



Annual hydrology monitoring report for the Wellington region, 2009/10

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Annual hydrology monitoring report for the Wellington region, 2009/10

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1. Introduction

Knowledge of hydrological patterns and trends is vital for achieving sustainable management of water resources. Greater Wellington Regional Council (Greater Wellington) carries out a hydrological monitoring programme that includes a hydrometric network for measuring rainfall, river flows, groundwater levels and lake levels. The information gathered is important for:

- Detecting long and short-term trends in climate and water resources;
- Providing warning of floods and droughts;
- Policy and plan development and review; and
- Resource consent monitoring.

This annual hydrology monitoring report, covering the period 1 July 2009 to 30 June 2010, describes the existing surface water hydrometric network and major changes to the network during the year. It also provides an overview of the trends in rainfall, river flows, lake and wetland levels and notable hydrological events of the year. A report containing an analysis of long-term trends is produced every six years (e.g., Watts 2005).

This 2009/10 annual report covers surface water hydrology only; for information on the groundwater monitoring programme and trends in groundwater levels during 2009/10 see Tidswell et al. (2010).

2. Overview of the hydrological monitoring programme

The objectives of Greater Wellington's hydrological monitoring programme are to:

- Provide information on the baseline quantity of surface water;
- Assist in the detection of spatial and temporal trends in surface water quantity;
- Provide information to help develop regional policies and plans, and assess resource consent applications; and
- Provide information to help determine the effectiveness of regional policies and plans.

Greater Wellington's current monitoring network consists of 47 automatic rainfall sites, 42 automatic river level and 11 automatic lake or wetland level monitoring sites (Figures 2.1 to 2.3; see Appendix 1 for site details). Some of these sites are also equipped to monitor climate and soil parameters (such as air temperature, wind speed, soil temperature and soil moisture), and water quality parameters (such as water temperature); the five soil moisture sites shown in Figure 2.3 are those that are regularly reported on by Greater Wellington.

In addition to the 47 rainfall sites referred to above, a further seven rainfall sites in and around Wellington City – that are owned by the city council – are operated by Greater Wellington according to the same hydrometric standards (these additional sites are also shown in Figure 2.1). See section 2.1 for a list of these new sites.

River level is converted to river flow using a rating curve. However, some of the river level monitoring stations have rating curves that are only accurate for high flows or low flows, as indicated in Appendix 1. NIWA also operates a network of river flow monitoring sites in the Wellington region, some of which are partly funded by Greater Wellington (Figure 2.2). Flow data from the co-funded sites are included in this report where appropriate, to provide an indication of regional river flow patterns.

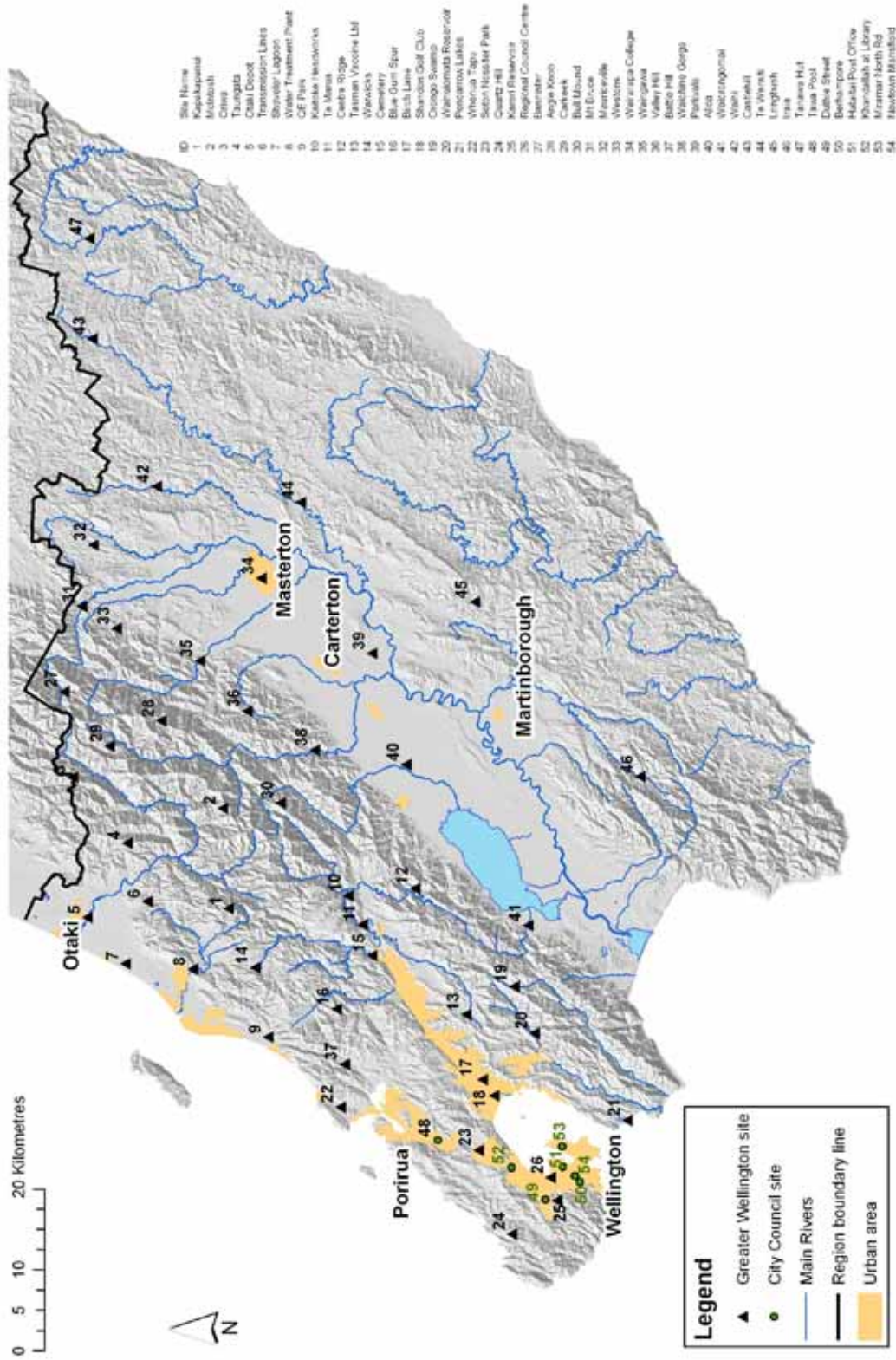


Figure 2.1: Location of Greater Wellington's automatic rainfall monitoring sites

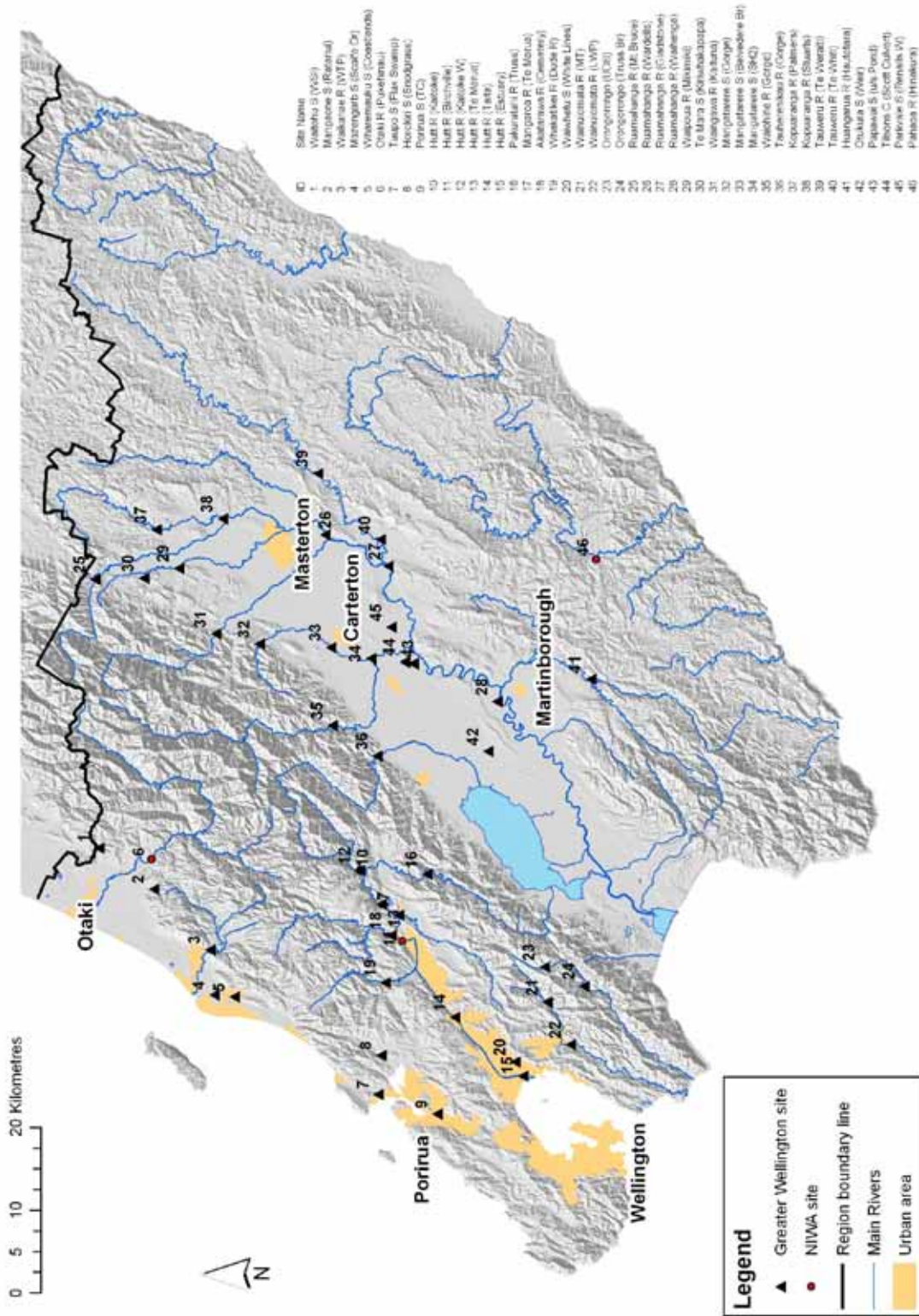


Figure 2.2: Location of automatic river level monitoring sites

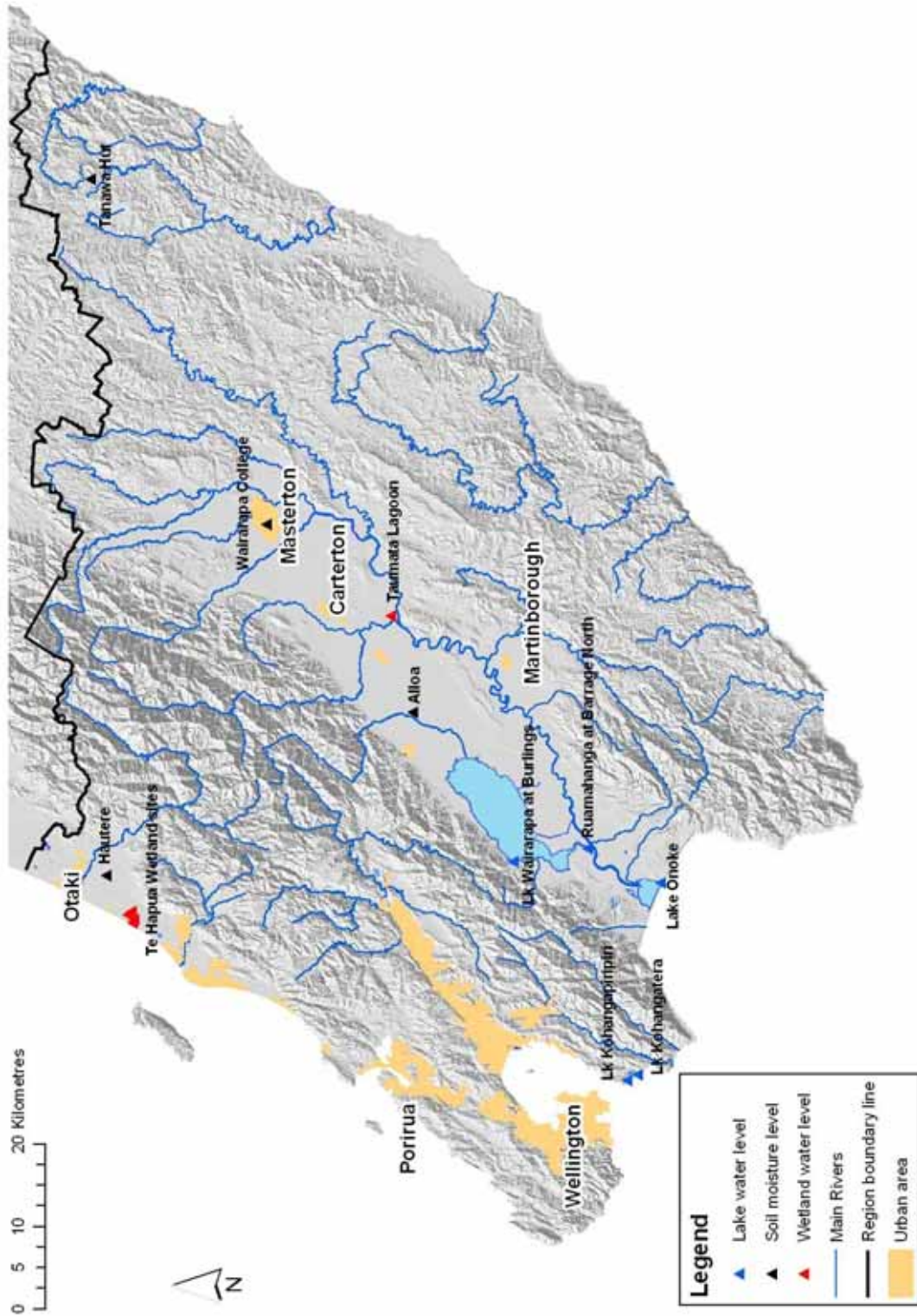


Figure 2.3: Greater Wellington's automatic lake/wetland level monitoring sites and selection of soil moisture monitoring sites that are reported on regularly

2.1 Hydrometric network changes in 2009/10

The following major changes¹ to Greater Wellington's surface water hydrometric network were made in 2009/10:

- Rainfall station 'Phelps' in the Waiohine River catchment was closed in January 2010.
- Rainfall station 'Centrepont' in the Mangaone Stream catchment was closed on 11 August 2009.
- Rainfall station 'Snodgrass' in the Horokiri Stream catchment was closed on 4 June 2009 and replaced with station 'Battle Hill' on 30 March 2010.
- River flow stations were established on the Kopuaranga River at 'Stewarts' in August 2009, and on the Mangatarere Stream at SH2 and Taueru River at Te Whiti Road Bridge in September 2009.
- A new water level monitoring station was established at Taumata Lagoon (also known as Taumata Oxbow Lake and situated near the confluence of the Waiohine and Ruamahanga rivers) in April 2010.
- A new soil moisture monitoring site at Hautere near Otaki was opened on 26 January 2010.

