

Proposed Muggerridges pumpstation – drainage management plan

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1 Introduction

The proposed Muggeridges pumpstation is an important capital works project within the Pouarua area of Piako River Scheme (PRS). The purpose of the pumpstation is to provide and maintain a continued drainage service to the current PRS standard for the community and farmland in the Muggeridge area.

The area of land bounded by Kaihere Road to the East and South, Pouarua Road to the West and Orchard Road to the North is experiencing poor drainage and ponding, due to ongoing peat settlement. This area is a part of Pouarua Peat Dome which has been developed over many years into pastoral farming. This change in land use has resulted in steady rate of peat settlement, and the drainage system has been progressively modified to suit the changed land contour to provide ongoing drainage to the area.

A number of pumpstations (Phillips Road, Torehape, Stitchbury's and Kaihere) and floodgates (Phillips Road, Muggeridges, Torehape, Stitchbury's and Kaihere) were installed along Piako River in the area (generally in the 1960's and earlier) through the Piako River Scheme, to provide drainage services for existing farmland. Refer to Figure 1 for Muggeridges catchment and locations of the pumpstations.

As the peat soil within the Muggeridge area has consolidated, resulting in land contour changes overtime, this drainage service is now becoming compromised. Peat settlement has resulted in land within the Muggeridge area now approaching mean sea level (MSL) in some parts, and the present scheme floodgate and pump outlets are becoming ineffective for this area. This peat settlement will continue until underlying clay levels are reached in approximately 100 years, with land levels expected to be around 1.5metres below MSL at that time.

The Muggeridges pump is to provide drainage to the specific area which is currently poorly drained and experiencing ponding, and the expectation that peat consolidation will continue to compound this issue, and eventually result in complete failure and loss of this farm land. As well as avoiding future degradation of this productive farmland, the operation of the pumpstation will maintain the productivity of the land, maintaining economic activity in the area and contribute to the overall productivity of the Waikato Region. The Muggeridge pumpstation would replace the existing scheme outlets currently servicing this area.

The Muggeridges catchment was initially conceived as a part of Pouarua catchment. However further investigations, the pattern of drainage and peat settlement indicates that the low lying Muggeridges catchment is currently largely separate from the Pouarua catchment, and can be totally isolated from the Pouarua catchment. This would both provide optimisation of the drainage network, and protection of the adjacent Torehape wetland from drainage within the Muggeridge area.

The purpose of this report is to set out a drainage plan for the development and management of the Muggeridges area, with the aim of achieving both:

- Maintenance and optimisation of drainage and farm productivity
- Minimisation of adverse effects, including protection of the Torehape wetland and minimising rate of peat settlement.

The report includes:

- An outline of expected peat settlement and land changes over the next 100 years

- Infrastructure and drainage network changes, required to maintain land productivity and service levels, and adapt to changing land levels over time
- Management actions and practices required to ensure isolation of the Mugeridges area from Torehape wetland, and to minimise other potential adverse affects
- Roles and responsibilities

This report provides an overall view of the current drainage system and drainage issues and failures in the Mugeridges catchment and also highlights the future drainage problems due to peat settlement if the proposed pumpstation is not installed, and provides a layout for the changes required in the drainage system to sustain the impact of land settlement in future.

Refer to **Figure 1** for the location and the area of Mugeridge and Pouarua Catchments

2 Scheme background

2.1 Introduction

Land and scheme development in this area has generally been undertaken over the last 50 – 100 years, with initial drainage and river works undertaken in the 1920's. A major upgrade to the river system and drainage network was undertaken in 1960's through the Piako River Scheme. Land development has been progressively undertaken in conjunction with and following these major works, with land development occurring initially in the north and east of the area.

The Waikato Regional Council (WRC) through the PRS, provides the major river flood protection and drainage outlet services to the area, and the area is rated for these current services under the PRS. Local internal drainage network services are provided by the Hauraki District Council (HDC) through the Western Plains Drainage District (WPDD), and are rated by HDC for these services.

The Pouarua and Mugeridge area consists mainly of peat land that includes the remaining elevated Torehape peat dome and wetland in the higher parts of the catchment at the south western end. Early development saw the catchment draining off the peat dome by gravity, with the Piako River Scheme providing drainage and flood management via several small floodgates and pumps along the Piako River to the east, and through the Pouarua canal floodgate and pumpstation to the northwest. As the Pouarua peat dome has consolidated over time the drainage patterns have changed, and will continue to change. Originally the area was a large elevated peat dome that shed water in several directions by gravity. Increasingly, with peat settlement, the lower land levels reflect the underlying clay contours, and the need for drainage to be supplemented by increased pumping. The underlying clay falls from the Maukoro canal in the west to the Piako River clay terrace in the east.

The changing drainage patterns require a staged approach over time for altering or upgrading the drainage network as the peat consolidates, along with the provision of new and replacement assets such as floodgates, canals, drainage systems and pumpstations to service affected areas. Refer to **Figure 2 & 7** for the existing drainage system and flow directions in the area. The Pouarua and Mugeridge area is made up of several catchments, flowing to several different streams, canals, and outlets.

2.2 Pouarua catchment surface hydrology

The Pouarua catchment can be sub-divided in five areas based on the surface hydrology as shown on **Figure 2**.

The area A includes Torehape wetland area and a small area on the north-west of the wetland. This area is bounded by a stopbank on Pitts Road on the east, Waikoura Stream on the south and Torehape Road on the north. This subcatchment drains towards south east. An 1800mm diameter culvert across Torehape Road at Central Road intersection connects a small area of land on northern side, to a drain through the wetland area.

Area B is the area adjacent to the Torehape Wetland towards the north. Flows from this area are draining towards east to Pouarua Canal, and then south through to Pitts Road floodgate.

Area C is the higher land in the Pouarua catchment and drains North-East to the Pouarua Canal. The major canals of this sub catchment are Maukoro canal, Central Road canal and Pouarua Canal.

