TECHNICAL COMMITTEE AGENDA

18 October 2018

9:00am, Council Chamber

Level 2 Philip Laing House, 144 Rattray Street, Dunedin

Membership

Cr Andrew Noone	*(Chairperson)*
Cr Ella Lawton	*(Deputy Chairperson)*
Cr Graeme Bell	
Cr Doug Brown	
Cr Michael Deaker	
Cr Carmen Hope	
Cr Trevor Kempton	
Cr Michael Laws	
Cr Sam Neill	
Cr Gretchen Robertson	
Cr Bryan Scott	
Cr Stephen Woodhead	

Disclaimer

Please note that there is an embargo on agenda items until 48 hours prior to the meeting. Reports and recommendations contained in this agenda are not to be considered as Council policy until adopted.

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1. APOLOGIES

2. LEAVE OF ABSENCE

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5. CONFLICT OF INTEREST

Members are reminded of the need to stand aside from decision-making when a conflict arises between their role as an elected representative and any private or other external interest they might have.

6. PUBLIC FORUM

7. PRESENTATIONS

8. CONFIRMATION OF MINUTES

Recommendation

That the minutes of the meeting held on 12 September 2018 be received and confirmed as a true and accurate record.

Attachments

1. Minutes of Technical Committee 12 Sep 2018 **[8.1.1]**

9. ACTIONS

Status report on the resolutions of the Technical Committee.

Report	Meeting Date	Resolution	Status
An assessment of the Clean Heat Clean Air program's effectiveness	13/6/18	*That this report be used to inform the review of ongoing financial incentives for Air Quality, proposed for 2018/19 in the 2018-2018 Draft Long-Term Plan*	OPEN
Lake Hayes Restoration	1/8/18	*That the consultant report by Castalia be re-framed into a more public intelligible document.* *That staff develop options for consideration by Council on the remediation of Lake Hayes, including a comprehensive description and assessment of benefits, effectiveness, costs, precedents risks, implementation and timelines and funding.*	IN PROGRESS (Castalia have been briefed) IN PROGRESS
State of the Environment: Surface Water Quality in Otago (2006-2017)	12/9/18	*That this paper be referred to the Policy Committee for their consideration and review and policy recommendations related to this report*.	

Attachments
Nil

10. MATTERS FOR COUNCIL DECISION

Nil

11. MATTERS FOR NOTING

11.1. Director's Report on Progress

Prepared for: Technical Committee
Report No. EHS1828
Activity: Governance Report
Prepared by: Rachel Ozanne, Environmental Resource Scientist
Dr Ben Mackey, Manager Natural Hazards (acting)
Dr Gavin Palmer, Director Engineering, Hazards and Science
Date: 11 October 2018

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1. Précis

This report presents an update on the following matters:

2. Roxburgh Debris Flows Risk Mitigation;
3. Lake Hayes Remediation Progress;
4. Leith Flood Protection Scheme.

It is recommended that this report is received and noted.

1. Roxburgh Debris Flows Risk Mitigation

Risk mitigation work continues following the November 2017 debris flow event in Roxburgh. ORC, Central Otago District Council and the New Zealand Transport Agency held a public meeting in May 2018 to present the technical report prepared by GNS Science[1] and seek public feedback on a range of mitigation and management options. A wide range of feedback was received, with the common theme of the feedback the need to improve protection at Reservoir Creek, which runs through northern Roxburgh (Figure 1). ORC is currently seeking engineering advice about potential improvements to Reservoir Creek, and risk management of this and neighbouring debris flow prone catchments. This assessment is due to be complete early next year. This will inform the development of options for consideration by the community, stakeholders and Council.

[1] Dellow GD, Jones K, Rosser BR. 2018. *Hazard and risk assessment of the Roxburgh debris flows of 26th November 2017*. Lower Hutt (NZ): GNS Science. 35 p. (GNS Science consultancy report; 2018/65).

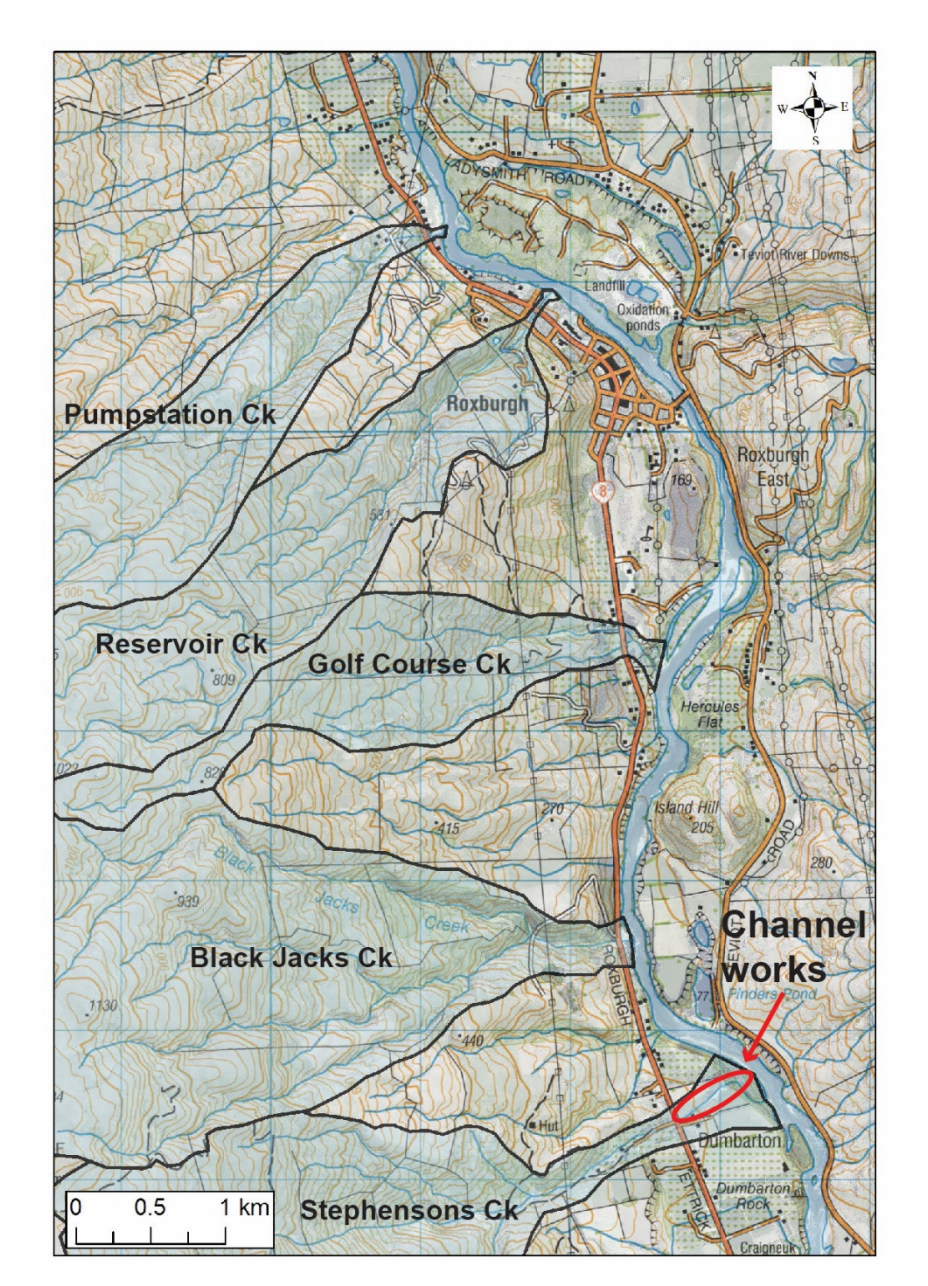

Figure 1. Map of catchments near Roxburgh. The four northern catchments had exposed channels re-seeded by ORC. Work was undertaken by ORC to reinstate the channel in the lower reach of Stephensons Ck (see Fig. 3).

Some of the options will likely require funding for the Central Otago River Management Special Rating District to be increased above what is presently provided for in the 2018/2028 Long Term Plan (LTP). The LTP provides the sum of $348,776 for river management works in this Special Rating District (SRD) across Central Otago for the 2018/19 year (Table 1). In the current LTP, landowners in the Teviot Valley Ward will be contributing $33,619 of the targeted rate for the SRD (Figure 2). The proportion of the SRD rate paid by landowners in the Ward may need to be revisited in future years if significant flood mitigation capital works are to be undertaken at Reservoir Creek.

Table 1 Central Otago River Management Special Rating District targeted rates for 2018/19 (2018/28 Long Term Plan)

Ward Name	Amount
Alexandra	$43,099
Cromwell	$126,474
Earnscleugh/Manuherikia	$90,040
Maniototo	$44,650
Teviot Valley	$33,619
Utilities (District-wide)	$10,894
Total	**$348,776**

Figure 2. Wards within the Central Otago River Management Special Rating District.

Additional actions by ORC following the November 2017 debris flow event have included clearing the lower part of Stephensons Creek (south of Roxburgh) (Figures 1, 3), and re-seeding 18 ha of channels which were left scoured and exposed by the November 2017 flows (Figures 1 and 4). A telemetered rain gauge will be installed this month in the Reservoir Creek catchment with the measured data to be displayed on ORC's website in real-time. This will allow residents to monitor rainfall and enable staff to establish the rainfall characteristics (duration, intensity) that cause sediment movement if there are future debris flow events.

Staff attended a meeting of the Roxburgh Community Board on 30 August 2018, and updated the Board on these activities being undertaken to address the debris flow risk.

Figure 3. View down the lower reach of Stephensons Creek (south of Roxburgh) before (top) and after (bottom) channel restoration works undertaken by ORC.

Figure 4. ORC operations staff undertaking aerial re-seeding of the channels that were eroded (September 2018).

