Te Awarua-o-Porirua Whaitua Committee

greater WELLINGTON REGIONAL COUNCIL Te Pane Matua Taiao

Title: Hydrology and water allocation in Te Awarua-o-Porirua Whaitua

Purpose: To provide an overview of the hydrological systems and current water allocation within Te Awarua-o-Porirua Whaitua.

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Hydrology and water allocation in Te Awarua-o-Porirua Whaitua

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1. Executive summary

This report gives a brief overview of the hydrological systems of Te Awarua-o-Porirua Whaitua (hereafter referred to as the Whaitua) and associated water take. The Whaitua covers an approximate area of 21,300 ha on the south-western coast of the North Island just out of Wellington. It is a low lying valley that was once covered in native forest but now has largely pastoral and urban (residential and commercial) land use.

Porirua Harbour (hereafter referred to as the Harbour) is divided into two arms, Onepoto Arm and Pauatahanui Inlet, fed by three primary streams (Horokiri, Pauatahanui and Porirua Streams) and numerous tributaries. The building of State Highway One (SH1) and the North Island Main Trunk Railway has modified the Whaitua extensively with shoreline and saltmarsh in Onepoto Arm replaced by steep rockwalls. Pauatahanui Inlet is a slightly steeper catchment with less modification and includes a significant wetland area.

Flooding, in particularly stormwater flooding, is the most frequently occurring hazard in the Whaitua with flood detention structures built as part of flood control measures. Greater Wellington Regional Council (GWRC) operates a hydrometric network as part of the Hydrology State of the Environment (HSoE) programme (Harkness, 2014). The HSoE programme collects data on the 'quantity' of the region's water resources. Rainfall, river level/flow and turbidity are monitored on three streams. Several of the monitoring sites are alarmed for when rainfall and/or river levels rise above a set level.

GWRC are responsible for managing the allocation of freshwater doing so via resource consents. There are currently six consents for water take within the Whaitua; there are no significant groundwater aquifers so all water taken is surface water, primarily used for irrigation purposes. The use of consented water in this Whaitua is minimal compared with the other four Whaitua (except the eastern Wairarapa).

The hydrological system in the Whaitua supports a wide range of activities. Water take may put pressure on a stream by reducing the amount available for other activities such as ecological processes and cultural uses. As part of the Regional Plan review, GWRC are proposing interim extraction limits of 50 and 30% mean annual flow (MALF) for rivers and streams respectively.

2. Hydrology of the Whaitua

Hydrology encompasses the occurrence, distribution, movement and properties of water, and is divided into surface water, groundwater and marine water.

The Harbour is a large (870 ha), well flushed 'tidal lagoon' type estuary (Stevens & Robertson 2013). It has the highest proportion of subtidal area at low tide of any estuary in New Zealand. Its entrance is only a few hundred metres wide opening up into two arms, Onepoto Arm and Pauatahanui Inlet, each of approximately 3km in length. The arms are constrained at their junction by the railway and motorway. The maximum depth of the harbour is 5.5m underneath the Paramata Bridge with much of the harbour less than 3m deep at high tide (LINZ chart NZ 4632). The harbour is fed with freshwater from several sub-catchments within the Whaitua (Fig. 1A). The outer harbour adjacent to Plimmerton Beach has freshwater draining into it from the Taupo Stream catchment originating in the Pukerua Bay area.

Extensive modifications have occurred throughout the harbour, with much of the Onepoto shoreline and saltmarsh reclaimed in the 1950s and now lined with steep rockwalls. Pauatahanui Inlet is less modified with large extensive saltmarsh remaining in the north and east thanks to community restoration activities. Urban (residential and commercial) land use surrounds the Onepoto Arm while pasture, mixed with urban (residential), dominates the steeper Pauatahanui Inlet catchment.

The hydrological system of the Whaitua consists of three primary streams (Horokiri, Porirua and Pauatahanui streams) entering the harbour at either Onepoto Arm or Pauatahanui Inlet. The Whaitua has numerous (50+) tributaries feeding in along the length of these primary streams (Fig. 1B). Two of the larger tributaries, Kenepuru and Mitchell Streams, feed into the Porirua Stream and are part of GWRC's State of Environment monitoring programme/s. Some of the hydrology of the Whaitua has already been touched on in the report of the physical geography (Ammundsen 2015).

2.1 Horokiri Stream

The Horokiri Stream (catchment area 3, 302 ha) runs from the north alongside the Paekakariki Hill Road into the wetlands on the eastern side of Pauatahanui Inlet. The catchment was once '*an almost impervious tangle…of every tree common to the New Zealand bush*' (Buller as quoted in Healy 1980) but is now predominately pastoral land with encroaching rural residential (lifestyle block) development. The stream is characterised by a gravel bottom with limited riparian vegetation. There are often high nutrient levels measured in the stream. The Stream will be significantly affected by the construction of Transmission Gully.