Area D is the Northern subcatchment of the Pouarua catchment. This area has been developed for a long time, and the peat in this area is almost exhausted and no further land settlement is expected. The drainage system is well established and working satisfactorily. This area has four small pumpstations managed by HDC, and the main floodgate and pumpstation (Pouarua pumpstation) for the Pouarua canal managed by WRC.

The four HDC internal drainage pumpstations, Central Road, Hopai East, Hopai West and Rawerawe, were the last pumps installed in the catchment in 2001 as a part of Pouarua Scheme, to service localised low lying areas to north of SH2.

Area E is the Muggeridges catchment (which is the lowest subcatchment). This area and the higher terrace to the east, currently drains east to the Piako River. This catchment has a series of separate subcatchments, and drains discharging through several floodgate and pump outlets to the Piako River. This subcatchment is currently serviced by five floodgates and four small pumpstations.

Area marked as F is draining towards Ngatea and the Piako River in the north, and is not a part of the broader Pouarua area.

The flows from the higher parts of the Pouarua catchment, areas B & C, to the west of the Pouarua canal, drain to the Pouarua and Maukoro canals. The majority of flows from these sub-catchments go to Pouarua floodgate and pumpstation to the North, and remaining (from catchment B) to Pitts Road floodgate to the South.

The generally much lower Muggeridge area "E" and adjacent clay terrace to the east, are currently drained by a series of canals draining east towards the Piako River. This area was initially included as a part of Pouarua catchment, but recent review of the catchment has established that it is largely an independent and separate catchment, draining west to east directly to the Piako River. The Pouarua canal (and associated road and earth embankments) acts as a cut-off drain, separating the upper areas B & C to the west, from the Lower area E.

The existing Pouarua pumpstation and floodgate doesn't currently serve much of the proposed catchment area of the Muggeridges pumpstation (only a small area in the northern part of the Muggeridge catchment presently drains to the Pouarua canal). Due to land settlement, existing drainage to the Pouarua canal north will become increasingly ineffective, and dependent on additional pumping.

The sub-catchment "E" and clay terrace are currently serviced by four pumpstations and floodgates discharging directly into the Piako River. These are the Kaihere, Stitchbury's, Torehape, and Philips Road and all these pumpstations are managed by WRC.

In spite these existing pumpstations and floodgates, the Muggeridges catchment marked by area "E" has an increasingly poor drainage standard. This can be attributed to the ongoing land settlement, resulting in lower ground levels below the present lowest pumping levels of the pumpstations and associated floodgates. Also with increasing reliance on pumping, the existing pumps do not have sufficient pumping capacity or capability to serve effectively the both Muggeridges and clay terrace catchments.

In the Muggeridge area at present, the worst inundation occurs in isolated low-lying pockets, particularly in the area north of Philips Road and some part of Stitchbury's catchment. These areas are already experiencing permanent water logging, drainage failure and seasonal ponding that severely restrict farming.

The more elevated areas don't currently experience drainage failure, as their elevation gives them year-round gravity fall to the low-lying areas. In future these areas will experience progressively worsening drainage conditions due to peat settlement and they will eventually be in a similar position (and therefore be just as reliant on pumping) as the presently low-lying areas.

The relationship between current ground levels and the invert levels of drainage outlets primarily affects the delay in receiving maximum scheme benefits. The land is expected to sink 0.5 to 0.6m in the next 25 years, 1.0 to 1.25m in the next 50 years and 2.0 to 2.5m in the next 100 years. This will result in approximately 65% of the Muggeridge catchment (generally land below RL 1.5m) being inundated or waterlogged within 25 years and 90-95% within 50 years.

2.3 Ground and clay levels

The current ground levels in the Muggeridges area vary from 3.5 to 0.5m with around 65% of the area currently below 1.5m and around 45% below 1.0m. Some of the low lying land with ground level around 0.5m is getting waterlogged and seasonal ponding due to drainage failure. This has restricted the farming in the area in these areas and further deterioration will occur if nothing is done to improve the drainage system.

The depth of clay in relation to the invert levels of the existing floodgates and pumpstations dictates the future standard of drainage without Muggeridges pumpstation. The lowest clay levels are in the range of -1.3 to -1.5m indicating the maximum potential for future peat settlement and future dependency on pumping.

The tidal range affects the functioning of the floodgate action and drainage dependency on pumping. Any future rise in mean sea level due to climate change will also reduce the floodgate actions and increase requirement of pumping. The tidal range at Ngatea is from 1.2m to -1.0m, whereas the existing floodgate inverts and pumpstation pumping level ranges from -0.15 to -1.0m. This means that the existing floodgate levels are at the limits of their effective operation, and will only operate effectively during the lower portion of the tidal range. When the land settles below 1.0m, the water from the low lying area

will not gravitate effectively to the existing outlets and the drainage service level cannot be reliably met. The pumpstations are independent of tide levels; however they are also reaching the limits of their lowest effective pumping levels (LEPL).

2.4 Catchment areas adjacent the Muggeridges catchment

To the East of Muggeridges catchment, a clay terrace of approximately 1km wide runs along the Piako River, which means that there will be no significant settlement of this strip, and will be increasingly higher than the Muggeridge area in the medium to long term. These catchments will need to be separated in the future from the Muggeridge area, to optimise gravity drainage and minimise pumping requirements.

The area north of Muggeridges and SH2, and north-west of Ngatea Township, has already been largely developed and has a good drainage system, and the ground contour has almost reached the underlying clay layer except for a small pocket around Orchard East Road near Pouarua Canal intersection.

Areas to the west of the Pouarua canal and Muggeridges catchment, and to the north of the Torehape wetland, have generally been developed more recently, and are currently on significantly higher land. This area still has a significant peat layer underneath, and the area is expected to continue to settle in future with ongoing pastoral use. The drainage and management issues of this area will need to be separately investigated in the future, to minimise impacts particularly on the adjacent wetland.

Torehape Wetland is on the south-west of Muggeridges catchment, and is presently separated from Muggeridges by the Pouarua canal, and an earth embankment along Pitts Road and Pouarua South Road embankment further north. Ensuring effective separation and isolation of the Muggeridge catchment from the Torehape wetland is an important requirement in the further development and management of the Muggeridge area.