2. Lake Hayes Remediation Progress

Following the workshop and paper to committee in August 2018, work has continued on improving Lake Hayes water quality (Figure 5). Staff are working to bring together the additional information requested by the Technical Committee prior to technical remediation options and funding mechanisms being presented for public consultation[1].

Figure 5. View southwest across the mid part of Lake Hayes from Bendemeer Bay, July 2018

[1] Technical Committee made the following resolutions at its meeting on 1 August 2018: "*That staff develop options for consideration by Council on the remediation of Lake Hayes including a comprehensive description and assessment of benefits, effectiveness, precedents, risks, costs, implementation, timelines, and funding" and "That the consultant report by Castalia be re-framed into a more public intelligible document".*

Council advanced funding in the 2018-28 Long Term Plan to construct some of the infrastructure required to transfer water from the Arrow Irrigation Company's scheme to Mill Creek, at Millbrook's new Dalgleish Farm golf course (Figures 6, 7, 8). A component of this work was required to be completed in September 2018, to fit in with Millbrook's development schedule for construction of the new course. Installation of a 450 mm diameter, 100 m long pipe has been completed (Figures 7, 8), and installation of a submerged discharge structure is scheduled for November 2018. Installation of the pipe and discharge structure at this time is required to preserve the option to add Arrow River water to Mill Creek, while Millbrook continues to develop the course.

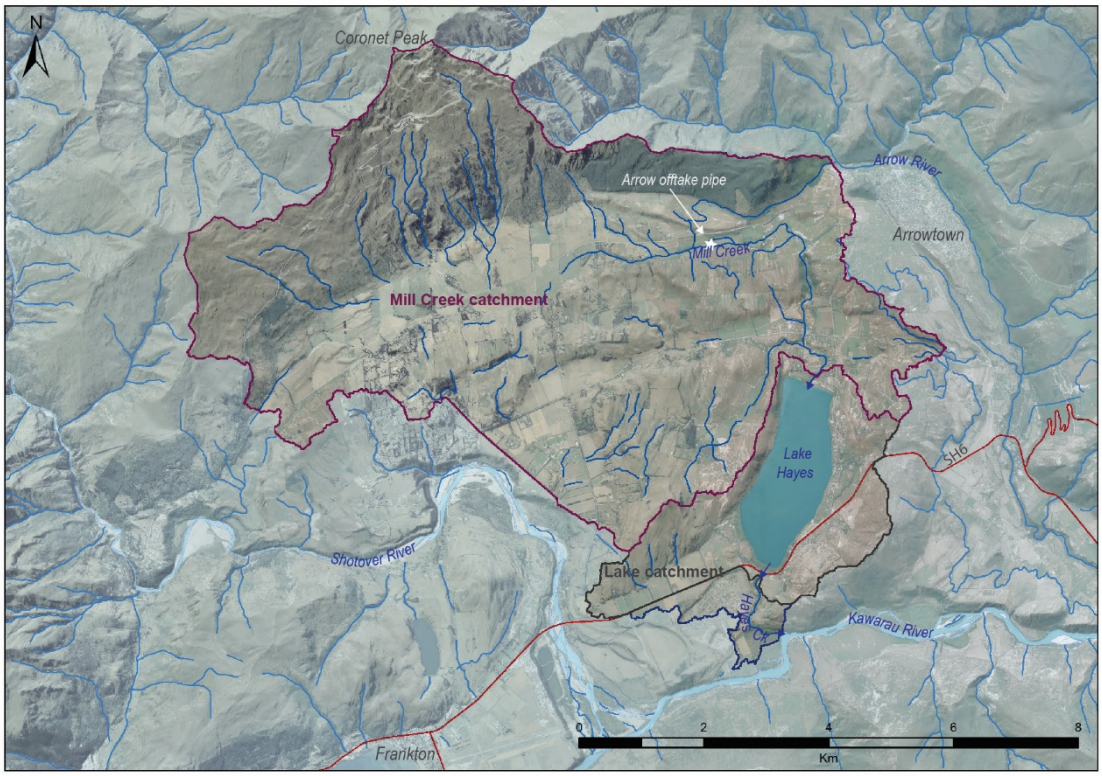

Figure 6. Map of Lake Hayes catchment and surrounding features. Catchment extents defined by Light Detection and Ranging (Lidar) topography and there may be variations due to drains or stormwater infrastructure near the margins.

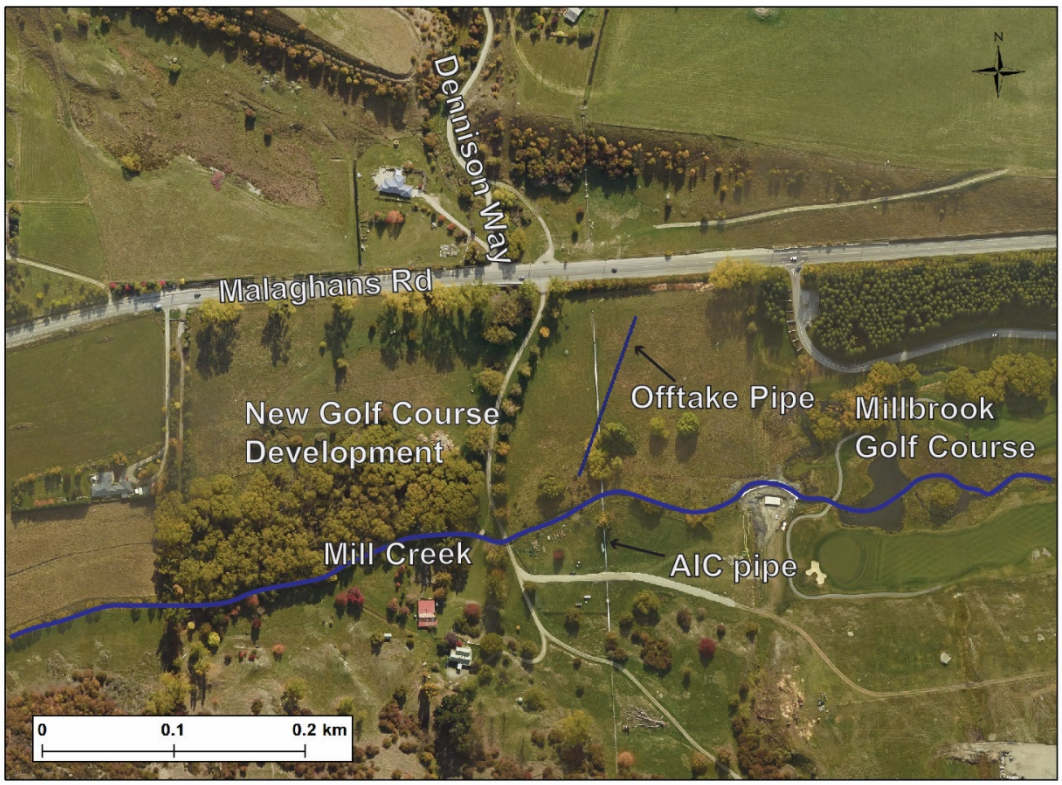

Figure 7. Location of the offtake pipe at Millbrook's Dalgleish Farm development. The Arrow Irrigation Company pipe visible in photo has since been re-routed. Mill Creek will eventually be diverted (by Millbrook) to the north.

Figure 8. Installation of the pipe at Millbrook's Dalgleish Farm development to enable transfer of water from the Arrow Irrigation Company scheme to Mill Creek. View to the south.

ORC's Mill Creek catchment study is underway. The study and reporting on its findings are targets in the 2018-28 Long Term Plan for the 2018/19 and 2019/20 years. The objective is to analyse the spatial and temporal variability of stream phosphorus (P), nitrogen (N) and bacteria concentrations and loadings in the Mill Creek catchment. This study has replicated the location of catchment monitoring stations used by Caruso (2000)[1], ten sites in total, to allow a comparison between the two studies. Continuous turbidity and nitrate monitors were installed in Mill Creek at the end of August 2018 and the results are being telemetered to ORC's website[2]. The automatic samplers (to be installed in Mill Creek to capture storm events) are in the process of being sourced.

The Lake Hayes Monitoring buoy is contracted to be installed by the end of November 2018. The consenting process with QLDC is in progress. Installation of the buoy along with buoys in Lakes Wanaka and Wakatipu are targets in the 2018-28 Long Term Plan for the 2018/19 year.

[1] Brian S. Caruso (2000) Spatial and temporal variability of stream phosphorus in a New Zealand high-country agricultural catchment, New Zealand Journal of Agricultural Research, 43:2, 235-249, DOI: 10.1080/00288233.2000.9513424

[2] https://www.orc.govt.nz/managing-our-environment/water/water-monitoring-and-alerts/kawarau/mill-creek-at-lake-hayes.

Staff met with representatives of Friends of Lake Hayes in early September 2018 to discuss progress with ORC's lake remediation work. In addition, science and communication staff have developed a web page detailing the range of activities being undertaken to improve Lake Hayes water quality[1]. This will be updated as projects progress.

3. Leith Flood Protection Scheme

Engineering works on the Union to Leith Footbridge stage of the Leith Flood Protection Scheme are nearing completion. Work is continuing with the construction of instream bed level control weirs and the placement of rock riprap between the weirs in the bed of the river (Figure 9). The contractor (Downer NZ Ltd) advises that the works will be completed at the end of November 2018. The rain event in mid-September 2018 has prevented the works from being completed prior to the university examination period (17 October to 12 November 2018). The site will be shutdown during this period to avoid noise and disruption to students and staff of the university.

[1] https://yoursay.orc.govt.nz/lakehayes

Figure 9. Looking downstream (top) and upstream (bottom) along the bed of the Water of Leith near the Information Technology Services (ITS) Building (9 October 2018). The river is temporarily diverted adjacent to the right-bank wall.