2.2 Porirua Stream

The Porirua Stream (catchment area 5,300 ha), runs from Johnsonville to the Harbour entering at the southern end of Onepoto Arm (~11km). It is a defining feature on the western side of the Wellington motorway and railway corridor. On the eastern side of the stream, tributaries have sculpted the landform but much of the native forest has been cleared. Over the years there have been extensive channel modifications, with the stream pushed around by railway, roads and other development. The lower stream is surrounded by some housing, light industry and the Porirua CBD. It is listed in the Regional Policy Statement as supporting indigenous ecosystems, particularly in some of the headwater catchments. Monitoring studies show water quality is poor, with high nutrient, turbidity and metal levels (zinc and copper) often exceeding relevant guidelines (e.g., Milne & Watts 2008, Perrie 2008, Sorenson & Milne 2009). There are five larger tributaries that feed into the Porirua Stream (Kenepuru, Mitchell, Belmont, Takapu and Stebbing's Streams), and ultimately into the harbour. Much of Porirua Stream runs through privately owned land, exceptions being where the

stream passes through various Wellington and Porirua City reserves. The southern 70% of the catchment lies within the Wellington City district.

2.2.1 Kenepuru Stream

The main stem of Kenepuru Stream (~7 km), a tributary of Porirua Stream, flows through Bothamley Park in Cannons Creek and discharges to the tidal area. The stream is highly modified due to increased impervious surfaces (e.g. roads, driveways and rooftops), modification of the lower reaches of the stream, and clean fill from land development being placed next to the stream. As a result the stream has become channelised due to increased water flow during heavy rains and erosion of the bank. The middle reach of the stream between Cannons Creek Lakes and the main stem runs through a concrete channel (approximately 800m in length) before cascading about 50m through a series of steps and into the main stem. It has been estimated that ~60% of sediment in the stream comes from bank erosion (Forsyth & Todd 2012), including Belmont Regional Park where the headwaters of Cannons Creek are situated. The recent May 2015 floods totally filled the Cannon Creek Lakes with sediment. Most of this likely originated from the Park. Aquatic health and recreational use of the stream have declined, there are low levels of heavy metals and PAH, with DDT occurring at levels above the lowest recommended in the lower reaches of the stream. The tidal reach of the stream is the best inanga nursery in the Porirua Stream catchment, although the numbers of inanga have declined due to reduced habitat, and blockages to fish barriers. Greater detail of the stream can be found in Forsyth and Todd (2012).

2.2.2 Mitchell Stream

Mitchell Stream drains from Colonial Knob through an industrial area below Spicer Landfill and through the Kenepuru Hospital Grounds, before entering the Porirua Stream. Its channel is highly modified by historic cut and fill. The upper reaches of the stream run through Department of Conservation (DoC) native forest land and Spicer Park where there is good water quality and a number of native fish species such as inanga and banded kokopu. The stream discharges into the main Porirua Stream opposite Kenepuru Station. This catchment also contains the Broken Hill Industrial Area which is a mixture of light and heavy industry and extensive vehicle yards.

2.2.3 Belmont Stream

The Belmont Stream is one of a few remaining relatively natural lowland streams in Wellington. Historically there was a closed private landfill (called Cottles) in the Belmont Stream headwaters that is classified as a category V hazardous site on the GWRC database. According to Blaschke et al. (2009), Cottles was a poorly managed site and was known to contain a number of waterway pollutants. Local community groups have undertaken riparian restoration of the stream. The aim is to stabilise the streambanks to reduce sediment and filter nutrients to improve water quality before the water enters the main Porirua Stream at Glenside. It is one of the streams in the Million Metres Streams Projects hoping to get funding to plant out 409m of the stream length (http://millionmetres.org.nz/open-project/belmont-stream/).