The existing ground levels in the Muggeridges catchment are in the range of 3.5 to 0.5m RL, and the tidal range of Piako River is between 1.2mRL to -1.0mRL. During high tides the drainage of the area is managed by pumping. The capacities and lowest effective pumping level (LEPL) of the existing pumpstations in the catchment are listed below

- Stitchbury's Pumpstation – 0.85cumec; -0.15m(LEPL)
- Torehape Pumpstation – 1.0cumec ; -0.50m(LEPL)
- Philips Road Pumpstation – 0.6cumec ; -0.50m(LEPL)

The five floodgates installed on the east side of the catchment provide gravity drainage to the river at lower tide levels, while preventing river water backflowing into the internal drains during high tides. When operating fully the floodgates provide significantly greater discharge capacity, however this is limited by tide levels in relation to the level of the land it services. The outlet levels of these floodgates are

- Stitchbury's Floodgate – -0.85mRL
- Torehape Floodgate – -0.6mRL
- Muggeridges Floodgate- -0.74mRL
- Philips Road Floodgate – -0.5mRL

These collective outlets currently provide the primary drainage for the Muggeridge catchment area and the higher clay terrace adjacent the Piako River. However with peat

settlement these outlets are becoming ineffective in servicing the increasingly low lying Muggeridges area, and require both the installation of the new Muggeridge pumpstation, and future separation of the higher land on the clay terrace from the lower land.

As noted above the Muggeridges catchment is separated from the western catchments by the Pouarua Canal on the western side, and associated earth and road embankments.

2.5 Benefits from the Muggeridges pumpstation and the associated works

Without the new Muggeridges pumpstation, it is envisaged that

- The catchment will settle to a point where it cannot be drained by gravity through floodgates.
- The catchment area of the existing pumpstations along Kaihere Road will get reduced considerably and they will cease serving the Muggeridges area and only serve the area on the clay terrace near the Piako River.
- Within 25years approximately 65% of the Muggeridges area will have settled to below RL1.0m, and substantial part of which will be below 0.5m
- Within 50years approximately 95% of the Muggeridges area will be below 1.0m
- Within 100years, it is expected that all land in the Muggeridges area will be lower than 0.5m which will result in full drainage failure and inundation of whole area during winter.

Without installation of the Muggeridge pumpstation or alternate pumping system, land settlement will result in the progressive drainage failure and reduction in productivity and eventual complete loss of the current 1087ha of farmland across the Muggeridge area.

Direct benefit of pumpstation

The following direct benefits are envisaged by the implementation of Muggeridges project

- Elimination or reduction of economic losses presently occurring through water logging, drainage failure and ponding.
- Slowing the rate of reversion to unproductive swamp land, and loss of farm land
- Facilitating the effective use and land development, and resultant increased farm productivity
- Enabling change in land use from dry stock to more profitable dairying.

Indirect benefit

All properties within the Muggeridges area and within a large area of Pouarua catchment will get indirect benefit from the project. Some of them are listed below

- The proposed isolation of Muggeridges catchment from the Pouarua catchment will prevent water flowing westwards, enable predominant gravity drainage from the higher land in the southwest of the Pouarua catchment, and thus reducing Pouarua pumping costs and improve the effectiveness of Pouarua drainage outlets.
- Future improvement in farm productivity will generate additional economic activity that will benefit the local area and town of Ngatea.

3 Land change

3.1 Introduction

The Muggeridge catchment contains the lowest underlying clay levels in this area, and will progressively form a low lying basin between the higher ground on the clay terraces to the east, and Pouarua canal to the west. Separation of this basin and catchment from the surrounding higher land enables optimisation and efficiency of the drainage system, with the Muggeridge pumpstation servicing only this lowest land. This enables maximising use of gravity drainage for the higher land in the other catchments.

Soil Type -The soil in the catchment area is mostly peat and has been sub-classified into acidic, organic and peat soils. Refer to **Figure 3** for soil classes in the Muggeridges catchment area.

Underlying clay- Most of the Muggeridges and its surrounding area was originally part of large peat swamp, centred around the Torehape peat dome. Land clearance, and improvement in drainage system and construction of canals to allow drainage, started the cycle of land consolidation.

The earliest recorded survey was undertaken in 1923-24, and the second major survey was done in 1957 and this survey determined the underlying clay layer levels. In 1979 four cross section levels were established across peat dome from SH27 to the Piako River to map the depth of peat deposition. Three of these cross sections were re surveyed in 1990 and mapped. These cross sections provide the depth of clay layer within the area and peat settlement occurred in those years.

3.2 Peat settlement rate

The average rate of peat settlements recorded* along the surveyed cross section mentioned above in the vicinity of Muggeridges pumpstation are

1924 to 1957	45mm/year
1957 to 1979	18mm/year
1979 to 1990	16mm/year

(*Source:- Doc #1413071, *The Hydrology of the Waitakaruru River and Maukoro Canal Systems and Drainage of Pouarua Peat Dome*, WRC, July 1993, Table 5, page 28)

In 2013, a research on subsidence rate of peat was carried out by a student of Waikato University as a part of his BSc thesis and his observations were that the future rate of peat settlement in the region would be around 20mm/year. His conclusions were based on the past subsidence rate of peat in three different areas of Waikato region.

For this report we have assumed a conservative future rate of settlement of 25mm/year for design purposes. However it is also anticipated that drainage and farming practices will improve and become more sustainable in future, and that further reduction of peat settlement rate is achievable.

To have more precise information of clay levels in the Muggeridges catchment, Civil Engineering Services (CES) were engaged to dig 100 boreholes in the area (Refer Doc # 2245559 for the ground levels and clay depths of each borehole).

The underlying clay layer in the area has been verified by boreholes and is generally at -0.5mRL to -1.0mRL across much of the Mugeridge catchment area, whereas the current ground level varies from 2.5 to 0.5mRL. This means that the average peat thickness is around 1m in the low land (East side of the catchment) and around 2m in the high land (West side of the catchment). Refer **Figure 4** for clay layer contours and depth.

