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Baseline Environmental Monitoring, Program 3: Hydrological & Hydrogeological Assessment – Exploration Permit # 51985 at Puhipuhi, Northland

Evolution Mining NZ Pty Limited

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Prepared for

Evolution Mining NZ Pty Limited

April 2016

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Quality Control Sheet

TITLE	Baseline Environmental Monitoring, Program 3: Hydrological & Hydrogeological Assessment – Exploration Permit # 51985 at Puhipuhi, Northland
CLIENT	Evolution Mining NZ Pty Ltd
VERSION	Final
ISSUE DATE	28 April 2016
JOB REFERENCE	A02982701
SOURCE FILE(S)	A02982701R001_P3_FINAL.docx

DOCUMENT CONTRIBUTORS

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Limitations:

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Executive Summary

Pattle Delamore Partners Ltd (PDP) was engaged by Evolution Mining New Zealand Pty Ltd (ENZ) to undertake an assessment of hydrological and hydrogeological processes associated with the ENZ tenement area (Exploration Permit #51985). This study identifies the geology of the area, sources of ground and surface water, the direction of water flow, and where it flows to. This provides information that can be used during the planning of any future exploration drilling activities to minimise the potential impact on ground and surface water, and its users.

Using existing literature, NRC data and relevant data from PDP's Program 1 (groundwater) and Program 2 (surface water) field investigations, an initial hydrological and hydrogeological conceptual site model has been produced.

Three main aquifer units were identified within the study region, and were named; Puhipuhi Basalt Aquifer (BA), Purua Beds Sedimentary Aquifer (PBSA), and the Greywacke Aquifer (GA). The aquifer units comprise the major geological units within the shallow (<150 m depth) subsurface at Puhipuhi. The BA was identified as the primary aquifer used for water supply, although the GA is also used as well.

Flow within the BA is interpreted to be primarily within open joints and rubbly zones present within the basalt flows layers. Flow within the BA is primarily horizontal towards topographic lows and the aquifer is generally considered to be of high permeability. Groundwater levels within the basalt are recorded between ~10 m – ~30m below ground level (bGL) – considered moderately deep. The BA is generally considered to have good yields and good drinking water quality.

The PBSA comprises lake and river deposited sedimentary rocks. Based on rock descriptions, the aquifer is anticipated to have a generally moderate hydraulic conductivity. Groundwater levels within the PBSA area likely to be relatively high, however little data is available to confirm. The ENZ 3D geological model interprets Purua Bed deposition to significant depths (> 100 m) in depression within the greywacke. These areas are also associated with hydrothermal sinter deposits. The PBSA is not known to be used directly as a water aquifer within the region.

Groundwater flow within the GA is largely dominated by open fractures and joints (secondary permeability) in unweathered greywacke (Waipapa Group) and sheared mudstone (Northern Allochthon). Bulk permeability of the GA is generally considered to be low, except zones of intense fracturing. Groundwater levels recorded in the greywacke within the region are predominantly high (artesian to ~20 m bGL.). Water quality is generally good for domestic drinking use.

Hydraulic connection between the BA and underlying GA is expected to be variable across sites, but generally low. Significant connection may occur however near major faults and crush zones, areas near to basalt source/conduits, or areas of greywacke associated with paleo (pre-basalt) surface water drainage.

The main streams draining the ENZ tenement area are the Pukekaikiore, Waikiore and Whenuaroa Streams which are the major tributaries of the Waiariki River. The western side of the tenement area is drained by tributaries of the Waiotu River and a small area on the eastern side is drained by tributaries of Kaimamaku Stream. The flow pattern in the Waiariki River is highly modified by two dams and a weir which intercept flow from the upstream catchment area. Flow downstream of these structures are governed by regulated flow releases from these structures as specified in consents. The flow patterns in the streams that are not influenced by in- stream structures can be expected to show more 'natural' flow patterns.

The streams and river in the tenement area are part of the Wairua/ Wairoa River catchment that drains a substantial part of central Northland. The Waiotu and Whakapara Rivers are the major tributaries of the Wairua River in the immediate vicinity of the tenement area and form part of the headwaters of the wider catchment which originate close to the Northland east coast. Further downstream the Wairua River becomes the Wairoa River and flows past Dargaville into the Kaipara Harbour on the west coast. The key receiving river environments downstream of the study area are the Waiariki River, Waiotu River, Kaimamaku Stream, Whakapara River, Wairua River, Wairoa River and the Kaipara Harbour.

Data from relevant Northland Regional Council recorder sites indicate that the five day field survey by PDP (including the gaugings) were undertaken at times when recorded flows in the wider catchment were around the median. As expected the gauging results from the field survey indicate a general trend that flow increases with distance downstream of the ENZ tenement area as the contributing catchment area increases.

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1.0 Introduction

1.1 Project Background and Objectives

Pattle Delamore Partners Ltd (PDP) has been engaged by Evolution Mining NZ Pty Ltd. (ENZ) to provide baseline data and assessment prior to any exploration drilling or any drilling-related environmental disturbance at Puhipuhi, Northland.

The purpose of this report is to provide a robust conceptual hydrological/hydrogeological site model to inform ENZ and interested parties on the shallow groundwater system associated with the tenement area. A groundwater sampling program (Program 1) and surface water, stream sediment and aquatic organisms sampling program (Program 2) was commissioned by ENZ and undertaken by PDP in March 2016. Relevant hydrogeological/hydrological data collected in these programs has been incorporated into this study.

Baseline environmental monitoring is presented within Program 1: Groundwater Sampling (PDP, 2016), and Program 2: Surface Water Sampling, Stream Sediment, Aquatic Organisms report, which is yet to be published.

1.2 Scope and Tasks

This report presents hydrogeological and hydrological interpretation of current and predicted site processes and the potential effects of exploration activities at site. The tasks undertaken for Programmes 1 and 3 are as follows:

Hydrogeological Elements

- Identify and interpret of important geological units, characteristics and structures.
- Characterise the hydraulic properties of the relevant geological units (or provide estimates of aquifer properties if no data is available).
- Interpret existing hydrogeological processes and aquifer interactions.
- Interpret groundwater-surface interactions and processes with focus on the potential discharge of contaminants from groundwater source.
- Assess available groundwater level, spring and stream flow data to produce conceptual groundwater flow map.
- Provide a high-level assessment of groundwater flow rates and water budget.

Hydrological Elements:

- Delineate catchment boundaries for the Waikiore Stream incorporating the entirety of ENZ permit area.
- Assess available rainfall, stream flow, and level data to inform the development of a conceptual hydrologic model.

- Assess surface water regime including an evaluation of seasonal and annual flow patterns in the Waikiore Stream and its tributaries.
- To produce two maps defining the key hydrological features within the ENZ permit site and wider catchment including downstream receiving environments.

2.0 Site Data Sources

2.1 Key Sources of Information

Data from a number of sources were analysed to formulate the hydrological and hydrogeological conceptual understanding at site. Key data sources are detailed as follows:

- (PDP, 2016) - Baseline Environmental Monitoring, Program 1 Groundwater Sampling.
- Evolution Mining New Zealand Pty Ltd - Exploration geological logs, geophysics surveys, and 3D Geological Leapfrog Model (Beach, 2015).
- (White, 1983) - Hydrothermal Alteration and Mineralisation in a Fossil Geothermal System at Puhipuhi, Northland, New Zealand. Auckland University MSc Thesis (unpublished).

Table 1 below lists the key sources of data used in the project.

Table 1: Available Data

Data	Source	Comment on Data
Well locations, maps, validated log data, NRC file data, etc.	- Evolution Mining NZ Pty Ltd. - Northland Regional Council (NRC) - New Zealand Petroleum and Minerals (NP&M)	Historical exploration data provided by ENZ was originally sources from NZP&M reports (Accessed 2016).
Geological Information	- Beach, 2016 - Edbrook, 2009 - Grieve, 2006 - Craw, 2005 - Smith, 1993 - White, 1983 (unpublished)	Data presented in LeapFrog 3D Model based on geophysics, NRC bore logs and exploration bore logs.
Groundwater / Spring Discharge Chemistry	PDP, 2016	P1 – Groundwater Monitoring Baseline Study.
Rainfall Data	Northland Regional Council (PDP accessed April, 2016)	Data obtained for Whakapara Rainfall Station (E1715721, N6070047).

Table 1: Available Data

Data	Source	Comment on Data
Flow data	Northland Regional Council	Data obtained for flow recorder sites Waiotu at SH1, Whakapara at Cableway and Wairua at Purua.
	PDP, 2016	Surface water flow gauging (P2 (currently unpublished)).
Minimum flow releases for dams and weir in Waikiore Stream, Pukekaikiore Stream and Waiariki River	Northland Regional Council (NRC)	

3.0 Site Description

3.1 Site Setting and Topography

Geographically the site is centred at approximately 1713831 mE: 6073652 mN (NZTM 2000). The site is located ~4.2 km due north of Whakapara and ~25 km north of Whangarei, Northland, New Zealand. Land use in the area comprises; actively grazed farmland (mainly dairy), commercial forestry, and the rural residential community of Whakapara, which includes the Whakapara Marae.

The tenement area is essentially a volcanic plateau, elevated >100 m above the surrounding land to the south and west. Within the plateau area, the landscape is characterised by multiple undulating stream valleys with relatively steep slopes. Stream valleys are relatively narrow (~500 m – 1 km wide). Elevation difference between valley and ridge line can be significant, with differences of > 100 m. Topographic contours within and surrounding the ENZ tenement are shown in Figure 1.

3.2 Climate and Rainfall

Puhipuhi experiences a sub-tropical climate with warm, humid summers and mild wet winters (Chappell, 2013). Daily rainfall data going back to 1906 was obtained for Whakapara Rainfall Station from Northland Regional Council (NRC) database (NRC, 2016). Located on the southern site boundary (1715721 mE: 6070047 mN - Figure 1) at a topographic elevation of ~215 m RL, the Whakapara Rainfall Station is considered representative of site conditions. The station is also situated within the same river catchment to the majority of site (Waiariki Catchment).

Mean annual rainfall (1906-2015) is approximately 2000 mm, but can be greatly variable; with a maximum of 3584 mm (in 1955) and minimum of 612 mm (in 1914). Intra-annually, highest average rainfall is experienced in July and lowest

in November, however December through April also typically experience lower rainfall totals.

Assessment of the time series data indicates that the highest annual groundwater level is likely to occur- in September-October (end of winter), and lowest levels in March-April (end of summer).

4.0 Site Conceptualisation

4.1 Geology

The majority of geological information discussed in this section is derived from published geological maps and text (Edbrooke, 2001), Smith et al (1993), White (1983, unpublished), Craw (2004), (Grieve, 2006), and ENZ's 3D geological model (Beach, 2016). ENZ have developed a detailed computerised 3D geological model, incorporating information from the above-mentioned sources as well as ENZ's interpretation of available field data, bore hole logs, and an extensive array of geophysical transects.

The area is primarily comprised of Waipapa Group basement 'Greywacke', unconformably overlain by lake deposited (lacustrine) sediments, and basalt deposited during the Cenozoic (~4-4.5 Million Years Age – Mya). Hydrothermal sinter deposits, associated with former geothermal activity in the area, are also present. Table 2 below describes the primary geological units and their sequence, and Figure 2 displays the surface geology of the region:

Table 2: Puhipuhi Stratigraphy

Typical Thickness (m)	Unit Description	Unit Name	Geological Epoch/Age
Unknown: suspect 0 – 20 m	Clays, Silts, Sands, Peat/Organic Silt	Tauranga Group	Holocene
Unconformity			
0 - 120	Weathered and Fresh Basalts	Puhipuhi Volcanics	Late Pliocene to Quaternary / 4 – 4.5 Mya
Unconformity			
0 - 100	Siltstone, Sandstone and Conglomerate	Purua Beds (Lake Sediments)	Miocene / 6 – 10 Mya
Unconformity			
Massive	Sheared Mudstone	Northland Allochthon	Late Oligocene to Early Miocene / 23 Mya to 15 Mya
Unconformity			
Massive	Greywacke / Metasediment	Waipapa Group	Late Triassic – Early Cretaceous

Detailed descriptions of the major geological units are described in the below sub-sections.

4.1.1 Waipapa Group – Greywacke Basement

The formal description of the greywacke unit, as taken from (Edbrooke, 2001) is:

Predominantly thin-bedded, alternating fine-grained, lightly metamorphosed 'greywacke' sandstone and argillite in composite beds up to tens of meters in thickness with discontinuously interbedded chert.

Greywacke is a sedimentary rock that has under gone low-grade metamorphism. The Waipapa Group rocks are aged Late Triassic to Early Cretaceous (~220 to 110 million years) and are the oldest in the region.

Greywacke rocks are the basement rock beneath much of the Northland region and extend to several kilometres below surface. Greywacke outcrops in a number of locations in eastern Northland; including at Puhipuhi and the Whangarei Coast.

At Puhipuhi, outcrops of greywacke are present as the hill country to the north of the tenement, as well as on lower lying areas to the southwest, near SH1. Within the tenement area, top of greywacke is encountered at varying depths – typically between 10 m – 100 m below ground surface.