In addition, from mid-October 2009, Greater Wellington assumed responsibility for the operation and regular maintenance of the following rainfall stations for Wellington City Council:

- 'Tawa Pool' (site opened 29 August 1996)
- 'Duthie Street' in Karori (site opened 8 October 1990)
- 'Berhampore at Nursery' (site opened 29 July 1996)
- 'Hataitai at Old Post Office' (site opened 25 February 1997)
- 'Khandallah at Library' (site opened 29 August 1996)
- 'Miramar at Miramar North Road' (site opened 4 October 2004)
- 'Newtown at Mansfield St' (site opened 11 September 1996)

¹ Major changes are sites being opened or closed. Other changes such as equipment replacements are not listed here.

3. Overview of hydrological conditions in 2009/10

Overall, 2009/10 was drier than average in central and western parts of the Wellington region and about 'average' in the Wairarapa. While there were no particularly significant region-wide droughts or floods there were some notable wet and dry spells and some unusual weather events. To indicate how hydrological conditions varied over the year compared to average, the monthly rainfall totals and monthly mean river flows, soil moisture levels and lake levels are tabulated along with the long-term means in Appendix 2. Figures 3.1 to 3.4 summarise the results for selected monitoring stations.

3.1 Rainfall and river flows

The mid-winter months of June and July 2009 were unusually dry across the Wellington region. July was particularly dry with Wellington City and Wainuiomata receiving less than half the long-term average rainfall for this month. Furthermore, up to one half of the rainfall for the month fell on 23 July when a strong northwesterly airflow brought relatively brief but heavy rainfall. This rainfall mostly affected the Tararua Range, Hutt Valley, and Wairarapa and brought river levels up to flood magnitudes in these areas (see Section 4). While rainfall climbed back up to average levels during August across most of the region, the weather was remarkably settled and warm for the time of the year. The settled spells of weather were punctuated by a few north or northwesterly storm events that mainly affected the west of the region, including one notable storm on the 30–31 August (see Section 4).

The settled weather continued into September 2009. Average to slightly above average rain fell on the Kapiti Coast and around Wellington City during September but rainfall was below average elsewhere in the region and there were no significant storms or high flow events. However, the second half of this month saw periods of strong northwesterly winds, and a deep wintery low from the south brought snow to the Tararua and Rimutaka ranges on 24 September.

The relatively dry winter and early spring came to an end in October 2009 with higher than average rainfall throughout most of the Wellington region. Rainfall in eastern Wairarapa and southern parts of the Wellington region – such as Wellington City, Lower Hutt, Wainuiomata and the southern Wairarapa plains – was up to double the long-term average for the month. This was due to an unusually high frequency of southerly fronts during October, which also led to record-low average temperatures for the month. The most significant rainfall events for the month occurred on 8-9 October and 15-16 October. Particularly heavy rainfall around Lower Hutt on 16 October caused surface flooding and high flows in the Waiwhetu Stream (Section 4). Higher than normal rainfall continued through November and December on the Kapiti Coast – to the extent that mean flow in the Waikanae River during December was higher than for any other December on record – but was below average elsewhere in the region.

January 2010 was extremely wet for the time of year in parts of the Wairarapa. Up to five times the average January rainfall fell around Masterton and the

eastern hill country as a result of a predominantly easterly airflow and a succession of storm events in the second half of the month. Mean monthly river flows reached record January highs and the largest floods of the year were recorded in some of the eastern Wairarapa rivers (e.g., the Pahaoa and Whareama rivers). Rainfall was also well above average in central and western parts of the Wellington region.

February marked the start of a dry spell across the region that persisted well into autumn. March was particularly dry in the west and south with parts of the Kapiti Coast and areas around Wellington City receiving half their normal monthly totals. April was exceptionally dry in eastern Wairarapa with some areas receiving less than a quarter of their normal rainfall. Monitoring sites at Tanawa Hut in the north eastern hill country and Longbush, southeast of Masterton, recorded their lowest April rainfall totals since records began 65 and 100 years ago, respectively. On the Wairarapa plains, the Alloa monitoring site recorded its driest April on record since 2001, and third driest since monitoring began in 1963. Only the Tararua Range received about average rainfall through the summer and early autumn, which helped maintain baseflow in rivers with their headwaters in this mountain range.

Brief respite to the dry conditions occurred in late April when a series of southwesterly fronts brought heavy rainfall to most parts of the region. However, settled, dry weather returned in early May leading to the second longest unbroken flow recession of the year in many rivers and below average flows for most of the month. Despite this, monthly rainfall totals in some areas were up to almost three times the long-term May average because of a series of south-easterly fronts associated with a complex low that swept across the region from 23 May onwards. The east and south Wairarapa and Porirua district were exceptionally wet; Castlepoint received its highest May rainfall in 25 years while Porirua City endured an estimated 1 in 10 year cloudburst (see section 4).

For most of the Wellington region June was a wet month. In the Wairarapa and central parts of the region (Wainuiomata and the Hutt Valley), rainfall was generally 25% to 50% higher than average for June. On the southwest coast and in localised parts of the Wairarapa, rainfall was 50% to 100% higher than average. Monitoring stations in Wellington City, Wainuiomata and Masterton recorded rainfall on about three out of every four days in the month.

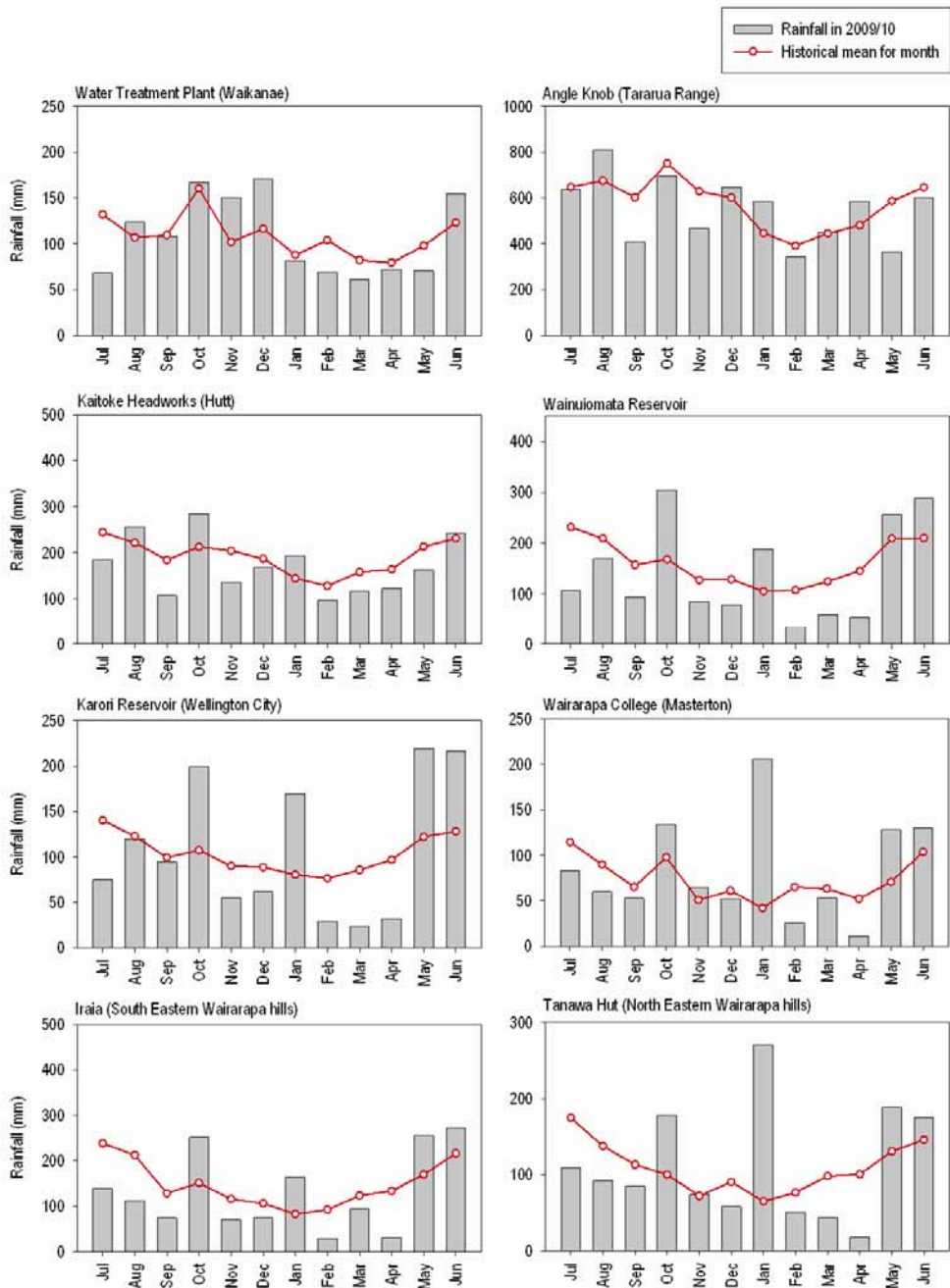


Figure 3.1: Monthly rainfall totals for 2009/10 (grey bars) compared to long-term mean monthly rainfall (red line) at selected rainfall monitoring locations in the Wellington region

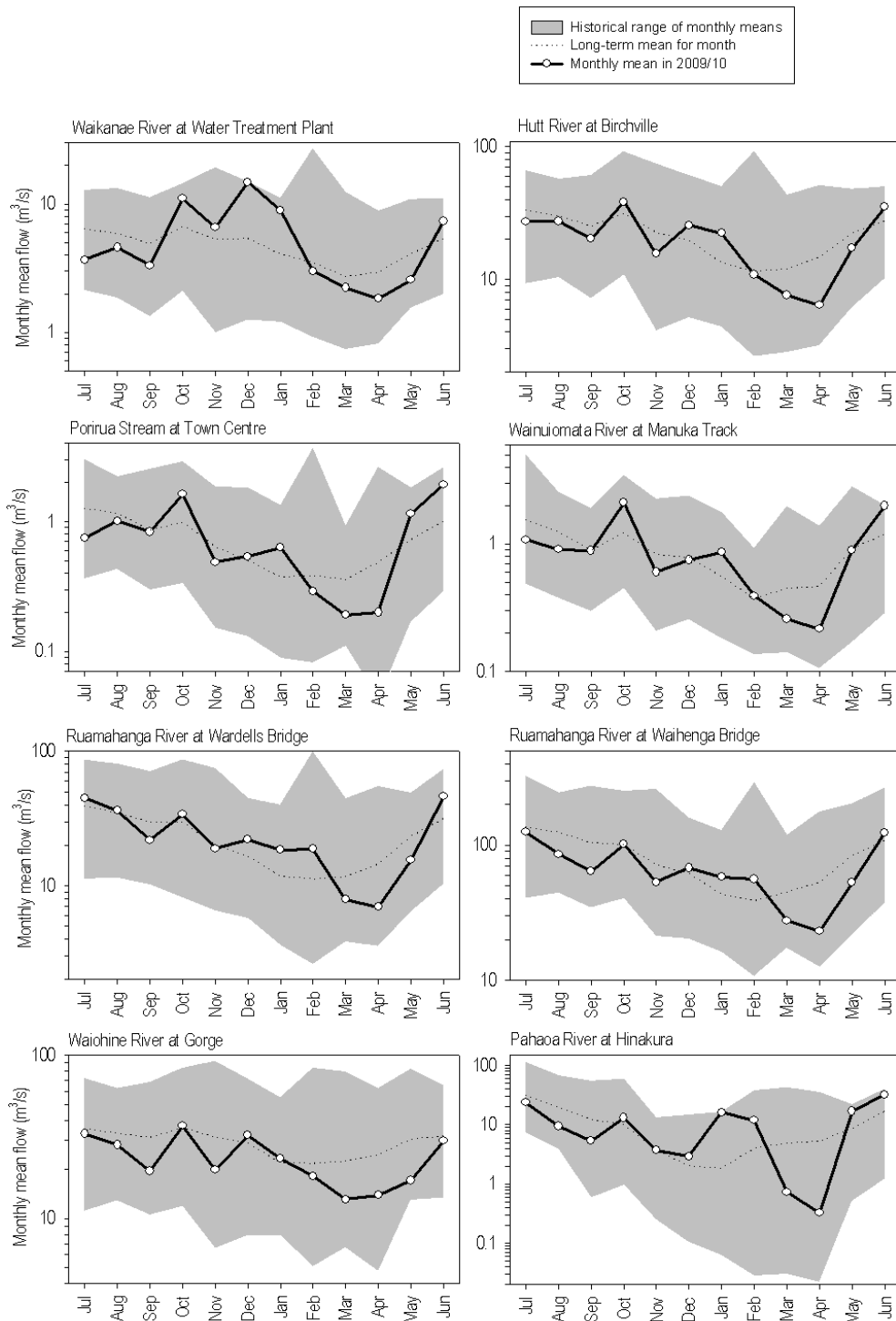


Figure 3.2: Monthly mean river flows for 2009/10 (black line) compared to long-term mean monthly river flows (dotted line) at selected monitoring locations in the Wellington region. The grey shaded area represents the historic range of monthly means. Note the logarithmic scale on the vertical axes.