Past development has seen an ongoing reduction of land levels as noted in this section above, with the lowest ground levels now approaching mean sea level. Under present land use, peat settlement will continue till the underlying clay levels are reached in approximately 100years. Without the new Mugeridges pumpstation the existing drainage outlets will be unable to provide adequate drainage to the catchment. The ongoing land settlement will result in low ground levels in relation to the lowest effective pumping level (LEPL) of the existing pumps resulting in half of the Mugeridges catchment experiencing a very poor drainage standard in spite of having the drainage assets.

Based on the depth of the underlying clay layer and uniform rate of peat settlement, the future Mugeridges PS catchment area is assessed at 1087ha and is shown on **Figure 5**. During the life of Mugeridges pumpstation it is expected that land contours will change with time resulting in the need for changing and managing the direction, levels and size of internal drains.

The catchments of the existing pumpstations will gradually reduce, and they will ultimately serve only the clay terrace area as shown on the **Figure 6**. It is estimated that the catchments and capacities of the existing pumps can be reduced by more than half, and further reduction and rationalisation of these pumpstations will be appropriate.

Without the new Mugeridges pumpstation, the catchment will settle to a point where it cannot be drained by gravity through floodgates or the existing pumps. And within the next 100years it is expected that farming in the entire area would progressively become neither practicable nor economically viable, and the area would return into unproductive swamp land.

3.3 Projected land contour

To plan requirements and a sequence of upgrade works for drainage improvement to mitigate the effect of land subsidence, it is important to understand the settling pattern and land contour at various timelines from now. This will help in planning pump and drainage network current and future upgrade requirements. The projected land contour will also help in understanding the reduction in catchment of surrounding pumpstations and the timeline when floodgates will stop getting flows from Mugeridges catchment.

3.3.1 Projected land contour for 2037(25years)

In 25years, the low lying lands in the current Stitchbury's, Torehape, and Phillips Road pumpstation catchments, and proposed Mugeridges pumpstation catchments, will have settled to approximately RL-0.5m. Overall approximately 65% of the Mugeridges catchment will have subsided to below RL1.0m, with a substantial part of the area below 0.5m. This would result in drainage failure and ponding in 65% of the catchment and the area reverting to swamp.

For effective gravity-driven flow, the feeder drain needs to be about one meter deep and their design must allow for hydraulic gradient from the low points to the outlets. When the ground subsides to below 1.0m, the water from low lying areas cannot gravitate

effectively to the existing outlets and Piako River Scheme(PRS) service levels cannot be reliably met.

It is expected that all floodgates on the Kaihere Road will stop receiving flows from the Muggeridges catchment due to land settlement to a point that it cannot be gravitated to the gates.

Refer **Figure 8** for the projected contours of 25 years. The ground contours as shown on the map ranges from 2.5m to -0.5m. The average ground level of the clay terrace along the Piako River east to Muggeridges catchment is 1.5m. The catchment area of most of the existing pumpstations will be reduced to less than half by this time.

The low lying strip of land parallel to Kaihere Road, within the Muggeridge catchment, will settle down to half a metre below the mean sea level. This area, shown by blue and light green colours on **Figure 8**, will get flooded if no drainage upgrade is undertaken. During low tide some of the pumpstations, mainly Stitchbury's and Philips, will continue to operate but for reduced catchment areas and effectiveness.

3.3.2 Projected land contour for 2062(50years)

In 50years time, the low lying land west of Stitchbury's, Torehape and Phillips Road Floodgates will subside to RL-1.0m and approximately 95% of the Muggeridges catchment will settle to below RL1.0m. The lowest parts are expected to be more or less permanently water logged. Under these conditions farming will become largely uneconomical, and dairying will no longer be possible, and with dry-stock feasible in limited areas only.

The area will turn into a big pond, which could only be serviced and drained by pumping. The flows from the Muggeridges catchment will no longer gravitate to the existing smaller pumpstations.

Refer **Figure 9** for the land contours after 50years. The land contours predicted are in the range from 1.5m to -1.0m.

If Muggeridges pumps are not installed and no drainage upgrade is carried out then some 95% of the area will become submerged under water.

3.3.3 Projected land contour for 2112(100years)

In 100years, the low lying area in the Muggeridge area will have largely settled down to the underlying clay layer, and generally no further settlement would occur. There would be some limited areas of residual higher land adjacent the Pouarua canal, that will still continue to settle for another 10-15years. The land contours in 100years will be in the range from 0.5m to -1.5m. The drainage can be managed only through pumping at that stage. Refer **Figure 10** for the Muggeridges ground profile in 100years time.

If no action is taken to upgrade the drainage system of Muggeridges the whole area will revert back to unproductive swamp land with no farming possible.

To minimise pumping requirements and to direct flows to the proposed pumpstation, the drainage network needs to be optimised and this can be achieved by preparing a drainage plan.

4 Muggeridges pumpstation and catchment plan

4.1 Muggeridges catchment plan

The Muggeridges catchment is bounded in the north by Rawerawe sub catchment near SH2, in the west by Pouarua Road, and in the south by Kaihere Road. Land in the Pouarua area is substantially flat, with a slight gradient from west to east.

The Pouarua Canal, and associated road and earth embankments, act as a cut-off for the Muggeridges catchment and prevent flows from western highland subcatchments (areas B & C) to enter into Muggeridges area. The Pouarua canal diverts the flow from these highland catchments northward to Pouarua floodgates and pumpstation and to southward to Pitts Road.

The Muggeridges catchment is separated from western subcatchments by Pouarua Road embankment and Pitts Road stopbank. The Muggeridges catchment is currently drained by a series of smaller channels flowing eastward from Pouarua Road to Kaihere Road. These channels drain to Kaihere, Stitchbury's, Torehape and Philips Road pumpstations and to Torehape, Muggeridges and Philips Road floodgates, which then finally discharge into Piako River. There are a couple of small channels in Muggeridges that are flowing west towards Pouarua Road and are connected to the roadside drain. This roadside drain is connected back to Stitchbury's and Muggeridges floodgates.