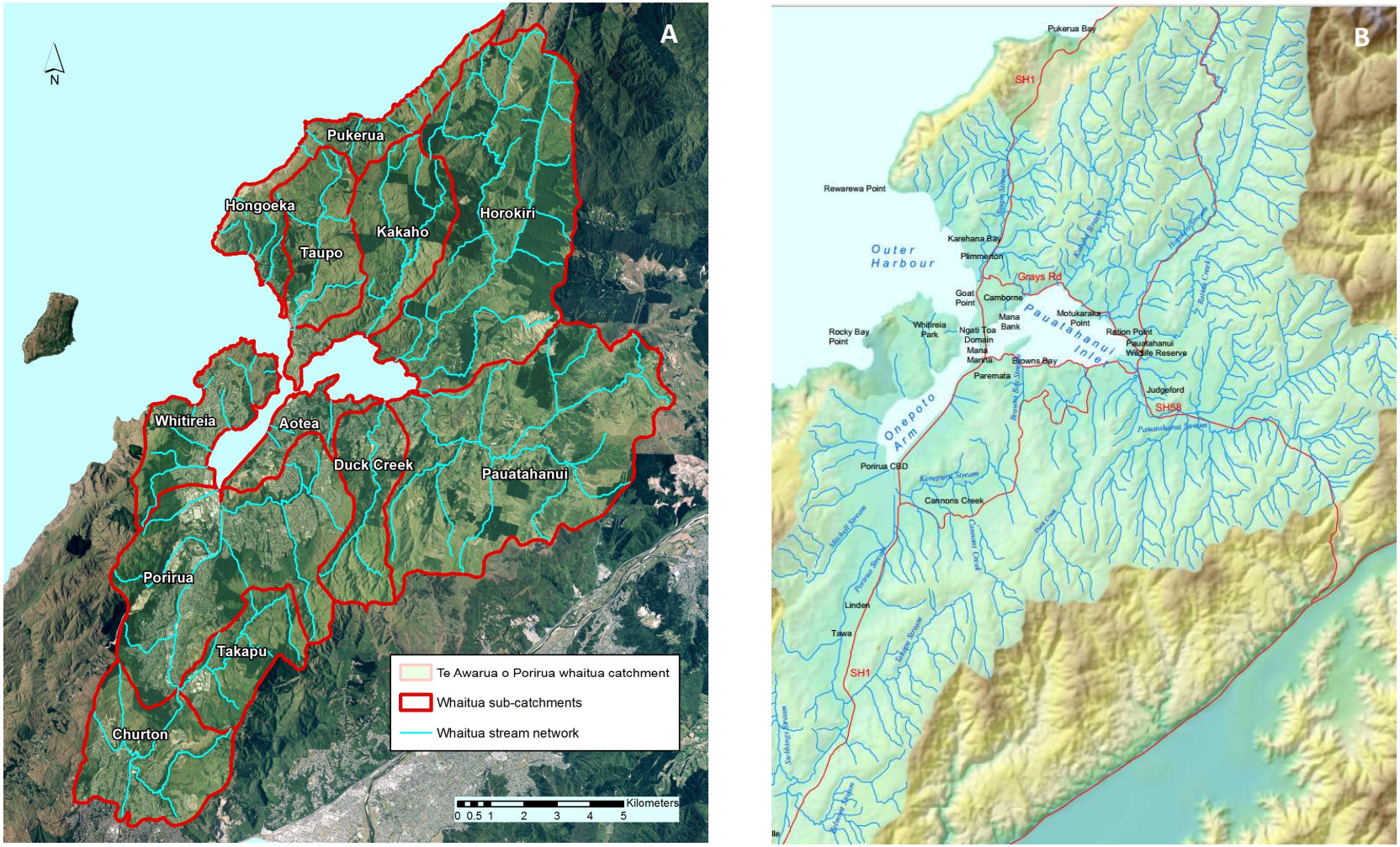

Figure 1: A) Map showing the sub-catchments and main streams and tributaries of Te Awarua-o-Porirua Whaitua and B) map showing greater detail of the streams and tributaries (courtesy Mike Harkness, GWRC).

2.2.4 Takapu Stream

Takapu Stream is the second largest sub-catchment in the Whaitua and is dominated by steep pasture and forestry. It feeds the clearest freshwater into Porirua Steam. However, the Granada North industrial area drains into the lower stream; the site of regular pollution events. The May 2015 floods demonstrated that the stream can carry a high bedload in such events. There is a pipe under SH 1 that restricts flood flows with a flood detention area just upstream. It has levels of DDT higher than in Porirua Stream (Kingett Mitchell 2005) and in the past has had high levels of nutrients originating from farm run-off (Cameron 1993). Despite this the stream teems with native fish (e.g. banded kokopu, upland bullies, and long finned eel). NZ Transport Authority (NZTA) is also proposing a road connecting Transmission Gully to the Petone to Granada link road that will go through Takapu Valley.

2.2.5 Stebbings Stream

The upper reaches of Stebbings Stream are mostly pasture with a small area of forestry and native bush at the top of the headwaters. The ecological condition of Stebbings Stream and the Porirua Stream system has significantly declined (Blaschke et al 2009). Blaschke et al (2009) recommended riparian buffers and appropriate stormwater treatment as part of an integrated water-sensitive urban design process, if this decline is to be halted. Stebbings Valley is zoned for residential development, and subdivision is underway in the lower end of the catchment. It will eventually have 800 houses covering the catchment.

Stebbings detention dam, completed in 1994, is situated in the lower reach of the Stebbings catchment and was built as part of the Porirua Stream flood control measure.

2.3 Pauatahanui Stream

Pauatahanui Stream runs through the Haywards Hill, Judgeford and Belmont areas, entering the eastern side of Pauatahanui Inlet. The vegetation changes from a mix of pasture land and forestry in the upper catchment to pasture with some residential and commercial in the lower catchment. Dissolved oxygen is low throughout the stream with high levels of metals and turbidity (more suspended solids in the water = higher turbidity) in the lower reaches.