3.2 Soil moisture in the Wairarapa

Greater Wellington monitors soil moisture at several locations in the Wairarapa, although generally the records are short and are therefore not suitable for long-term analysis. However, data from two sites – Alloa (near

Featherston) and Tanawa Hut (in the northeastern hill country) – are presented in Figure 3.3 to provide an indication of patterns in soil moisture during 2009/10 compared with recent years. After rapid drying out through December, the exceptionally wet January in the Wairarapa brought soil moisture back up to near winter levels. This peak was followed by a gradual reduction in soil moisture that progressed –largely uninterrupted – until the end of May as a result of three consecutive months of below average rainfall.

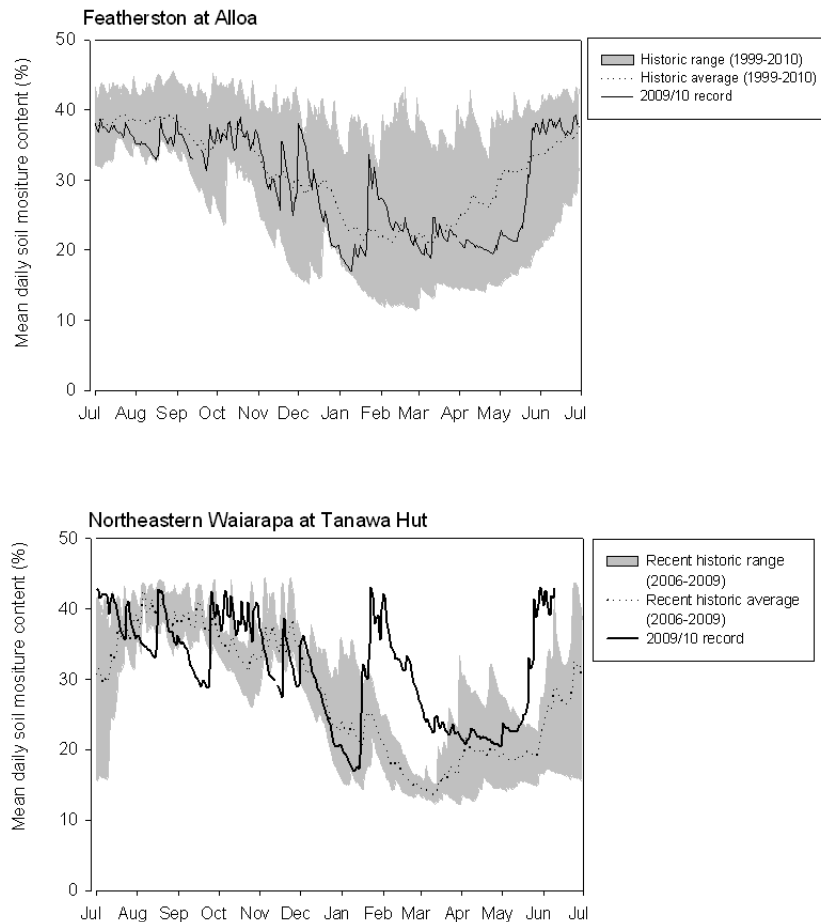


Figure 3.3: Mean daily soil moisture levels during 2009/10 at two monitoring sites in the Wairarapa: Alloa on the Wairarapa Plain near Featherston (top) and Tanawa Hut in the northeastern hill country (bottom). The 2009/10 record is compared to historic mean and range data for each site (note the amount of historic data available is limited, especially for Tanawa Hut).

Had the unseasonable rain not occurred in January, then the soil moisture deficit later in the summer and autumn could have been much greater across the district and created a more widespread problem for farmers. Even still, significant deficits were experienced in some areas, for example, Martinborough experienced 145 days with significant soil moisture deficit between December and May. While this is notable, higher numbers of exceedance days have occurred in Martinborough in three of the last ten years. Nevertheless, a medium-level drought was declared for the eastern Wairarapa by the Minister of Agriculture at the end of May 2010.

3.3 Lake Wairarapa and Lake Onoke

The monthly mean water levels in Lake Wairarapa followed a more or less typical pattern through the July 2009–June 2010 year with no record minima or maxima. The monthly mean level for August and September 2009 was below average due to lower than normal river flows; the Tauherenikau River, which flows directly into Lake Wairarapa and is one of the main sources of replenishment for the lake, was flowing at about 70–80% of its normal rate for this time of year.

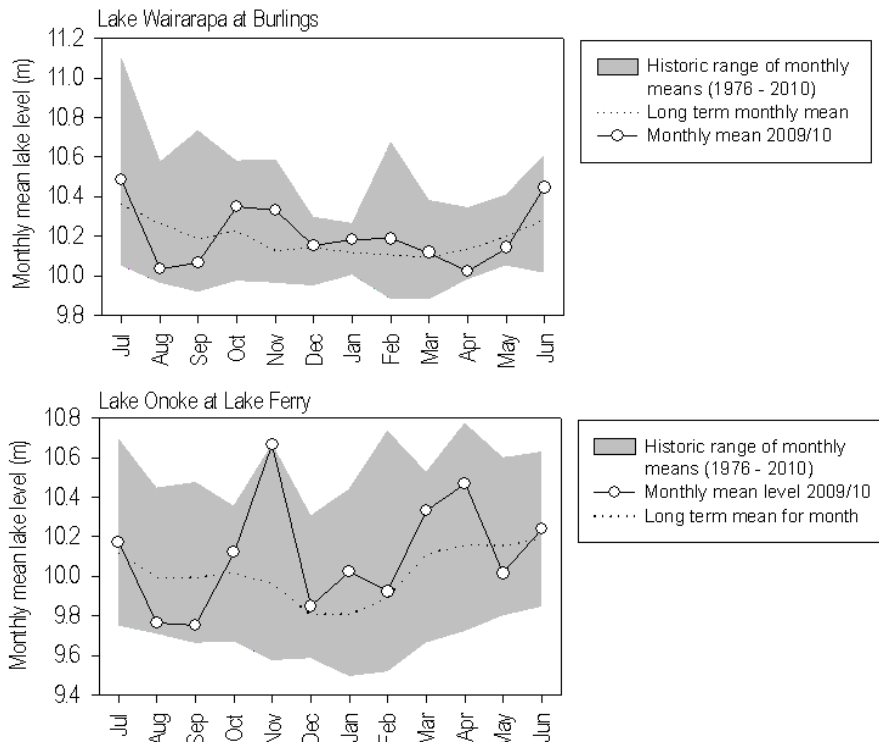


Figure 3.4: Mean monthly water levels in Lake Wairarapa (top) and Lake Onoke (bottom) during 2009/10, compared to long-term monthly mean levels (dotted lines)

Lake Wairarapa levels in October and November were higher than average for the time of year due to back-flow from Lake Onoke. Between December 2009 and March 2010 mean monthly lake levels were about average, or slightly higher, but fell below average in April and May due to the prolonged dry spell and reduced input from tributary rivers and streams.

Compared with Lake Wairarapa, Lake Onoke experienced some more notable departures from the long term mean, particularly in late winter / spring of 2009. Water level was well below average in August and September, reflecting the reduced inflow during a drier than normal winter and the lack of large southerly sea swells in Palliser Bay during this period (that would normally have closed the lake mouth). By contrast, lake levels reached a record high for November. The high levels were the result of the lake mouth being closed for longer than usual; the combination of low flows in the Ruamahanga River and a relatively persistent ocean swell prevented breaching of the gravel bar across the lake mouth.

3.4 Te Hapua Wetland

The Te Hapua wetland complex, near Te Horo, is an important remnant of “the Great Swamp” that spanned over 2,000 hectares of the Kapiti Coast from Paekakariki to Foxton. In autumn 2009, Greater Wellington, in consultation with Kapiti Coast District Council and the local community, installed monitoring equipment at four locations in the wetland complex to gather data on surface and ground water as well as rainfall. The aim of data collection is to help improve our understanding of natural hydrological variability as well as how activities on the land nearby may affect the wetlands.

Early results from hydrological monitoring at two locations approximately 800 m apart – ‘Jill and Joy’s Lagoon’ and ‘Shoveller Lagoon’ – are shown in Figure 3.4 and illustrate the clear correlation between the wetland open water and shallow groundwater levels that occurred at all sites throughout the year. A strong seasonal pattern of peak water levels in spring followed by summer recession to an autumn low was apparent, with groundwater and lagoon water levels converging towards the end of summer as a regional equilibrium was reached. However, some differences were also apparent, indicating local scale variability in hydrology. For example, the change in water level between the spring high and autumn low was noticeably higher at Jill and Joy’s Lagoon (0.8 m) compared with Shovellers Lagoon (0.5 m).

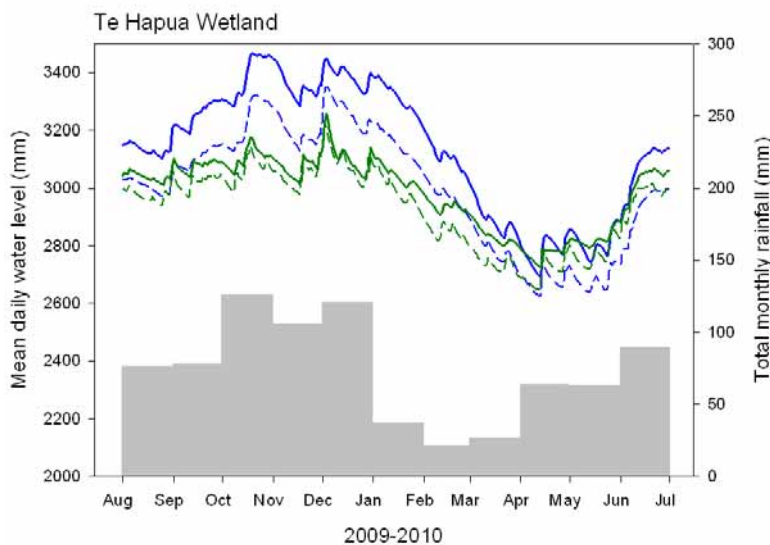


Figure 3.4: Mean daily open water and shallow groundwater levels at two sites at Te Hapua Wetland during the period July 2009 to June 2010: ‘Jill and Joy’s Lagoon’ (blue) and ‘Shoveller’s Lagoon’ (green). Solid lines show wetland water levels, dashed lines show shallow groundwater levels. Monthly total rainfall at Shoveller’s Lagoon is shown as the vertical grey bars.

More detailed analysis of the wetland hydrology is reported by Allen (2010), who suggests that the Te Hapua complex can be broadly split into an ‘eastern band’ and ‘western band’ of wetlands. The eastern wetlands (including Jill and Joy’s and Shoveller’s lagoons) are thought to be predominantly recharged by rainfall while the western wetlands are more likely to be recharged by shallow groundwater. It is the latter type of wetland that is most vulnerable to activities such as groundwater abstraction and land drainage.

4. Heavy rainfall and floods of 2009/10

One of the functions of the Greater Wellington hydrometric network is to provide information about floods, both in real-time for flood warning and for reporting and trend analysis. Statistics for the heaviest rainfall events and largest floods during 2009/10 are provided in Tables 4.1 to 4.3 at the end of this section.

Greater Wellington operates a flood warning service for some of the major catchments of the region. Alarms are triggered when rainfall exceeds a certain depth over a certain duration (e.g., 20 mm within 2 hours), or when a certain river level is reached (see Table A3.1, Appendix 3). The river level alarms that were triggered during the year are listed in Table A3.2, Appendix 3. There were a similar number of storm events that triggered river level flood warning alarms in 2009/10 (16 events) as in 2008/09 (18 events) but more than in the previous year (13 events in 2007/08). Most of the flood warning alarms for 2009/10 were triggered between July and December 2009.

4.1 July 2009

The first notable storm of 2009/10 occurred on 23 July 2009 and turned out to be the most significant event of the year with respect to river flows. A strong northwesterly airflow brought relatively brief but heavy rainfall that mainly affected the Tararua Range, Hutt Valley and Wairarapa.

One third to half of July's rainfall was received during this storm event. Rainfall was particularly significant over durations of 6 to 12 hours for sites in both the western and eastern Tararua Range and in Upper Hutt, with estimated return periods of 2–5 years. More than half of the rivers that Greater Wellington monitors (17 out of 31) recorded their peak flow of the year during this event. Estimated return periods for the peak flows were generally around mean annual flood (two years) but up to five years for sites in the upper reaches of the Ruamahanga River. There was surface flooding in parts of the Hutt Valley, including reports of flooding from small streams such as Pinehaven Stream in Upper Hutt.

4.2 August 2009

While August was mainly very settled and warm for the time of year, a significant storm occurred on the last two days of the month. A strong northwesterly air flow brought very strong winds to the region as well as heavy rain that particularly affected the Tararua Range, Hutt Valley, Porirua and Wellington City. In some parts of the region, up to half of the month's rainfall was received during this event. Rainfall was particularly significant over medium durations of 12 to 24 hours at sites on the Kapiti Coast and in the the Hutt and Wainuiomata valleys. However, with the exception of the Hutt Valley (four years), estimated return periods were generally less than two years.

The event on 30–31 August 2009 triggered 15 river level flood warning alarms in rivers across the region, more than any other single event during the year. However, the highest peak flows of the year were recorded in only five rivers

during this event and were generally less significant than mean annual flood peaks.

4.3 October and November 2009

Particularly heavy rainfall around Lower Hutt on 16 October 2009 caused surface flooding and the highest flows of the year in the Wainuiomata River and Waiwhetu Stream. An estimated 2-year return period flood occurred in the Waiwhetu Stream; the flood peak of 13 m³/s at our monitoring site at White Lines East was the largest recorded at that site since October 2006.

Flood warning alarms were triggered at 11 river level monitoring sites on 28 November 2009. However, rainfall and the resulting peak flows were only significant in the Otaki River catchment; the McIntosh rainfall site at the head of the catchment recorded its highest 24-hour and 72-hour duration totals for the year while the Otaki River also recorded its largest flood of the year. Both the rainfall and flow events had estimated return periods of less than a mean annual event.

4.4 December 2009

Two notable storms occurred during December. The first, on 12 December, triggered alarms on the Hutt, Ruamahanga and Otaki rivers and the Waitohu Stream but did not result in particularly significant rainfall totals or peak flows in any of these catchments.