Construction tenders for the Dundas Street Bridge stage closed on 10 September 2018. Completion of this stage in the 2018/19 year is a target in the 2018/19 Long Term Plan. It is the last of the Scheme's flood protection capital works stages (Figure 10). Staff are proposing to make a recommendation to the 31 October 2018 meeting of Council on the award of a contract. The programme proposed for the construction works provides for "no work" on nine days that coincide with some of the University of Otago 150th celebrations and commemorations, as follows:

- Clocktower Lawn Picnic: 15 February 2019
- Street Parade: 16 March 2019
- Homecoming Weekend: 12-14 April 2019 (inclusive)
- Concert: 13 April 2019
- Graduations: 11 and 18 May 2019
- Ceremony and Anniversary Dinner: 1 June 2019.

The additional direct and indirect costs associated with site shutdown and consequential effects on work sequence and programme are being met by ORC. The expected costs will be known once tender evaluation and contract negotiations are completed. Actual costs will depend on a number of factors, including the state of

completion of the flood works at the time of each shutdown. The inherent uncertainty associated with this presents a financial risk for ORC.

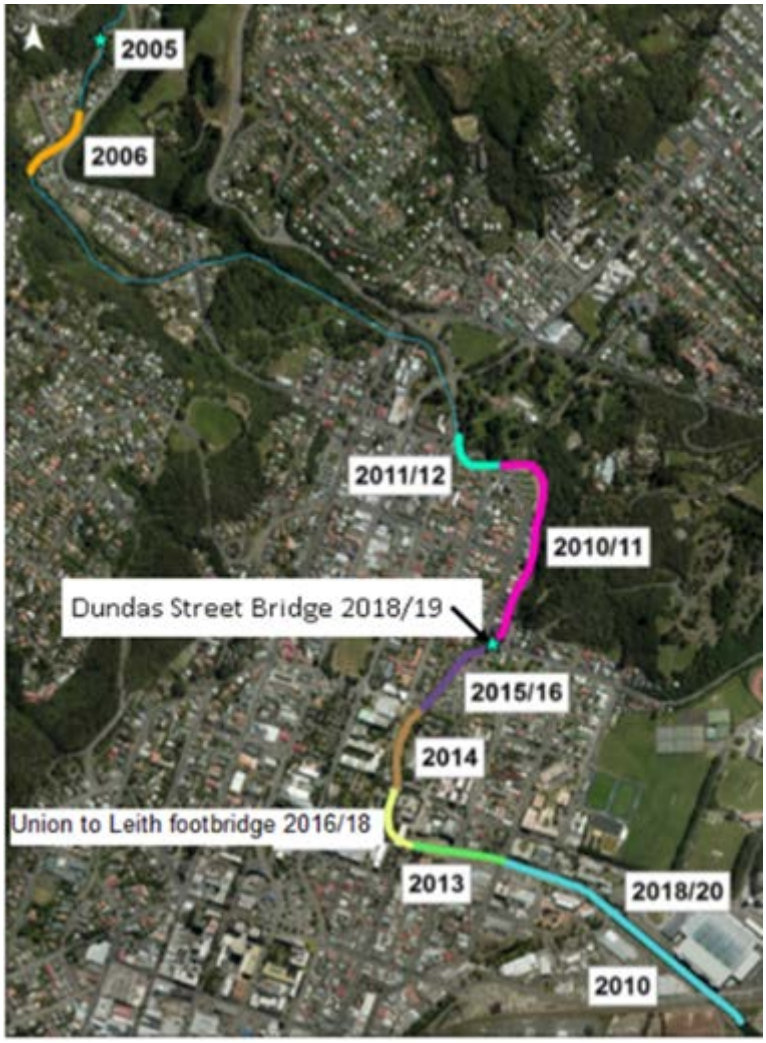

Figure 10. Staging of construction of the Leith Flood Protection Scheme

4. Recommendation

5. *This report be received and noted.*

Endorsed by: Dr Gavin Palmer
Director Engineering, Hazards & Science

Attachments

Nil

11.2. South Dunedin Technical Work Programme update.

Prepared for:	Technical Committee
Report No.	EHS1829
Activity:	Safety & Hazards: Natural Hazards
Prepared by:	Dr Sharon Hornblow, Natural Hazards Analyst Ellyse Gore, Natural Hazards Analyst Dr Ben Mackey, Manager Natural Hazards (Acting) Dr Gavin Palmer, Director Engineering, Hazards and Science
Date:	10 October 2018

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1. Précis

The 2018/28 Long Term Plan provides for ORC to support Dunedin City Council (DCC) in the South Dunedin Future programme in the years 2018/19 to 2021/22. ORC has a programme of technical work underway to provide better understanding of natural hazards and the effects of future climate change in Dunedin. Plans for data collection have progressed significantly since ORC outlined needs for better understanding the issues of the multi-hazard setting of South Dunedin in the 2016 report, "*The Natural Hazards of South Dunedin*". The scope of this project has also extended beyond the South Dunedin flat with the plan for an improved groundwater model now encompassing all the low-lying area around the coast of Dunedin's Central Business District (CBD), from the Oval to the university (Figure 1).

This report expands on the information contained in the Director's Report to the 12 September 2018 meeting of Technical Committee. It describes the technical work and data gathering planned for the coming year and explains why this data is necessary for progressing the development of a multi-hazard 'Climate Change Adaptation Plan' for South Dunedin/Harbourside. This includes an expanded groundwater monitoring network, a 'next generation' groundwater flood model, coastal erosion and elevated sea level data, and liquefaction susceptibility data. An important part of the future work is communication with the public around why this data is sought and how it will help planning for a better city longer-term. It is vital that the technical work delivers the technical information needed to make adaptation decisions, as that is its primary purpose. This in turn depends on ORC having a clear understanding of what the adaptation options and pathways could be and the process and timeframe for decision-making on those options and pathways. Without that, the models being constructed, and the information being prepared may be insufficient to make the right adaptation decisions at the right points in time.

It is recommended that this report is received and noted.

Figure 1: Greater South Dunedin and Harbourside.

2. Background and Previous Work

2.1. Physical setting

The land surface in the greater South Dunedin area ('The Flat') is low-lying and surrounded by steep hill suburbs. The majority of housing in the area is built on ground that is below current mean high-water springs (MHWS) with much of it within 50 cm of current mean sea level (Figure 2). The area also comprises schools, businesses, public utilities and community facilities. This physical setting means the area is vulnerable to rises in the underlying water table caused by sea level rise, heavy rainfall and runoff from the hills, and to ground settlement and shaking. The approximate size of the South Dunedin natural catchment is 14.8 km^2. For comparison, the Lindsay Creek and Water of Leith catchments are 12.5 km^2 and 42 km^2, respectively[1].

The South Dunedin flat has no natural drainage and prior to settlement and modification by Europeans, was a generally marshy area of wetland and lowland forest vegetation with a lagoon and low, rolling sand dunes at the southern coast. There are historic reports of storm-surge flooding from both the harbour and open coast which reached well into the settled area during the late 19th and early 20th centuries, exacerbated by modification and mining of the St Clair sand dunes[2]. This mining took place to supply settlers with fill for low-lying sections, many of which were reclaimed from wetland to just above the height of the water table at the time. Progressive reclamation and settlement of Dunedin's coastal flats, which previously provided a transition from marine to terrestrial systems, has increased the vulnerability of this city to coastal hazards such as storm surge and climate change induced sea level rise and to seismic hazard.

[1] Otago Regional Council, 2015. *Coastal Otago flood event 3 June 2015.*
[2] DTEC, 2002. *Dunedin City Council Coastal Dune Conservation Works Programmes*.

