ltd were engaged by Save our Hills to critically evaluate the various hydrological and hydraulic modelling work undertaken on behalf of GWRC and UHCC over an extended period by various engineering consultancies, whose studies have been used by those Councils to ascertain the possible impact of future urban development in the catchment, to compile flood extent maps for the whole catchment and to design hydraulic upgrades for the stream channel and associated infrastructural assets in the lower reaches of the catchment.

R.J. Hall & Associates investigated the "Future Case Scenario" by SKM (25 May 2010) and subsequent related work by various agencies for GWRC and UHCC on the effects on flooding of future development in the upper Pinehaven catchment, viz. "Pinehaven Stream Flood Mapping Audit" by Michael Law of Beca (13 July 2015), the reworking of the "Pinehaven Development Scenarios [DS]1 & [DS]2" by Peter Kinley of Jacobs (23 June 2016), a review of the latter by Michael Law of Beca (1 & 7 March 2016), Michael Law's UHCC "Plan Change 42 Statement of Evidence para 37-40 & 59-67 (30 August 2017), and Michael Law's UHCC "Plan Change 42 Supplementary Evidence para 12-16, 23-31, 43, 58-61 (19 Oct 2017).

Save Our Hills requested that R.J. Hall & Associates Ltd independently investigate whether or not Jacobs' (2016) reworkings of the Pinehaven flood modelling actually did rectify SKM's (2010) future development hydrology error. This error was acknowledged in the Beca audit (2015), reworked by Peter Kinley of Jacobs (2016) and reviewed by Michael Law (Beca Letters 01 & 07 March 2017; PC42 Statement of Evidence 30 August 2017 paras. 40 & 61; Supplementary Evidence 19 October 2017 paras. 14-16, 43, 61). Mr. Law was satisfied the error had been rectified. However, R.J. Hall concluded that Jacobs reworking (2016) did not resolve SKM's error regarding the effects of future development on flood extents.

Regarding SKM's (2010) pre- and post-development comparison map (SKM 2010 Fig. 19) the Beca auditor Michael Law suggested it should show a post-development increase in runoff volume of about 5.6% in a 100-year storm. Inexplicably, this reduced to about 1% in Jacobs' reworking (Jacobs, 2016, Table 1).

In contrast, R.J. Hall & Associates Ltd find increases in post-development runoff volumes for the SKM / Jacobs' various Development Scenarios DS1 and DS2 in a 100-year storm to be in the order of about 300% - 500% (peer reviewed by Macky Fluvial Consulting Ltd). R.J. Hall's critical evaluation of pre- and post-development hydrology by GWRC and UHCC and their agents finds their hydrology grossly inaccurate. Consequently, the hydrology being used to inform the flood extent mapping, the effects of future urban development and the intended upgrades to be undertaken in the lower reaches of the catchment grossly overstates the runoff volumes to be expected from the catchment in its present state.

R.J. Hall & Associates' analysis of flood estimates of the 8 December 2019 flood event and observations of the flood extent experienced that day in Pinehaven and Silverstream clearly reinforce this assertion.

The effect of overstating the pre-development storm runoff peak flows and volumes both in terms of their scale and likely frequency of occurrence has the effect of significantly diminishing and misrepresenting the actual scale of the changes that should be expected when development of this kind takes place. Any attempt to apply hydraulic neutrality procedures to this situation will clearly produce spurious results, **and hydraulic neutrality will not happen.**

In order to critically evaluate the work that had been done by the two Councils and their agencies, R.J. Hall & Associates Ltd. independently carried out a rainfall - runoff model study using the Cardno, 9 April 2019 publication " Reference Guide for Design Storm Hydrology " and the HEC-HMS hydrological model.

The results of this study are reported by the R.J. Hall & Associates in "Pinehaven Stream ARI 100 Year Hydrological Assessment Various Development Scenarios, 5 November 2019" (peer reviewed by Macky Fluvial Consulting Ltd).

The methodology relies on selecting representative runoff coefficients for the catchment which must take account of catchment soil types and infiltration capacities, the hydrological condition of the catchment at storm onset (wet, dry , normal), catchment cover and terrain. To that effect Save Our Hills carried out a series of infiltration tests (see "Infiltration report" by A.K. Ross) to assist this

selection process. This study clearly demonstrated that the hydrology being relied upon in the GWRC and UHCC studies grossly over-estimates runoff in the pre-development situation relative to the post development situation.

R.J. Hall & Associates subsequently carried out a detailed analysis of the flood frequency characteristics of the Pinehaven Catchment using a variety of empirical techniques currently widely employed in New Zealand using both regional and local hydrological methodologies where stream flow records are not available, in order to obtain a realistic flood frequency curve (FFC) on which to inform flood extent mapping, hydraulic neutrality exercises and stream works and associated infrastructure upgrades.