The unweathered greywacke is typically hard to very hard and can be closely fractured, often with extensive micro-veining of quartz, calcite, prehnite, chlorite and zeolites. Hydrothermal alteration in the Puhipuhi area has resulted in mineralised veining with associated deposits of quartz, chloride, sericite and minor pyrite.

High rainfall, warm temperatures and abundant organic activity has facilitated physical weathering of the greywacke in places, typically near rock mass fracture zones. Alteration of the greywacke, where crystalline minerals within the rock slowly change to clay minerals, has also occurred in places. Weathering and alteration can result in a clay rich 'soil' zone. At Puhipuhi, well-developed regolith profiles up to 30 m in thickness have been identified.

4.1.2 Sheared Mudstone - Northland Allochthon

Sheared mudstone from the Northland Allochthon, an ancient, slow moving landslide, was deposited in the late Oligocene to early Miocene (23 Mya – 15 Mya), over the greywacke rocks. Within the Puhipuhi region, the Northland Allochthon comprises units of:

- Melange unit - comprises a matrix of sheared mudstone and tectonic blocks of Northland Allochthon and Waitemata Group lithologies.
- Mangakahia Complex - comprises a matrix of sheared mudstone, limestone and claystone.

4.1.3 Lake Sediments - Purua Beds

There is evidence that an ancient lake was present within the central portion of the tenement, within small depressions in the greywacke. The Purua Beds consist of lacustrine (lake derived) and alluvial (river/stream) deposits, consisting primarily of sandstone, mudstone and siltstone, which commonly contain organic material. Palynology studies (the identification of pollen from fossil plants) from carbonaceous lake sediments have been dated at between ~12.7 Mya to ~6 Mya (Mildenhall, 1982).

Formation of the lake is not formally proven, however it is hypothesised that fault movement (before ~10 Mya), raised and/or lowered certain areas of the greywacke, forming elongate basins. A lake then formed within the ancient basins.

4.1.4 Hydrothermal Sinter

During the time of Purua Beds deposition, hydrothermal activity was also occurring within the Puhipuhi region. Deposits of silica sinter were precipitated from geothermal fluids, which rose from depth via fissures and fractures within the greywacke.

As hydrothermal activity within the Puhipuhi region declined, sinter deposits containing metal sulphides of pyrite (iron sulphide), galena (lead sulphide), marcasite (iron sulphide), arsenopyrite (arsenic and iron sulphide) and cinnabar (mercury sulphide) were emplaced. Within the tenement, two distinctive zones of sinter are recognised:

- Mount Mitchell – southern sinter outcrop, which overlies in excess of 100 m of Purua Beds lake sediments;
- Northern sinter (adjacent to Waikiore stream) – outcrop overlies approximately 60 m of Purua Bed lake sediments.

The association of sinter deposits with large thickness of Purua Beds supports the theory that significant fracturing of the greywacke exists beneath/proximal to the sinter locations indicates that hydrothermal activity was spatially associated with localised small basins, which were accumulating lacustrine and alluvial sediments. This spatial relationship between hydrothermal activity and topographic depressions is commonly observed in geothermal regions, and reflects underlying fault geometry.

4.1.5 Basalt Flows - Puhipuhi Volcanics

A period of tectonism and volcanic activity between 2 and 5 million years ago deposited an extensive basalt plateau associated with the Puhipuhi-Whangarei Volcanic Field. The basalts flowed over the lake sediments of the Purua Beds and the greywacke. The basalts were deposited as a succession of multiple lava flows. Time periods in between each flow allowed for the creation of a weathered soil horizon, referred to as a paleosol. Available borehole logs from

within the region indicate the occurrence of up to three separate flow events, separated by paleosol horizons and ash deposition.

Subsequent uplift, deep weathering and extensive erosion has removed much of this basalt cover, leaving a highly weathered veneer of discontinuous, remnant basalt coverage, present predominantly along existing ridgelines. Within the tenement this extensive erosion has produced two primary remnant basalt occurrences, which rise to approximately 400 m RL (North) and 260 m RL (South) respectively. These lava flows are aged at approximately 4-4.5 Ma (Smith et al, 1993).

4.1.6 Tauranga Group

Sediments of the Tauranga Group are recent deposits (<5000 years old) which typically drape the lower lying areas of the catchments within the study area. Typically comprising unconsolidated to poorly consolidated mud, sand, silt, gravel, often with some organic/peat deposits. Primarily alluvial (river/stream) deposited, as well as colluvium (landslide) and lacustrine (lake deposited) origin.

Thickness in the area is not defined, but is likely to typically vary between 2 m to 5 m.

4.1.7 Geological Structure

Structural features within the Waipapa basement are likely to have had a strong influence on the spatial extent and degree of fracturing across the Puhipuhi site. Fracturing is likely to have had a controlling influence on groundwater flow within and between geological units.

Regional faulting and fracturing at Puhipuhi is extensive within the greywacke, with lineaments showing 3 main orientations; NW-SE, NE-SW and N-S. The most prominent faults trend NW and are likely to postdate hydrothermal activity.

Faults observed in drillcore include silicified breccias, unconsolidated fracture zones or crush zones and clay or quartz gouge zones. The youngest faults are most likely to represent zones of enhanced permeability, whereas some earlier faults may be sealed by clay or by quartz cementation.

4.2 Hydrology

Figures 3 and 4 provide an overview of the key hydrological features for the Wairoa/Wairua catchment and for ENZ’s tenement area. Figure 5 identifies the key hydrological features of the receiving environment downstream of the tenement area and Figure 3 identifies the key hydrological features within the tenement area, including identification of relevant streams and rivers, (sub)catchment boundaries and key structures (dams and weirs). Figure 4 displays the area immediately surrounding the tenement area, to identify the key catchments which the streams and rivers in the tenement area flow into.

4.2.1 Hydrology - Wairua/Wairoa River Catchment

The Wairua River catchment drains a large part of central Northland having its headwaters in the steep hills a few kilometres inland of the east coast (refer to Figure 4). The Wairua River generally flows to the southwest and passes through the Hikurangi Swamp. Further downstream the Wairua River joins the equally large Mangakahia River to become the Wairoa and flows past Dargaville into the Kaipara Harbour on the west coast.

The Waiotu and Whakapara are the major tributaries of the Wairua River in the immediate vicinity of the tenement area. The Waiariki River, the main river within the Evolution Mining's permit area is a tributary of the Waiotu River and flows into the Waiotu River just upstream of its confluence with the Whakapara River. The drainage of the Hikurangi swamp has been extensively modified by channelization, stopbanking and installation of pumpstations. Below the swamp the Wairua River is joined by the Mangere and Waipao Streams and by the Karukaru River below Wairua Falls. The Wairua becomes tidally influenced at its confluence with the Mangakahia River.

There are three continuous flow recorders in the Wairua/Wairoa catchment which are relevant for the project. These are the Waiotu at SH1, Whakapara at Cableway and Wairua at Purua. The locations of these flow recorders are shown in Figure 3 and Figure 4 and information about these recorders together with key flow statistics are detailed in Table 3 below.

Table 3: Details of Recorder Sites

		Waiotu at SH1	Whakapara at Cableway	Wairua at Purua
Available Record Period		1987 - date	1959 - date	1960 - date
Catchment Area (km^2)		127	162	544
Flow (m^3/s)	Min	0.11	0.31	0.75
	Max	237.63	581.60	312.85
	Mean	4.30	6.15	18.37
	Lower Quartile	0.73	1.45	3.80
	Median	1.54	2.44	7.79
	Upper Quartile	3.49	4.68	18.38

Flow duration curves based on the available record periods for the three recorder sites are included in Appendix A.

4.2.2 Hydrology - Tenement Area

The main river draining the permit area is the Waiariki River (refer to Figure 4) with the Pukekaikiore, Waikiore and Whenuaroa Streams being the major tributaries. The western side of the permit area is drained by tributaries of the Waiotu River and a small area on the eastern side is drained by tributaries of the Kaimamaku Stream (refer to Figure 3) which joins the Whakapara River approximately 1 kilometre east of the Whakapara at Cableway flow recorder.

The flow pattern in the Waiariki Catchment is highly modified by two dams which intercept flow from Pukekaikiore and Waikiore Stream. In addition there is a weir in the Waiariki River which further controls the flow into the downstream reaches of the Waiariki River. At these three structures water is taken for irrigation purposes and the relevant consents of the dams and weir govern the flow releases to the downstream water bodies.

The damming and taking of water for the eastern dam is authorised by consents AUT.004961.01.02 and AUT.004961.02.01. The consent conditions for these two consents are combined into one consent document and condition 1 of this combined consent specifies that the flow immediately downstream of the dam in the Pukekaikiore Stream shall not reduce to less than 17.3 L/s.

The damming, taking and discharge of water for the western dam and for the weir is authorised by consents AUT.004964.01.02m, AUT.004964.02.02, AUT.004964.03.02 and AUT.004964.04.02 and is also combined into one set of consent conditions. For the western dam the minimum flow release into Waikiore Stream is 11 L/s (condition 9). For the weir in the Waiariki River the minimum flow release is 37.5 L/s. Subject to approval from Northland Regional Council (NRC) the downstream flow release from the weir can be reduced to less than 37.5 L/s when flows into the western reservoir are less than 37.5 L/s (condition 10).

These structures modify the natural flow pattern in the Pukekaikiore, Waikiore and Waiariki River downstream of the dams and weir. Flows downstream of these features are controlled by flow releases governed by consent conditions, irrigation demand, storage drawdown and storage refill. In addition, when the dam is full and water flows into the dam during storm events dam outflows will be attenuated resulting in reduced and delayed flood flows downstream of the dams and weir. These effects will be most pronounced immediately downstream of these structures and less pronounced with distance further downstream.

The flow patterns in the other streams that drain the permit area are not influenced by structures and can be expected to show more ‘natural’ flow patterns.

4.2.3 Downstream receiving environment

Based on the catchment description provided above the key receiving environments downstream of the permit area are the Waiariki River, Waiotu

River, Kaimamaku Stream, Whakapara River, Wairua River, Wairoa River and the Kaipara Harbour.

4.2.4 Gauging results and surface water flow regime

Table 4 below shows the results of the gaugings undertaken by PDP as part of the March 2016 field survey. The location of the gauging sites is shown on Figures 3 – 5. For comparative purposes the range of recorded flows at the three NRC recorder sites over the five day field survey period is provided as well. The Table is ordered by catchment area starting with the smallest catchment area at the top (PUX, 6 ha) and the largest catchment area at the bottom (PDX, 70628 ha).

Table 4: Gauging Results from Field Survey

Sampling ID	(Sub) catchment	Catchment Area (ha)	Gauging date	Flow (m^3/s)
PUX	Waikiore Stream	6	13/03/2016	0.004
PTX	Waikiore Stream	53	12/03/2016	0.012
PSX	Waikiore Stream	62	12/03/2016	0.011
PWX	Waikiore Stream	69	12/03/2016	0.011
PVX	Pukekaikiore Stream	95	11/03/2016	0.017
PNX	Whenuaroa Stream	117	13/03/2016	0.020
PRX	Waikiore Stream	145	12/03/2016	0.027
PMX	Whenuaroa Stream	281	11/03/2016	0.044
PKX	Papanui Creek	358	10/03/2016	0.040
PQX	Pukekaikiore Stream	659	11/03/2016	0.119
POX	Waiariki River	1183	11/03/2016	0.253
PLX	Waiariki River	1730	10/03/2016	0.380
PYX	Kaimamaku Stream	2021	13/03/2016	0.542
PJX	Waiariki River	2445	10/03/2016	0.505
Waiotu at SH1[1]	Waiotu River	12700	9/3/2016 - 13/03/2016	1.752 - 1.415[2]
Whakapara at Cableway[1]	Whakapara River	16200	9/3/2016 - 13/03/2016	2.246 - 1.924[2]
PHX	Wairua River	37211	9/03/2016	5.145
PGX	Wairua River	52829	9/03/2016	6.768
PFX / Wairua at Purua[1]	Wairua River	54651	9/03/2016 - 13/3/2016	9.669 - 7.272[2]
PDX	Wairua River	70628	13/03/2016	5.980

Notes:

1. *NRC recorder site*
2. *Based on raw (unarchived) flow data provided by NRC.*

The gaugings were undertaken over a period of five days with flows at the three recorder sites around the median flow. Hydrographs for the three recorder sites from 1 January 2016 till 23 March 2016 is shown in Appendix B. Considering that the gaugings were not undertaken on the same day a direct comparison of flow between the different sites cannot be made. However, the gaugings can be used to provide an indication of the relative flow contribution from the relevant streams and rivers in the permit area to the downstream receiving (river) environment. As expected, there is a general trend that flow increases with distance downstream of the permit area as the contributing catchment area increases.

Flow gauging information was requested from NRC for the streams and rivers in the permit area. However, very limited gauging information was available for the area. In addition, as detailed in section 4.2.2, the flow regime in the Waiariki Catchment is highly modified by two dams and a weir which affect the downstream river flows. Without detailed information on these structures and their operation, reliable estimates of the flow pattern (flow statistics and flow duration curves) in the Waiariki River and its tributaries cannot be made. Flow statistics, flow duration curves and hydrographs for the three NRC recorder sites are provided in Table 4 and Appendix A and B which provide an indication of the flow regime for the Waiotu, Whakapara and Wairua River.