Majority of flows from the catchments west of the Pouarua Road flow to Pouarua floodgate and pumpstation, and part of it goes to the Pitts Road floodgate. No flow comes to Muggeridges catchment from the western subcatchments A,B,C.

As discussed in the previous sections the Muggeridge catchment consists of peat and is situated on the edge of the adjacent Torehape peat dome. Due to past development the area has settled over the years at a rapid rate and the lowest level now is approaching mean sea level. If the same farming pattern continues it is estimated that the land will settle down to underlying clay layer in 100years. The existing drainage outlet will not be able to provide adequate drainage to the catchment resulting in the area turning into a swamp.

The proposal is to isolate the Muggeridges catchment by blocking any remaining drains connected to Pouarua Canal, and by raising or strengthening the Pitts Road stopbank/Pouarua Road embankment separating the western catchments, if required.

The new Muggeridges pumpstation is proposed to cater for the whole Muggeridges catchment, the inlet canal of the pumpstation will be fed by a main canal proposed along the lowest land of the catchment. The land in the catchment will settle progressively and this will lead to more and more area unable to be serviced by the existing outlets due to low ground level in relation to lowest effective pumping level of the existing pumps and drainage failure. To avoid drainage failure, new drains will be constructed and connected to the main canal progressively as required.

Within 25years, the new and modified drainage network would be fully in place to provide the level of service required. These drains will be shallow initially but will get deepened as the land settles. The water level in the drains will be maintained close to the ground surface through various controls to minimise over-drainage, and excessive peat oxidation and land settlement. It is estimated that by this time all the existing

pumpstations presently serving Mugeridges catchment will not be able to serve due to land settlement below their LEPLs. And all flows from the catchment will have to be served by the proposed Mugeridges pumpstation as no gravity or existing pumpstation outlet operation will be possible.

Refer to **Figure 6** for the catchments of existing pumpstations and overlap with Mugeridges pumpstation.

4.2 Existing pumpstations

The existing pumpstations in the Mugeridges catchment are Kaihere, Stitchbury's, Torehape and Philips Road. The capacities of these pumpstations are 0.34, 0.85, 1.0 and 0.6 cumecs respectively. These pumpstation are along Kaihere Road and are managed by WRC.

Kaihere, Stitchbury's and Torehape pumpstations are on the South side of the proposed Mugeridges pumpstation whereas Philips Road is to the north.

The capacity of existing pumpstations will have to be adjusted for the change in catchment size. Reduction in the size of existing pumps is inevitable, and this will be carried out as a part of ongoing renewals when the pumps need replacement.

4.3 Proposed pumpstation design

The new Mugeridge pumpstation is proposed to ultimately service and provide for runoff from the full assessed catchment of 1087ha. However, initially the existing pumpstations will continue to provide some drainage outlet over the next 25 years, with progressive reduction in their effectiveness over the next 25 Years.

It is therefore proposed that the Mugeridge pumpstation development be staged. Initially it is proposed that the first stage will serve the equivalent of 700ha of land, and the second stage for the remaining area. The second stage will need to be fully operative within the 25 year timeframe, and it is anticipated that it will be required within the next 15-20 Years. This would be subject to rate of land settlement, and assessment of drainage performance.

The drainage design level of service for the Piako River Scheme (PRS) is to evacuate floodwater from a 10year ARI flood event from the farm land within 3 day period. The design 10year event is assessed on the basis of a rainfall depth of 38mm/day over floodgate catchments, while pumps were designed to assist drainage by discharging 19-mm/day runoff over the catchment.

In 25years, the gravity drainage will eventually get lost, and therefore the full 38 mm standard will need to be fully pumped.

4.3.1 Sizing of pumps

Stage	Pumped area (ha)	Design pump capacity (m3/s)
Stage 1	700	3.1
Stage 2 and Final	1087	4.8

4.3.2 LEPL

The lowest effective pumping level (LEPL) has been adopted based on the underlying clay layer. The canal gradients of 1 in 10,000 has been adopted for the design of pumping level and which gives a LEPL of -1.4 for stage 1 and -2.5 for stage 2.

The pumpstation structure for both stages would need to be designed for the full LEPL of RL-2.5m, to enable future effective operation and performance. However the canal and pumps would be set initially at the higher level, and adjusted as the land contours and drainage gradient requirements change.

4.3.3 Design flood level

For the purpose of calculating the pumping head, the external design level (Piako River Level) of 2.75m, which is a 100year flood level including climate change effect has been used.

Refer to **DM Doc#1154844** Muggeridges Pumpstation: Preliminary Design for the pump details.

4.4 Inlet canal sizing and staging

Construction of inlet canal will be staged, the first stage will be to serve the primary 700ha area of catchment, and the depth of the canal will be to suit the LEPL of the proposed pumps for the stage, which is -1.4m. It is proposed that the main link canal would be implemented to connect and be able to service all of the Muggeridge catchment, but would initially be limited in the size and capacity as necessary to service and support the existing pumpstations.

Within 25 years as the land settles further, the inlet and main link canals will be deepened to allow run off from lowest settled land in the catchment and to suit the final LEPL for the proposed pumps of -2.5m. The size of inlet canal based on preliminary design will be 6m x 6m (base width)x(depth), however the actual size will be known after the detailed design.

Refer to **DM Doc#1154844** Muggeridges Pumpstation; Preliminary Design for inlet canal details.

4.5 Drainage network design and management

The future land contours (based on depth to clay layer) are shown on **Figures 4, 8, 9 & 10**, based on this depth to clay an estimated 1087ha of catchment (refer to **Figure 5**) will need to be redirected to the proposed Muggeridges pumpstation. Therefore with time, changes will need to be made to the internal drainage network.

When all peat settles, and ground contours reach the clay layer to form the final ground profile (refer to **Figure 4**), the catchment will drain to the lowest point of clay layer. However these changes in the drainage will occur gradually.

The internal drains will be modified and upgraded as land settles to provide cover to the whole catchment area and to provide the PRS level of service. The catchment will be isolated from the adjacent catchments by blocking the upstream ends of the drain. The drains will be shallow initially but will be deepened in alignment with the settlement of the catchment land. Refer to **Figure 9** for the proposed upgrade of internal drains in the Muggeridges catchment.