A critical component in this exercise was estimates made of the 8 December 2019 flood at the Dutch Reform Church weir (see R.J. Hall & Associates Ltd - Report on Pinehaven Flood 8 December 2019, incl. Flood Frequency Curve, Figures 1, 2 & 3 – Reviewed by Graeme Horrell Consultancy Ltd).

This estimate allowed for a review of the flood peak of the 23 July 2009 flood which in turn assisted in updating the stage – discharge relationship for this site. This work clearly demonstrated that the flood frequency curves being relied upon by GWRC to date in this catchment significantly over-estimate the peak flow to be expected for any given return period. Or to put it another way, for any GWRC estimated discharge, GWRC's flood frequency curve will result in an unrealistically low return period, as seen in R.J. Hall's Figure 2 Flood Frequency Curve referred to above (and **attached**). For example, GWRC's estimated discharge of 8.8m^3/s (SKM 2010) for the storm on 23 July 2009 reads on GWRC's flood frequency curve (SKM 2010) as occurring on average at least fortnightly, which is an absurdity.

This work formed the basis of R.J. Hall's evidence to the Upper Hutt City Council's hearing earlier this year (3-5 August 2020) in respect of the proposed lower Pinehaven Stream upgrades.

The purpose of drawing attention to these deficiencies in the GWRC hydrology is the inability of this hydrology to realistically address future hydraulic neutrality exercises undertaken in this catchment. In order to identify, understand and

provide a sound basis to mitigate additional runoff from future development, the deficiencies in the hydrology must first be fixed. If the hydrology is not fixed it will result in deleterious effects from future urban development on the presently well-vegetated stable ridges and upper slopes within this catchment. Deficiencies in the hydrology also result in gross over-statement of flood volume and extents in the Pinehaven flood maps, over-engineering of the stream improvements, and increases in sediment loading removing any gains from the channel upgrades.

These outcomes result from the deficiencies in the hydrology rendering the UHCC Plan Change 42 hydraulic neutrality provisions ineffective, and will consequently allow large volumes of unmanaged additional runoff from future development on the hills to significantly increase flooding in the catchment.

It has been customary with hydraulic neutrality provisions to modify the increased peak flow arising from a reduction in infiltration capacity because of urbanization by installing detention dams. These structures have the effect of regulating stream outflow to a level comparable to that which occurred before the development.

This approach however is not suited to the urbanizing of a steep well-vegetated catchment because simply attenuating the peak flow does not avoid adverse effects arising from the greater volume of runoff that occurs and which must pass out of the catchment. When detention storage is employed, the regulated outflow results in a peak flow typically equivalent to the pre-development peak flow but sustained for a number of hours.

This change in the catchment flow regime results in adjustments having to be made to the channels downstream of the detention dams to accommodate this greater bulk of water. Typically stream beds incise and channel widths increase and, where channel degradation is limited by the strength of underlying soils / rock etc., lateral bank erosion becomes more pronounced.

If these effects were to arise in the Pinehaven Stream's upper reaches then both the erosion products and riparian vegetation destabilized by the lateral bank erosion will tend to accumulate in the upper reaches and be periodically swept

out in subsequent rainstorms. These processes have the potential to destabilise slopes and result in an increase in the propensity for landslides. Consequently, the increased sediment loading being deposited in the flatter downstream reaches of the stream channel may quickly remove any gains from the channel upgrade.

Singularly and together these responses ultimately will have significant deleterious effects in the lower flatter reaches of the catchment such as aggradation of stream beds and blocking of culvert entries. If they result in the formation and failure of debris dams during major storms then there can be very serious consequences (viz. Blandswood Settlement incident, Peel Forest, South Canterbury January 1975, four lives lost), including landslide debris dam formations and sequential failures.

It is opined that these effects must be avoided in this catchment. Realistically, if detention dams are to be employed, then their outflows must be modified to the extent that the hydrograph passing down the catchment's tributary streams mimic that which would occur in the absence of the urban development. This gives rise to the need for additional runoff to be piped away via a stormwater reticulated system and safely disposed of in the Hutt River.

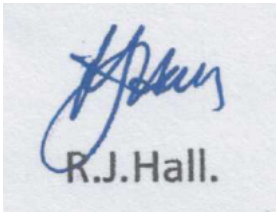
It should also be noted that a reduction in the infiltration capacity of those parts of the catchment where new urban development is to occur will have the effect of reducing the volume of water entering groundwater systems in the catchment. The effect of this reduction in groundwater storage will be to permanently reduce stream flows in the catchment which may result in some stream flows becoming ephemeral (i.e. a dry stream bed except during and shortly after rain events) at times when otherwise it wouldn't be.

Future hydraulic neutrality studies that must accompany any future urban development in this catchment cannot rely on GWRC and UHCC current baseline hydrology.