2.4 Pauatahanui Wildlife Reserve

As an estuary, Pauatahanui Inlet is unusual in the fact that it has a small range of salinity. This means that the head of the Inlet is considered brackish (more salty than freshwater) restricting the species that can survive there. The dominance of saltwater occurs as the amount of freshwater entering the Inlet is not enough to dilute the incoming seawater.

The Reserve and adjacent wildlife management area occupies the north eastern edge at the head of Pauatahanui Inlet (which covers about half of the Inlet) are considered a nationally significant wetland. It is bordered by SH 58 to the south, and bisected and bordered by Grays Road to the North. Pauatahanui Village sits at the eastern end and junction of these two roads. It is the largest remaining area of saltmarsh in the lower North Island as well as Porirua Harbour. Until reticulation in 2014, Pauatahanui residents were all on septic tanks and the Reserve and head of the Inlet were affected by leakage of human waste.

It is an area rich in wāhi tapu (areas of cultural and spiritual significance to Māori), archaeological sites and historic places. It has a diverse range of local and migratory waterfowl and wading birds, and contains threatened fish species and endangered vegetation.

A natural gas pipeline passes through the reserve, and while the Natural Gas Corporation has right of entry there are restrictions on activities, such as buildings and plantings, that occur around the pipeline (Conwell, 2010). There is also a series of man-made drains in the central and northern parts of the reserve. All the waterways (Pauatahanui Stream, Ration and Creeks and smaller tributaries) receive and transport agricultural waste and land runoff (Conwell, 2010).

2.5 Lagoons, Lakes and a Swamp

There are several lagoons (shallow waterbody separated from the Harbour by a barrier but with a water interconnection), freshwater lakes and a swamp in the Whaitua (Fig. 2):

- Papakowhai, Aotea and Okowai lagoons are manmade and all tidal to varying degrees, controlled by the size of culverts connecting them to Onepoto Arm.
- Whitby Lakes and Cannons Creek Reserve Lakes are also manmade. Whitby is an 'ornamental' lake, while Cannons Creek Lakes were built primarily for flood detention.
- There are also two other small man-made waterbodies: one simply called the 'duck pond' adjacent Aotea Lagoon and one in the Royal New Zealand Police College grounds.

2.5.1 Papakowhai Lagoon

Papakowhai Lagoon, a mere sliver of water on one side of SH1/NIMT and bisected by Paremata Road, was formed as a result of rail realignment in the early 1950s and motorway extension in the 1960s. Several bird species, such as spoon bills and white faced herons have been observed in the Lagoon. Like the other two lagoons, it contains fish sprat and a significant population of eels, have been observed in the lagoon.

2.5.2 Aotea Lagoon

Aotea Lagoon (5 ha) is a heavily polluted, artificial saltwater lagoon created during causeway construction to realign the North Island Main Truck Railway between 1958 and 1961, compounded by causeway widening to accommodate the motorway extension in the late 60s. It is connected to the harbour via a valve-controlled culvert and also has three stormwater drains that empty into it from the motorway and others that drain from the small catchment above, mostly occupied by the Police College. Infrequent controlled flushing and resultant poor water quality means that swimming is not allowed. There is a small duck pond within the Aotea Lagoon complex which, until lately, has been one of the most 'faecally' contaminated waterbodies in the catchment due to accumulating duck excrement. The Lagoon and associated garden and playground facilities are a favourite amenity space for the City.

2.5.3 Okowai Lagoon

Okowai Lagoon (~2.08 ha) is another artificially-created lagoon located east of SH1 north of the Porirua City Centre and was also the result of the same causeway construction above. Motorway extension saw the lagoon split into two sections, with the southern section acting as a defacto freshwater sediment pond, feeding into the tidal northern section. However, a lack of tidal flushing combined with ongoing earthworks and land development has caused several problems such as ongoing reduced water quality, litter accumulations, seasonal algal blooms with associated odour issues. GWRC, PCC and Carrus Corporation recently (2010) re-profiled the southern section of the lagoon into a wetland more suitable for waterfowl. Adjacent to and connected by a culvert is a large best-practice, three-phase, sediment pond used to filter land runoff from the ongoing earthworks on the Aotea Block.

Figure 2: Map showing all three lagoons (Papakowhai, Aotea [including the 'duck pond'] and Okowai), the man-made waterbody in the NZ Police College grounds, the freshwater wetland and the silt filtration pond (built as mitigation for sediment loss as part of the development of Aotea) at the southern end of Okowai Lagoon.