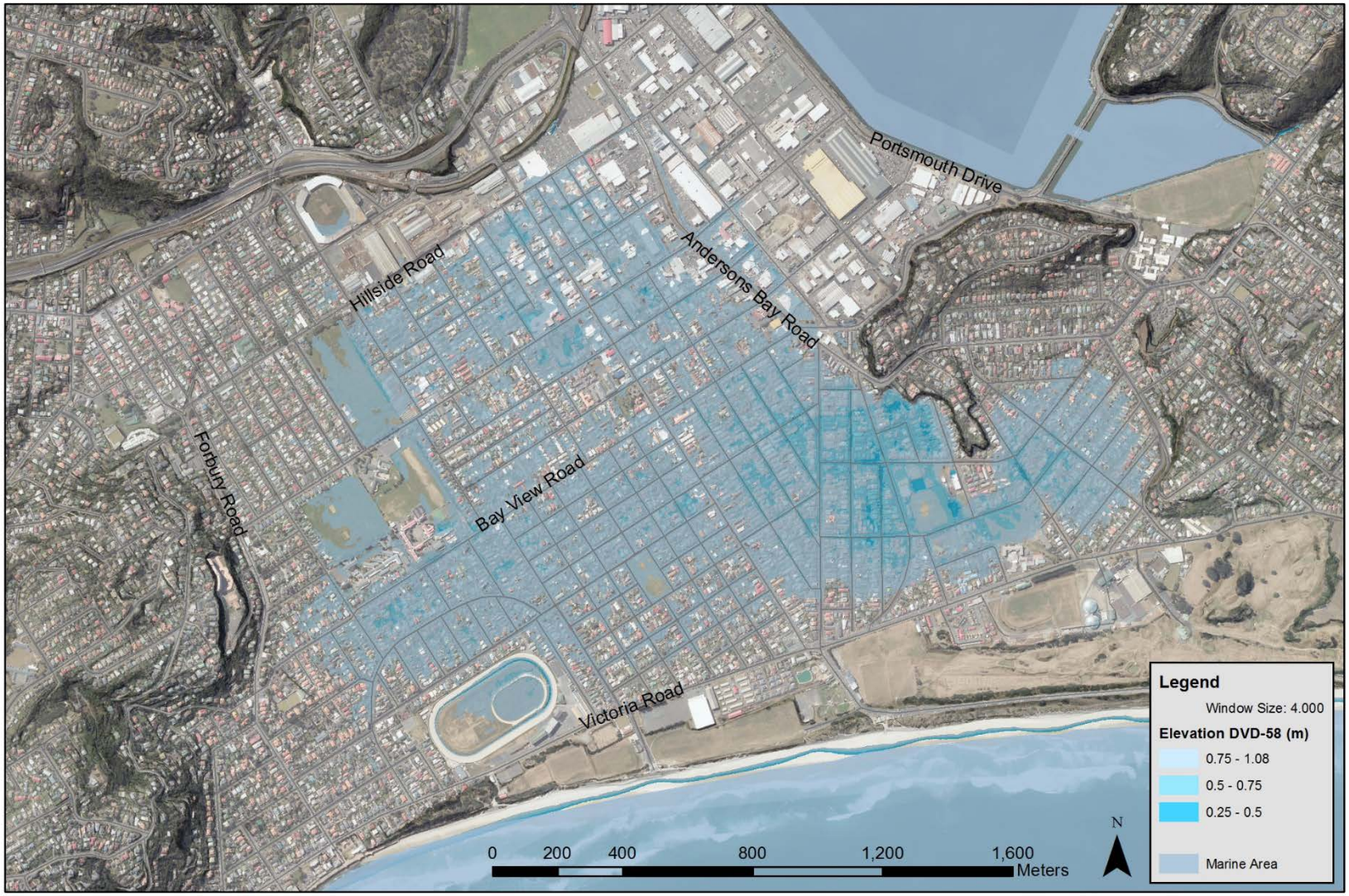

Figure 2: Greater South Dunedin with those areas below MHWS (1.08 m above mean sea level, Dunedin Vertical Datum 1958) highlighted in blue shades.

2.2. Ground water modelling and data needs

Many of the issues facing low-lying areas of Dunedin are related to ground water. ORC ground water level monitoring from mid-2009, and subsequent groundwater modelling, has indicated that the water table height within parts of South Dunedin is influenced largely by sea level, which has risen by about 17 cm since European settlement. This is based on the Port Otago sea level gauge and is comparable to sea level rise rates observed nationally. Further rise in sea level could have a significant impact on groundwater levels in South Dunedin[8]. Transient groundwater fluctuations, such as the effect of runoff, rainfall, or pumping are superimposed on this sea level influence. Determining the extent of impact requires the collection of robust hydrogeological data such as the stratigraphy of soils at depth, the influence of deep groundwater, and physical properties relating to the transport of water beneath the ground surface (e.g., hydraulic conductivity).

Previous modelling which investigated sea level impacts on groundwater flooding had to make assumptions about key hydraulic properties which, consequently, may over or under estimate surface ponding of water. Another important factor which needs further analysis is the extent to which piped waste- and stormwater networks beneath South Dunedin act as a drain on the water table[9]. For example, having data showing flows through parts of the stormwater network on a dry day, or the wastewater network at 4 am (when use is at its lowest) would allow corrections to the model to be made.

2.3. Ground water management

There has been community interest in the feasibility of infrastructural solutions to rising groundwater, and responses to this issue in other countries, especially following the June 2015 flooding. In 2016/17, ORC and DCC jointly commissioned Golder Associates and Deltares Ltd to carry out an international review of situations where protection options have been implemented, or are being implemented, for managing rising groundwater (Figure 3). A copy of the review report is attached[10]. The review focused on areas where protection is the primary mitigation measure or is a significant component of a suite of measures. The factors that made protection a viable option or component in each situation were described. This is intended to help decide what it would take for the option to be viable for further consideration for South Dunedin.

The report does not make recommendations on which protection options to investigate and whether protection is likely to be a viable option for South Dunedin. Decisions have yet to be made on whether to take this investigation work any further. That decision depends on whether options like this will be considered for implementation in South Dunedin/Harbourside. This matter requires further discussion between ORC and DCC so that ORC's technical work, including monitoring, is fit for purpose. It depends in part on how seismic hazard is to be managed and any co-benefits (opportunities) or risks that are created. For example, the construction of open channels might reduce the hazard for some components of the water cycle, for some period into the future, but introduce the risk of lateral spreading under some seismic events.

[8] Otago Regional Council, 2012. *The South Dunedin Coastal Aquifer and Effect of Sea Level Fluctuations*.
[9] Fordyce E., 2013. *Groundwater dynamics of a shallow coastal aquifer*. Unpublished MSc thesis, Geography Department, University of Otago.
[10] *Protection Options for Managing Rising Groundwater in South Dunedin, Review of International Case Studies*, Prepared for Otago Regional Council and Dunedin City Council, Golder Associates and Deltares, July 2017, 54p.

Figure 3: Greater New open canal dug during the district renovation of Oosterwolde-Zuid: water storage, drainage, improved water quality and overall quality of the public space.

2.4. Communicating the issues

In late 2016 DCC and ORC jointly undertook a series of sessions with the South Dunedin community on actions following the 2015 flood and the changing environment. The natural hazards of South Dunedin were explained based on ORC's 2016 natural hazards report along with what is presently known about the changing climate and its potential effect on groundwater levels. The sessions were attended by approximately 300 members of the public.

Figure 4: One of the joint DCC/ORC community information sessions that took place in South Dunedin in late 2016.

In 2017 ORC was involved in the 'What Lies Beneath' project, part of the Government-funded Curious Minds Programme. In this initiative, King's and Bayfield High School students were paired with scientists of GNS Science and ORC to investigate the changing nature of the physical environment in South Dunedin[11] (Figure 5). This hands-on project aimed to encourage students to look at the ground beneath their feet, schools, homes and community to give them a better understanding of South Dunedin's changing physical environment and its impacts on residents and businesses. With the support of scientists, they undertook research, collected and analysed data, and presented their findings to their peers, families and wider community. Some of the students presented at a councillor workshop in 2017.

The project played an important and innovative role in providing knowledge to the wider community through the younger generation. This was facilitated by encouraging the students to discuss their findings with their families at home and the conclusion of the project through an evening of student presentations to the community. Bringing knowledge to the community is key in enabling them to engage in the decision-making process. The South Dunedin community faces important decisions about the best way to adapt to the effects of climate change.

Figure 5: ORC and GNS Science staff delivering the Curious Minds programme to pupils of Bayfield High School and Kings High School, in 2017.

[11] Report to Communications Committee, 2017/1030. *Review of South Dunedin Project: What lies beneath – looking at the changing ground environment in South Dunedin*.

2.5. NZSeaRise programme

In 2017 ORC entered into a joint Ministry for Business, Innovation and Employment (MBIE) funded NZSeaRise research venture with the Research Trust of Victoria University of Wellington and GNS Science. The project objective is to improve sea-level rise projections for New Zealand to better anticipate and manage impacts such as flooding at the coast from rising groundwater levels.

The project will deliver an authoritative, scientifically-robust set of national probabilistic sea level rise projections to the end of the 21st century and beyond. South Dunedin has been selected as a regional case study as it is a low lying urban area likely to be impacted by sea level rise, and potentially subsidence as well. The case study outcome will be used to develop planning and risk assessment toolkits for planners, decision makers, iwi and the public who require technical and risk information to effectively adapt to the sea level rise.

3. Current Workstreams

3.1. NZSeaRise project – ORC Contribution

ORC has agreed to support the NZSeaRise project, led by scientists from GNS Science and Victoria University of Wellington. Our role in the project is to improve understanding of groundwater, and to work with GNS scientists to collate information about the physical environment of South Dunedin to inform a robust geological model of the area.

As noted earlier, current groundwater modelling efforts are limited by a lack of subsurface data. To rectify this knowledge gap, a key piece of work will involve deep investigation bores to bedrock (~50-70 m depth). Natural Hazards staff of ORC are presently working with scientists at GNS to develop a drilling programme and proposal, and constrain cost estimates for the work. Additional work involves collating existing information from multiple sources about the near-surface soil and hydrological properties. Combined, this information will enable construction of a 3-D model of the porous aquifer layers and impermeable silty sediment layers which are inferred to make up the subsurface beneath South Dunedin.

In addition to revealing the stratigraphy and basement architecture beneath South Dunedin, the benefits of deep bores are two-fold. First, deep subsurface data is needed to design subsequent aquifer tests, which will improve understanding of groundwater connectivity and behaviour. Second, deep drilling and core recovery will allow direct dating of sediments from various depths, allowing the subsidence and sea level history of the area to be reconstructed (Figure 6). Understanding the geological subsidence over time is important for modelling sea level impacts into the future.

The improved groundwater model will ultimately form one of the main published outputs of the NZSeaRise project and a core piece of work under ORC's climate change adaptation programme in the 2018/28 Long Term Plan.

Although the NZSeaRise project has a South Dunedin focus, ORC is future-proofing the work so it can be readily expanded to the Harbourside area as more data is acquired. This includes expanding the geographic scope of the groundwater model north to Logan Park, and initiating the collection of groundwater data in the northern part of the city (Figure 7).