4.3 Hydrogeological Conceptual Model

4.3.1 Puhipuhi Groundwater Units

For the purposes of this study, the groundwater system within the study region has been separated into 3 key groundwater units (aquifers), as described in Table 5 below.

Table 5: Identified Major Groundwater Units at Puhipuhi

Name	Encompassing Geological Units	Aquifer Type & Use
Greywacke Aquifer (GA)	Greywacke metasediment	Confined and Unconfined – dependant on location. Potential for localised areas of 'perched' groundwater. Majority of groundwater flow within fractures and fracture networks. Some water supply use within the tenement region.
Purua Bed Sedimentary Aquifer (PBSA)	Former lake sediments. Primarily muds, sands, silts, gravels. Minor inclusions of carbonaceous peats, sandstone, mudstone conglomerate and hydrothermal breccias.	Unconfined (water table aquifer). Majority of groundwater flow within pore space between sediment grains, but also potential for some fracture related flow. There is one known bore within the PBSA.

Table 5: Identified Major Groundwater Units at Puhipuhi

Name	Encompassing Geological Units	Aquifer Type & Use
Basalt Aquifer (BA)	Unweathered and weathered basalt. Includes the series of lava flows and weathering profiles; consisting of regolith in between consolidated crystalline basalt.	Predominantly unconfined (water table aquifer), but also potential for localised areas of 'perched groundwater'. Majority of groundwater flow within joints and joint networks Primary water supply aquifer in the tenement region.

Groundwater within the key aquifers at Puhipuhi are expected to be almost exclusively held within pore space (between grains of rock or sediment), or within narrow (i.e. <1 mm to <50 mm width) rock fractures. Large, open underground 'caverns' – like that possible within underground limestone caves – are not expected within the Puhipuhi region.

Figure 6 schematically presents the conceptual understanding of key groundwater flow processes within and between the defined aquifer units at Puhipuhi. Groundwater levels compiled from all available monitoring records, and are presented in Appendix C. Detailed description of groundwater flow processes are described in the below sub-sections.

4.3.2 Puhipuhi Groundwater Flows

4.3.2.1 Basalt Aquifer (BA)

Flow within the BA is interpreted to be primarily within open joints and joint networks present within the unweathered zones of the basalt flows. Flow within the BA occurs primarily at shallow gradient towards topographic lows. Figure 7 displays generalised flow directions and flow divides, interpreted for the BA.

Due to the zones of weathered basalt/regolith which separate the unweathered, open jointed basalt, vertical separation of groundwater bodies within the BA is possible. Where this occurs, the upper groundwater bodies are referred to as 'perched'. Vertical interconnection within the BA units is likely to occur preferentially in some areas however, most likely where weathered zones or regoliths did not form or were eroded away. These areas of interconnection are important for replenishment of recharge to groundwater within the deeper zones of basalt.

Groundwater levels within the basalt are recorded between ~10 m – ~30m below ground level (m bGL) – based on the information available. Wells completed in the BA generally have good yields, and it is the primary water supply aquifer within the tenement region. The highest yields are usually obtained from the basal rubble zones beneath or within areas of wide open joints and joint networks in unweathered basalt. Storage in the BA is likely to be overall low to moderate on a unit volume basis compared to an alluvial sand aquifer, however the rubble zones may provide significant storage. Groundwater level response to

recharge from rainfall is likely to be rapid within the basalts, with groundwater level fluctuations up to 5m seasonally.

4.3.2.2 Purua Beds Sedimentary Aquifer (PBSA)

The PBSA within the southern Puhipuhi plateau, comprises lake bed sedimentary rocks of the Purua Beds, and is anticipated to have generally low to moderate permeability. Moderate permeability within sand dominant rocks or sediment, but significantly lower permeability in areas of silt/clay dominated rocks or sediment. Vertical permeability is likely to be generally low due to presence of layers of silt or clay within the unit. The ENZ 3D geological model interprets Purua Bed deposition to significant depths (> 100 m) in areas of deep greywacke depressions (likely eroded fault zones). These areas are also associated with hydrothermal sinter deposits (Figure 6). As a result, Purua Beds at these locations are anticipated to be intensely fractured but also potentially silicified; resulting in variable secondary permeability.

No groundwater level information was available for the PBSA, but due to the general position of the unit within the catchments (lower areas), depth to groundwater is expected to be typically shallow i.e. <10 m bGL. Groundwater flow is likely to be primarily at shallow gradient towards topographic lows – eventually discharging into streams.

There are no known groundwater wells or takes within the PBSA, in the tenement area.

4.3.2.3 Greywacke Aquifer (GA)

Groundwater flow within the GA is largely dominated by open fractures and faults in unweathered rock. Within the weathered/regolith zone, which may develop ~30 m bGL, permeability is likely to be relatively low due to the infilling of fractures with clay minerals. Within the tenement area, GA groundwater flow direction is regionally from the north-east to the southwest, with the majority of flow entering and exiting as groundwater through-flow.

In unweathered greywacke bulk permeability and storage is characteristically very low. However, in instances of intense fracturing, especially associated with major faults/fractures and crush zones, significant permeability has been found to occur at other locations such as Ngawha. Groundwater levels recorded in the greywacke within the region are predominantly high (artesian to ~20 m bGL.; Appendix C, Figure 6). Localised areas of perched groundwater may also occur within the weathered/regolith zones.

Hydraulic connection between the BA and underlying GA is expected to be generally low, but variable across site. Where basalt flow has overlain a weathered greywacke surface, connection between the units is anticipated to be poor due to the low permeability of the greywacke weathered contact zone. Furthermore, during deposition of the flowing basalt, minor ‘baking’ (contact metamorphism) may have further reduced permeability. The inference of limited

connection between the BA and GA is supported by the occurrence of a several springs, which emerge from the BA, often near the basalt-greywacke contact. Figure 2 displays the spring locations visited during Program 1, which were all associated with the BA.

Although spring flow is likely to be a major discharge mechanism of BA groundwater, good connection between the BA and GA may occur in areas of intense GA fracturing. Such areas would include:

- major faults and crush zones;
- areas near to basalt source/conduits – due to high likelihood of fracturing and greater depth of basalt;
- areas of greywacke associated with paleo (pre-basalt) surface water drainage – which may also include permeable Purua Beds deposits.

Artesian pressure is recorded at one exploration borehole location (GW04; Appendix C), which is understood be to accessing the GA. There is insufficient data at present to fully understand groundwater flow and groundwater pressure distribution within the GA.

Figure 6 displays a conceptual model diagram of the shallow groundwater system at Puhipuhi.

4.3.2.4 Long Term Groundwater Level

Figure 8 shows is an Accumulated Monthly Residual Rainfall (AMRR) curve, based on the rainfall data from the Whakapara station. The AMRR curve provides a useful means of assessing the relationship between rainfall and groundwater level by ascertaining the cumulative excess or deficit of rainfall. No time series groundwater level data was available for any of the aquifers within the Puhipuhi region, which prevents in-depth correlation between rainfall and groundwater level. However, the patterns of the AMRR curve are likely to match well the fluctuations in groundwater level for BA and PBSA – which are primarily unconfined. It is inferred that over the past decade, the current groundwater levels are likely to be near long term average. As displayed on Figure 8, the last inter-annual groundwater low is likely to have occurred during the mid-1990's.

4.4 Groundwater Geo-Chemical Properties

Analysis of major ion composition from groundwater samples collected within Program 1 was completed to provide a basic assessment of groundwater chemistry and provide additional information to the conceptual model.

Nine (9) water quality samples sourced from BA groundwater were dominated by sodium cations (Na^+) and chloride anions (Cl^-). Two (2) samples were sourced (or suspected to be sourced) from the deeper GA, and are dominated by bi-carbonate anions (HCO_3^-) and sodium and calcite cations. Figure 9, shows a

graphical plot of the samples grouped by aquifer unit (BA or GA) and source (borehole or spring discharge).

The Na-Cl water typing of the BA bore samples, plus low electrical conductivity (65 to 120 µS/cm - indicative of low salinity), supports the inference that groundwater within the BA is dominated by recharge sourced recently from rainfall. BA spring samples were also Na-Cl water type, which supports the inference that spring discharge from the BA is from groundwater sourced from the BA i.e. is not from deep upwelling of GA groundwater. The likeness in BA bore and spring water chemistry also supports the inference that groundwater residence time within is relatively short; indicating high lateral hydraulic conductivity, with flow radially towards the springs on the margins of the basalt.

There are two (2) samples with bi-carbonate (GW01 and GW06) as the dominant anion, and significant proportions of calcium. These samples are believed to have been sourced from the GA. The samples also contain significantly greater EC (240 µS/cm and 430 µS/cm), which indicated longer residence times. Dissolution of carbonate minerals within the GA, primarily calcium carbonate (calcite), is the likely cause of the elevated bi-carbonate within these samples. This groundwater chemistry is not uncommon within greywacke geology, particularly given the nearby units of the Northland Allochthon, which often contains limestone blocks. Over 5 m of limestone is noted in the bore log of GW06. A geological and borehole construction log of GW01 was not available for this bore, but from discussions with the bore owner on pump depth, assessment of basalt thickness, and the samples' high EC, alkalinity and water type, it is suspected that this borehole accesses the GA.

4.5 Potential Interactions: Drilling and Groundwater/Surface Water

Any exploration drilling conducted within the tenement is required to be completed in accordance with the New Zealand Environmental Standard for Drilling of Soil and Rock (NZS 4411:2001). Prescribed methods within the standard act to prevent both the potential connection of different aquifers, and potential contamination of aquifer(s) from the drilling process itself.

4.5.1 Potential Aquifer Connection During and Post Drilling

During the drilling process, specialist drilling fluid is used. The fluid is typically denser than water. The fluid primarily acts as a lubricant for the drill-bit, but is also designed to minimise groundwater inflow to the hole, from the surrounding formation (aquifer). Fluid pressure within the open hole is maintained higher than that of the surrounding formation (aquifers), and subsequently minimal connection of aquifers via the drill hole is possible. In summary, the drilling process inherently acts to minimise mixing of deep and shallow groundwater via the drill hole.

Post drilling, the New Zealand Environmental Standard for Drilling of Soil and Rock requires appropriate measures to be taken to prevent mixing of aquifer waters and/or surface contamination i.e. casing off of shallow and deep aquifers, capping of holes if artesian flow is discharging. Ultimately, the drill hole will require decommissioning (grouting) or conversion to a monitoring well – both of which are required to be completed in accordance with the relevant standards and are designed to prevent aquifer mixing.

4.5.2 Potential Aquifer Contamination from Drilling Fluid

Due to subsurface permeability, and the fact the drill hole fluid pressure is maintained higher than adjacent groundwater pressure, some migration of drilling fluid into the formation surrounding the drill hole will occur. New Zealand Environmental Standard for Drilling of Soil and Rock prescribe the use of drill fluid products that leave no residual toxicity, and nowadays the majority of products are bio-degradable. These drilling fluid specifications minimise the effects on groundwater quality.

Should significant fluid loss occur, mitigation measures would be implemented to reduce loss and re-gain circulation i.e. grouting of the hole and subsequent re-drilling to continue advancement (or advancement of casing).

In addition, any drilling fluid migrating away from the drill hole will mix with formation groundwater and become increasingly diluted with distance. The limit of groundwater quality effects related to drilling fluid depends on a range of factors but principally; permeability and porosity of the formation.

Based on the available information and assuming drilling fluid loss management, the limit of groundwater quality effects - relevant to the NZ Drinking Water Standards - is unlikely to extend greater than 200 m radius from the drill hole.

4.6 Other Groundwater Users

A table of the existing groundwater users are presented in Appendix D. Where available, groundwater source (aquifer unit) and intended groundwater usage are identified. Consented abstraction volumes are unknown.

4.7 Generalised Water Budget Estimate

The main river draining the tenement area is the Waiariki River (Figure 5) comprising three principle tributaries; the Pukekaiore, Waikiore and Whenuaroa streams. The Waiariki River catchment covers the majority of the tenement area and is therefore considered a suitable catchment boundary in which to calculate a high level water budget. The total calculated catchment area of the Waiariki River, draining over and above gradient of the tenement area, is approximately 22 km^2.

Average annual rainfall is approximately 2000mm/yr; based on the available long-term (1906-present) rainfall data from Whakapapa Weather Station (NRC,

2016; Figure 8). This contributes to an average total water input of 22000 ML per year to Waiariki River catchment; across and up-gradient of the tenement area.

Potential evapotranspiration (ET) is estimated at approximately 1000 mm/yr. This is based on (Chappell, 2013) estimates for the Northland region, as well as assessment of long term flow recorder sites near the tenement area, namely:

- Waiotu at SH1, catchment area 127 km^2, mean flow 4.295 m^3/s (1987-2016), which indicates ~1000 mm annual rainfall has been lost to ET.
- Whakapara at Cableway, catchment area 162 km^2, mean flow 6.147 m^3/s (1959-2016), which indicates ~800 mm of annual rainfall has been lost to ET.