2.5.4 Whitby Lakes

Whitby Lakes are two ornamental (i.e. aesthetic) man-made lakes; upper (3.22 ha) and lower (3.57 ha) with a nature reserve around the upper lake and retirement homes and a shopping centre surrounding the lower lake. The nature reserve was historically a shelterbelt. Both lakes are home to wildlife such as birds (pukeko and black swans), eels and grass carp. The carp were 'removed' recently. The upper reserve has remnants of kanuka and broadleaf forest including amenity planting around the lake.

2.5.5 Cannons Creek Lakes Reserve

Cannons Creek Lakes Reserve (CCLR) is a narrow 7.532 ha valley reserve established in the 1950s to act as flood detention and attenuation basin. There are two man-made lakes: an upper southern lake and a lower northern lake. CCLR is separated from the lower Kenepuru Stream by an 800m concrete channel that then descends an approximately 50m cascade of 2m concrete 'steps' into the main stem of the Kenepuru.

A report by Boffa Miskell Ltd and PCC in 2010 looked at ecological and landscaping issues and options of CCLR. They found that:

- the lakes are in excellent ecological health with healthy populations of fish including nationally threatened species
- the lakes can successfully respond to stormwater inputs and seasonal flooding
- some minor issues such as contamination (heavy metals primarily) from residential stormwater, degradation and scouring of stream banks and changing land uses in upper catchment
- barriers created by the concrete channel and steep cascade (below Warspite Ave) inhibit fish passage, and;
- there was surprising high native fish biodiversity in the lakes to warrant being regionally significant.

The recent May 2015 floods have totally filled both lakes with silt, probably largely from the upstream Belmont Regional Park. The ecological health of the Lakes is currently unknown.

Flood protection is a vital role of this Reserve delaying flood waters entering the Kenepuru Stream and Porirua Harbour. Recent hydrological modelling shows the Reserve basin can manage floods up to a 100 year event (41 m^3 /s of water). The complete filling with silt of both lakes has compromised its use as a detention area. It is unknown what, if any, plans there are to rehabilitate the lakes as both a detention structure and as habitat.

Sediments from Belmont Regional Park are captured in the lakes which has reduced sediment entering the lower Kenepuru Stream and the Harbour but has resulted in infilling of the lakes. The expectation had been that the upper lake would eventually become a wetland. This has occurred quicker than anticipated. PCC has previously removed sediment and pond weeds from both lakes.

2.5.6 Taupo Stream and Swamp

Taupo Stream flows from the Pukerua Bay township south through Taupo Swamp and then into the outer harbour sea at Plimmerton the north end of South Beach. There is significant riparian margin along the lower reaches of stream providing habitat and cover for the high diversity of freshwater fish found there.

Taupo Swamp (Ara Harekeke; Fig. 3) is the largest (30 ha) and nationally significant harakeke (flax) wetland in the Wellington region. It plays a role in sediment trapping, maintenance of water quality and support of aquatic and terrestrial food chains. It is surrounded by the North Island Main Trunk Railway, SH 1, Airlie Road and private land. The catchment is predominately pasture with some forestry and scrub. The southern end of swamp has been reclaimed and developed for farming, playing fields and industrial use. The catchment and stream above the swamp has been highly modified – including ephemeral streams flowing from pasture and into a compacted channel stabilised and covered by healthy native vegetation. There are elevated flax swamp remnants to the west of the rail line. Historically, the stream and swamp were an area where mahinga kai (such as tuna) and harakeke were gathered. It is home to a number of threatened plants, birds such as the bittern and fish such as mudfish and longfin eel. In localised areas exotic weeds are rapidly displacing indigenous vegetation.

The area was purchased in 1986 by Queen Elizabeth II National Trust and has a management plan to "provide protection, maintenance and enhancement of the natural values of the swamp and surrounding high ground (collectively referred to as Taupo Swamp) for the benefit and enjoyment of the public".

The swamp will now be bordered to the west, beyond SH1, by Porirua City's Northern Growth Area for residential development contiguous with the suburb of Cambourne to the south. A Structure Plan for the development has been designed in consultation with affected agencies and the Plimmerton community, and adopted by PCC (in early 2015). Several streams drain into the Swamp from the area and the Plan seeks to recognise and protect the values of the Swamp through retiring, planting and protecting some of the more significant streams and gullies. Any development is unlikely for 8-10 years.

The completion of Transmission Gully Motorway is likely to see a significant reduction in road traffic using the current SH1 adjacent to the Swamp and stream.

Figure 3: Map showing area of Taupo Swamp off SH1 in Te Awarua-o-Porirua Whaitua.

3. What is measured in the Whaitua?

Rainfall, river flow, turbidity and tide level are all measured within the Whaitua either by GWRC, PCC or NIWA (Fig. 4). Rainfall information is vital for flood warning, water management during drought and detecting long-term trends in climate. Raw data for both rainfall and flow are logged on a regular basis (every 5 or 15 minutes) and uploaded to GWRC's database every 2-3 hours. Key rainfall and water-level sites are telemetered and available in real-time to the public on the GWRC website.