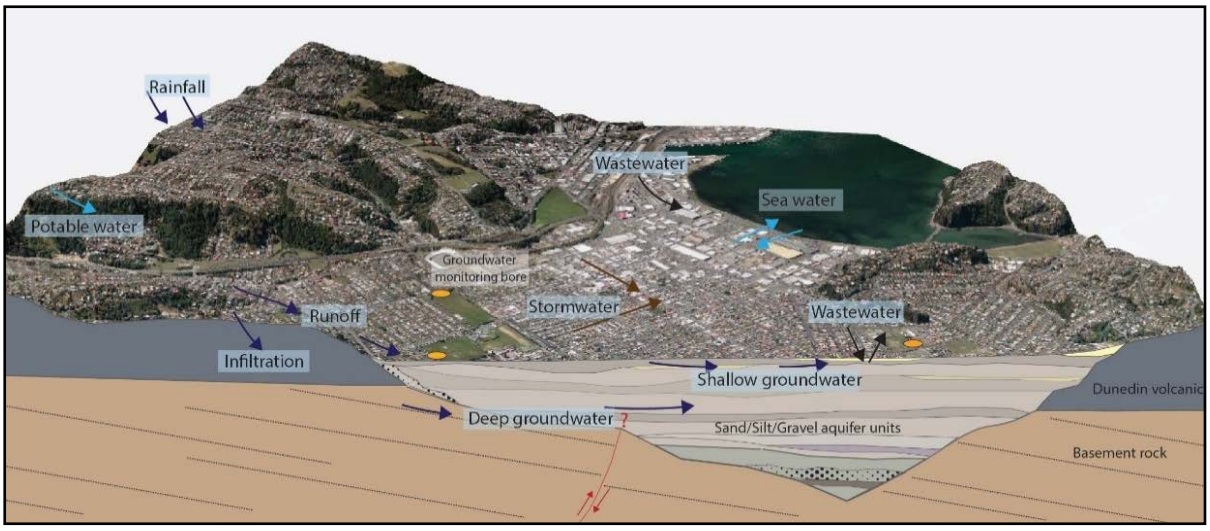

Figure 6: Diagram showing examples of different hydrological interactions occurring in the South Dunedin catchment. Constructing a robust groundwater model will involve giving volumes and flow rates to these 'nine waters'.

3.2. Cone Penetrometer Tests (CPTs)

A collaborative project led by EQC (with funding also from ORC, DCC, GNS Science) is due to carry out a series of 20 cone penetrometer tests (CPTs) to investigate the sediment properties beneath South Dunedin. A CPT is a sensor pushed into the ground, and the relationship between friction, resistance, and pore pressure can be used to infer subsurface soil properties (Figure 7). CPT tests will reach to approximately 20 m depth and will allow characterisation of different aquifer and non-porous sediment units. This data will be uploaded to the New Zealand Geotechnical Database (NZGD) so that it can be readily accessed by scientists and engineering consultants undertaking work for clients in South Dunedin.

CPT data will assist in selection of drilling locations for deeper and more detailed investigation of the hydrogeological properties of the aquifer. Data from CPTs in the South Dunedin area will allow quantification of liquefaction and ground settlement risk during seismic shaking.

Figure 7: A cone penetrometer (CPT) rig testing ORC's floodbanks on the Taieri Plain in 2015.

3.3. South Dunedin and Harbourside extended groundwater monitoring network.

The CPT testing process allows for piezometers (specialised pipes for measuring groundwater levels) to be installed while the tests are carried out. ORC have worked with EQC, GNS Science and DCC to select nine new groundwater monitoring sites through South Dunedin to supplement the current network of four. These have also been strategically sited to enable monitoring of groundwater response when aquifer pump testing is carried out as part of aquifer characterisation. Five sites through Harbourside (blue dots in Figure 8) have also been identified for installation of piezometers to monitor ground water.

Figure 8: Proposed ORC groundwater monitoring sites around harbourside area, and extension of the South Dunedin groundwater model.

3.4. Seismic hazard assessment

Geologists from GNS Science, the University of Otago, and the Geological Survey of Spain have recently completed a study of unknown faults underlying the Dunedin area[12] (Figure 9). Following the 2010-11 Christchurch earthquakes, there has been a national focus on improving understanding of faults near cities, as a moderate earthquake near an urban area can cause significant damage.

Newly calculated earthquake magnitude estimates for fault sources near Dunedin range from M_W 6.7 to 7.7 and recurrence intervals range from 5000 years to several millions of years. The shaking scenarios from known faults have been re-assessed and predicted levels of ground shaking could result in damage to unreinforced masonry, localised landslides, and

[12] Villamor P., et al., 2018. *Unknown faults under cities*. Lower Hutt (NZ): GNS Science. 71p. (GNS Science miscellaneous series 124)

liquefaction in some areas. The likelihood of this type of shaking occurring is low, though not necessarily lower than those of the faults involved in the Canterbury earthquake sequence. Along with existing liquefaction susceptibility mapping for South Dunedin[13] commissioned and previously reported by ORC[14] (Figure 10), this will provide valuable data for assessing seismic hazard risk. This study identified some new seismic sources, but re-categorised some previously mapped faults, with the result the integrated seismic hazard facing Dunedin is largely unchanged.

ORC will work with GNS Science to update active fault mapping in the Dunedin and Clutha Districts in the coming year, following current work describing active faults in the Queenstown Lakes and Central Otago Districts that has been commissioned by ORC.

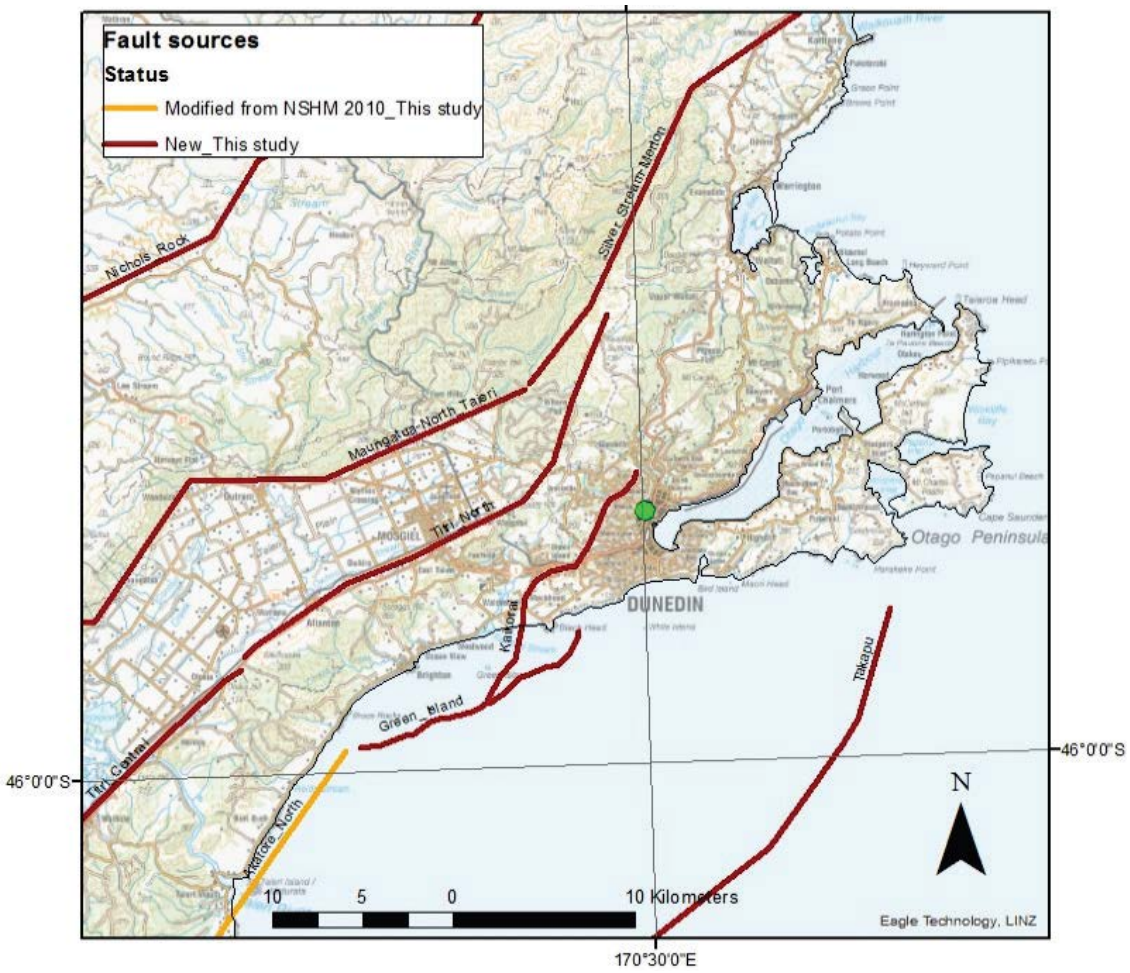

Figure 9: Updated surface traces for fault sources in the Dunedin region. Orange lines: fault sources modified from the 2010 National Seismic Hazard Model (NSHM). Red lines: new fault sources (not in the current NHSM). Figure from Villamor et al. (2018)

[13] Barrell, DJA, et al., 2014: *Assessment of liquefaction hazards in the Dunedin City district*. GNS Science Consultancy Report 2014/068

[14] *Assessment of liquefaction hazard in the Dunedin City district*. Report to 4 June 2014 meeting of the Otago Regional Council Engineering and Hazards Committee, Report 2014/0832.

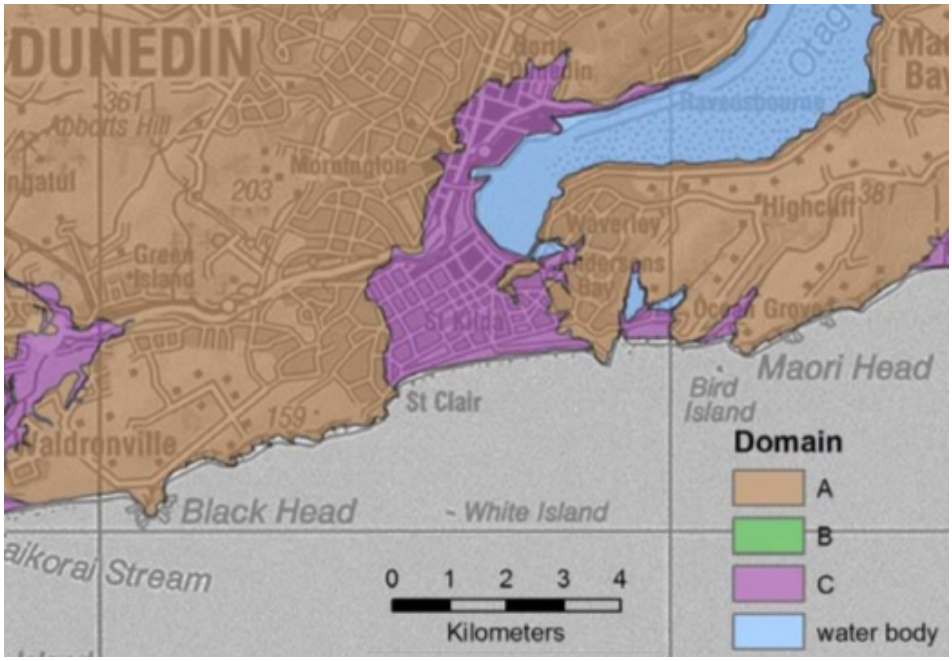

Figure 10: Map of liquefaction susceptibility domains for the Dunedin urban area. Domain C is ground with a moderate likelihood of being underlain by liquefiable material (i.e. silts and sands) and with a shallow water table. From Barrell et al. (2014) prepared for ORC.