This results in approximately 11000 ML transiting through the catchment as either surface water runoff or groundwater through-flow.

Groundwater through-flow within the catchment aquifers units is not explicitly quantifiable, due to the absence of groundwater level and hydraulic properties information. However, an understanding of groundwater recharge and discharge to surface water within the catchment is possible, using the low-flow stream gauge measurements, collected as part of Program 2. Runoff vs recharge proportions can also be estimated.

Groundwater is inferred to flow readily through the permeable BA, in generally similar directions to the existing surface water drainage. Along the margins of the BA, groundwater discharges as spring flow, subsequently becoming surface water inflow to the Waikiore Stream (northern basalt plateau) and Whenuaroa Stream (southern basalt plateau). For the purposes of the water balance, it is assumed no net gain or loss of groundwater to/from the underlying PBSA and GA units is occurring i.e. losses and gains cancel each other out. More data is required to provide a more accurate estimate of inter-aquifer flow losses or gains, but this assumption is deemed appropriate for this level of assessment.

Streamflow gauging undertaken by PDP (2016) on the Waikiore Stream and Whenuaroa stream at locations PVX, PRS and PMX (shown on Figure 3), indicates flow of between 170 L/s to 440 L/s. These flows are assumed to be predominantly from groundwater discharge (stream baseflow), as the reading was taken during an extended period of dry conditions, with no recorded rainfall within the previous 8 days. These sites are also out of the influence of the western dam and eastern dam, so are not affected by potential dam releases. The measurement is also likely to be near seasonal low, as it was collected in March i.e. end of summer.

Assuming no net losses or gains to/from the PBSA and GA, the annualised baseflow readings for these sites, which are indicative of annualised recharge for their respective catchment areas, equates to 28% of the 2000 mm of annual rainfall.

Using this as a percentage representative of the entire 22 km catchment extent, this calculates to approximately 12,100 ML of groundwater discharge as stream baseflow. Estimates of recharge are typically made from 5 year return period 'mean annual low flow' measurements, but as this information was not readily available for this catchment, the snapshot baseflow reading from Program 2 has been used.

Table 6 below outlines the basic water balance calculation for the Waiariki River catchment, within the extents described above.

Table 6: Permit Area Water Budget

Water Budget Element	Proportion of total rainfall (mm/yr)	Volume (ML)
Total Rainfall	2000	+44,000
Evapotranspiration (at 50%)	1000	-22,000
Surface Runoff (at 22%)	300	-9900
Groundwater Recharge (at 28%)	550	+12,100
Groundwater Discharge as Baseflow	N/A	-12,100

5.0 Considerations for Groundwater Data Collection during Exploration Drilling

The groundwater quality data collected during Program 1, as well as the conceptual assessment completed within this study, have provided a useful base of information for environmental management of a potential exploration drilling program. PDP suggests the following items for consideration into the proposed drilling program, which are separated into, a) installation of properly constructed groundwater monitoring bores, or b) groundwater testing in open drill holes, before hole decommission/sealing:

1. Groundwater Monitoring Infrastructure - Conversion of the exploration drill holes into properly constructed groundwater monitoring bores, or drilling of separate bore for the same purpose, is recommended. The monitoring bores should be constructed to industry standard (Australian Government National Water Commission, 2012). Design and positioning of the monitoring bores would need to be finalised after drilling, to allow for assessment of geological and preliminary hydraulic testing analysis. However, monitoring bores should only be open/screened within one aquifer i.e. just the BA, or just the GA – to provide specific information on the properties of that aquifer. Subsequently, the three key aquifer units at Puhipuhi – BA, PBSA, and GA - should be monitored

individually, via separate monitoring bores. Spatial distribution of potential monitoring bores is also important, ideally upper catchment and lower catchment bores would be constructed for each aquifer.

2. Groundwater Level Data – Further groundwater level data would be highly useful for understanding the flow regime within the tenement area. If monitoring bores are constructed (as per Recommendation 1), ongoing monitoring could take place, which would ideally be performed by automated pressure transducers – which continuously record groundwater level (head). This provides useful information on the hydrological system, namely; heads in various aquifers, response time to rainfall events, and groundwater flow direction/gradients.

3. Hydraulic Properties Data – Further hydraulic properties data would be highly useful for understanding groundwater flow rates and volumes within the tenement area. If monitoring bores are constructed (as per Recommendation 1), quantitative hydraulic testing i.e. pumping tests, or local scale slug tests, can be performed. Otherwise, if the bore hole is to be decommissioned, semi-quantitative hydraulic testing could be performed within the open hole before it is sealed. This can be done via short-term air-lift flow testing, or use of a submersible pump. Note – the drill holes would require 'development' (cleaning of the bore) in order for testing to occur.

4. Groundwater Quality Data – to provide additional groundwater quality data, sample collection from the above mentioned monitoring bores or pre-decommission flow tests should be completed. Analysis should include at least; field pH, field EC, major ions. Otherwise, or in addition to this, if holes are converted/installation of monitoring bores is possible, future groundwater quality monitoring could be completed – which would provide the most benefit. There are numerous groundwater sampling methodology available, and the most appropriate would be selected when the time comes.

5. Downhole Geophysics / Testing – numerous downhole tests are available which can provide useful groundwater flow and quality information. The testing can be run at the completion of the hole. Selected tests would be determined once more information on the proposed drilling program was determined, but downhole logs of; temperature or heat tracer, EC, impeller, sonic, and CCTV are likely to be the most useful.

Site specific groundwater level, hydraulic properties, and water quality data would be integral to a comprehensive groundwater related Assessment of Environmental Effects (AEE) – should the prospect progress to this stage in the future.

6.0 Conclusions

Three main aquifer units were identified within the study region, and were named; Puhipuhi Basalt Aquifer (BA), Purua Beds Sedimentary Aquifer (PBSA), and the Waipapa & Northland Allochthon Aquifer (GA). The aquifer units comprise the major geological units within the shallow (<150 m depth) subsurface at Puhipuhi.

Conclusions attained on the hydrogeological system at Puhipuhi are outlined below for each groundwater unit.

Basalt Aquifer - BA:

- Flow within the BA is interpreted to be primarily within open joints and rubbly zones present within the basalt flows layers.
- Flow within the BA is primarily at shallow gradient towards topographic lows, discharging either as spring flow or to streams.
- The aquifer is generally considered to be of high permeability.
- Groundwater levels within the basalt are recorded between ~10 m – ~30m below ground level (bGL) – considered moderately deep.
- Water chemistry is predominantly sodium-chloride type water, and of low salinity – indicating source is from recent rainfall.
- Chemistry was similar between bores and springs, supporting the inference of high permeability and short residence times within the BA.
- The BA is the primary water supply aquifer within the tenement region and is generally considered to have good yields and good drinking water quality.

Purua Beds Sedimentary Aquifer – PBSA:

- Comprises lake and river deposited sedimentary rocks and unconsolidated sediments
- Generally anticipated to have low-moderate permeability.
- Groundwater levels are likely to be relatively high, however little data is available to confirm.
- Groundwater flow is likely to be primarily at shallow gradient towards topographic lows – eventually discharging into streams.
- In greywacke depression the PBSA can be >100 m thickness, and these areas are also associated with hydrothermal sinter deposits.
- No water quality information was available for the PBSA.

- The PBSA is not known to be used directly as a water aquifer within the region.

Greywacke Aquifer – GA:

- Groundwater flow within the GA is largely dominated by open fractures and joints (secondary permeability).
- Bulk permeability of the GA is generally considered to be low, except zones of intense fracturing.
- Groundwater levels recorded in the greywacke within the region are predominantly high (artesian to ~20 m bGL).
- Within the tenement area, GA groundwater flow direction is regionally from the north-east to the southwest, with the majority of flow entering and exiting as groundwater through-flow.
- Water chemistry contained notable calcium and bi-carbonate, and higher salinity than that of the BA. Longer residence times are also inferred from this chemistry.

There is some water supply use from this aquifer within the region (but less than the BA), and water quality is generally good for domestic use.

Hydraulic connection between the BA and underlying GA is expected to be variable across site. A generally poor connection where low permeability weathered greywacke/regolith zone is present, which acts to confine the GA. Good connection may occur however near; major faults and crush zones, areas near to basalt source/conduits, or areas of greywacke associated with paleo (pre-basalt) surface water drainage.

Drilling Related Conclusions:

Due to modern drilling processes and standards (New Zealand Environmental Standard for Drilling of Soil and Rock), the potential for groundwater quality degradation, and subsequently surface water quality degradation, is deemed to be low. The drilling process acts to minimise the mixing of deeper and shallower groundwater via the drill hole. After the hole is complete, the New Zealand Environmental Standard for Drilling of Soil and Rock requires implementation of appropriate measures to prevent mixing of aquifer waters and/or surface contamination i.e. casing off of shallow and deep aquifers, capping of holes if artesian flow is discharging. Ultimately, the drill hole will require decommissioning (grouting) or conversion to a monitoring well – both of which are required to be completed in accordance with the relevant standards and are designed to prevent aquifer mixing.

The New Zealand drilling standards-prescribe the use drill fluid products that leave no residual toxicity, and nowadays the majority of products are bio-degradable.

Conclusions attained on the hydrology and the surface water system at Puhipuhi are outlined below.

- The flow pattern in the main river draining the tenement area (Waiariki River) is controlled by two dams and a weir and is therefore governed by (regulated) flow releases from these structures. The natural flow pattern in the streams and rivers downstream of these structures are heavily modified and is therefore likely to result in long periods of stable outflows at the minimum flows specified in the consents. In addition, when the dam is full and water flows into the dams during and following storm events, outflows will be attenuated resulting in reduced and delayed flood flows downstream of the dams and weir.
- These flow characteristics (periods of stable flows and attenuated flood flows) will be most pronounced immediately downstream of the dams and weir and less pronounced with distance further downstream.
- The streams in the tenement area that are not influenced by in- stream structures can be expected to show more 'natural' flow patterns.
- This study has identified that the key receiving river environments downstream of the tenement area are the Waiariki River, Waiotu River, Kaimamaku Stream, Whakapara River, Wairua River, Wairoa River and the Kaipara Harbour.
- Data from relevant Northland Regional Council recorder sites indicate that the five day field survey (including the gaugings) were undertaken at times when recorded flows in the wider catchment were around the median.

As expected gauging results from the field survey indicate a general trend that flow increases with distance downstream of the Tenement area as the contributing catchment area increases.

7.0 Works Cited

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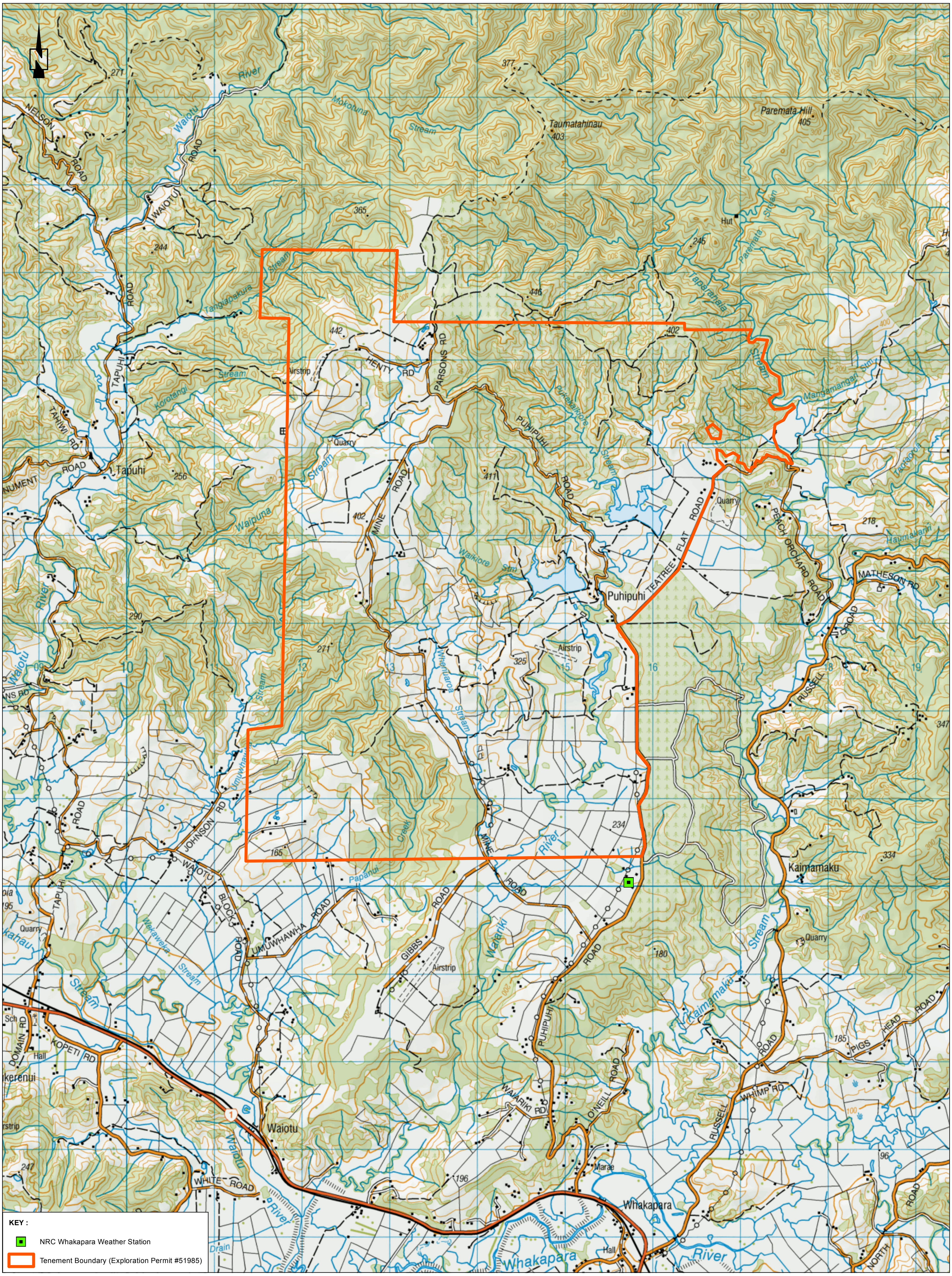