The principles for the drainage upgrade are to cover the maximum area of the catchment to gravitate to the proposed pumpstation, to provide shallow drains as far as possible, and to maintain the water level close to the ground through various drainage controls to minimise peat degradation. The drainage upgrade will be taken through various stages

- First stage – Isolate the catchment by blocking drains connected to adjacent catchments and construct the main drain along the low lying areas of the catchment to allow gravity flow. Install controls on the drains to maintain the water level close to the adjacent ground.
- Second Stage – Modify and extend the existing internal drains and connect them to the main drain.
- Third Stage – Deepen the drains as land settles. Raise the embankment or stopbank if required.

In order to manage the drainage network, the following changes and actions are anticipated with time.

Anticipated change	Estimated time	Proposed action
Parts of Muggeridges catchment unable to drain to any existing outlets.	Now till around 25 years	Install Muggeridges pumpstation and canal (2015-2017)
Potential impact on Torehape wetland.	Over 25 years	Investigate and ensure that the stopbank and ground permeability along the boundary of Muggeridges pumpstation catchment and the wetland is effective (2015) - Completed. Monitor ground water levels at boundary, and ensure catchment separation performance. Implement any mitigation if required.
Reduction in catchment to Kaihere, Stitchbury's, Torehape and Phillips Road pumpstations.	Over 25 years	Review the drainage catchment of the pumpstation and adjust existing drains and pumping system to service the reduced catchment.
Reduction of catchment to Muggeridges floodgate.	Over 25 years	Review the drainage catchment and adjust existing drains. Review the option of providing an upgraded floodgate.
Key changes to the internal drains (drain invert levels and flow directions).	Over 25 years	Installation of weirs (refer to Figure 11). Installation of new drains (refer to Figure 11). Re-grading the drains as catchment areas change (refer to Figure 11).

Refer to **Figure 11** for the proposed drainage network. Drains shown by black arrows are the existing drains to be lowered to match the new ground levels, yellow arrows indicates

the drains need change in direction and blue arrows are the new proposed drains in future.

Surface water flow from the Torehape wetland is prevented from flowing to the Muggeridges catchment by an earth stopbank along Pitts Road. Similarly the Pouarua canal to the East of the Torehape wetland controls the groundwater flows. Monitoring is recommended to ensure that groundwater flows directions are not changed due to the operation of the proposed Muggeridges pump. If monitoring shows that groundwater flows are being directed towards the Muggeridges pumpstation catchment then install clay cut-off along Pitts Road.

The changes to the internal drains would be a gradual process based over a period of 100year on following

- feedback from farmers
- flooding complaints
- future LIDAR survey
- performance of the drains
- performance and operating level of pumps

Weirs will be installed to isolate drains from the adjacent catchment, to maintain the level of water and to divert flows to new drains. The water level in the drain will be maintained close to the adjacent ground level to minimise peat degradation rate. The locations and number of weirs will be decided later at the detailed design stage; however some weirs as marked on **Figure 8** will be installed at the start of the project to isolate the catchment.

The internal drains will be re-graded once their bed level goes below the invert level of the floodgates. The reduction in catchment areas of the existing pumpstations will leave some areas un-drained. These areas will need new drains to get connected to Muggeridges pumpstation.

The size of main drain and internal drains are assumed to be around 1 to 2m wide (base width) and 1m to 4m deep at this stage.

Refer to **DM Doc#1154844** Muggeridges Pumpstation; Preliminary Design for canal and drain sizing.

4.6 Adjacent catchment

4.6.1 Torehape/ Pouarua separation

The catchments on the west of Muggeridges are at higher elevation and this includes Torehape wetland. The lie of land would normally naturally allow both surface and ground water to flow toward the low areas ie towards Muggeridges. Refer **Figure 2** for the catchment surface hydrology. The land in the Pouarua catchment generally falls from the Maukoro canal in the west to the Piako River clay terrace in the east allowing runoff towards east.

However the natural flows have been substantially modified by development, including land changes, drainage, and roading and embankment development. In particular the Pouarua canal intercepts the surface runoff and predominant groundwater flows from the higher Torehape peat dome, and diverts it to the north and south outlets. The Pitts Road stopbank and Pouarua Road embankment also further separates the western catchments and Torehape wetland, from the Muggeridges, and in particular largely cuts

off the predominant groundwater flow through the shallow peat in this area (generally 1-2metres of peat, overlying a relatively impervious clay layer).

The Torehape wetland is a protected area, and it is important that the project and development ensure that the proposed pumpstation and its associated work do not affect the ground water levels of the wetland. An investigation has been carried out by CES to study the ground water movement across the stopbank, and its finding indicates that the stopbank is preventing surface water movement across from Torehape wetland to Mugeridges catchment. The groundwater gradients measured in summer show that the canal along Pitts Road controls the flow direction and is the lowest point in groundwater. Therefore the groundwater flows from the Torehape Wetland does not flow across to the Mugeridges catchment. Refer to Doc #3388488 for the report on groundwater level investigation across Pitts Road prepared by Civil Engineering Services Ltd.

There are a couple of small drains flowing westward from the Mugeridges catchment and are connected to Pouarua canal making it a part of Pouarua catchment. The proposal is to block those drains and divert them back to the Mugeridges catchment, making the catchment independent and isolated from the adjacent catchments.

4.6.2 Local pump catchments

Refer to **Figure 6** for the local pump catchments and catchment overlaps with Mugeridges. The catchments of Kaihere, Stitchbury's, Torehape and Philips Road pumpstations constitutes about 60% of the Mugeridges catchment. With time, as the land settles the catchment area of these pumpstations will be reduced, and they will stop being able to serve the low-lying parts of the present catchments. The runoff from these lower lying areas of the catchments will then get diverted to the Mugeridges catchment. The Mugeridges pumpstation will replace the loss in capacities of the existing pumpstation and floodgate outlets.