3.5. Green Island Sea Level

ORC and the National Institute for Water and Atmospheric Research (NIWA) have maintained a tide gauge on Green Island off the coast of Brighton since 2002 (Figure 11). In 2016 a continuous Global Navigation Satellite System (GNSS) instrument was also installed on the island to monitor vertical tectonic movement. Establishing vertical tectonic movement is important, as is can augment or diminish rates of sea level change recorded by the tide gauge. The GNSS station, maintained by the University of Otago Survey School and funded by ORC, has been operating for over two years, with over 700 daily position estimates. This time interval has allowed horizontal velocities to be well defined, but 4-5 years of data is required to establish a reliable vertical signal. The station picked up a 5mm shift south during the November 2016 Kaikoura earthquake due to far-field tectonic deformation (Figure 12). This station ties into a regional network of GNSS survey points which, allow geodesists to analyse the regional tectonic signal and strain accumulation on local faults. This information has many practical uses including the assessment of relative sea level changes.

Figure 11: Location of the tide gauge on Green Island, Dunedin.

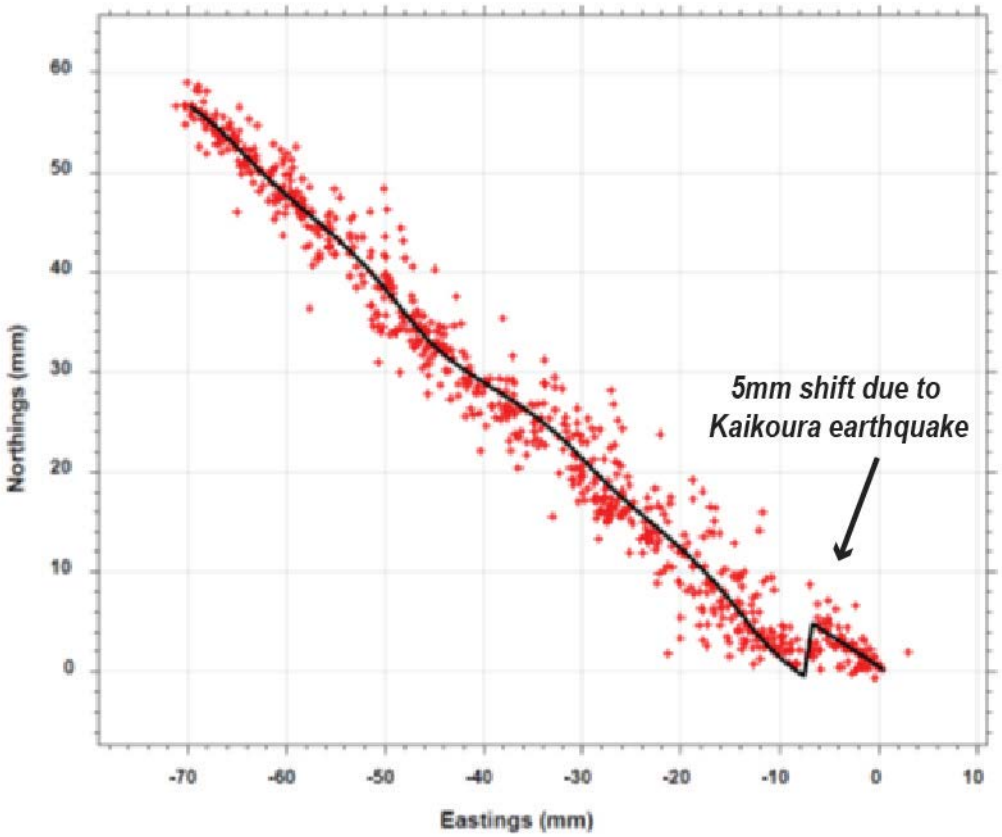

Figure 12: Horizonal position plot of the Green Island GNSS since 2016, showing a trend of movement to the northwest (start of record is x,y = 0). The sudden shift south is due to the November 2016 Kaikoura earthquake. Figure from University of Otago Survey School.

3.6. Coordination with Dunedin City Council Stormwater Management

Accurate knowledge is required of the volume and speed of water which makes its way to the flood-prone coastal areas of Dunedin's central city via steep, inner-city and suburban catchments. The small streams are captured by the DCC stormwater network, though in cases of high rainfall intensity an unknown amount of water overflows the stormwater network and crosses sub-catchment boundaries on the flat. ORC and DCC aim to collect stormwater flow data of these hillside catchments to better establish the pressure-points which require upgrade and can help mitigate the contribution to flooding posed by stormwater overflows. Flow monitoring of these streams is necessary to understand how much of the rainfall volume during a high intensity event makes it into the stormwater system and which points. This will also aid the design of stormwater infrastructure that will both cope with high-rainfall events in the short-term and deal with issues of rising groundwater in the mid to long-term.

3.7. Ocean Beach Coastal Hazards and tidal data capture

Staff are supporting DCC on a management plan for the long-term adaptation of Ocean Beach to hazards, especially those related to climate change such as increasing storm surge height and severity of erosion events. This will involve community members working with technical experts, DCC, and ORC staff to develop a suite of dynamic adaptive management pathways for the wider beach area. These will outline what the short-, mid- and long-term options are for dealing with sea level rise and increasing storm damage at St Clair, and the changing dune along the rest of Ocean Beach. This could include identification of trigger points for when to move from 'hold the line' to a longer-term direction for the management of the physical environment along the coast.

ORC and DCC technical staff are working together to have a permanent pressure transducer installed on the shore platform at St Clair Beach. This would provide a year-round record of high-water levels and assist in the management and modelling of storm surge events. This data when compared with the Green Island sea-level record would provide insight into local-scale wave set-up and the size, frequency, and timing of sea level anomalies such as storm surge events. Furthermore, when compared with data from nearby groundwater stations, it could provide insight into the connectivity between sea level and ground water levels and inform the groundwater model.

3.8. ORC communication plan and data sharing

ORC and DCC are working in partnership on a communications plan for the upcoming and future technical work in South Dunedin. Recently this has included working collaboratively with associated parties on a media release for the imminent CPT work by EQC. In the future this work could encompass combined community meetings, written communication, or a shared webpage dependent on what is most appropriate for each stage of the work. The communications plan is in its early stages and will continue to adapt and develop as the work stream and communities needs do.

The data requirements for this workplan will be varied in scope and in application. ORC and DCC are also working collaboratively to ensure the data will be shared collectively to ensure its effective use. This will include uploading data to the New Zealand Geotechnical Database (NZGD), sharing between ORC and DCC, and ensuring relevant data is shared with the public via the ORC website.

4. Conclusions

ORC has a programme of technical work underway to provide better understanding of natural hazards and the effects of future climate change in Dunedin. Plans for data collection have progressed significantly since ORC outlined needs for better understanding the issues of the multi-hazard setting of South Dunedin in the 2016 report, "*The Natural Hazards of South Dunedin*". The scope of this project has also extended beyond the South Dunedin flat with the plan for an improved groundwater model now encompassing all the low-lying area around the coast of Dunedin's CBD, from the Oval to the university.

Technical work and data gathering over the coming year includes an expanded groundwater monitoring network, a 'next generation' groundwater flood model, coastal erosion and elevated sea level data, and liquefaction susceptibility data. An important part of the future work is communication with the public around why this data is sought and how it will help planning for a better city longer-term. This needs to be aligned with other communication and stakeholder engagement initiatives, such as community response plans and planning[1].

It is vital that the technical work delivers the technical information needed to make adaptation decisions, as that is its primary purpose. This in turn depends on ORC having a clear understanding of what the adaptation options and pathways could be for South Dunedin/Harbourside and the process and timeframe for decision-making on those options and pathways. Without that, the models being constructed and the information being prepared may be insufficient to make the right adaptation decisions at the right points in time.

5. Recommendations

a) This report is received and noted.

Endorsed by: Gavin Palmer
Director Engineering, Hazards & Science

Attachments

1. 1671023 7410-004- R- Rev 2 Managing Rising GW in South Dunedin- International Review- FINAL **[11.2.1]**

[1] *Community Response Planning*, Report to Otago Regional Council Technical Committee 18 October 2018.

11.3. Community Response Plans

Prepared for: Technical Committee
Report No. EHS1831
Activity: Safety & Hazards: Emergency Management
Prepared by: Chris Hawker, Director (Non-Executive) and Group Controller, Emergency Management Otago
Date: 3 October 2018

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1. Précis

This report summarises Emergency Management Otago's progress in the development of Community Response Plans across Otago.

Community Response Plans provide a consistent basis for residents and groups within an agreed area to organise and implement their own local arrangements for emergencies. Plans are being developed at community level for priority communities (approved by each Local Authority) with the guidance and support of Emergency Management Otago staff. They are tailored to reflect local hazards, capability, circumstances and preferences. Once adopted, these localised arrangements become the basis of each community's response to emergencies.