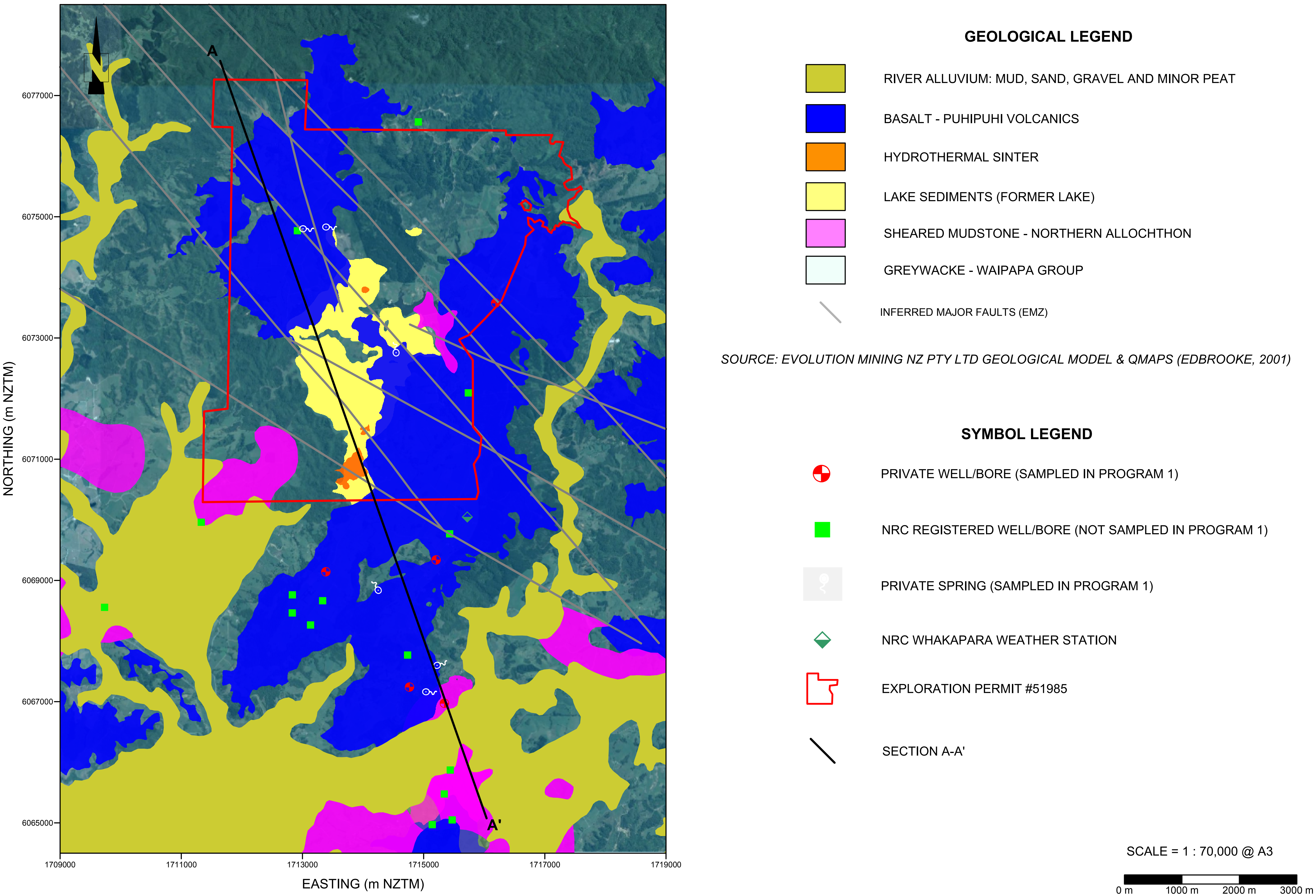
SOURCE: :
1. AERIAL IMAGERY (FLOWN 27/03/2014) DERIVED FROM GOOGLE EARTH PRO (MAY NOT BE SPATIALLY ACCURATE).
2. TOPOGRAPHIC INFORMATION DERIVED FROM LINZ.

FIGURE 1: SITE LOCATION PLAN

SCALE : 1:40,000 (A3)

0 250 500 1,000
Meters

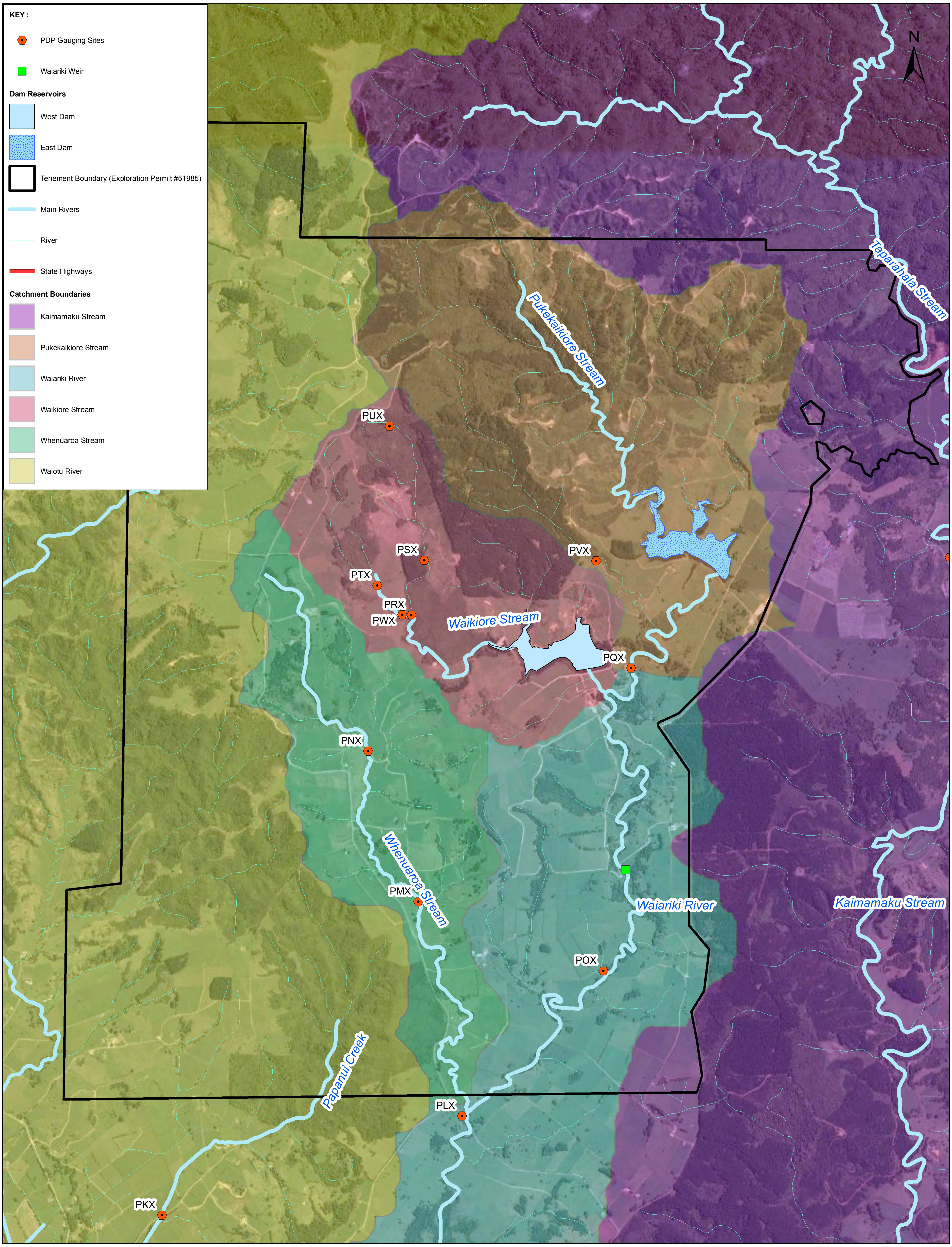
A02982700Z002_Figure 1_Site Location Plan.mxd



SOURCE: EVOLUTION MINING NZ PTY LTD GEOLOGICAL MODEL & QMAPS (EDBROOKE, 2001)

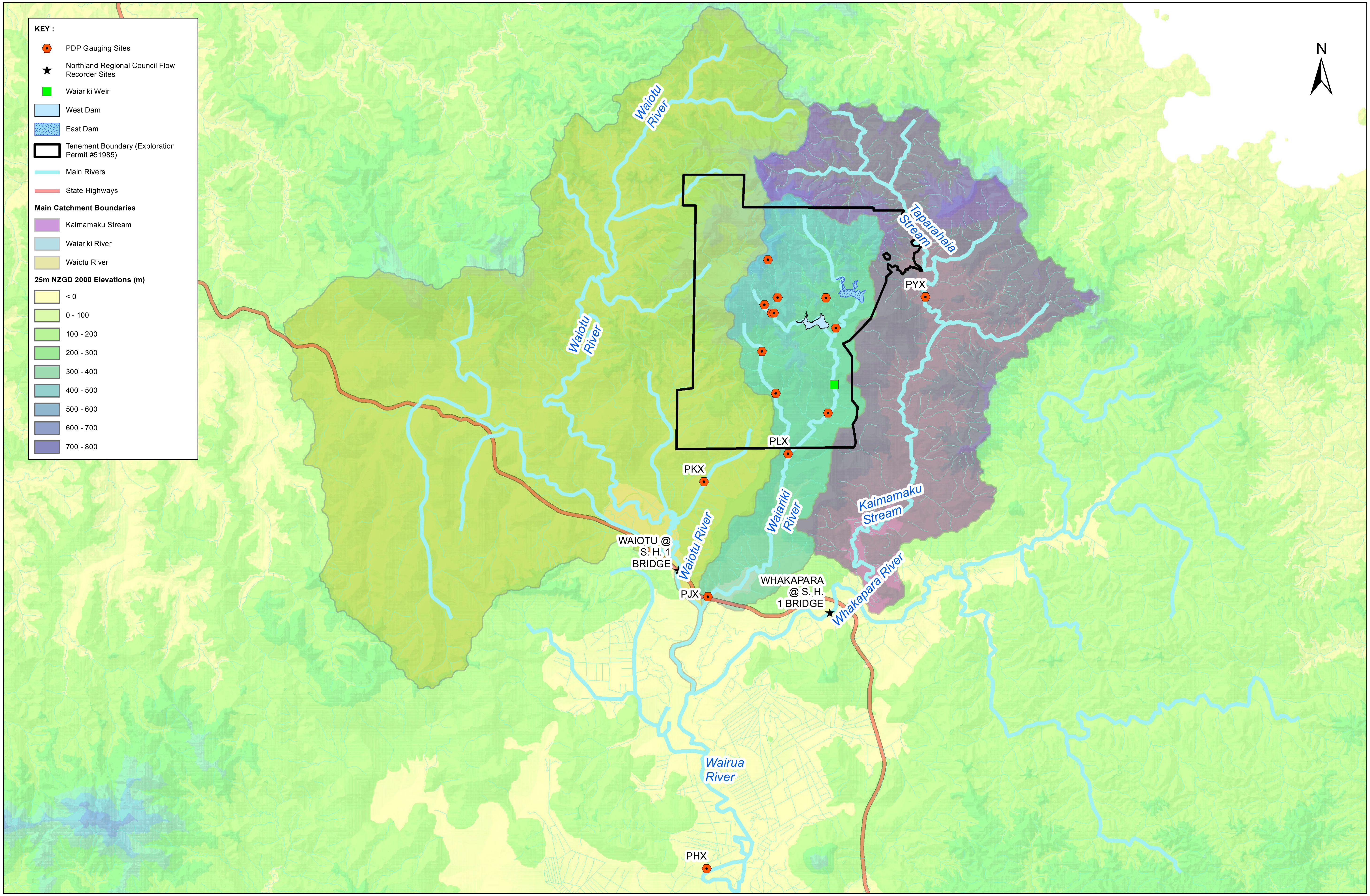
SOURCE: AERIAL IMAGES FROM GOOGLE EARTH (2016)