A second storm, on 27 December, was more focussed on the Kapiti Coast and the west and south-western Tararua Range. Particularly significant rainfall totals were recorded at the Waikanae Water Treatment Plant site and at 'Warwicks' (at the head of the Akatarawa catchment), although estimated return periods were less than two years (i.e., less than the return period of a mean annual event). Peak flows for the year were recorded for the Waitohu and Mangaone streams and the Waikanae River; the estimated return period for the peak flow of 54 m³/s in the Waitohu Stream was four years.

4.5 January 2010

As mentioned earlier in Section 3.1, January was an unseasonably wet month, especially in the eastern Wairarapa. This was the result of a predominantly easterly airflow and a succession of storm events. The first notable storm occurred on 4 January and affected mainly central areas around the Tararua Range. Year-high rainfall totals for short (1 hour) and long (48 hour) durations were recorded at two sites in the Tararuas (Angle Knob in the east and McIntosh in the west), although return periods were not particularly significant. High flow alarms were triggered on the Ruamahanga and Waiohine rivers but no flooding occurred.

On 15 January Wellington City's south coast experienced a heavy rainfall event that produced some significant totals (e.g., with return periods up to 6 years at the Karori Reservoir monitoring site) but, again, no flooding resulted in major rivers and streams.

Several heavy rainfall events occurred in the eastern Wairarapa between 20 and 31 January associated with slow moving frontal systems. Long duration (1–3 day) rainfall totals for sites between Castlepoint on the coast and Masterton were the highest for the year and had return periods of up to five years. The unseasonable nature of this rainfall meant that some monitoring sites received up to five times their January average. However, one of the most notable features of this stormy period was a downpour around Masterton that began on 28 January. At one stage, our monitoring site at Wairarapa College recorded a 1-hour total of 41.6 mm, a record high for a short duration event at this site and one which is estimated to have a return period of about 80 years². As a result of the heavy rainfall in late January, river levels in eastern Wairarapa rose several times and the Tauweru River alarm was triggered on 23 January. The peak flow in the Tauweru River at Te Weraiti of 137 m³/s was the highest for January since records began in 1969 and almost twice the previous January high. The Pahaoa River peak of 190 m³/s (at the Hinakura monitoring site) was the second highest for this river in the month of January since records began in 1986.

4.6 March and April 2010

On 12 March 2010, a fast-moving southerly front swept inland from the south coast. This front affected the Wairarapa and areas around Wellington City and brought very high winds, hail and driving rain. However, it was short-lived, did not produce any significant rainfall totals and resulted in only minor freshes in most waterways.

In the last two days of April a southwesterly front brought prolonged heavy rain to the eastern Tararua Range – the Angle Knob monitoring site at the head of the Waiohine River catchment recorded year-high 1 and 3-day duration rainfall totals – and shorter bursts to the Kapiti Coast and central districts. Rivers came up but peaked at less than mean annual flood levels.

4.7 May 2010

In the last week of May, a series of southeasterly fronts associated with a complex low brought bad weather to much of the region. The heaviest rainfall occurred on 24–25 May and many areas received year-high event totals including Featherston, the Hutt Valley and Porirua. For Porirua, the event was particularly exceptional as several slow-moving heavy rain cells were generated in a narrow convergence zone between two lows and tracked across the area. The rain gauge ‘Seton Nossiter Park’ at the head of the Porirua Stream catchment recorded 94 mm in 24 hours, which is estimated to be a one in 10 year event. The Porirua Stream responded with a one in seven year flood event, peaking at 50 m³/s. Surface flooding was reported in Tawa and Porirua City but no significant damage occurred.

4.8 June 2010

The most notable rainfall event of the month occurred on 6 June. This was a very localised event bringing a short downpour that affected only the Akatarawa catchment. The 1-hour duration total of 33 mm recorded at the

² Based on analysis using NIWA High Intensity Rainfall Design System (HIRDS v3) software

'Warwicks' raingauge at the head of the catchment was estimated to have a 20-year return period. However, no other monitoring sites in the Hutt Valley, Porirua or Wainuiomata areas registered any significant rainfall during this event and the Akatarawa River did not rise to flood flows.

Table 4.1: Maximum short-duration rainfall depths during 2009/10 at selected rainfall monitoring stations in the Wellington region

Site (Catchment/area)	1 hour		6 hours		12 hours	
	Depth and start date	Est. return period (years)	Depth and start date	Est. return period (years)	Depth and start date	Est. return period (years)
Water Treatment Plant (Waikanae)	26.5 mm 24 Mar 2010	5	36.5 mm 28 Nov 2009	<2	54.5 mm 30 Aug 2009	<2
QE Park (Paekakariki)*	19.5 mm 27 Apr 2010	2	41.0 mm 27 Apr 2010	<2	62.5 mm 30 Aug 2009	2
Warwicks (Akatarawa)	33.0 mm 12 Jun 2010	20	81.0 mm 27 Dec 2009	4	100.5 mm 30 Aug 2009	2
Te Marua (Upper Hutt)	19.0 mm 25 May 2010	<2	72.5 mm 23 Jul 2009	4	115.0 mm 30 Aug 2009	5
TVL (Mangaroa / Whitemans Valley)	23.5 mm 23 Jul 2009	3	60.5 mm 23 Jul 2009	4	77.0 mm 30 Aug 2009	4
Birch Lane (Lower Hutt)	16.0 mm 16 Oct 2009	<2	36.5 mm 30 Aug 2009	<2	63.0 mm 30 Aug 2009	<2
Wainuiomata Reservoir (Wainuiomata)	19.5 mm 27 Apr 2010	2	42.0 mm 26 Jun 2010	<2	64.5 mm 30 Aug 2009	<2
Seton Nossiter Park (Porirua)	16.0 mm 25 May 2010	<2	51.5 mm 25 May 2010	5	75 mm 25 May 2010	4
Karori Reservoir (Wellington City)	14.4 mm 23 Jan 2010	<2	43.0 mm 16 Jan 2010	2	71.6 mm 15 Jan 2010	6
McIntosh (W Tararua Range)	29.5 mm 12 Feb 2010	2	112 mm 23 July 2009	3	141 mm 23 July 2009	<2
Angle Knob (E Tararua Range)	43.5 mm 3 Jan 2010	2	178.5 mm 23 Jul 2009	5	248.5 mm 23 Jul 2009	<2
Waiohine Gorge [#]	28 mm 24 Mar 2010	5	79.5 mm 23 Jul 2009	5	99.5 mm 23 Jul 2009	3
<i>Wairarapa College (Masterton)*</i>	<i>41.6 mm 28 Jan 2010</i>	<i>80*</i>	<i>41.6 mm 28 Jan 2010</i>	4	<i>50.0 mm 22 Jan 2010</i>	3
Alloa (Featherston)	12.4 mm 24 Mar 2010	<2	35.0 mm 25 May 2010	2	41.0 mm 24 May 2010	<2
Castlehill (Tauweru)	14.5 mm 18 Nov 2009	2	59.5 mm 18 Nov 2009	n/a [^]	72.0 mm 17 Nov 2009	<2
Iraia (Huangarua)	25 mm 12 Mar 2010	5	34 mm 12 Mar 2010	<2	49.5 mm 24 May 2010	<2
Tanawa Hut (Whareama)	25.0 mm 27 Oct 2009	6	50 mm 27 Oct 2009	2	68.5 mm 22 Jan 2010	2

* Return periods estimated using HIRDS v3.0 (NIWA).

[#] Return periods estimated using 'Waiohine at Phelps' site that was closed in January 2010.

[^] Rain gauge thought to be over-reading during this month.

Italics indicate data that has not been quality assured.

Table 4.2: Maximum long-duration rainfall depths during 2009/10 at selected rainfall monitoring stations in the Wellington region

Site (Catchment/area)	24 hours		48 hours		72 hours	
	Depth and start date	Est. return period (years)	Depth and start date	Est. return period (years)	Depth and start date	Est. return period (years)
Water Treatment Plant (Waikanae)	55 mm 30 Aug 2009	<2	71.5 mm 27 Dec 2009	<2	81.5 mm 26 Dec 2009	<2
QE Park (Paekakariki)*	64.5 mm 30 Aug 2009	<2	64.5 mm 29 Aug 2009	<2	69.5 mm 6 June 2010	<2
Warwicks (Akatarawa)	109.5 mm 30 Aug 2009	<2	122 mm 27 Dec 2009	<2	145 mm 27 Dec 2009	<2
Te Marua (Upper Hutt)	138.0 mm 30 Aug 2009	4	139.0 mm 30 Aug 2009	3	140.0 mm 29 Aug 2009	2
TVL (Mangaroa / Whitemans Valley)	83.5 mm 1 July 2009	<2	103 mm 24 May 2010	<2	113 mm 24 May 2010	<2
Birch Lane (Lower Hutt)	66.5 mm 30 Aug 2009	<2	91 mm 24 May 2010	<2	98 mm 24 May 2010	<2
Wainuiomata Reservoir (Wainuiomata)	77 mm 26 Jun 2010	<2	85.5 mm 25 Jun 2010	<2	106.5 mm 25 May 2010	<2
Seton Nossiter Park (Porirua)	94 mm 25 May 2010	10	111.5 mm 24 May 2010	6	120.5 mm 25 May 2010	5
Karori Reservoir (Wellington City)	92.4 mm 1 July 2009	8	104.6 mm 15 Jan 2010	4	107.0 mm 15 Jan 2010	2
McIntosh (W Tararua Range)	167 mm 28 Nov 2009	<2	207.5 mm 2 Jan 2010	<2	217 mm 28 Nov 2009	<2
Angle Knob (E Tararua Range)	288 mm 29 Apr 2010	<2	345 mm 30 Aug 2009	<2	360.5 mm 27 Apr 2010	<2
Waiohine at Gorge#	119 mm 23 Jul 2009	<2	121 mm 23 Jul 2009	<2	129 mm 21 Jul 2009	<2
Wairarapa College (Masterton)*	<i>62.2 mm</i> <i>22 Jan 2010</i>	<2	<i>67.4 mm</i> <i>22 Jan 2010</i>	<2	<i>70.6 mm</i> <i>20 Jan 2010</i>	<2
Alloa (Featherston)	51 mm 30 Aug 2009	<2	59.8 mm 24 May 2010	<2	65.0 mm 24 May 2010	<2
Castlehill (Tauweru)	95.8 mm 31 Jan 2010	5	104.8 mm 31 Jan 2010	4	104.8 mm 30 Jan 2010	3
Iraia (Huangarua)	76.5 mm 25 May 2010	<2	86.0 mm 25 May 2010	<2	111.0 mm 25 May 2010	<2
Tanawa Hut (Whareama)	91.5 mm 22 Jan 2010	2	104.5 mm 21 Jan 2010	<2	116.5 mm 20 Jan 2010	<2

* Return periods estimated using HIRDS v3.0 (NIWA).

Return periods estimated using 'Waiohine at Phelps' site that was closed in January 2010.

Italics indicate data that has not been quality assured.

Table 4.3: Maximum river and stream flows during 2009/10 at river flow monitoring sites in the Wellington region^{3,4}

Site	Highest flow in 2009/10 (m ³ /s)	Date of occurrence	Estimated return period (years)
Waitohu S at Water Supply Intake	54	27 Dec 2009	3–4
Otaki R at Pukehinau*	859	28 Nov 2009	<2
Mangaone S at Ratanui	15	27 Dec 2009	2
Waikanae R at Water Treatment Plant	118	31 Aug 2009	<2
	115	27 Dec 2009	<2
Hutt R at Te Marua	390	23 July 2009	2
Hutt R at Birchville*	715	23 July 2009	2
Hutt R at Taita Gorge	774	23 July 2009	2
Pakuratahi R at Truss Bridge	108	23 July 2009	4
Mangaroa R at Te Marua	138	23 July 2009	<2
Akatarawa R at Cemetery	187	31 Aug 2009	<2
	172	04 Jan 2010	<2
Whakatikei R at Dude Ranch	47	31 Aug 2009	<2
Waiwhetu S at Whites Line East	13	16 Oct 2009	2
Wainuiomata R at Manuka Track	20	25 May 2010	<2
	19	16 Oct 2009	<2
Wainuiomata R at Leonard Wood Park	43	16 Oct 2009	2
Orongorongo R at Upper Dam Site	29	23 July 2009	2
Taupo S at Flax Swamp	5.6	23 July 2009	4
	5.5	31 Aug 2009	4
Horokiri S at Snodgrass	24	31 Aug 2009	n/a [#]
Porirua S at Town Centre	50	25 May 2010	7–8
Ruamahanga R at Mt Bruce	348	23 July 2009	4
Ruamahanga R at Wardells Bridge	598	24 July 2009	5
Ruamahanga R at Gladstone Bridge	938	24 July 2009	3–4
Ruamahanga R at Waihenga Bridge	910	24 July 2009	<2
Waipoua R at Mikimiki Bridge	147	23 July 2009	<2
Waingawa R at Kaituna	284	23 July 2009	2
Mangatarere S at Gorge	45	23 July 2009	<2
Waiohine R at Gorge	870	23 July 2009	2
Tauherenikau R at Gorge	302	23 July 2009	2
Kopuaranga R at Palmers	40	24 July 2009	<2
Tauweru R at Te Weraiti	137	23 Jan 2010	<2
Huangarua R at Hautotara	121	26 Jun 2010	<2
Pahaoa R at Hinakura*	210	25 May 2010	<2

*Data provided by NIWA but frequency analysis performed by Greater Wellington.

[#]Record not long enough for analysis.

³ For sites where the largest flood was within 10% of the second largest, both floods are listed. This accounts for error in flow measurement.

⁴ River level stations that are not rated for high flows are omitted from the table.

5. Dry spells and low flows of 2009/10

5.1 Periods of low rainfall

The minimum rainfall depths at selected rainfall monitoring stations over 14 and 28 day durations (Table 5.1) give an indication of the driest periods in 2009/10. January and February are usually the months with the lowest rainfall in the Wellington region. However, January 2010 was much wetter than average, as described in Section 3.1. As a consequence, the driest periods in 2009/10 tended to occur before or after this mid-summer period. While the shorter duration (14 day) rainfall minima were widely distributed between September 2009 and May 2010 for the various sites in Table 5.1 (due to localised climate variability), the last week of March was consistently signalled as the beginning of the more prolonged (28 day) dry spell across the region. The lowest 28 day rainfall totals occurred in central areas (Hutt Valley, Wainuiomata, Wellington City) and the Wairarapa.