All local and district response plans fit within the overarching framework of the Otago Civil Defence Emergency Management Group Plan. The Group Plan is under review and is due to be adopted by the Joint Committee on 14 November, with public notification planned for 21 January 2019. ORC has set a performance measure for the Chief Executive requiring Community Response Plans for Otago's priority communities by 30 June 2019. These communities are assessed as being:

Queenstown Lakes – Glenorchy and Makarora
Dunedin – South Dunedin, Aramoana, Long Beach / Purakanui, Mosgiel-Taieri and Waikouaiti
Central Otago – Teviot Valley
Clutha – Toko Mouth, Inch Clutha / Kaitangata, New Haven and Pounawea
Waitaki – Waitaki Bridge and Kakanui

The status of each plan is set out in Table 1. All are either completed or underway with the exception of Kaitangata / Inch Clutha where there are existing community response arrangements in place. Work will have begun to revise these in the community response plan format by June 2019.

Community response planning reflects the "4Rs" principles of Reduction, Readiness, Response and Recovery. Regionally, 12 plans are complete, eight are being finalised, work is underway on another 21 and the remaining 18 plans are yet to be initiated (refer to Table 1).

2. Background

Community response planning is underway in every district of Otago with local variations. Some communities have existing emergency response arrangements which are being updated or expanded, while others are starting from scratch. Table 1 sets out the schedule for developing plans in each district. It reflects the priorities and preferences set by each district / city council, and the wishes of the communities themselves. Twelve plans have been completed and adopted to date. Another eight are in the final stages and are expected to be complete in November. Work is underway on a further 21 plans and the remaining 18 have yet to be initiated.

Some suburbs of Dunedin are not proposed to have a separate community response plan. This reflects the priorities and preferences of the Dunedin City Council. As shown in Table 1, the following urban areas within the city have been identified as needing plans: Brockville, South Dunedin (referred to as the Southern Urban Area) and North East Valley.

There is no “one size fits all” for the response plans as they reflect the hazards, risks, resources and capability of their community. They are community driven in terms of timing, content and implementation so while each has common elements, some of the content is location-specific.

Each plan is based on the premise that a community will need to cope without outside assistance for several days during a severe and widespread emergency. Local leadership and local resources are critical elements of each community response plan. In most areas, a community response group has been central to the development of their local plan. Some of these groups have self-organised, some have come together with encouragement from Emergency Management Otago, and others have spun off from local community boards or community associations. All are guided and supported by our locally-based Emergency Management Officers.

The survey of hazard awareness and emergency preparedness that Emergency Management Otago commissioned earlier this year confirms that most Otago residents know and accept that their lives could be disrupted by earthquakes, floods and storms. Fires, tsunami, landslides and pandemic disease are seen by many to pose lesser risks. Across the region, 88 percent believe they will experience a severe earthquake in their lifetime.

Over 70 percent of those who took part in the survey said they had already taken steps to prepare for an emergency. Their preparations included at least some of the following: storing water, food and essential items; having a family plan; having an alternative means of cooking. Just under half of the respondents said they intended to do more. Only 8 percent said nothing would motivate them to prepare for an emergency.

These levels of individual preparedness provide the foundations of community readiness. Households which are able to look after themselves are better able to lend support to others. Almost everyone who responded to the survey said they would check on their neighbours or others in their community and share food and supplies with others. 61 percent said they were likely to step forward and volunteer to help in a civil defence centre in an emergency. Community Response Plans provide the framework within which these community volunteers can organise and respond to local needs in the event of an emergency. All local activities are aligned to the district-wide response managed from each Council’s Emergency Operations Centre (EOC), which in turn is coordinated across the region by the Otago CDEM Group from the Emergency Coordination Centre (ECC).

Each Community Response Plan includes generic and specific information on the area’s hazards, advice about preparedness and what households should do in the event of different types of emergency. This information is consistent across the plans for each area and is also in step with the national readiness information produced by the Ministry of Civil Defence & Emergency Management. The locally targeted information includes maps showing hazards such as fault lines, inundation zones for areas below dams, and evacuation routes for communities at heightened risk of bushfire or flooding. The plans include maps showing vulnerable population sites such

as schools, rest homes and hospitals. Other maps show tactical response sites including fire stations, reserves which can be used for helicopter operations, and the location of civil defence centres. Response plans for communities with large visitor populations contain information about where visitors can find shelter and support.

The Kingston Community Response Plan, which is the most recently completed, is appended as an example.

Table 1: Community response plans

District	Community	Yet to Begin	Engagement	Developing Draft	Finalising Draft	Plan Complete	Notes
Queenstown Lakes	Arrowtown						
	Cardrona						
	Central Queenstown						
	Frankton						
	Gibbston / Victoria Flats / Kawarau Gorge						
	Glenorchy						Plan is 90% complete.
	Jacks Point / Kelvin Peninsula						
	Kingston						
	Lake Hawea / Hawea Flat						
	Makarora						
	Matukituki						
	Shotover Country / Lake Hayes / Lake Hayes Estate						
	Wanaka						First draft complete, with designer
Central Otago	Cromwell						
	Ida Valley						Draft being discussed with the community. A supplementary dam-break plan will be developed. Aiming to present to the Maniototo Community Board in November
	Manuherikia						Discussions begun with first responders. A supplementary dam break plan will be developed. Aiming to present to the Maniototo and Dunstan CBs in November
	Naseby, Ranfurly, Maniototo						
	Queensberry						Draft being considered by the Queensberry

District	Community	Yet to Begin	Engagement	Developing Draft	Finalising Draft	Plan Complete	Notes
							response group. Expected to go to the Cromwell Community Board in November
	Tarras / Lindis						Engagement underway
	Teviot						With the Community Board for final sign-off. A supplementary dam-break CRP is being developed
	Clyde						Plans for these three communities overlap and will be developed together. Work will be initiated by the end of March 2019.
	Earnscleugh						
	Alexandra						
Waitaki	Hampden						In draft with further consultation underway
	Kakanui						
	Kurow						
	Moeraki						In draft with further consultation underway
	Oamaru						Work will be initiated by the end of March 2019.
	Omarama						Work will be initiated by the end of March 2019.
	Otematata						Work will be initiated by the end of March 2019.
	Palmerston						In draft with further consultation underway
	Waitaki Bridge						Complete. Mayor launching at a community function in October
	Weston						
Clutha	Balclutha / Stirling / Finegand						Formal planning yet to begin; informal response arrangements already exist
	Catlins						Initial meeting held
	Clinton / Waipahiu						Formal planning yet to begin; informal response arrangements already exist
	Clutha Valley						Revisions complete, in final design
	Kaitangata / Inch Clutha						Formal planning yet to begin; informal response arrangements already exist. New plan will be in draft by 30 June 2019.

District	Community	Yet to Begin	Engagement	Developing Draft	Finalising Draft	Plan Complete	Notes
	Lawrence / Waitahuna / Beaumont						Initial community meeting held
	Milton / Tokoiti / Milburn						Formal planning yet to begin; informal response arrangements already exist
	New Haven						Revisions complete, in final design
	Papatowai / Takahopa / Chaslands						Formal planning yet to begin; informal response arrangements already exist
	Pounawea						Revisions complete, in final design
	Tapanui / Heriot						Formal planning yet to begin; informal response arrangements already exist
	Toko Mouth						Revisions complete, in final design
	Waihola						Formal planning yet to begin; informal response arrangements already exist
Dunedin	Aramoana						Group met in August. Next meeting in October
	Blueskin Bay						To plan with Community Advisor
	Brighton Coast						Community Board considered draft standing operating procedure for local response in August. Next step is meeting with local response group
	Brockville						Work will be initiated by the end of March 2019.
	Dunedin Southern Urban Area						Met in August. Group recruiting more members. Developing their standard operating procedures for local response
	Long Beach / Purakanui						
	Mosgiel / Taieri						Plan in final design stage
	North East Valley						Meeting scheduled for October
	Otago Peninsula						Community has an existing response procedures. Being reviewed to align material
	Saddle Hill / Fairfield / Green Island						

District	Community	Yet to Begin	Engagement	Developing Draft	Finalising Draft	Plan Complete	Notes
	Strath Taieri						
	Waikouaiti / Karitane						Community meeting held in August. Next meeting in October
	West Harbour						

3. Recommendations

1. This report be received.

2. Progress on developing community response plans for priority communities is noted.

Endorsed by: Gavin Palmer
Director Engineering, Hazards & Science

Attachments
Kingston Community Response Plan

11.4. Lake snow technical workshop proceedings and research priorities - recommendations and programme cost estimates

Prepared for: Technical Committee
Report No. EHS1832
Activity: Environmental: Water
Prepared by: Rachel Ozanne, Environmental Resource Scientist
Date: 17 October 2018

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1. Précis

Lake snow (*Lindavia intermedia*) has been causing significant problems in Lake Wanaka for a number of years and findings from research funded by ORC (Novis, 2017[1]) were that the diatom responsible for lake snow, Lindavia intermedia, is almost certainly invasive (there is no evidence that it was in New Zealand before 2001) and has been identified in archived samples from more than a dozen New Zealand lakes or lake outlets.

ORC initiated and hosted the first lake snow experts' workshop on lake snow on 20 December 2016. During this workshop a research plan was developed, prioritising research needed to inform and support management of lake snow. This plan has previously been presented to Council (2017/0705, 15 March 2017; 2017/0802, 14 June 2017). It informed preparation of the 2017/18 Annual Plan and the 2018/19 Long Term Plan. The 2018/28 Long Term Plan (LTP) includes the target "*Continue to lead research into feasible methods of managing the effects of lake snow on water quality*". The LTP makes financial provision ($75,000 in each of three years, 2018-2021) for lake snow research.