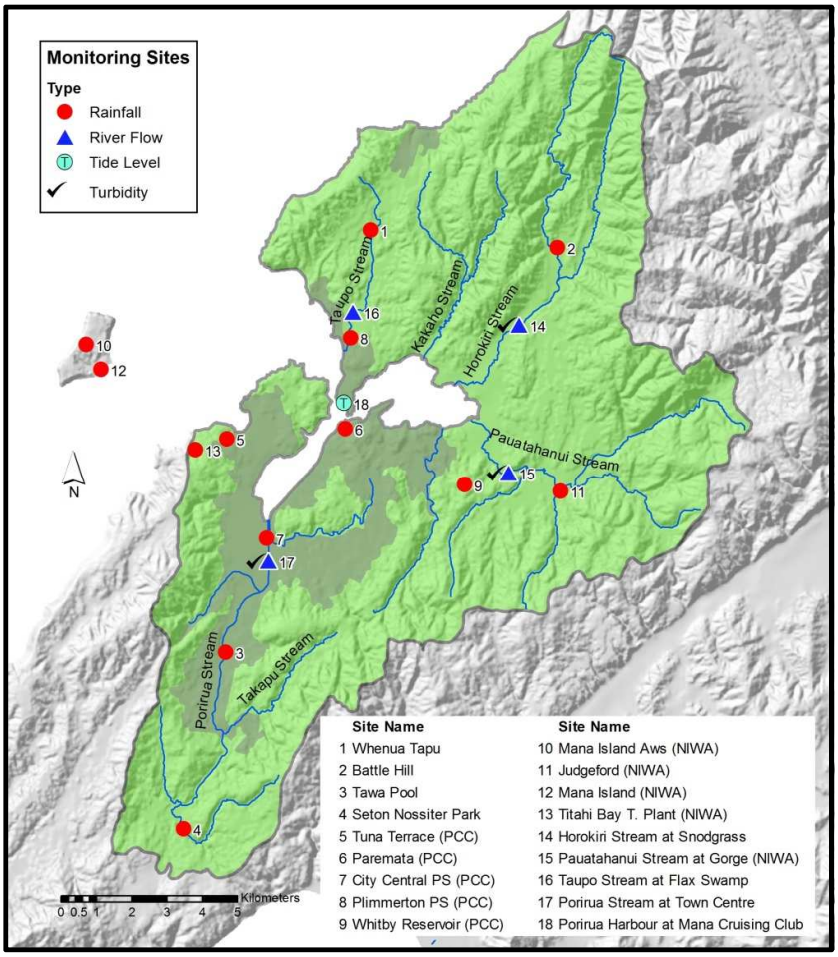

Figure 4: Location of rainfall, turbidity, river flow and tide level sites in Te Awarua-o-Porirua Whaitua.

More in-depth information can be found on the LAWA site, such as rainfall at a particular site in the last 24 hours or averaged over the last 12 months, as well as live flow data.

Total rainfall throughout the Whaitua is approximately 0.25 billion m^3 per year with runoff to the sea about half that figure. The mean annual rainfall varies across the catchment from 1000-1200mm in the west to 1200-1400mm in the east.

Variations in river flows are controlled by both rainfall and catchment characteristics such as geology and vegetation cover. In the Wellington region, most rivers/streams have a high flow during winter and low

flow during summer. In summer 2014/15 (prior the May flood), Porirua Stream (at the Town Centre) recorded a peak flow of 14 m^3/s (average highest flow for entire year was 35 m^3/s).

Flood warning alarms were triggered four times in Porirua Stream in 2012/13 and twice in 2013/14 all at Porirua town centre (Harkness et al 2013, Harkness 2014). In May 2015, flooding occurred throughout Porirua and Tawa (and the wider Wellington region) with 144 mm of rainfall recorded over a 24 hour period which equates to a one in 50 year rainfall event. Porirua Stream peaked at 66 m^3/s of water flow; the third largest flow since the 1976 flood which was a 1 in 15 year rainfall event. Damage from the flooding was primarily the result of the stormwater system being unable to cope with the intense rainfall that occurred and significant streambank erosion, including damage to streambank protection infrastructure.

GWRC publish quarterly and annual hydrological summaries that provide an overall picture of recent trends in rainfall and river flow (http://www.gw.govt.nz/quarterly-hydrological-summaries/). Rainfall and river levels for each region are also available, almost instantly on its website (http://graphs.gw.govt.nz/).

4. Water take in the Whaitua

GWRC are responsible for managing water take throughout the region and do so through issuing resource consents. All consented water taken is surface water (that is water directly from streams or tributaries). Not all water takes are metered, therefore the actual amount of water removed is largely unknown (Keenan et al 2012) and may not reflect that allocated. There are steps being taken to expand water metering.