The hydrology must first be transparently corrected by using infiltration rates that are truly representative of the catchment, and by ensuring proper account is had of the rainfall interception effects of the catchment's heavy vegetation cover.

Future hydraulic neutrality studies must then be fulsome and not limited simply to attenuating the increase in peak flow which will accompany such development but go further and fully address the contingent morphological adjustment to both stream channels and adjacent hillslopes which will arise in the absence of such an assessment.

R.J. Hall
R.J. Hall & Associates Ltd.
CMEng.N.Z., CPEng IPENZ (Civil), Int PE (NZ)
ME (Nat Res), BE (Civil), NZCE (Civil)



Attachment: R.J. Hall & Associates Figure 2 – Flood Frequency Curve (updated 02 Dec 2020)

References (Reports commissioned by 'Save Our Hills'):

$Hall_1$: R J Hall and Associates Ltd, "Report: Pinehaven Stream ARI 100 Hydrological Assessment – Various Development Scenarios", 05 November 2019

$Hall_2$: R J Hall and Associates Ltd, Addendum A: At-A-Site Evaluation of Appropriate CN Numbers', 2019-9-27'

$Hall_3$: R J Hall & Associates Ltd – Letter 29 June 2020 to SOH

$Hall_4$: R J Hall & Associates Ltd – Report 27 July 2020, amended 3 August 2020, Pinehaven Stream Flood 8 December 2019 at Chatsworth Road Gauge Site and Its Implications for Flood Frequency Estimates in the Catchment

Horrell, G., 27-7-2020: Review of "Pinehaven Stream flood 8 December 2019 at Chatsworth road gauge site and its implications for flood frequency estimates in the catchment" by R J Hall & Associates Ltd, 27 July 2020.

Horrell, G., Letter re 23 July 2009 flood, Revised 31-7-2020, Updated 27-11-2020

Keane Associates Ltd, Memorandum to SOH (3 July 2020), Pinehaven rainfall assessment for 08 December 2019 storm

Macky, G. - Macky Fluvial Consulting Ltd, 14 November 2019: Review of report by R J Hall and Associates Ltd – 'Pinehaven Stream: ARI 100 Hydrological Assessment – Various Development Scenarios, November 2019, including Addendum A: At-A-Site Evaluation of Appropriate CN Numbers', 2019-9-27'

Ross, A. K., "Report on Infiltration Tests carried out on the Pinehaven Stream Catchment During July 2019"

SOH: Save Our Hills (Upper Hutt) Inc. – Pinehaven Sub-catchment B – Time of Concentration

SOH: Save Our Hills (Upper Hutt) Inc. – Pinehaven Storm on 08 December 2019_18 Dec 2019, updated 7 Aug 2020, amend 1, 25 Nov 2020

References (Reports and documents by GWRC, UHCC and their agents):

Cardno, Reference Guide for Storm Hydrology: Standardised Parameters for Hydrological Modelling. (Prepared for Wellington Water Ltd) 9 April 2019

Beca, (Michael Law, auditor) Pinehaven Stream Flood Mapping Audit, 13 July 2015

Jacobs, 23 June 2016, Memorandum, Pinehaven Developments – Scenarios [DS]1 and [DS]2

Michael Law (emails – M. Law and Kristin Stokes, MWH, 11 June 2015) RE: Pinehaven Stream hydrology -Existing and Future Development

[these emails show M. Law was aware of HWH using the same rainfall losses in pre and post-development hydrology modelling, which explains the lack of increase in post-development flood volume and extents in SKM's 'Future Case Scenario" Fig. 19, 2010, but M. Law did not report this in the Beca audit, stating instead: *"The issue of no increase in post-development flood volume was raised with MWH, but they have not been able to provide an explanation as to why there is not an increase in flood volume."* Beca Audit, 13 July 2015, pp 9, 17, 27]

Michael Law, Beca Letters (01 & 07 March 2017) Response to Jacobs 2016 revised Pinehaven development scenario update [i.e. Review of Jacobs' Development Scenarios DS1 and DS2]

Michael Law, UHCC "Plan Change 42 Statement of Evidence (30 August 2017)

Michael Law, UHCC "Plan Change 42 Supplementary Evidence (19 October 2017).

MWH, Pinehaven Stream Flood Hydrology, 4 November 2008, revised 25 November 2009

SKM, Pinehaven Stream Flood Hazard Assessment: Flood Hazard Investigation Report, Revision E, 25 May 2010, Volume 1 – Report, and Volume 2 – Flood Maps

Wallach, L., UHCC Director of Infrastructure_06-6-2014 email to S. Pattinson, incl. 1-in-25 year flood maps (before & after Option 11 Combination Pinehaven Stream Channel Improvements)

WWL: Wellington Water Ltd – Pinehaven Stream Improvements, Resource Consent Application and Notice of Requirement – Executive Summary, September 2019