Table 5.1: Lowest rainfall totals during 2009/10 for 14-day and 28-day durations at selected monitoring locations in the Wellington region

Site Name	14 days		28 days	
	Rainfall minima (mm)	Start date	Rainfall minima (mm)	Start date
Angle Knob (Tararua Range)	45.0	28 Mar 2010	194.5	25 Mar 2010
Waikanae Water Treatment Plant	0	24 Jan 2010	28.0	24 Mar 2010
Kaitoke Headworks (north Upper Hutt)	7.0	30 Oct 2009	30.0	28 Mar 2010
Shandon Golf Club (Petone)	1.0	12 Dec 2009 24 Mar 2010*	8.5	24 Mar 2010
Wainuiomata Reservoir	3.5	28 Mar 2010	14.0	24 Mar 2010
Karori Reservoir (Wellington)	2.4	12 Dec 2009	13.8	28 Mar 2010
Waiohine Gorge (Tararua foothills – Wairarapa)	6.5	2 May 2010	36.5	28 Mar 2010
Wairarapa College (Masterton)	1.6	19 Feb 2010	7.6	14 Apr 2010
Alloa (Featherston)	1.8	3 Sept 2009	11.2	28 Mar 2010
Tanawa Hut (NE Wairarapa)	0	4 Sept 2009	16.5	28 Mar 2010
Iraia (SE Wairarapa)	1.5	19 Feb 2010	15.5	28 Mar 2010

* There were two events with equally low 14-day duration rainfall totals for this site.

5.2 Low river flows

Rivers in the western part of the Wellington region tended to experience their lowest flows for 2009/10 during late March or April (Table 5.2), coincident with the period of lowest rainfall.

Table 5.2: Lowest 7-day and 28-day mean river flows during 2009/10 at monitoring stations in the western Wellington region. A return period of two years is generally equal to mean annual low flow (MALF), the average of the low flows on record.

Site Name	7-day duration			28-day duration		
	Lowest mean flow in 2009/10 (m ³ /s)	Start date	Estimated return period	Lowest mean flow in 2009/10 (m ³ /s)	Start date	Estimated return period
Waitohu S at WSI	0.185	6 Apr 2010	<2	0.266	26 Mar 2010	<2
Otaki R at Pukehinau*	5.362	7 Apr 2010	<2	8.006	26 Mar 2010	3
Mangaone S at Ratanui	0.060	20 Dec 2009	4	0.143	28 Mar 2010	<2
Waikanae R at WTP	1.109	17 Apr 2009	<2	1.432	30 Mar 2010	<2
Hutt at Birchville*#	2.944	18 Apr 2010	<2	3.638	30 Mar 2010	3–4
Hutt R at Taita Gorge#	3.373	18 Apr 2010	3	4.126	30 Mar 2010	4–5
Pakuratahi R at Truss Bridge	0.239	18 Apr 2010	2	0.292	30 Mar 2010	3–4
Mangaroa R at Te Marua	0.158	18 Apr 2010	15	0.418 [^]	7 Apr 2010	3–4
Akatarawa R at Cemetery	1.019	18 Apr 2010	2	1.170	30 Mar 2010	4
Whakatikei R at Dude Ranch	0.228	18 Apr 2010	6	0.255	30 Mar 2010	8
Wainuiomata R at Manuka Track	0.150	7 May 2010	3–4	0.174	30 Mar 2010	4
Wainuiomata R at LWP#	0.431	19 Apr 2010	<2	0.447	30 Mar 2010	<2
Orongorongo R at UDS	0.036	6 May 2010	2	0.045	28 Mar 2010	3–4
Taupo S at Flax Swamp	0.027	3 Feb 2010	n/a	0.036	15 Jan 2010	n/a
Horokiri S at Snodgrass	0.079	30 Mar 2010	n/a	0.083	28 Mar 2010	n/a
Porirua S at Town Centre	0.122	17 Apr 2010	3	0.142	30 Mar 2010	5

* Data provided by NIWA but frequency analysis performed by Greater Wellington.

Low flow likely to have been significantly affected by upstream abstraction.

[^] Data for the period 30 January to 7 April 2010 could not be included in this analysis.

In some of the monitored rivers, particularly many of those on the Kapiti Coast, the low flows were not significant (i.e., the mean annual low flow was not reached). However, in most rivers of the western part of the region the lowest flows of 2009/10 typically had an estimated return period of 3 to 5 years. The exceptions were the Mangaroa and Whakatikei rivers, both tributaries of the Hutt River and draining catchments located in the part of the region that experienced the driest weather of the summer. The minimum 7-day low flow that occurred on the Mangaroa River in April 2010 (0.158 m³/s) had an estimated return period of 15 years and was the third lowest flow for this river since records began in 1979. Overall, low flows in the western part of the region were similar in severity to 2008/09 but much less severe than 2007/08.

In stark contrast to the west of the region, rivers in the Wairarapa did not generally drop to significant low flows in 2009/10 (Table 5.3). While the lowest

Table 5.3: Lowest 7-day and 28-day mean river flows during 2009/10 at monitoring stations⁵ in the Wairarapa. A return period of two years is generally equal to mean annual low flow (MALF), the average of the low flows on record.

Site Name	7-day duration			28-day duration		
	Lowest mean flow in 2009/10 (m ³ /s)	Start date	Estimated return period	Lowest mean flow in 2009/10 (m ³ /s)	Start date	Estimated return period
Ruamahanga R at Mt Bruce	1.399	7 Apr 2010	<2	2.633	26 Mar 2010	<2
Ruamahanga R at Wardells [#]	3.706	7 Apr 2010	<2	5.012	27 Mar 2010	<2
Ruamahanga R at Waihenga Br [#]	13.092	7 Apr 2010	<2	18.668	31 Mar 2010	<2
Waipoua R at Mikimiki [^]	0.429	2 Apr 2010	<2	0.559	20 Apr 2010	3
Waingawa R at Kaituna	1.655	7 Apr 2010	<2	3.129	26 Mar 2010	<2
Mangatarere S at Gorge	0.178	20 Apr 2010	<2	0.292	1 Apr 2010	<2
Waiohine R at Gorge	4.513	7 Apr 2010	<2	7.945	22 Feb 2010	<2
Tauherenikau R at Gorge	1.834	18 Apr 2010	<2	2.563	31 Mar 2010	<2
Kopuaranga R at Palmers [#]	0.394	20 Apr 2010	<2	0.423	2 Apr 2010	<2
Otukura S at Weir [#]	0.121	5 Jan 2010	<2	0.140	3 Apr 2010	<2
Papawai S at U/S Oxi Pond [#]	0.140	5 Jan 2010	n/a	0.173	19 Dec 2009	n/a
Pahaoa R at Hinakura [*]	0.149	5 Jan 2010	<2	0.321	3 Apr 2010	<2

[#] Low flow likely to have been significantly affected by upstream abstraction.

^{*} Data provided by NIWA.

⁵ Only the river level sites that are rated for low flows are shown in the table.

flows of the year were again coincident with the particularly dry spell of late March and April, only one river, the Waipoua, experienced a low flow that was less than mean annual low flow. The Waipoua River typically recedes faster than most of the other large rivers in the Wairarapa. Overall, flow minima for rivers in the Wairarapa during 2009/10 were higher than they have been since at least 2005/06, and since 2003/04 in many cases.

5.3 Low flow restrictions

There are 12 rivers and streams listed in the Regional Freshwater Plan (WRC 1999) with low flow thresholds that trigger water take restrictions. Table 5.4 shows the number of days in 2009/10 that mean flow in each of these rivers was below the first (upper) flow threshold⁶, and compares this to the last two years. Of the 12 rivers and streams, only the Mangatarere Stream and Waingawa River in the Wairarapa had significant periods under the low flow threshold in 2009/10. Two streams on the Kapiti Coast dropped only briefly below the first threshold while all others remained above throughout the summer. This contrasts somewhat with 2008/09 when only three of the waterways did not drop to restriction levels for at least a week and greatly with 2007/08 when a drought saw most waterways under restriction flows for well over 50 days.

Table 5.4: Number of days in 2009/10 (and the previous two years) where mean flow was lower than the first restriction threshold for rivers specified in Greater Wellington's Regional Freshwater Plan

Part of the region	River and site	First low flow restriction threshold (m ³ /s)	Number of days below threshold		
			2007/08	2008/09	2009/10
Kapiti Coast	Waitohu Stream	0.18	89	42	1
	Otaki River	4.375	20	14	0
	Mangaone Stream	0.045	0	0	2
Wairarapa	Ruamahanga River	9.8	53	27	0
	Waiohine River	3.04	5	6	0
	Tauherenikau River	1.35	55	7	0
	Waingawa River	1.9	92	46	17
	Kopuaranga River	0.27	72	2	0
	Waipoua River	0.3	54	20	0
	Mangatarere Stream	0.33	116	90	46
Central and south	Hutt River	1.45	0	0	0
	Wainuiomata River	0.36	79	37	0

⁶ There are three thresholds for each river in the RFP to ensure an appropriate 'step down' in water abstraction occurs as flow drops; the highest threshold is when restrictions begin and the lowest – the minimum flow – is when abstraction must generally cease altogether.

6. Summary

Overall, 2009/10 was a little drier than average in central and western parts of the Wellington region and about average in the Wairarapa. While there were no particularly extreme region-wide droughts or floods there were some notable wet and dry spells.

The mid-winter months in 2009 were unusually warm, dry and settled across the region, leading to below average rainfall and river flows. Settled weather continued through September but came to an end in October 2009 with higher than average rainfall throughout most of the Wellington region. November and December were again relatively settled but January 2010 was extremely wet for the time of year, especially in the eastern Wairarapa where record rainfall totals were recorded. February marked the start of a three-month dry spell that, if it were not for the high January rainfall, could have resulted in significant and widespread soil moisture deficits in the Wairarapa. In May and June, persistent showery weather interspersed with some heavy downpours led to above average monthly rainfall totals and mean river flows.

A similar number of flood warning alarms were triggered in 2009/10 compared with the previous year, but there were no overly significant floods. Several storms – such as those around Masterton in January 2010 and Porirua in May 2010 – resulted in localised heavy rainfall. The storm on 23 July 2009 turned out to be the most significant event of the year with respect to river flows; more than half of the rivers that Greater Wellington monitors (17 out of 31) recorded their peak flow of the year during this event. However, estimated return periods for the peak flows were generally around mean annual flood (two years) and are not considered significant compared to other floods on record.

Low flows were not particularly severe in 2009/10. The lowest prolonged river flows of the year generally occurred during late March and April 2010. The most significant of these occurred in the Mangaroa and Whakatikei rivers, both tributaries of the Hutt River and draining catchments located in the part of the region that experienced the driest weather of the summer; low flow in the Mangaroa River had an estimated return period of 15 years. However, overall, low flows in the western part of the region were similar in severity to 2008/09 but much less severe than 2007/08. Rivers in the Wairarapa did not generally drop to significant low flows in 2009/10 and flow minima for monitored sites were higher than they have been since at least 2005/06, and since 2003/04 in many cases. Fewer low flow thresholds were breached across the region compared with the previous two years.

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Appendix 1: Monitoring site details

Note: Easting and northing map references for all sites in the following tables are in the ‘NZ Trans Mercator’ (TM) GIS map projection. This projection has been adopted by Greater Wellington and replaces the previous ‘NZ Map Grid’ projection.

Table A1.1: Rainfall monitoring sites

Site name	Catchment/Location	Altitude (m)	Start date	Easting (TM)	Northing (TM)
Kapakapanui	Otaki (Tararua Range)	1090	06/09/1991	1782082	5467184
McIntosh	Otaki (Tararua Range)	1020	26/09/1991	1794483	5467883
Oriwa	Otaki (Tararua Range)	1050	08/09/1991	1798285	5486386
Taungata	Otaki (Tararua Range)	980	06/09/1991	1790183	5479685
Otaki Depot	Otaki	17	18/07/1984	1780983	5484586
Transmission Lines	Mangaone	140	13/10/1992	1782983	5477185
Shoveller Lagoon	n/a (Te Hapua wetlands)	3	30/03/2009	1775282	5479885
Water Treatment Plant	Waikanae	40	02/08/1969	1774582	5471585
QE Park	Whareroa (Paekakariki)	15	12/09/2001	1766239	5462294
Kaitoke Headworks	Hutt	223	02/01/1991	1783680	5452483
Te Marua	Hutt	150	22/07/1993	1780080	5450684
Centre Ridge	Pakuratahi	510	06/04/1984	1784579	5444183
Tasman Vaccine Ltd	Mangaroa	229	03/05/1968	1768979	5437885
Warwicks	Akatarawa	345	16/06/1980	1774781	5463885
Cemetery	Akatarawa	100	29/03/1988	1776280	5449484
Blue Gum Spur	Whakatikei	335	13/10/1981	1769680	5453885
Birch Lane	Hutt (Lower Hutt)	10	25/04/2001	1760979	5435886
Shandon Golf Club	Hutt (Petone)	4	03/04/2000	1758998	5434456
Orongo Swamp	Orongorongo	420	03/10/1980	1772477	5431985
Wainuiomata Reservoir	Wainuiomata	125	01/01/1890	1766677	5429485
Pencarrow Lakes	Gollans / Pencarrow Lakes	8	22/08/2007	1755922	5418015
Whenua Tapu	Taupo	45	17/04/1991	1757581	5453386
Battle Hill	Horokiri	60	30/03/2010	1762880	5452885
Seton Nossiter Park	Porirua	100	06/07/1992	1752279	5436387
Quartz Hill	Makara	270	03/09/2007	1741915	5432265
Karori Reservoir	Kaiwharawhara	141	02/01/1879	1746078	5426688
Regional Council Centre	n/a (Wellington city)	30	26/07/1996	1748878	5427488
Bannister	Ruamahanga (Tararua Range)	1000	30/09/1974	1808833	5487428
Angle Knob	Waingawa (Tararua Range)	1200	27/12/1974	1805258	5475462
Carkeek	Waiohine (Tararua Range)	1158	30/09/1974	1802166	5481870
Bull Mound	Tauherenikau (Tararua Range)	1000	23/03/1976	1795128	5460805
Mt Bruce	Ruamahanga	300	30/07/1984	1819278	5485284
Mauriceville	Kopuaranga	230	07/05/2008	1826879	5483853
Westons	Waipoua	470	08/11/2007	1816567	5480958
Wairarapa College	Ruamahanga (Masterton)	115	29/05/2002	1822753	5463166