5 Environmental management

5.1 Introduction

The dominant soil type in the Mugeridges catchment is peat which is irreversibly damaged through oxidation. The average peat shrinkage is estimated at the rate of 20-25mm/year, and the shrinkage will eventually give way to the less productive underlying clay layer. Land settlement due to peat shrinkage will cause drainage failure and flooding on existing farmland in the Mugeridges area, if proper mitigation measures are not taken up. Minimising peat shrinkage is of utmost importance to maintain the productivity of the land, and to limit the oxidation of peat and contribution to increased atmospheric carbon dioxide.

Pastoral farming predominates in the area and it is estimated that about 75% of the catchment is used for dairying and 25% for stock farming. Poor drainage due to drainage failure caused by land settlement restricts pasture growth and utilisation at critical times of the year.

The key desired outcomes of the environmental management are

- Protect people, property and essential services from flooding
- Improve natural biodiversity and protect existing significant natural areas from existing threats
- Sustain the *mauri* of the water.

The core guiding principles for the environmental management are

- Promotion of best practice techniques
- Focus on sustainability
- Importance of partnership between agencies and community.

Catchment values

Following are the key values to be considered for environmental management

- Ecological value
- Land use and agricultural values
- Economic values
- Social and cultural values.

5.2 Peat management

Development and use for farming purposes, and associated water drainage, exposes the peat in the area to oxidation which irreversibly damages the peat soil leading to shrinkage and land settlement. The rate of shrinkage is dependent on a number of factors including cultivation and re-working which can break down the natural fibrous nature of the soil, drainage of the peat soil also accelerates compaction especially where the groundwater table is too low.

The level of groundwater table is one of the main drivers of peat shrinkage; a low water table leads to irreversible shrinkage, whereas a high water table affects the sustainable use of land for agricultural purpose. The peat shrinkage rate can be minimised by careful soil and land use management.

Peat soils are also degraded by the addition of fertilisers for agriculture to improve the productivity. Peat is very acidic with pH value below the level that will sustain and promote clover growth. Lime is added to adjust the pH of the peat soil to a level where it can maintain agriculture and nutrients are added to increase the productivity.

Leaching of nutrients is also one of the issues with peat which can impact waterways.

Agricultural degradation of peat soils can be minimised by following sustainable and good farming practise as outlined below.

- Avoid deep drainage
- Maintain the water table over summer
- Avoid excessive drainage
- Drains should be spaced at a distance which will maintain the groundwater table
- Minimise cultivation on peat soil
- Use no till method to renew pasture where possible
- Use cultivation methodology which creates minimum disturbance to the peat soil
- The application of lime should be done as deep as possible into the soil to distribute lime throughout the cultivated depth.
- Apply fertilisers in split dressings in spring and autumn, avoid applying nitrogen fertilisers in mid winter
- Use sustainable and best land use management practices like management of grazing, stock movement, feed pad operations, effluent management etc
- Use sustainable and best farm management practices like reduced stocking rates, stand-off pads for cows and planting riparian margins for reduction of nutrient losses.

5.3 Torehape wetland

Torehape wetland is situated west to the Muggeridges catchment and is separated by Pitts Road Stopbank from the catchment.

The Torehape wetland is a significant natural area managed by Department of Conservation and is an active peat forming dome containing threatened vegetation and biota. Protection and management of wetland is particularly dependent on the careful management of surrounding land use and maintenance of water levels within the wetland. Management of hydrology of the wetland is very important for the protection of the ecological values. Refer to the draft Pouarua sub-catchment management plan for the wetland management details.

The surface hydrology indicates natural flows predominantly towards south-east. The wetland is bounded by drains along Torehape Road and Pitts Road, which provide both a significant potential influence on the wetland and a hydrological separation from the adjacent catchments. A culvert across Torehape Road at Central Road intersection also allows some flows from a small catchment on the northern side of the wetland, and drains through the wetland. The Waikoura stream bounds the wetland on the southern side.

The Muggeridges catchment is on the edge of the residual peat dome, and is significantly and increasingly lower than the Torehape wetland. This would normally allow runoff from the wetland to flow towards the catchment, and potentially drainage impact on the wetland. However this potential influence is significantly limited by the Pitts Road stopbank and the Pouarua canal, which intercepts and diverts both surface runoff and groundwater flow towards south. Groundwater flows between these catchments are also significantly limited by the shallow depth of the peat (1-2 metres depth, overlying a relatively impervious clay layer). Refer to **Figure 2** for the surface hydrology.

In February 2015, an investigation to check the groundwater levels, permeability of the stopbank and groundwater movement was undertaken by Civil Engineering Consultants and the result indicates that the Pouarua Canal and associated earth embankment has an impact on the groundwater flows and levels. The conclusions from the investigations report are

- Groundwater level gradient measured at three locations across the stopbank were negative which indicates flow from Torehape wetland is not flowing towards Muggeridges catchment. The flows intercepted by Pouarua canal and discharge south towards Kaihere Road along Pitts Road.
- The groundwater from wetland will be unable to flow eastward towards Muggeridges as it is controlled by Pouarua Canal and discharge through Pitts Road floodgate.
- Permeability measured beside the stopbank in the area ranges from 1.6×10^{-4} to 2×10^{-5} . This is around 13.82m/day to 17.28m/day flow rate. This indicates that the soil in the area is very permeable, and these values are consistent with that of peat soil layer. Permeability of underlying impervious clay soil is around 0.0009m/day to 0.00009m/day.
- In this location the peat soil layer is quantified as between 1.0 – 2.5metres, which is similar to the depth of the adjacent Pouarua canal.

On the basis of above results it is considered that the Muggeridges pumpstation and its canal are very unlikely to have any impact on the water level of Torehape wetland.

However it is recommended that water level monitoring in the piezometers should be undertaken before and after installation of the pumpstation to check and confirm that the flow direction does not change once the pumpstation is operational.

In the event that the future monitoring shows the ground water level promoting towards Mugeridges then a compacted clay cut off can be installed in the trench along the Pitts Road. The width of the clay layer will be between 1 to 2m and the depth of the clay layer would be to the clay contours below the ground surface. This will be done by excavating a trench to key in compacted clay layer which will act as a liner which will reduce the permeability to 1×10^{-8} m/s to 1×10^{-9} m/s and thus act as a barrier to ground water flow from Torehape wetland to Mugeridges catchment.