FIGURE 2: GEOLOGY OF THE PUHIPUHI REGION



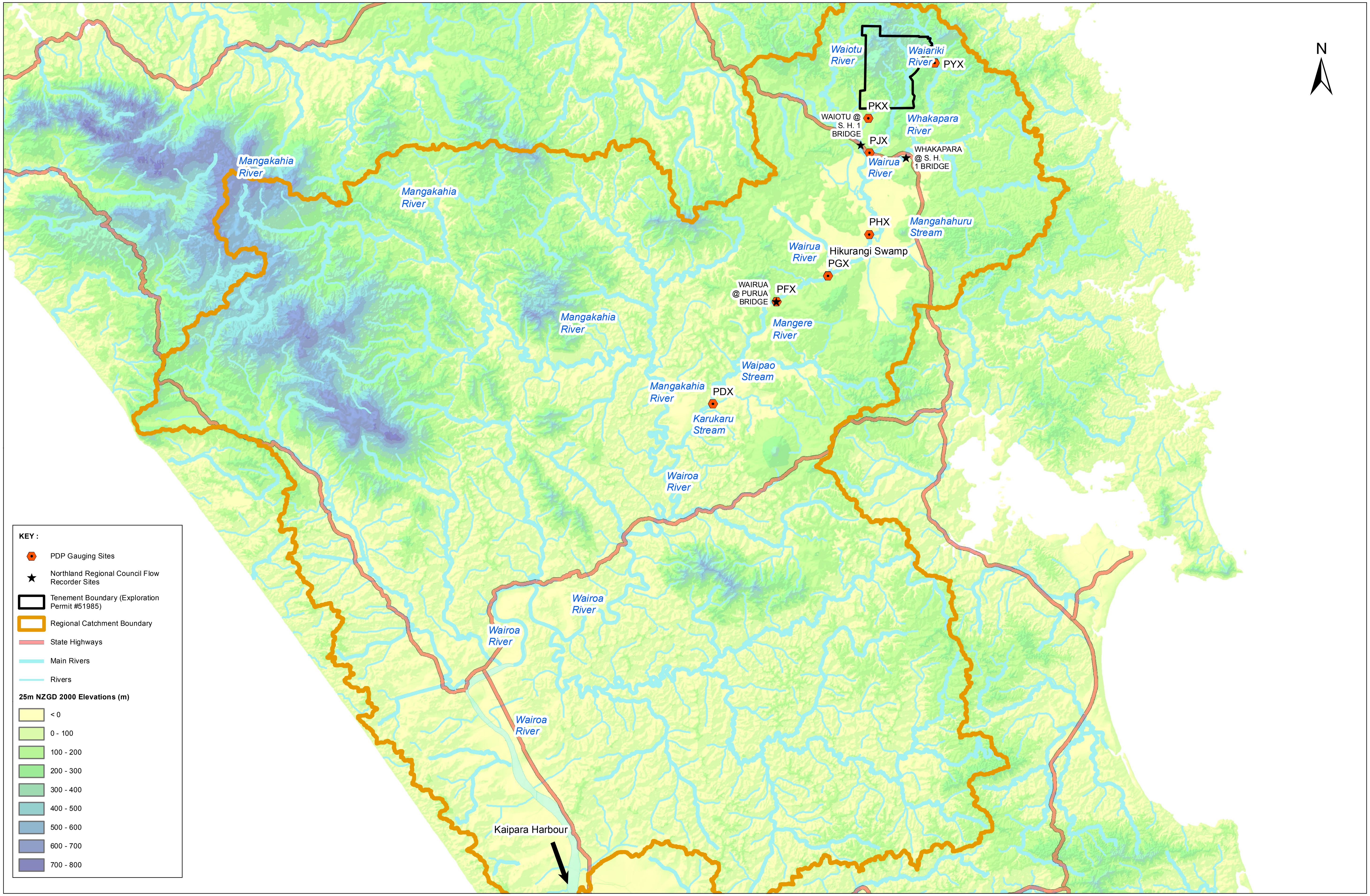
SOURCE:
1. AERIAL IMAGES SOURCED FROM GOOGLE EARTH
2. RIVERS SOURCED FROM LAND INFORMATION NEW ZEALAND

FIGURE 3 : DETAILED CATCHMENT MAP



SOURCE:
1. RIVERS AND ELEVATIONS SOURCED FROM LAND INFORMATION NEW ZEALAND

FIGURE 4: SITE CATCHMENT MAP



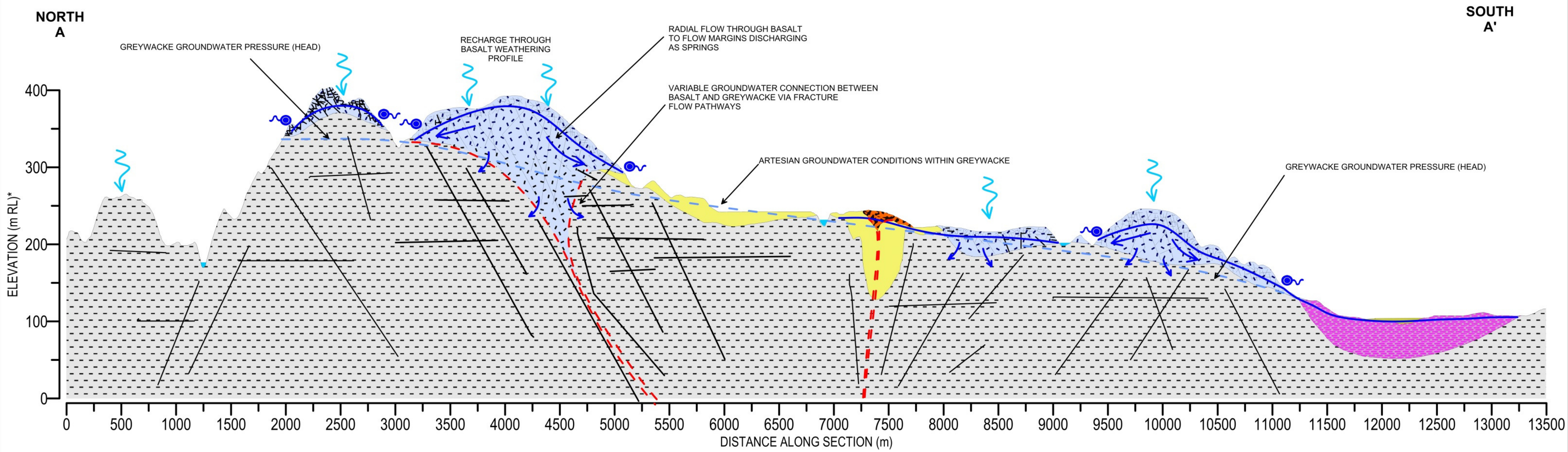
SOURCE:
1. RIVERS AND ELEVATIONS SOURCED FROM LAND INFORMATION NEW ZEALAND

FIGURE 5: REGIONAL CATCHMENT MAP

SCALE: 1:300,000 (A3)

0 1,850 3,700 7,400 11,100 14,800 18,500
METRES

FILED: A02982701_Figure_5_Regional Catchment Map.mxd



CROSS SECTION KEY

- BASALT (BA)
- GREYWACKE (GA)
- SHEARED MUDSTONE
- RIVER ALLUVIUM
- INFERRED GROUNDWATER LEVEL
- INFERRED GREYWACKE GROUNDWATER PRESSURE (HEAD)
- INFERRED GROUNDWATER FLOW DIRECTION
- FORMER LAKE SEDIMENTS (PBSA)
- HYDROTHERMAL SINTER
- INFERRED EXTRUSION PATHWAY
- RAINFALL RECHARGE
- SPRING DISCHARGE

Vertical exageration ~10x

SITE PLAN

GEOLOGICAL LEGEND

- RIVER ALLUVIUM: MUD, SAND, GRAVEL AND MINOR PEAT
- BASALT - PUHIPUHI VOLCANICS
- HYDROTHERMAL SINTER
- LAKE SEDIMENTS (FORMER LAKE)
- SHEARED MUDSTONE - NORTHERN ALLOCHTHON
- GREYWACKE - WAIPAPA GROUP
- INFERRED MAJOR FAULTS (EM)

SOURCE: EVOLUTION MINING NZ PTY LTD GEOLOGICAL MODEL & QMAPS (EDBROOKE, 2001)

SYMBOL LEGEND

- PRIVATE WELL/BORE (SAMPLED IN PROGRAM 1)
- NRC REGISTERED WELL/BORE (NOT SAMPLED IN PROGRAM 1)
- PRIVATE SPRING (SAMPLED IN PROGRAM 1)
- NRC WHAKAPARA WEATHER STATION
- EXPLORATION PERMIT #51985
- SECTION A-A'

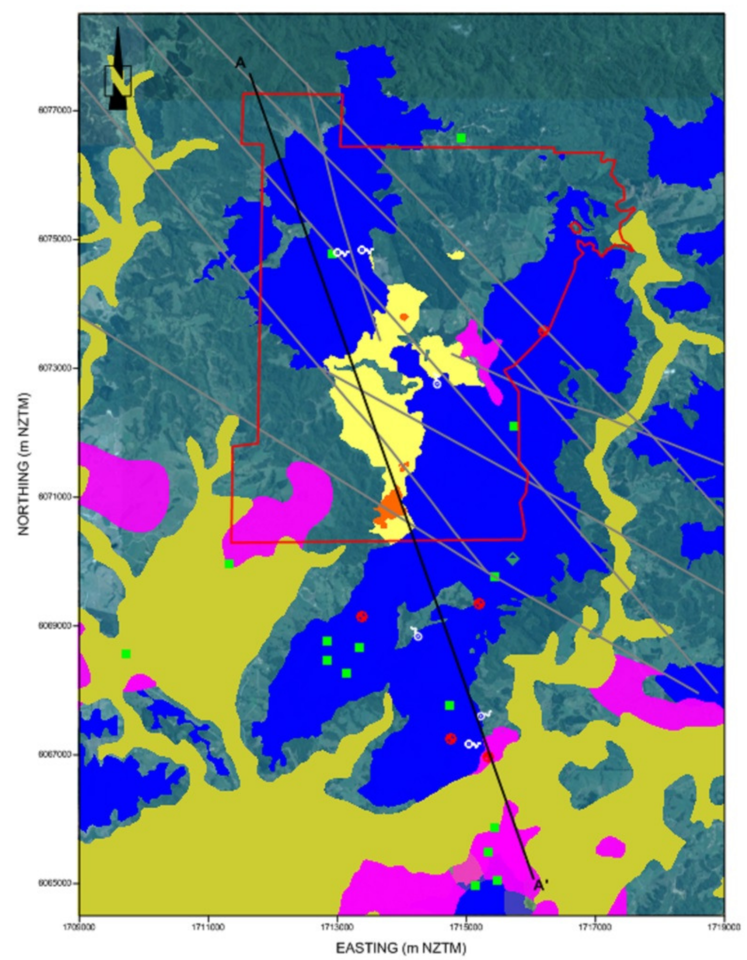
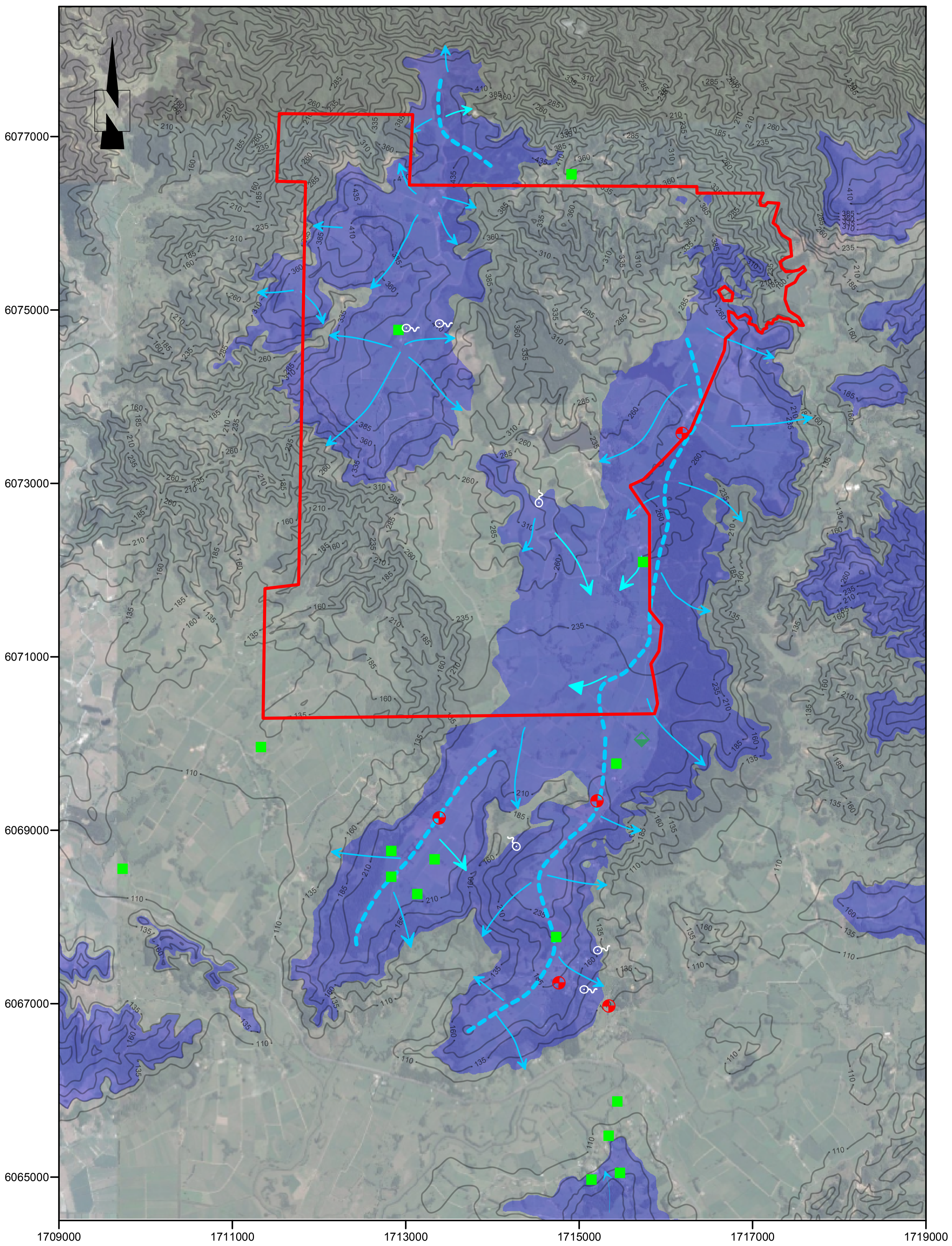