Site name	Catchment/Location	Altitude (m)	Start date	Easting (TM)	Northing (TM)
Waingawa	Waingawa	240	09/05/1994	1812545	5470730
Valley Hill	Mangatarere	483	21/04/1997	1806484	5464882
Waiohine Gorge	Waiohine	140	02/02/2006	1801682	5456581
Parkvale	Parkvale (Carterton)	100	08/01/2008	1813496	5449490
Alloa	Tauherenikau (Featherston)	40	01/03/1963	1799870	5445286
Waiorongomai	Waiorongomai	25	18/05/2009	1780017	5430263
Waihi	Whangaehu	175	10/01/2001	1834110	5476076
Castlehill	Tauweru	240	10/04/1991	1852366	5483971
Te Weraiti	Tauweru	80	09/09/1997	1832112	5458262
Longbush	Southern Whangaehu	255	01/11/2006	1819836	5436843
Iraia	Ruakokoputuna	260	09/04/1969	1798384	5416435
Tanawa Hut	Whareama	280	01/01/1956	1864716	5484384
Tawa Pool*	Porirua Stream (Tawa)	40	29/08/1996	5441387	1753480
Duthie Street*	Wellington City (Karori)	200	08/10/1990	5428088	1746178
Berhampore*	Wellington City	20	29/07/1996	5423888	1748278
Hataitai Old Post Office*	Wellington City	15	25/02/1997	5425988	1750178
Khandallah at Library*	Wellington City	160	29/08/1996	5432287	1750079
Miramar North Rd*	Wellington City	25	04/10/2004	5426088	1752678
Newtown Mansfield*	Wellington City	25	11/09/1996	5424488	1749078

* These sites are maintained by Greater Wellington but owned by Wellington City Council

Table A1.2: River level/flow monitoring sites

Site name	Start date	Catchment area (km ²)	Easting (TM)	Northing (TM)	Comments
Waitohu Stream at Water Supply Intake	17/10/1994	19.2	5484786	1786886	
Mangaone Stream at Ratanui	13/01/1993	9.2	5478174	1781874	
Waikanae River at Water Treatment Plant	03/03/1975	125	5471385	1774571	
Mazengarb Stream at Scaife Drive	03/05/1995	4.5	5470867	1769081	Funded by KCDC
Wharemauku Stream at Coastlands	16/12/1980	7.8	5468427	1768842	Funded by KCDC
Hutt River at Kaitoke Weir	03/02/2004	86.8	5453283	1784181	River level only
Hutt River at Te Marua	05/03/1984	191	5450684	1780080	
Hutt River at Taita Gorge	16/03/1979	556	5441797	1766410	
Hutt River at Estuary Bridge	28/09/1976	623	5433586	1759278	River level only (tidal site)
Pakuratahi River at Truss Bridge	22/05/1978	37.2	5445183	1783679	
Mangaroa River at Te Marua	20/05/1977	102	5448583	1778753	
Akatarawa River at Cemetery	19/02/1979	114	5449499	1776288	
Whakatikei River at Dude Ranch	08/09/1976	46	5450185	1770580	
Waiwhetu Stream at Whites Line East	31/05/1978	11.6	5434500	1760996	

Site name	Start date	Catchment area (km ²)	Easting (TM)	Northing (TM)	Comments
Wainuiomata R at Manuka Track	10/06/1982	27.1	5430632	1768226	
Wainuiomata R at Leonard Wood Park	14/04/1977	77.5	5427825	1763092	
Orongorongo R at Upper Dam Site	09/10/1980	7.1	5430985	1772477	
Orongorongo R at Truss Bridge	12/03/1998	31.7	5426164	1770159	
Taupo S at Flax Swamp	17/08/1979	8.2	5451057	1757073	Funded by PCC
Horokiri S at Snodgrass	15/02/2002	28.8	5450686	1761780	
Porirua S at Town Centre	08/09/1965	44.8	5443970	1754677	
Ruamahanga R at Mt Bruce	01/01/1975	76.5	5485284	1819288	
Ruamahanga R at Wardells	10/11/1954	637	5457478	1824685	
Ruamahanga R at Gladstone Bridge	06/06/1992	1315	5449878	1820883	Rated for high flows only
Ruamahanga R at Waihenga Bridge	31/12/1956	2340	5436679	1804579	
Waipoua R at Mikimiki Bridge	05/02/1979	80.5	5475182	1820587	
Te Mara S at Kiriwhakapapa	28/11/2008	13.4	5479407	1819413	
Waingawa R at Kaituna	14/05/1976	79	5470682	1812685	
Mangatarere S at Gorge	09/02/1999	33.3	5465421	1811469	
Mangatarere S at Belvedere Bridge	26/01/2004	55.9	5456798	1811046	Rated for low flows only
Mangatarere S at SH2	01/09/2009	119	5451980	1809682	
Waiohine R at Gorge	27/12/1954	180	5456581	1801682	
Tauherenikau R at Gorge	30/03/1976	112	5451181	1797981	
Kopuaranga R at Palmers	15/03/1985	100	5477882	1825288	
Kopuaranga R at Stuarts	28/08/2010	166	5469872	1826601	
Tauweru R at Te Weraiti	10/12/1969	373	5458377	1832087	Rated for high flows only
Tauweru R at Te Whiti Rd Bridge	06/09/2009	496	5450777	1824084	
Huangaaru R at Hautotara	01/01/1968	140	5425378	1807277	Rated for flows stage only
Otukura S at Weir	17/12/1997	36.2	5437780	1798579	
Papawai S at U/S Oxidation Pond	06/12/2005	-	5446809	1809149	Catchment area not defined (spring)
Tilsons Ck at Scott Culvert	03/11/2005	-	5447839	1809331	Catchment area not defined (spring)
Parkvale S at Renalls Weir	15/01/2002	-	5449490	1813496	Catchment area not defined
Otaki R at Pukehinou	17/07/1980	306	5478485	1785483	NIWA site partly funded by GW
Hutt R at Kaitoke	21/12/1967	89	5453283	1784181	NIWA site partly funded by GW
Hutt R at Birchville	07/09/1970	427	5448184	1775580	NIWA site partly funded by GW
Pahaoa R at Hinakura	04/09/1986	563	5424774	1821678	NIWA site partly funded by GW

Table A1.3: Lake and wetland level monitoring sites

Site Name	Start date	Easting (TM)	Northing (TM)
Lake Wairarapa at Burlings	18/09/1953	1781777	5433083
Lake Onoke at Lake Ferry	27/04/1953	1779174	5415284
Lake Wairarapa at Barrage North	01/01/1974	1783376	5424083
Ruamahanga River at Barrage South	01/01/1974	1783376	5424083
Lake Kohangapiripiri	20/08/2007	1755213	5419272
Lake Kohangatera	17/08/2007	1755922	5418015
Taumata Lagoon	19/04/2010	5447952	1811660
Te Hapua Wetland at Pateke	07/04/2009	1775764	5479452
Te Hapua Wetland at Shoveller Lagoon	30/03/2009	1775288	5479884
Te Hapua Wetland at Trotter	04/06/2009	1774724	5479152
Te Hapua Wetland at Jill & Joy	03/04/2009	1774344	5479298

Appendix 2: Monthly hydrological data summary

Table A2.1: Monthly rainfall totals (mm) for July to December 2009 and long-term (LT) mean monthly totals at Greater Wellington rainfall stations

Site	July		August		September		October		November		December	
	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean
Kapakapanui	131.5	201.4	220.0	202.3	157.5	224.6	354.5	275.1	272.5	217.0	315.5	257.9
McIntosh	513.0	504.0	447.0	430.3	292.0	451.1	594.5	599.6	458.0	492.6	549.0	468.0
Oriwa	348.5	383.3	367.0	357.0	303.0	456.4	538.0	580.2	607.0	504.6	671.0	535.1
Taungata	191.5	237.7	224.5	207.7	161.0	258.7	372.5	343.0	408.0	288.1	481.0	316.1
Otaki Depot	62.0	91.3	88.5	83.7	87.0	82.9	130.5	97.8	145.5	87.4	146.5	91.7
Transmission Lines	103.0	139.6	131.0	123.0	108.0	147.9	224.0	184.9	237.5	137.6	317.5	180.1
Shoveller Lagoon	67.5	n/a	76.5	n/a	78	n/a	126	n/a	106	n/a	121.5	n/a
Water Treatment Plant	68.0	132.0	123.5	106.9	108.5	109.8	167.0	160.5	150.5	102.1	171.0	116.5
QE Park	52.0	n/a	121.0	n/a	90.0	n/a	156.0	n/a	88.5	n/a	112.0	n/a
Kaitoke Headworks	184.0	244.9	257.0	221.9	107.5	184.8	285.5	212.9	136.5	204.6	168.5	187.3
Te Marua	150.0	204.4	249.5	167.9	85.0	136.8	232.5	242.0	125.0	171.2	148.0	147.7
Centre Ridge	153.5	229.2	160.5	205.1	119.0	156.8	250.0	215.4	124.0	177.7	173.5	157.5
Tasman Vaccine Ltd	122.0	182.0	164.0	146.6	75.0	120.1	265.0	166.0	104.5	115.5	99.5	117.5
Warwicks	146.0	191.8	255.5	194.5	158.5	186.0	310.5	267.4	265.5	209.5	318.0	226.5
Cemetery	127.9	158.0	217.5	158.7	88.0	134.8	195.5	210.5	136.5	140.2	128.5	146.1
Blue Gum Spur	127.5	176.5	196.0	170.5	127.5	155.1	256.0	223.0	173.0	187.1	189.5	191.0
Birch Lane	82.5	160.4	133.6	152.6	63	79.3	225.5	152.2	68.0	90.7	63.5	108.7
Shandon Golf Club	64.5	121.0	137.0	110.0	57.0	60.4	187.5	111.3	53.5	66.5	55.0	79.6
Orongo Swamp	173.0	305.6	200.5	239.8	158.5	177.7	360.0	277.9	129.0	212.7	134.5	199.1
Wainuiomata Res.	107.0	231.7	170.0	209.6	94.0	157.6	304.5	168.5	85.0	127.6	78.5	128.9
Pencarrow Lakes	n/a	n/a	85.5	n/a	48	n/a	154.5	n/a	48	n/a	35	n/a
Whenua Tapu	80.0	106.7	120.5	93.4	76.0	88.1	143.5	115.0	98.5	82.6	123.0	80.5
Seton Nossiter Park	81.5	139.5	177.0	118.2	81.5	94.8	187.0	135.5	64.0	94.0	72.5	96.4
Quartz Hill	63.5	n/a	110.0	n/a	90.5	n/a	176.0	n/a	n/a	n/a	68.5	n/a
Karori Reservoir	75.2	140.3	120.0	122.8	94.6	99.4	199.4	107.3	55.0	90.1	62.0	88.8
Regional Council	43.1	111.0	96.2	90.1	60.0	64.3	165.0	100.8	51.0	66.9	44.6	66.4
Bannister	553.5	611.0	n/a	535.8	429.0	544.2	657.5	617.4	676.5	526.7	776.0	537.7
Angle Knob	636.0	648.2	808.5	676.4	407.0	602.7	695.5	751.4	469.0	629.2	648.5	602.5
Carkeek	395.5	483.5	n/a	472.7	261.5	439.8	498.0	489.7	383.5	387.4	474.0	413.9
Bull Mound	407.5	496.6	415.0	452.3	235.5	393.1	518.0	480.8	221.5	391.6	310.0	380.0
Mt Bruce	257.5	247.3	308.5	242.0	138.0	196.9	245.0	281.1	192.5	214.4	174.5	184.9
Mauriceville	175.0	n/a	141.0	n/a	85.5	n/a	207.0	n/a	107.0	n/a	91.0	n/a
Westons	326.5	n/a	371.0	n/a	162.0	n/a	268.0	n/a	167.0	n/a	165.5	n/a
Wairarapa College	83.2	114.6	59.8	89.8	53	65.3	134.2	97.8	64.6	50.8	52.4	61.1
Waingawa	157.5	223.7	198.5	194.2	89.5	156.4	219.0	254.9	119.5	164.5	n/a	137.1
Valley Hill	298.5	298.4	311.0	284.2	145.5	229.4	359.5	395.7	178.0	247.9	237.0	239.0
Phelps	189.5	224.4	203	210.3	103.5	163	261	212	106.5	173.9	121	153.9
Waiohine Gorge	216.5	n/a	233.5	n/a	125.0	n/a	277.5	n/a	108.0	n/a	120.5	n/a
Parkvale	65.0	n/a	31.0	n/a	34.0	n/a	113.5	n/a	63.0	n/a	59.5	n/a
Alloa	73.0	116.9	97.8	95.4	55.6	66.8	134.8	118.7	93.0	89.2	73.4	88.3
Wairongomai	100.5	173.8	138	157.8	77	129.5	239.5	146.9	119	89.5	116.7	83.5
Waihi	112.0	139.1	85.5	116.7	79.5	85.3	160.0	129.8	63.5	65.8	52.5	88.5
Castlehill	201.5	160.7	134.5	109.7	97.5	84.4	206.0	105.3	99.0	91.2	86.5	72.3
Te Weraiti	96.0	111.2	43.5	87.8	44.5	50.8	105.0	86.6	58.5	53.3	n/a	62.5

Site	July		August		September		October		November		December	
	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean
Longbush	77.0	n/a	49.0	n/a	41.5	n/a	120.5	n/a	58.0	n/a	62.0	n/a
Iraia	139	238.3	111.5	212.4	74	128.3	251.5	151.3	70.5	115.8	75	106.2
Tanawa Hut	109.5	174.8	92.0	137.8	85.5	113.5	178.5	100.3	74.0	72.4	58.5	90.7

Note: n/a denotes data not available. Numbers underlined indicate that monthly mean rainfall has been estimated from another rainfall station. Numbers in italics indicate that data have not yet been audited and archived.