A second workshop on lake snow was hosted by ORC on 8 August 2018, the primary objectives of the second workshop were:

1. To revisit the main themes from the December 2016 workshop documented in Ryder (2017)[2];
2. Discuss the findings from priority work streams identified by workshop participants in December 2016;
3. Further discuss research work planned; and
4. Identify if further work is required and to identify potentially feasible methods to
5. manage the effects of lake snow.

This report summarises that second workshop. It is recommended that:

a. This report is received
b. The outcomes of the lake snow expert workshop convened by ORC in August 2018 are noted.

[1] P Novis et. al. (2017). Lindavia intermedia, the causative organism of New Zealand lake snow: relationships between New Zealand, North American and European populations according to molecular and morphological data. Prepared for Otago Regional Council.

[2] Ryder Consulting Ltd Report: Lake Snow Technical Workshop, 20 December2016, Report on Workshop Discussion and Outcomes.

c. The Chief Executive write to the chief executives of all other regional councils and the Ministry for Primary Industries inviting them to formally endorse and support the proposed programme of research and to discuss funding arrangements.

2. Research to date

Significant progress has been made with the priority work streams identified by workshop participants in 2016. ORC funded a number of these research programmes including:

- Genetic analysis to determine whether Lindavia is likely to represent a recent introduction to New Zealand (Landcare Research[1])
- A lake coring study of Otago Lakes to determine *Lindavia* diatom incursion timelines (University of Otago)
- A literature review to increase understanding of *Lindavia (*University of Otago)
- Screen archived diatom samples for the presence of *Lindavia (*NIWA)
- A citizen science project in lake snow and water quality (Aspiring Environmental)

These related to components 1 ii); 1 iii); 2A i); 2B i); and 5 in the 2016 work programme[2] and were identified as being of highest priority for direct funding by ORC. The total external cost of these work streams was $121,000.

3. Second technical workshop

The second technical workshop revisited the state of knowledge around lake snow in light of various research projects that had been undertaken since the inaugural workshop held in December 2016. It is notable that the second workshop attracted interest from a wider number of regional councils.

NIWA have prepared a report summarising the 2018 workshop, this is attached as Appendix 1. The key findings from the workshop and the research outcomes arising from the first workshop (outlined above) are described below.

1. *Lindavia intermedia*, the centric diatom responsible for lake snow, is an invasive species. It is therefore a biosecurity issue.
2. Assessment of archived lake and lake outlet diatom samples confirmed that *L. intermedia* has been present in New Zealand since at least around 2002 and indicated it was well dispersed over both the North and South Island by 2005. As of June 2018, *L. intermedia* had been recorded in 26 lakes spanning the regions of Otago, Southland, Canterbury, Hawke's Bay, Waikato and Manawatu-Wanganui. It is therefore a national issue.
3. Methods/tools are now available for the effective sampling, identification and quantification of the presence of *L. intermedia.* These are being refined through

[1] https://www.orc.govt.nz/media/3031/combined-technical-agenda-13-september-2017.pdf

existing MBIE-funded research. Some tools to quantify slime production are still in development. These are essential to effective management.

4. A review of the literature indicates that climate warming appears to be a key driver in many of the overseas lakes which reported shifts in lake phytoplankton communities towards centric diatoms similar to *Lindavia*, although the relevance of this to lake snow production is unknown. Other hypotheses for the shift in phytoplankton communities include increasing nutrient inputs and a change in grazing pressure due to the arrival of the invasive water flea *Daphnia pulex*.
5. Initial trials indicate that freezing is the only treatment that is 100% effective at killing *L. intermedia* cells. Detergent, bleach and drying were at least 90% effective but an extended treatment time was recommended from the currently recommended 1 minute used in the trial.
6. The potential use of parasites specifically associated with *L. intermedia* as a possible biological control warrants further investigation. In theory, such a control could reduce the abundance of *L. intermedia* without modifying a lake's trophic or toxicological status.
7. The Touchstone and Wanaka lake Swimmers Club lake snow study and wider citizen science-based water quality project has been successful in raising awareness about freshwater biosecurity issues and current recreational and potential future water quality challenges facing Lake Wanaka.

4. Programme of further research for 2018/19

Table 1 shows the ongoing lake snow research programmes already funded by the MBIE Smart ideas project.

Table 1 Ongoing Lake Snow Research Programme

ONGOING RESEARCH PROGRAMME			
3) Develop technologies to sampling and monitor of *L. intermedia* and lake snow?			
i) The development of new sensor technology to monitor in situ polysaccharide concentrations in lakes.	**FUNDED via current MBIE Smart Ideas project and in progress**	Capacity to monitor the abundance and spatial variability of lake snow is critical to understanding the environmental drivers that lead to lake snow production. At present these techniques do not exist.	**Landcare Research / Uni. Of Otago / Support from ORC**
ii) The development of cost-effective and efficient methods for quantitatively sampling lake snow in lakes (at different depths).			**Landcare Research / Uni. Of Otago / Support from ORC**
iii) Can DNA methods be developed for the sensitive detection of *L. intermedia* in lakes?			**Landcare Research / Cawthron / support from RC's**

Table 2 shows the revised 2018 work programme, as discussed with the experts following the second technical workshop.

The highest priority research that requires funding is to further investigate drivers of lake snow mucilage as detailed in Table 2 (2a, b, c) including investigation into climatic drivers, nutrient related investigations and grazing pressure. This work has been identified as suitable for a PhD student research project at a cost of $200,000 over three years, but ideally would be contracted to research staff at the University through collaborative funding opportunities (~$250,000).

The new research component investigating the potential use of a parasite biological control agent is detailed in Table 2 (3a). This is a staged work programme with Year 1 costing $28,000, results from Year 1 will determine whether Year 2 or 3 progress.

Table 2 – Revised Lake Snow Research Programme (numbering relates to original 2016 programme)

REVISED RESEARCH PROGRAMME				
Sub-program	Priority Ranking	Associated costs	Justification	Lead agency
2 What are the drivers of (A) *L. intermedia* dominance in lakes?				
2A ii) Are historical *L. intermedia* dynamics correlated to environmental drivers in our lakes?	**Medium - Medium term**	Will be funded by the existing MBIE Endeavour "Lakes380" Research Programme, jointly led by GNS Science and the Cawthron Institute	This work-stream is extensive and best delivered through a University postgraduate and post doctoral research programmes.	**University of Otago**
2A iii) Are proliferations of *Didymo* and *L. intermedia* in South Island waters related to a common driver or species incursion?	**Low - Medium term**	Costing and delivery difficult to estimate until study design developed (originaly estimated in 2017 at a minimum of $19K)	If the timing and spread of these two incursions are coherent, then that would provide evidence of a common incursion (both place and time) and support management of future incursions and responses.	**University of Otago/CRI's**
2) What are the drivers of (B) polysaccharide overproduction by *L. intermedia* ?				
2a) Investigation into climatic drivers *assessment of historic lake water temperature and other climatic records in NZ *experiment based investigations (e.g., water temperature changes)	**High – Medium term**	$200K spread over 3 years as a PhD project	High priority given the actual and potential impacts of lake snow - Part b) has potential implicaitons for the rural community if nutrients are a key driver. Various options exist to structure this research which require scoping (e.g., delivery could be shortened to 1-2 years using research staff at approx $250K, part 2c could be a separate MSc thesis, etc) but cost efficiencies are greatest in progressing all three components together	**University of Otago with CRI and RC support**
2b) Nutrient related investigations: *assessnent of historic data from affected lake catchments * experiment-based investigation of the effects of changes in nutrient availability				
2c) Investigation into changes in grazing pressure from Daphnia pulex				
3) Are there biocontrol agents that could be used on *L. intermedia* ?				
3a) Study to investigate the possibility of using natural parasites of *L. intermedia* as a form of biological control via reducing abundance and therefore mucilage production	**High - Medium term**	Year 1: $28K Year 2: $67K Year 3: $66K Delivery 3 years	3 year project with associated stage gates. *Year 1 (Feb to Jun 2019): national and international sample collection, DNA extraction and assembling of metabarcoding results. Results determine if work proceeds to year 2. *Year 2 Culture related work. Work ceases here is unable to get anything to grow *Year 3: Culture testing under quarantine conditions	**Landcare Research/Uni. Of Otago / Support from ORC**

The 2018/28 Long Term Plan (LTP) includes the target "*Continue to lead research into feasible methods of managing the effects of lake snow on water quality*". The LTP makes financial provision ($75,000 in each of three years, 2018-2021) for lake snow research.

The Science team of ORC are working with Otago University and Landcare Research to finalise the scoping of the key research components (2a, 2b, 2c and 3a as identified in Table 2).

Given the wide distribution of *L. intermedia* across New Zealand (Novis, 2017), and potential for lake snow issues to arise in lakes outside Otago, this revised research programme is of national importance. The programme should be endorsed and supported by all regional councils with an interest in this matter, and by central government so that research is delivered in the most effective and efficient way and appropriately funded.

The outcome from polysaccharide production research (Table 2 a-c) will establish if some of the drivers of mucilage production could be controlled through management of inputs into the lakes (e.g., nutrients). The biocontrol research (3a, Table 2) is a feasibility study regarding the potential to develop a biocontrol agent which, if successful, could potentially reduce the biomass of Lindavia (and lake snow) and could even eradicate it from the lakes

5. Recommendation

a. This report is received.
b. The outcomes of the lake snow expert workshop convened by ORC in August 2018 are noted.
c. The Chief Executive write to the chief executives of all other regional councils and the Ministry for Primary Industries inviting them to formally endorse and support the proposed research programme and to discuss funding arrangements.

Endorsed by: Gavin Palmer
Director Engineering, Hazards & Science

Attachments

1. Lake Snow Technical- Workshop _8 08 2018 NIWA **[11.4.1]**

12. NOTICES OF MOTION

13. CLOSURE