Until now there have been no limits in the Regional Plan governing the allocation and use of fresh water in the Whaitua. Applications for resource consent to take water have been assessed on a case by case basis, taking into account the likely sustainability of the take and impact on stream ecosystems. Information on current water resource consents held by GWRC to date is listed in Table 1.

Table 1: List of resource consents currently held by Greater Wellington Regional Council for water take from streams and tributaries in Te Awarua-o-Porirua Whaitua.

Consent Number	Consent Holder	Location	Purpose	Maximum take rate (L/s)
WGN140309	NZTA	Pauatahanui Golf Course,	irrigation	1.7 L/s (until 2016) 0.9 L/s (until 2024)
WGN090221	Pikarere Farm Limited	Pikarere Street, Titahi Bay,	stock and domestic use	0.91 L/s (until 2019)
WGN120031	Leacroft Nurseries Limited	Horokiri Stream, 169 Paekakariki Hill Road,	horticultural irrigation	1.8L/s (until 2021)
WGN090021	Judgeford Cleanfill Limited	Pauatahanui Stream, 346C Paremata Haywards Road,	irrigation of pasture and dust control associated with the operation of a cleanfill.	1.71 L/s (until 2018)
WGN120062	Judgeford Golf Club	Pauatahanui Stream, 328 SH 58	irrigation	12.2 L/s (until 2022)
WGN060086	Porirua City Council	Whitby Lakes, Discovery Drive, Whitby	eradication of pest fish and plant species	Until Nov 2015

There are no on-stream storage or hydro generation schemes on water courses in the Whaitua, nor does it contain any significant groundwater aquifers. The three main streams have modest summer flows and do not support large water takes (Table 1). Water take in this Whaitua is relatively low compared to other Whaitua. Water use is managed via default rules such as "allocation from a stream must not exceed 30% of the mean annual low flow" (Thompson 2014) and is done on a case by case basis.

4.1 Groundwater bores and wells

Groundwater (water found underground in the cracks and spaces in soil, sand and rock) is a limited resource in the Whaitua, and while there are no resource consents for groundwater take, there are a few bores and wells (Fig. 5). It is unknown a) whether any water is taken from these bores and wells, and b) if it is, how much. Some of the bores are quite shallow (less than 10 m deep) indicating they may have been used to see if there was any groundwater available or to estimate the depth for building.

It should be noted that groundwater and surface-water bodies (streams, lakes, wetlands, and estuaries) interact in many ways. For example, wetlands may gain water from groundwater systems while water take from streams may reduce groundwater availability. Contamination of surface-water bodies can cause degradation of ground-water quality and vice versa.

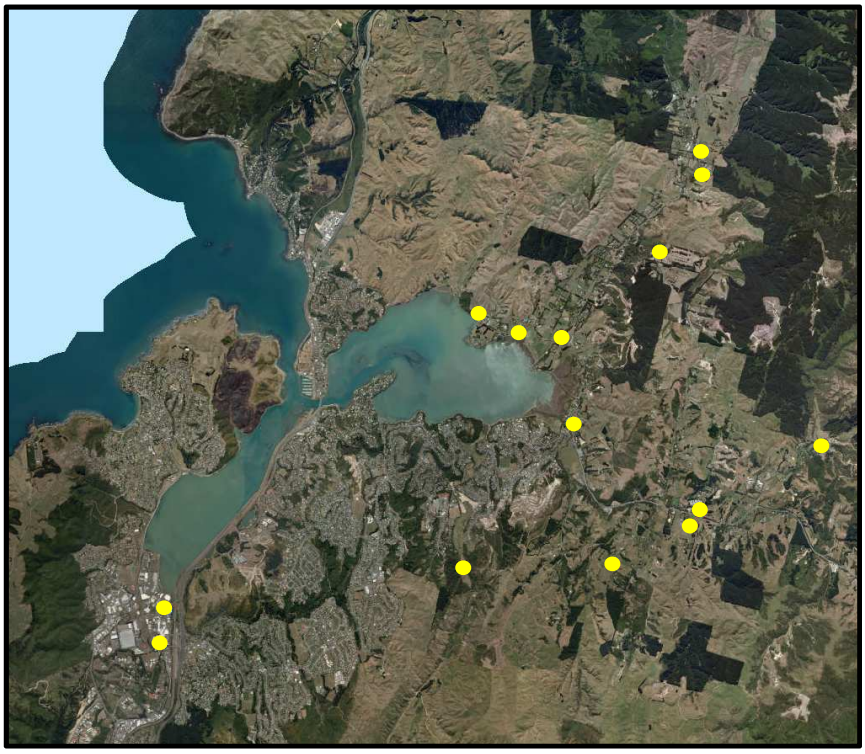

Figure 5: Map showing location of known bores and wells (yellow dots) in Te Awarua-o-Porirua Whaitua.