Table A2.2: Monthly rainfall totals (mm) for January to June 2010 and long-term (LT) mean monthly totals at Greater Wellington rainfall stations

Site	January		February		March		April		May		June	
	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean
Kapakapanui	260.5	165.7	198.0	168.3		160.2	139.5	149.4	155.5	197.5	141.5	222.1
McIntosh	484.0	343.0	311.0	345.0	295.0	349.7	346.0	323.0	326.5	420.2	466.0	451.2
Oriwa	404.5	308.7	358.5	319.1	200.0	292.4	232.5	282.5	159.5	379.1	380.0	383.3
Taungata	285.0	198.1	220.0	218.6	132.5	180.0	191.5	173.1	128.5	218.1	252.5	220.3
Otaki Depot	79.5	68.8	53.5	83.4	36.5	58.3	67.0	67.6	89.5	83.0	118.5	104.9
Transmission Lines	147.0	97.8	128.5	108.1	53.5	93.3	102.5	98.0	116.0	133.6	106.0	163.1
Shoveller Lagoon	37	n/a	n/a	n/a	27	n/a	63.5	n/a	n/a	n/a	<u>100</u>	n/a
Water Treatment Plant	82.0	87.9	69.0	103.9	61.0	82.4	72.0	79.4	71.0	98.0	154.5	123.3
QE Park	50.5	n/a	46.5	n/a	40.5	n/a	64.5	n/a	87.5	n/a	184.5	n/a
Kaitoke Headworks	193.5	144.4	97.0	128.5	116.0	158.3	122.5	164.6	163.0	213.5	243.5	231.5
Te Marua	147.5	100.8	62.0	115.0	95.0	109.1	78.5	111.0	157.0	140.9	206.0	182.0
Centre Ridge	202.0	121.2	100.0	148.2	126.0	147.5	67.0	138.0	243.0	178.3	315.0	208.8
Tasman Vaccine Ltd	104.5	91.4	48.0	83.2	58.0	93.9	63.0	105.2	195.5	152.3	262.5	176.1
Warwicks	177.0	161.7	127.5	137.3	86.5	156.6	144.0	137.2	113.0	173.6	267.0	209.3
Cemetery	115.5	114.7	62.0	105.9	73.5	133.6	81.0	99.1	106.5	123.9	204.5	162.3
Blue Gum Spur	140.5	151.7	82.5	109.3	71.5	104.5	91.5	119.5	138.0	148.6	n/a	176.6
Birch Lane	95.0	80.4	31.0	104.6	40.5	62.8	40.5	68.9	184.5	112.1	203.0	145.6
Shandon Golf Club	86.5	52.9	26.5	63.3	32.5	44.5	38.0	60.3	199.0	92.4	196.0	120.7
Orongo Swamp	232.0	148.1	69.5	122.3	99.0	178.9	80.5	150.6	289.5	242.3	<u>375.5</u>	271.5
Wainuiomata Res.	188.0	105.7	34.5	107.6	59.5	124.9	54.0	145.9	256.0	209.2	288.0	210.0
Pencarrow Lakes	46.5	n/a	12.5	n/a	30.5	n/a	22.5	n/a	226	n/a	135.0	n/a
Whenua Tapu	n/a	70.2	115.5	85.4	58.5	61.0	63.5	59.0	207.5	86.7	178.5	106.0
Seton Nossiter Park	144.0	75.2	42.5	79.5	34.0	75.4	44.5	83.6	227.0	112.5	218.5	132.9
Quartz Hill	146.0	n/a	32.5	n/a	39.0	n/a	29.0	n/a	150.0	n/a	214.5	n/a
Karori Reservoir	32.8	80.5	29.4	76.5	23.8	85.8	31.8	96.9	219.2	122.1	216.2	128.1
Regional Council	112.6	64.3	20.6	62.3	37.6	57.6	24.8	55.7	166.0	91.4	144.8	99.2
Bannister	522.6	382.3	463.0	375.6	306.5	435.3	473.5	417.5	264.5	482.8	610.5	538.9
Angle Knob	585.0	447.6	342.5	391.6	450.0	446.6	584.5	481.5	364.5	587.7	601.0	646.6
Carkeek	346.0	287.9	269.5	276.4	211.0	323.5	308.5	289.2	221.0	397.3	466.0	438.6
Bull Mound	388.0	269.6	207.0	265.3	291.0	322.5	246.0	303.7	316.5	398.8	493.5	437.6
Mt Bruce	239.0	163.7	104.5	160.3	125.5	147.5	91.5	151.5	142.0	183.5	312.5	240.2
Mauriceville	264.0	n/a	90.5	n/a	<i>68</i>	n/a	<i>47.5</i>	n/a	<i>139.5</i>	n/a	<i>226.5</i>	n/a
Westons	207.5	n/a	101.0	n/a	155.0	n/a	115.5	n/a	<i>223.5</i>	n/a	<i>289</i>	n/a
Wairarapa College	<i>205.4</i>	42.1	<i>25.6</i>	65.1	<i>53.4</i>	63.3	<i>11.4</i>	52.3	<i>128.2</i>	70.8	<i>130.4</i>	103.7
Waingawa	164.5	109.9	70.0	120.6	n/a	122.2	n/a	130.0	163.0	142.0	200.5	206.5
Valley Hill	274.0	165.2	112.5	163.7	197.5	192.2	149.0	152.5	209.5	217.8	305.0	289.0
Phelps	Site decommissioned in January 2010											
Waiohine Gorge	229.0	n/a	57.0	n/a	167.5	n/a	87.5	n/a	192.5	n/a	255.0	n/a

Site	January		February		March		April		May		June	
	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean
Parkvale	149.5	n/a	?	n/a	69.0	n/a	?	n/a	116.5	n/a	<i>96.5</i>	n/a
Alloa	119.2	57.7	32.8	72.6	65.6	80.5	27.2	60.8	144.0	89.3	174.4	117.2
Waiorongomai	98.2	199	94.1	37	104.5	84.5	115.6	51	150.6	154.5	166.1	253
Waihi	283.0	n/a	40.5	72.3	56.0	60.8	11.0	64.6	137.5	89.1	182.0	132.7
Castlehill	289.6	80.1	50.2	71.3	45.4	68.6	19.8	77.2	145.0	97.9	180.0	121.9
Te Weraiti	160.0	77.5	16.5	47.6	34.0	50.1	8.5	49.3	137.0	77.9	129.5	87.3
Longbush	187.0	n/a	21.5	n/a	61.0	n/a	11.5	n/a	161.5	n/a	148.0	n/a
Iraia	164	83	29	92.4	94	123.5	31	133.7	256.5	169.7	271.5	215.9
Tanawa Hut	270.5	65.2	51.0	76.9	44.0	98.1	18.0	100.7	188.5	130.9	175.5	146.2

Notes: n/a denotes data not available. Numbers underlined indicate that monthly mean rainfall has been estimated from another rainfall station. Numbers in italics indicate that data have not yet been audited and archived.

Table A2.3: Monthly mean river flows (m³/s) for July to December 2009 and long-term (LT) mean monthly flows at Greater Wellington river monitoring stations

Site	July		August		September		October		November		December	
	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean
Otaki R at Pukehinau*	27.00	33.60	29.45	34.44	24.03	33.77	46.11	45.31	34.93	34.50	49.25	38.45
Waitohu S at WSI	0.54	0.94	0.71	0.83	0.64	0.83	1.56	1.32	1.47	1.19	2.16	1.10
Mangaone S at Ratanui	0.24	0.41	0.28	0.37	0.28	0.33	0.64	0.61	0.58	0.44	0.82	0.40
Waikanae R at WTP	3.68	6.39	4.59	5.91	3.33	4.92	11.08	6.70	6.57	5.31	14.82	5.41
Mazengarb S at Scaife Drive	0.16	0.18	0.19	0.17	0.20	0.15	0.21	0.18	0.15	0.18	0.11	0.17
Wharemauku S at Coastlands	0.06	0.22	0.13	0.16	0.10	0.15	0.19	0.12	0.06	0.10	0.14	0.11
Hutt R at Kaitoke Weir	n/a – river level only											
Hutt R at Kaitoke*	9.53	10.46	10.34	10.02	6.78	9.02	13.90	10.81	5.43	8.00	8.31	7.41
Hutt R at Birchville*	27.39	33.53	27.43	30.16	20.32	25.22	38.39	31.51	15.58	22.50	25.66	19.76
Hutt R at Te Marua	15.17	16.65	15.43	14.66	9.13	11.44	18.73	18.27	7.63	10.54	11.59	10.03
Hutt R at Taita Gorge	31.74	36.60	32.89	33.07	22.23	24.85	42.48	37.13	16.40	27.21	27.53	25.05
Hutt R at Estuary Bridge	n/a – river level only											
Pakuratahi R at Truss Bridge	2.73	3.29	2.15	2.65	1.65	1.97	3.30	2.77	1.38	2.08	2.31	2.01
Mangaroa R at Te Marua	5.65	6.10	4.03	4.94	n/a	3.54	6.04	4.91	1.96	3.24	2.79	2.75
Akatarawa R at Cemetery	5.29	7.15	6.88	7.01	5.22	5.51	9.62	8.74	4.81	5.85	7.87	5.05
Whakatikei R at Dude Ranch	1.47	2.04	1.72	2.01	1.71	1.60	2.76	2.48	1.25	1.92	2.47	1.74
Mawaihakona S at Golf Club	0.25		0.30		0.32	Decommissioned						
Waiwhetu S at WLE	0.35	0.45	0.38	0.35	0.26	0.33	0.72	0.41	0.22	0.27	0.22	0.24
Wainuiomata R at Manuka Tr	1.08	1.55	0.90	1.25	0.89	0.89	2.11	1.22	0.60	0.82	0.75	0.79
Wainuiomata R at LWP	2.50	4.45	2.27	3.33	2.06	2.66	5.45	3.06	1.40	2.24	1.50	1.83
Orongorongo R at UDS	0.42	0.64	0.38	0.50	0.29	0.35	0.70	0.59	0.23	0.39	0.35	0.36
Orongorongo R at Truss Br	1.79	3.51	<u>2.21</u>	3.40	1.60	1.75	4.53	3.20	1.04	1.60	1.61	1.77
Taupo S at Flax Swamp	0.17	0.16	0.17	0.14	<u>0.14</u>	0.09	0.24	0.12	0.06	0.07	0.12	0.05

Site	July		August		September		October		November		December	
	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean
Horokiri S at Snodgrass	0.56	0.85	0.63	0.91	0.59	0.51	1.11	0.84	0.36	0.51	0.70	0.36
Porirua S at Town Centre	0.75	1.27	1.01	1.16	0.83	0.86	1.62	0.99	0.49	0.64	0.54	0.50
Ruamahanga R at Mt Bruce	14.22	13.04	16.51	12.66	8.97	11.98	13.80	13.27	9.95	10.69	13.62	10.37
Ruamahanga R at Wardells	44.87	39.37	36.28	34.74	21.88	29.82	33.87	29.73	18.96	20.07	22.04	16.59
Ruamahanga R at Gladstone	n/a – river level only											
Ruamahanga R at Waihenga	125.19	136.30	85.68	124.80	63.82	104.52	101.30	100.61	53.13	71.71	67.73	61.90
Waipoua R at Mikimiki Br	7.04	7.25	5.90	6.83	3.98	5.90	5.35	8.26	2.57	6.03	3.03	5.81
Te Mara S at Kiriwhakapapa	1.37	n/a	1.26	n/a	0.90	n/a	1.41	n/a	0.48	n/a	0.70	n/a
Waingawa R at Kaituna	13.45	13.32	13.66	12.93	9.03	12.11	13.39	13.29	7.30	10.63	11.16	10.27
Mangatarere S at Gorge	3.49	2.95	2.31	2.74	1.46	1.55	3.03	2.98	1.04	1.64	1.95	1.49
Mangatarere S at Belvedere	3.99	4.22	2.22	3.94	1.32	1.76	3.00	3.50	1.18	0.90	1.77	1.08
Waiohine R at Gorge	33.07	35.52	28.23	33.26	19.50	31.42	36.86	35.95	19.86	31.56	32.29	29.01
Tauherenkau R at Gorge	12.27	13.40	10.55	12.12	7.07	10.55	14.82	12.00	4.77	8.38	7.44	8.55
Kopuaranga R at Palmers	n/a	4.96	3.62	4.29	2.51	3.20	4.99	3.82	2.09	2.24	1.81	1.45
Tauweru R at Te Weraiti	n/a – river level only											
Huangaaru R at Hautotara	n/a – river level only											
Otukura S at Weir	1.09	0.99	0.62	1.03	0.54	0.66	0.70	0.80	0.43	0.40	0.35	0.38
Papawai S at U/S Oxi Pond	0.49	0.46	0.39	0.55	0.31	0.35	0.33	0.38	0.31	0.35	0.25	n/a
Parkvale S at Renalls Weir	1.63	1.42	1.02	1.38	0.75	1.14	1.02	1.16	0.79	0.66	0.52	n/a
Pahaoa R at Hinakura*	23.74	31.07	9.44	19.42	5.39	12.40	13.12	10.07	3.73	3.75	2.91	2.05

*Data provided by NIWA. n/a denotes data not available. Data not available for Tilsons Creek at Scott Culvert due to problems maintaining rating curve. Numbers in italics indicate that data have not yet been audited and archived. Underlined numbers indicate one or more days of record were missing in the month and mean flow for these days was estimated using data from nearby sites.