FIGURE 6: PUHIPUHI HYDROGEOLOGICAL CONCEPTUAL MODEL



SOURCE: AERIAL IMAGES FROM GOOGLE EARTH (2016)

GEOLOGICAL LEGEND

BASALT - PUHIPUHI VOLCANICS

SOURCE: EVOLUTION MINING NZ PTY LTD GEOLOGICAL MODEL

GROUNDWATER FLOW LEGEND

INTERPRETED GENERALISED GROUNDWATER FLOW PATHS IN BASALT AQUIFER

INTERPRETED GROUNDWATER FLOW DIVIDE IN BASALT AQUIFER (EXCLUDES LOCALISED RADIAL FLOW)

SYMBOL LEGEND

PRIVATE WELL/BORE (SAMPLED IN PROGRAM 1)

NRC REGISTERED WELL/BORE (NOT SAMPLED IN PROGRAM 1)

PRIVATE SPRING (SAMPLED IN PROGRAM 1)

NRC WHAKAPARA WEATHER STATION

EXPLORATION PERMIT #51985

240 m

TOPOGRAPHIC CONTOURS @ 25 m INTERVAL
SOURCE: EVOLUTION MINING NZ PTY LTD GEOLOGICAL MODEL

SCALE = 1 : 70,000 @ A3

0 m 1000 m 2000 m 3000 m

FIGURE 7: INTERPRETED BASALT AQUIFER GROUNDWATER FLOWS

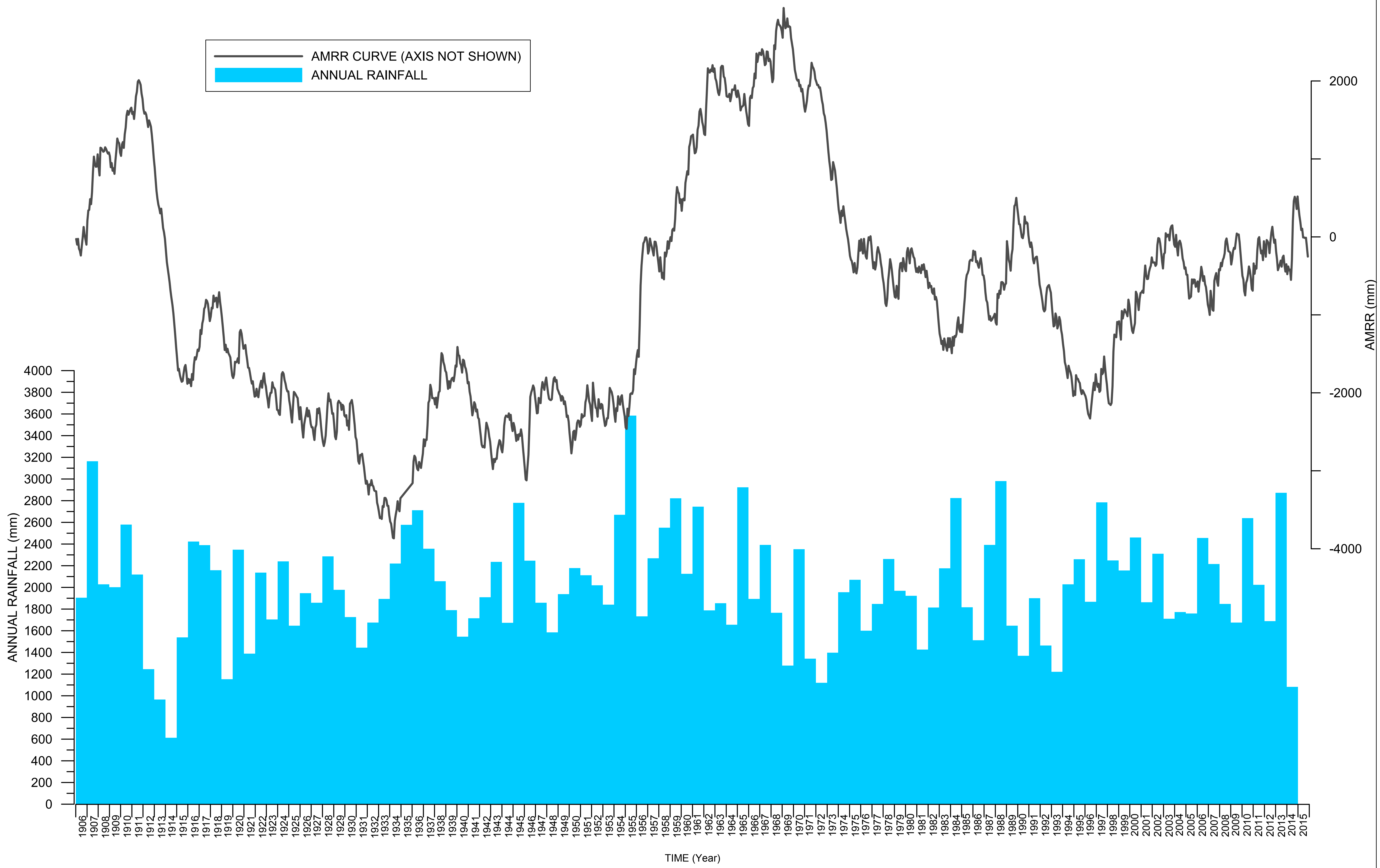


FIGURE 8: PUHIPUHI RAINFALL AND AMRR

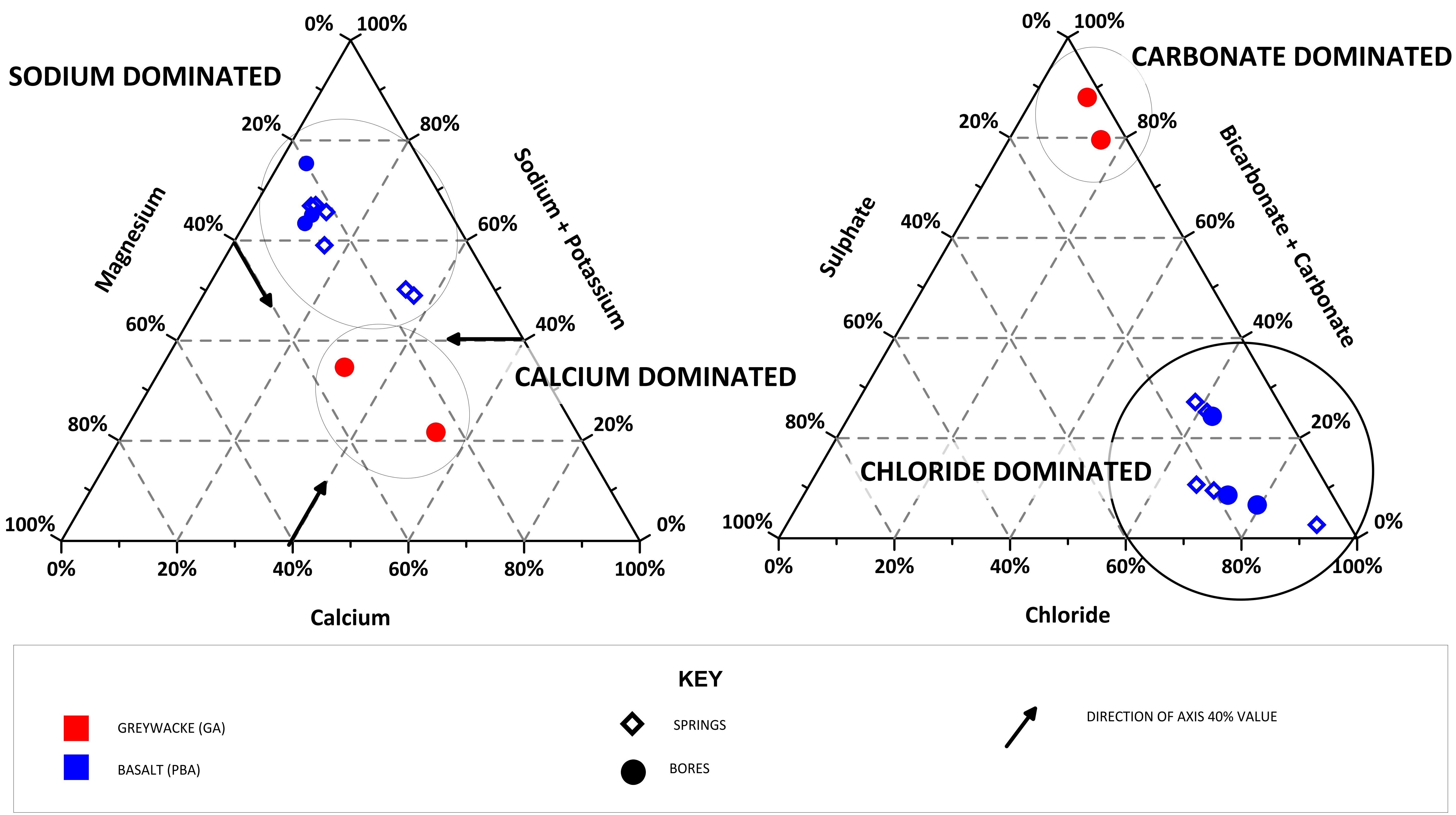
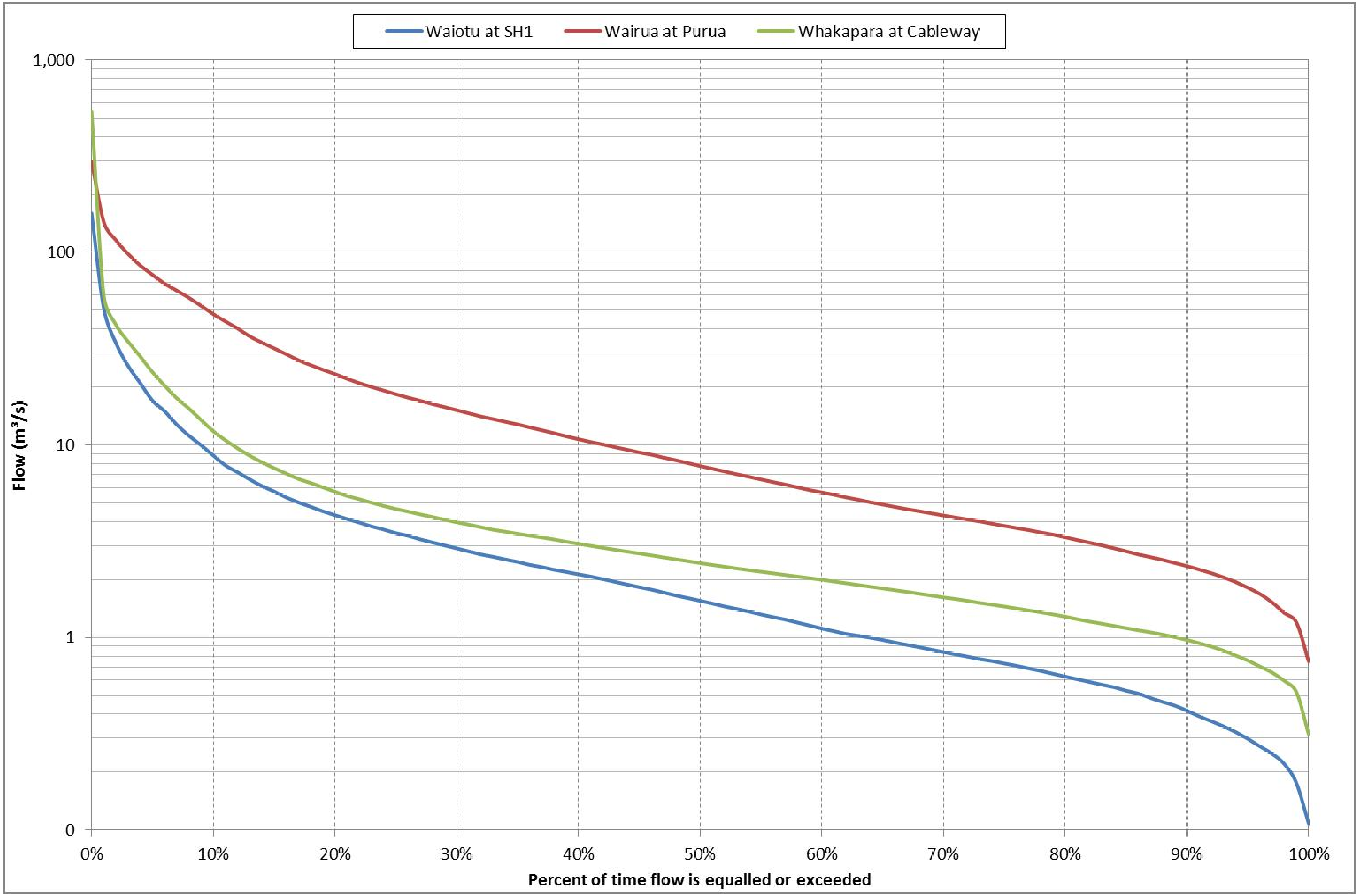