5 Water take and effect on activities

The rivers, streams, lakes and groundwater systems of the Wellington region support a wide range of activities, including ecological, cultural and recreational activities as well as having an aesthetic appeal for the public (Keenan et al 2012).

There is a direct interaction between stream flows and the health of that waterbody. Water take may put pressure on a stream by reducing the amount of water available for ecological systems and habitats, recreational and cultural activities and other in-stream uses and values. There can also be conflict between activities carried out on waterbodies. Decreased flows may lead to deterioration of water quality and habitat while high flows help flush streams preventing a build-up of contaminants and nuisance algae.

5.1 Potential impacts of low water flow on streams

Low flows occur naturally but can be worsened by water take. Demand for water take typically occurs during dry periods over summer when streams are naturally at their lowest. Taking water from a stream/river reduces water levels and changes natural flow patterns. Consideration must be given to the amount of water needed to support a 'healthy' ecosystem.

There are a number of impacts of low flow, both direct and indirect. Direct impacts include:

- reduced water depth and velocity (function of flow and stream size)
- reduction in habitat
- decrease in species abundance and diversity
- changes in sediment accumulation
- increased water temperature
- decreased dissolved oxygen
- less dilution of contaminants such as nutrients (nitrogen and phosphorous), particularly from dry-flow stormwater discharges

There are also indirect impacts such as increased algal growth due to increased water temperature and nutrient levels. Greater algal growth may change levels of dissolved oxygen and pH, smother streambed habitat and food sources and modify the invertebrate community.

There is anecdotal evidence that uncontrolled summer extraction from the Horokiri Stream is resulting in significant and adverse impacts on instream and amenity values, as well as difficulty for other users (Keith Calder, PCC, *pers. comm.*)

5.2 Potential impacts of high water flow on streams

High water flows can also have impacts; some good and some bad. Many fish species require both low and high water flows for various parts of their life cycle. High water flows can:

- increase water depth and velocity
- keep contaminants, such as sediment, suspended longer so they are flushed downstream
- aerate the water better (higher levels of dissolved oxygen)
- result in lower periphyton (slime) cover
- negatively affect introduced species, such as trout
- cause stream bank erosion and scouring affecting the stream channel/width, and can add to infilling of the Harbour

- disturb the stream bottom
- prevent aquatic plants from taking root
- capturing and transporting streambank litter
- produce critical flows for native fish spawning in ephemeral streams.

The variation in water flows, alternating between low and high, can support a greater diversity of species.

The recent May flooding resulted in stormwater outlets in the lower Porirua Stream being overwhelmed and blocked by aggregating levels of shingle bedload. This resulted in surface flooding in the Porirua CBD because of the inability of water to drain away. At the beginning of September 2015 GWRC undertook to remove 3500m^3 of shingle that had accumulated since the last shingle extraction in 2000 – a 14 year period. The elevated bed level increased the risk of overtopping and flooding of the Porirua CBD.

6. Flood detention and other mitigation strategies

Flooding is the most frequently occurring hazard affecting Porirua City. Causes include increased water from streams in the Whaitua as well as localised flooding of overflowing stormwater and sewer systems (particularly after very heavy rain) and coastal flooding during storms. Flood detention structures have been built and other mitigation solutions undertaken in the Whaitua as part of flood control measures, including:

- Stebbings flood detention dam (Fig. 6) at Churton Park to control flooding along Porirua Stream
- Debris arrestor situated on the Porirua Stream along Glenside
- Seton Nossiter Park flood detention dam in Paparangi
- Cannons Creek Lakes Reserve (more detail in section 1.5.5) (current status uncertain)
- Stream bank protection undertaken such as that along the Belmont stream, one of the few remaining natural lowland streams left in Wellington, and the tidal reach of the lower Porirua Stream
- Takapu Stream flood detention upstream of SH1.

Figure 6: Stebbings Stream flood detention dam at Churton showing the energy dissipation structure at the outlet prior flooding (photos S. Miller) and after flooding in May 2015 (photos K. Neill).

7. Future water availability

As part of the current Regional Plan review, GWRC is putting forward interim extraction limits of 50% and 30% of mean annual low flow (MALF) for rivers and streams, respectively. For rivers and streams in which these limits are already exceeded, GWRC is recommending no further allocation be allowed. This means that opportunities for abstraction of 'new' water from rivers, streams and directly-connected groundwater (considered as surface water) will be limited. This will not have significant effects on existing users. Under the existing Regional Freshwater Plan many rivers and streams in the greater Wellington region are currently already fully allocated. It is expected that limits will remain 'interim' until the Whaitua committees develop numerical catchment-specific limits on the basis of catchment values and levels of acceptable change.

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9. References

Links to many of the references listed here can be found on the Porirua City Council (PCC) website under publications for Porirua Harbour and Catchment Management http://www.pcc.govt.nz/Publications/Porirua-Harbour-and-Catchment-Management-Programme#research

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