Table A2.4: Monthly mean river flows (m³/s) for January to June 2010 and long-term (LT) mean monthly flows at Greater Wellington river monitoring stations

Site	January		February		March		April		May		June	
	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean
Otaki R at Pukehinau*	31.13	23.09	19.84	18.79	11.77	18.91	13.44	19.05	18.90	26.79	27.56	32.70
Waitohu S at WSI	1.28	0.70	0.75	0.64	0.41	0.44	0.46	0.45	0.51	0.61	0.89	0.78
Mangaone S at Ratanui	0.57	0.26	0.25	0.28	0.15	0.16	0.17	0.16	0.21	0.22	0.32	0.35
Waikanae R at WTP	8.92	4.08	3.00	3.51	2.23	2.73	1.83	2.95	<u>2.56</u>	4.11	7.35	5.39
Mazengarb S at Scaife Drive	0.12	0.16	0.10	0.14	0.08	0.12	0.07	0.11	0.06	0.13	0.09	0.15
Wharemauku S at Coastlands	0.07	0.06	0.04	0.04	0.02	0.03	0.03	0.05	0.05	0.09	n/a	0.14
Hutt R at Kaitoke Weir	n/a – river level only											
Hutt R at Kaitoke*	10.01	5.22	5.32	4.84	4.43	4.97	3.96	5.77	7.22	8.04	12.68	9.49
Hutt R at Birchville*	22.36	13.35	10.87	11.55	7.60	11.98	6.37	14.64	17.21	22.36	35.25	27.68

Site	January		February		March		April		May		June	
	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean
Hutt R at Te Marua	12.45	6.10	6.33	7.56	4.37	6.26	3.51	6.87	9.50	9.90	17.28	13.28
Hutt R at Taita Gorge	24.46	16.91	11.93	14.71	8.32	14.22	6.82	14.75	18.68	22.33	40.31	29.26
Hutt R at Estuary Bridge	n/a – river level only											
Pakuratahi R at Truss Bridge	2.39	1.23	1.11	1.29	0.66	1.50	0.47	1.34	2.67	2.13	4.22	2.71
Mangaroa R at Te Marua	<u>1.84</u>	1.84	<u>0.78</u>	1.62	n/a	1.34	<u>0.33</u>	2.15	2.51	3.46	6.83	4.72
Akatarawa R at Cemetery	5.89	3.75	2.81	3.53	1.83	2.98	1.86	3.41	3.15	4.94	7.80	6.10
Whakatikei R at Dude Ranch	1.56	1.37	0.60	1.13	0.38	0.97	0.41	1.08	0.74	1.53	2.34	1.90
Mawaihakona S at Golf Club	Decommissioned											
Waiwhetu S at WLE	0.22	0.20	0.12	0.23	0.10	0.17	0.15	0.19	0.36	0.27	0.59	0.36
Wainuiomata R at Manuka Tr	0.86	0.56	0.39	0.37	0.26	0.45	0.22	0.46	0.90	0.92	2.00	1.20
Wainuiomata R at LWP	<u>2.21</u>	1.33	<u>0.96</u>	1.34	0.66	1.12	0.55	1.32	2.46	2.31	6.49	3.46
Orongorongo R at UDS	0.40	0.24	0.14	0.25	0.10	0.23	0.08	0.25	0.53	0.47	<u>0.77</u>	0.55
Orongorongo R at Truss Br	3.88	2.26	0.90	3.73	0.43	1.36	0.31	0.91	3.59	2.74	5.29	3.33
Taupo S at Flax Swamp	0.05	0.04	0.04	0.05	0.05	0.03	0.11	0.05	0.16	0.08	0.34	0.12
Horokiri S at Snodgrass	0.37	0.41	0.16	0.63	0.10	0.24	0.14	0.17	0.38	0.35	n/a	0.56
Porirua S at Town Centre	0.63	0.38	0.29	0.39	0.19	0.36	0.20	0.49	1.15	0.73	1.94	1.01
Ruamahanga R at Mt Bruce	9.20	7.09	8.81	7.00	4.43	7.28	5.57	7.33	5.91	9.81	14.68	11.83
Ruamahanga R at Wardells	18.42	11.77	18.76	11.24	7.87	11.66	6.93	14.56	15.49	23.36	46.10	31.72
Ruamahanga R at Gladstone	n/a – river level only											
Ruamahanga R at Waihenga	58.14	43.35	<u>56.12</u>	38.77	27.70	45.06	23.10	53.16	52.89	83.54	123.59	108.71
Waipoua R at Mikimiki Br	1.86	4.74	2.22	5.36	1.18	4.45	0.80	4.84	2.85	5.63	7.11	7.40
Te Mara S at Kiriwhakapapa	0.40	n/a	0.44	n/a	0.24	n/a	0.20	n/a	0.74	n/a	2.04	n/a
Waingawa R at Kaituna	7.90	6.69	7.27	6.77	4.82	6.98	5.65	7.63	7.15	9.86	13.67	11.98
Mangatarere S at Gorge	1.34	0.88	1.12	1.07	0.76	0.97	0.41	0.84	<u>1.70</u>	1.78	3.55	2.64
Mangatarere S at Belvedere	n/a	0.55	0.99	1.24	0.58	0.92	0.28	0.44	1.63	1.59	3.87	2.49
Waiohine R at Gorge	23.31	21.95	18.23	21.79	13.08	22.51	13.92	24.59	17.09	30.71	29.99	32.03
Tauherenkau R at Gorge	8.56	5.31	5.98	5.20	4.87	5.89	3.77	6.56	8.58	9.17	14.36	11.85
Kopuaranga R at Palmers	2.66	0.97	2.64	1.58	0.66	1.10	0.43	1.34	2.01	2.41	6.53	4.11
Tauweru R at Te Weraiti	n/a – river level only											
Huangarua R at Hautotara	n/a – river level only											
Otukura S at Weir	0.48	0.23	0.23	0.22	0.17	0.21	0.14	0.23	0.46	0.39	1.56	0.63
Tilsons Ck at Scott Culvert	0.23	0.15	0.22	0.16	0.21	0.20	0.21	0.22	0.26	0.27	0.42	0.35
Parkvale S at Renalls Weir	0.82	0.29	0.64	0.41	0.40	0.36	n/a	0.43	0.51	0.45	<u>0.72</u>	0.84
Pahaoa R at Hinakura*	16.29	1.85	11.91	4.04	0.74	4.94	0.33	5.27	16.93	8.65	32.40	16.87

Notes: *Data provided by NIWA. n/a denotes data not available. Data not available for Tilsons Creek at Scott Culvert due to problems maintaining rating curve. Numbers in italics indicate that data have not yet been audited and archived. Underlined numbers indicate one or more days of record were missing in the month and mean flow for these days was estimated using data from nearby sites.

Table A2.5: Monthly mean lake and wetland levels (m) for July to December 2009 and long-term (LT) mean levels at Greater Wellington monitoring stations

Site	July		August		September		October		November		December	
	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean	2009	LT mean
Lake Onoke at L. Ferry	10.170	10.009	9.763	9.921	9.752	9.908	10.121	9.969	10.666	9.866	<u>9.848</u>	9.761
Lake Wairarapa at Burlings	10.484	10.543	10.036	10.431	10.064	10.333	10.349	10.346	10.332	10.231	10.153	10.215
Lake Wairarapa at Barrage North	10.417	10.293	10.011	10.215	9.992	10.149	10.278	10.181	10.358	10.116	10.190	10.175
Ruamahanga River at Barrage South	10.492	10.402	9.946	10.298	9.951	10.210	10.308	10.215	10.702	10.096	9.915	9.940
Taumata Lagoon	Site not established until April 2010											
Lake Kohangapiripiri	1.492	n/a	1.405	n/a	1.513	n/a	1.714	n/a	1.504	n/a	1.374	n/a
Lake Kohangatera	0.972	n/a	1.033	n/a	0.216	n/a	0.288	n/a	0.367	n/a	0.605	n/a
Te Hapua Wetland at Pateke	5.080	n/a	5.079	n/a	5.122	n/a	5.178	n/a	5.175	n/a	5.224	n/a
Te Hapua Wetland at Shoveller Lagoon	3.032	n/a	3.037	n/a	3.079	n/a	3.105	n/a	3.066	n/a	3.094	n/a
Te Hapua Wetland at Trotter	3.280	n/a	3.333	n/a	3.382	n/a	3.425	n/a	3.329	n/a	3.385	n/a
Te Hapua Wetland at Jill & Joy	3.059	n/a	3.135	n/a	3.251	n/a	3.380	n/a	3.346	n/a	3.383	n/a

Note: n/a denotes data not available. Numbers underlined indicate that monthly mean lake level has been estimated, due to some missing record. Numbers in italics indicate that data have not yet been audited and archived.

Table A2.6: Monthly mean lake and wetland levels (m) for January to June 2010 and long-term (LT) mean levels at Greater Wellington monitoring stations

Site	January		February		March		April		May		June	
	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean	2010	LT mean
Lake Onoke at Lake Ferry	10.022	9.783	9.921	9.874	<u>10.333</u>	10.065	<i>10.466</i>	10.141	<i>10.014</i>	10.078	<i>10.239</i>	10.1
Lake Wairarapa at Burlings	10.18	10.197	10.186	10.189	10.117	10.221	10.022	10.294	10.141	10.38	10.445	10.448
Lake Wairarapa at Barrage North	10.18	10.137	10.2	10.102	10.153	10.086	n/a	10.122	10.135	10.192	10.375	10.256
Ruamahanga River at Barrage South	10.078	9.919	10.008	9.992	10.314	10.178	10.472	10.287	10.051	10.313	10.43	10.402
Taumata Lagoon	Site not established until April 2010								<i>0.947</i>	n/a	<i>1.301</i>	n/a
Lake Kohangapiripiri	1.34	n/a	1.26	n/a	1.176	n/a	1.11	n/a	1.298	n/a	1.47	n/a
Lake Kohangatera	0.404	n/a	0.161	n/a	0.221	n/a	0.389	n/a	0.535	n/a	0.252	n/a
Te Hapua Wetland at Pateke	5.158	n/a	5.029	n/a	4.937	n/a	4.897	n/a	4.93	n/a	5.049	n/a
Te Hapua Wetland at Shoveller Lagoon	3.024	n/a	2.919	n/a	2.809	n/a	2.75	n/a	2.807	n/a	3.004	n/a
Te Hapua Wetland at Trotter	3.334	n/a	3.206	n/a	3.102	n/a	3.035	n/a	3.073	n/a	3.285	n/a
Te Hapua Wetland at Jill & Joy	3.301	n/a	3.096	n/a	2.882	n/a	2.778	n/a	2.81	n/a	3.07	n/a

Notes: n/a denotes data not available. Numbers underlined indicate that monthly mean lake level has been estimated, due to some missing record. Numbers in italics indicate that data have not yet been audited and archived.

Appendix 3: River flood warning alarm levels and occurrences

Table A3.1: Greater Wellington river flood warning alarm levels

Site	Flood warning alarm level (mm)	Comments
Waitohu S at Water Supply Intake	900	
Otaki Rat Pukehinau	4,500	
Mangaone S at Ratanui	1,700	
Waikanae R at Water Treatment Plant	3,200	
Hutt R at Te Marua	3,800	
Hutt R at Birchville	3,500	
Hutt R at Taita Gorge	28,000	
Mangaroa R at Te Marua	2,500	
Akatarawa R at Cemetery	2,000	
Waiwhetu S at Whites Line East	1,300	Initial alarm level
Wainuiomata R at Manuka Track	2,000	
Wainuiomata R at Leonard Wood Park	1,500	
Porirua S at Town Centre	900	
Ruamahanga R at Mt Bruce	4,000	
Ruamahanga R at Wardells Bridge	3,000	Initial alarm level
Ruamahanga R at Gladstone Bridge	2,000	
Ruamahanga R at Waihenga Bridge	3,350	Initial alarm level
Waipoua R at Mikimiki Bridge	1,800	Initial alarm level
Waingawa R at Kaituna	2,800	Initial alarm level
Mangatarere S at Gorge	1,800	
Waiohine R at Gorge	2,500	Initial alarm level
Tauweru R at Te Weraiti	9,000	
Huangarua R at Hautotara	3,400	

Table A3.2: River level flood warning alarms triggered during 2009/10

Event date	Alarm levels triggered	
	Wellington sites	Wairarapa sites
5 July 2009		Tauweru River at Te Weraiti
23–24 July 2009	Hutt River at Kaitoke Weir	Ruamahanga River at Gladstone
	Hutt River at Te Marua	Ruamahanga River at Wardells
	Hutt River at Birchville	Ruamahanga River at Waihenga
	Hutt River at Cemetery	Waiohine River at Gorge
	Hutt River at Taita Gorge	Waipoua River at Mikimiki
	Mangaroa River at Te Marua	
	Waiwhetu Stream at White Lines East	
27 July 2009		Ruamahanga River at Waihenga
30-31 July 2009	Hutt River at Kaitoke Weir	Ruamahanga River at Gladstone
	Hutt River at Birchville	Ruamahanga River at Waihenga
	Hutt River at Te Marua	Ruamahanga River at Wardells
	Hutt River at Taita Gorge	Waiohine River at Gorge
	Porirua Stream at Town Centre	Waipoua River at Mikimiki
	Waiwhetu Stream at White Lines East	
	Mangaroa River at Te Marua	
	Waikanae River at Water Treatment Plant	
	Otaki River at Pukehinau	
Akatarawa River at Cemetery		
4 August 2009	Hutt River at Kaitoke Weir	
16 October 2009	Akatarawa River at Cemetery	
	Waiwhetu Stream at White Lines East	
	Porirua Stream at Town Centre	
18 November 2009		Ruamahanga River at Gladstone
		Ruamahanga River at Wardells
28 November 2009	Hutt River at Birchville	Ruamahanga River at Gladstone
	Hutt River at Kaitoke Weir	Ruamahanga River at Waihenga
	Waitohu Stream at Water Supply Intake	Ruamahanga River at Wardells
	Akatarawa River at Cemetery	Waiohine River at Gorge
	Waikanae River at Water Treatment Plant	
	Mangaone Stream at Ratanui	
	Otaki River at Pukehinau	
12 December 2009	Hutt River at Birchville	Ruamahanga River at Gladstone
	Hutt River at Kaitoke Weir	Ruamahanga River at Waihenga
	Waitohu Stream at Water Supply Intake	Ruamahanga River at Wardells
	Otaki River at Pukehinau	

	Alarm levels triggered	
	Wellington sites	Wairarapa sites
27 December 2009	Waitohu Stream at Water Supply Intake	
	Waikanae River at Water Treatment Plant	
	Mangaone Stream at Ratanui	
29 December 2009	Waitohu Stream at Water Supply Intake	
4 January 2010	Ruamahanga River at Gladstone	
	Ruamahanga River at Waihenga	
	Ruamahanga River at Wardells	
	Waiohine River at Gorge	
23 January 2010	Tauweru River at Te Weraiti	
24 March 2010	Hutt River at Kaitoke Weir	
	Hutt River at Te Marua	
25 May 2010	Porirua Stream at Town Centre	
	Waiwhetu Stream at White Lines East	
27 June 2010	Tauweru River at Te Weraiti	

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Photo
Flood gauging at
Mangaone Stream at
Ratanui



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