FIGURE 9: PUHIPUHI MAJOR-IONS PIPER PLOTS

Appendix A

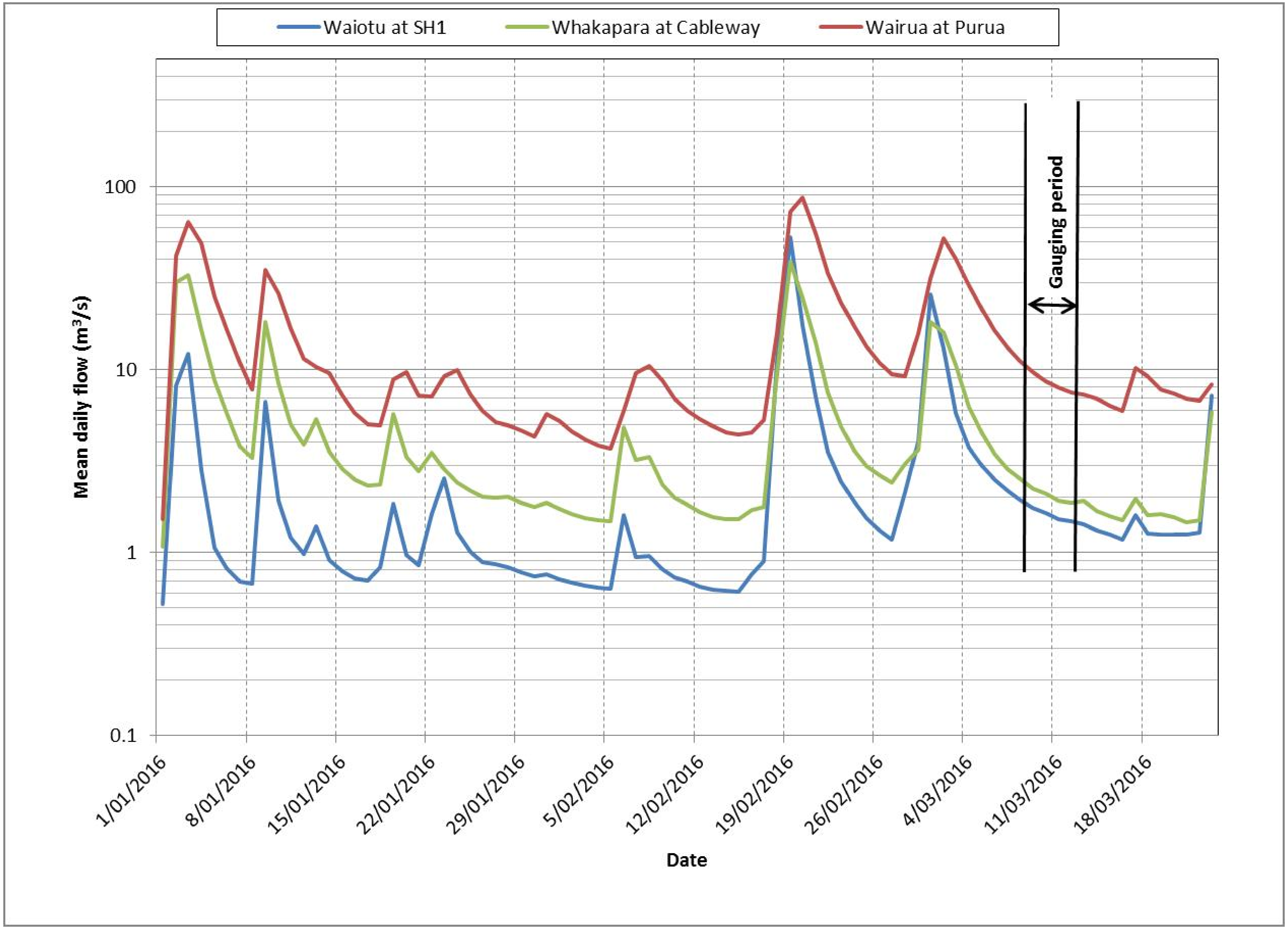
Flow Duration Curves



APPENDIX A: FLOW DURATION CURVES FOR NRC RECORDED SITES

Appendix B

Hydrographs



APPENDIX B: HYDROGRAPHS FOR RELAVENT NRC RECORDER SITES 1 JANUARY 2016 - 23 MARCH 2016

Appendix C

Groundwater Levels

Table C-1: Groundwater Levels

Bore ID	Type	Location (NZTM)		Aquifer Unit	Depth to Water (mbgl)	Groundwater Elevation (m RL)	Monitored Date	Source
		Easting	Northing					
GW01	Bore	[1]		BASALT	17	243	2/03/2015	PDP Field Survey (March 2016)
GW02	Bore	[1]		BASALT	7.2	214	2/03/2015	PDP Field Survey (March 2016)
GW03	Bore	[1]		BASALT	Unable to dip	-	1/03/2016	PDP Field Survey (March 2016)
GW05	Bore	[1]		BASALT	Unable to dip	-	2/03/2015	PDP Field Survey (March 2016)
GW06	Bore	[1]		GREYWACKE	8.75	98	4/03/2015	PDP Field Survey (March 2016)
GW07	Spring	[1]		BASALT	0	183	3/03/2015	PDP Field Survey (March 2016)
GW08	Spring	[1]		BASALT	0	-	3/03/2015	PDP Field Survey (March 2016)
GW09	Spring	[1]		BASALT	0	-	3/03/2015	PDP Field Survey (March 2016)
GW10	Spring	[1]		BASALT	0	300	4/03/2015	PDP Field Survey (March 2016)
GW11	Spring	[1]		BASALT	0	398	3/03/2015	PDP Field Survey (March 2016)
GW12	Spring	[1]		BASALT	0	398	3/03/2015	PDP Field Survey (March 2016)
202021	Bore	1709734	6068556	-	-	-	[2]	NRC Database (March 2016)
202023	Bore	1713333	6068665	-	9.1	212	[2]	NRC Database (March 2016)
202024	Bore	1714735	6067769	BASALT	11.6	201	[2]	NRC Database (March 2016)
202025	Bore	1714931	6069268	GREYWACKE	5.4	235	[2]	NRC Database (March 2016)
202026	Bore	1712916	6074770	GREYWACKE	10.1	384	[2]	NRC Database (March 2016)
202027	Bore	1715429	6069769	BASALT	Dry	-	[2]	NRC Database (March 2016)
202305	Bore	1715471	6065049	GREYWACKE	-	162	[2]	NRC Database (March 2016)
205127	Bore	1711330	6069960	-	-	122	[2]	NRC Database (March 2016)
205205	Bore	1715340	6065477	-	4.2	120	[2]	NRC Database (March 2016)
205579	Bore	1712832	6068464	BASALT	28.1	193	[2]	NRC Database (March 2016)
205580	Bore	1712833	6068762	BASALT	11.8	209	[2]	NRC Database (March 2016)
205581	Bore	1713133	6068265	BASALT	26.4	194	[2]	NRC Database (March 2016)
205615	Bore	1715142	6064971	GREYWACKE	19	127	[2]	NRC Database (March 2016)
205693	Bore	1715440	6065872	FORMER LAKE SEIMENTS	3.9	93	[2]	NRC Database (March 2016)

Table C-1: Groundwater Levels

Bore ID	Type	Location (NZTM)		Aquifer Unit	Depth to Water (mbgl)	Groundwater Elevation (m RL)	Monitored Date	Source
		Easting	Northing					
205870	Bore	1714912	6076565	GREYWACKE	2	399	2	NRC Database (March 2016)
209703	Bore	1715340	6066973	GREYWACKE	8.75	98	2	NRC Database (March 2016)
210203	Bore	1715737	6072094	GREYWACKE	12	248	2	NRC Database (March 2016)

Notes:
1. *Private bore locations are not publically available.*
2. *Historical monitoring dates at time of drilling.*
3. *(–) information unknown.*

Appendix D

Existing Groundwater Users

Table D-1: Identified Existing Groundwater Users

Bore ID	Type	Location		Aquifer Unit2	Use	Source
		Easting	Northing			
GW01	Bore	[1]		GREYWACKE	Private Supply (Domestic Potable & Livestock)	PDP Field Survey (March 2016)
GW02	Bore	[1]		BASALT (weathered)	Private Supply (Domestic Potable)	PDP Field Survey (March 2016)
GW03	Bore	[1]		BASALT (weathered)	Private Supply (Domestic Potable)	PDP Field Survey (March 2016)
GW04	Bore	[1]		GREYWACKE	Former mineral exploration test hole, water not in use	PDP Field Survey (March 2016)
GW05	Bore	[1]		BASALT (weathered)	Private Supply (Domestic Potable)	PDP Field Survey (March 2016)
GW06	Bore	[1]		GREYWACKE	Private Supply (use unknown)	PDP Field Survey (March 2016)
GW07	Spring	[1]		BASALT (weathered)	Private Supply (use unknown)	PDP Field Survey (March 2016)
GW08	Spring	[1]		BASALT (weathered)	Private Supply (Domestic Potable)	PDP Field Survey (March 2016)
GW09	Spring	[1]		BASALT (weathered)	Private Supply	PDP Field Survey (March 2016)
GW10	Spring	[1]		BASALT (Margin)	Private Supply	PDP Field Survey (March 2016)
GW11	Spring	[1]		BASALT (Margin)	Private Supply	PDP Field Survey (March 2016)
GW12	Spring	[1]		BASALT (Margin)	Private Supply	PDP Field Survey (March 2016)
202021	Bore	1709734	6068556	Unknown	Private Supply	NRC Database (March 2016)
202023	Bore	1713333	6068665	Unknown	Private Supply	NRC Database (March 2016)
202024	Bore	1714735	6067769	BASALT (weathered)	Private Supply	NRC Database (March 2016)
202025	Bore	1714931	6069268	GREYWACKE	Private Supply	NRC Database (March 2016)
202026	Bore	1712916	6074770	GREYWACKE	Private Supply	NRC Database (March

Table D-1: Identified Existing Groundwater Users

Bore ID	Type	Location		Aquifer Unit2	Use		Source
		Easting	Northing				
							2016)
202027	Bore	1715429	6069769	Basalt	Private Supply		NRC Database (March 2016)
202305	Bore	1715471	6065049	WAIPAPA	Private Supply		NRC Database (March 2016)
205127	Bore	1711330	6069960	Unknown	Private Supply		NRC Database (March 2016)
205205	Bore	1715340	6065477	Unknown	Private Supply		NRC Database (March 2016)
205579	Bore	1712832	6068464	BASALT (weathered)	Private Supply		NRC Database (March 2016)
205580	Bore	1712833	6068762	BASALT (weathered)	Private Supply		NRC Database (March 2016)
205581	Bore	1713133	6068265	BASALT	Private Supply		NRC Database (March 2016)
205615	Bore	1715142	6064971	GREYWACKE	Private Supply		NRC Database (March 2016)
205693	Bore	1715440	6065872	PURUA BEDS	Private Supply		NRC Database (March 2016)
205870	Bore	1714912	6076565	GREYWACKE	Private Supply		NRC Database (March 2016)
209703	Bore	1715340	6066973	GREYWACKE	Private Supply		NRC Database (March 2016)
210203	Bore	1715737	6072094	GREYWACKE		Private Supply	NRC Database (March 2016)

Notes:

1. Private bore locations are not publically available