5.4 Nutrients

The peat has low anion capacity, which can result in leaching. Leaching can bring lot of nutrients into the water bodies which can adversely affect its water quality. High nutrient level in waterways can lead to increase in algal and other plants growth. Peat also increases the potential for leaching and increasing nitrate and phosphate levels in rivers and streams.

Nutrient impacts from farming and intensive agriculture is an issue throughout the Waikato and Thames Valley catchments, and needs to be carefully managed. This issue is being further considered and addressed through the Regional Council's Healthy Rivers project. Currently this is focussed on the Waikato catchment, but it is programmed that this project would be extended into the Thames Valley catchments within the next year.

Refer to Kessels Ecology's report on the draft Pouarua sub-catchment management plan for details on Nutrients.

6 Implementation programme

6.1 Construction works

The upgrade work will require construction of a new pumpstation, inlet canal, new internal drains and weirs.

The pumpstation will be constructed in two stages; the first stage would be to cater for an equivalent 700ha of catchment area, and the second stage would come into effect within 25years for the whole Mugeridges catchment.

The inlet canal will also be staged, and will be constructed to serve the initial capacity of the pumpstation. It will then be widened to cater for full capacity, and deepened ground levels change within the Mugeridge catchment.

Refer table below for the sequence and estimated timeline for implementation

Construction item	Estimated timeline	Responsible
1.6km inlet canal to new pumpstation	2016-17	WRC
New Mugeridges pumpstation	2016-17	WRC
Internal drain-Phase I (Main drains)	2017-20	HDC
Raising of Pitts Road embankment	2025/26	WRC

Internal drain-Phase II (Secondary drains)	As required (2021 -37)	HDC
Internal drain-Phase II (Other drains/ deepening of main/secondary drains)	As required (2037 onwards)	HDC

WRC will engage a consultant to carry out detailed design of the pumpstation and canal in 2015/16 and if consent is granted the construction work will commence in summer of 2015/16. The material from the canal will be used to upgrade stopbanks in the Piako River Scheme.

HDC will undertake detailed design of the new internal drains required and carry out construction of main drains in 2016 -2018. The other drains will be constructed as required depending on the rate of peat settlement and ponding issues. This would include sizing of the canals and gradient controls to manage water levels and minimise adverse impact on peat degradation.

7 Management and monitoring plan

7.1 Roles and responsibilities

The drainage and flood management within the area is a joint responsibility of both the HDC and WRC.

WRC is responsible for the main Piako River Scheme, and associated pumpstation, floodgates and the stopbanks along the Kaihere Road. WRC will also be responsible for the management, maintenance and operation of the proposed Muggeridges pumpstation. WRC is also responsible for the maintenance and operation of the Maukoro Canal and Pouarua pumpstation and floodgates in the northern part of the Pouarua catchment. WRC is also responsible for Rawerawe, Philips Road, Torehape, Stitchbury's and Kaihere pumpstations and their associated floodgates. There is an existing Muggeridges floodgate located north of the proposed Muggeridges pumpstation.

HDC is currently responsible for the local drainage network and assets, including the No 29 Rawerawe West (at the end of Rawerawe West Road), No 73 Hopai West, west side of Pouarua Canal on Hopai West Road, No 75 Martinovich, east side of Pouarua Canal on Hopai West and No 75 Central North, on Central North Road pumpstations, Pouarua Canal and internal drains. In addition to these HDC will take responsibility for the management and maintenance of the Muggeridges canal. HDC will also take responsibility for internal drain/block/weir upgrades.

The Pitts Road stopbank and if required the compacted clay cutoff along Pitts Road will be upgraded by WRC.

Landowners and farmers have responsibility for the on-farm management, and the adoption of best management practices required to minimise impacts on land and water.

7.2 Management practices

7.2.1 Oversight

For the success of the project the role and responsibility of the project team member should be well defined and the project team should have good representation of both councils. There should be a good communication plan to keep all stakeholders informed about the project.

7.2.2 Pumpstation

The drainage of the catchment will shift from discharge by gravity to discharge by pumping into the Piako River. Over a period of time the floodgates will cease operating and will become redundant but this will be a gradual process. WRC should review the catchment every 10 years to verify the actual changes in the performance and effectiveness of the collective outlets and drainage system, and changes required to the catchment areas. The performance standard for the pumpstation is “to clear the catchment runoff from a 10 year 24 hour storm within a 72 hour period”.

7.2.3 Drainage network

Level of service for drainage network is “Drainage of protected land by gravity outlets and/or pumps, to ensure a maximum ponding period of three days in a 10-year rainfall event.”

The internal drainage will include controls such as weirs and culverts to prevent over drainage of the sensitive peat areas and to prevent rapid runoff from high parts of the catchments flooding lower areas. This will need to carefully balance the provision of effective land drainage necessary for agricultural productivity, while minimising over drainage and other potential adverse impacts.

The standard for the internal drainage systems is Hauraki District Council’s responsibility.

7.2.4 Land use management

Best management practices can prevent/reduce peat degradation and transport of sediments and nutrients to waterways. This includes management of grazing, stock movement, feed pad operation, raceway design, fertiliser use, effluent management and drainage management.

Refer to the draft Pouarua Sub-catchment Management Plan prepared by Kessels Ecology, for best practice recommendations.

7.2.5 Consent implementation

Once consent to construct the pumpstation and canals is granted implementation of the consent conditions will be the responsibility of WRC for pumpstation, and HDC for all internal drainage.

7.2.6 Land change monitoring

The land contour level change monitoring will be carried out by WRC; the monitoring will include changes to land levels, and hydrology of the catchment.

7.3 Monitoring

The estimated changes in the topography are based on a uniform rate of peat settlement however in practice there will be many variables and the settlement rate will vary. This will have an impact on the implementation of the drainage plan. Therefore a monitoring system is required to record the changes in time and based on that the actions for upgrading can be taken up.

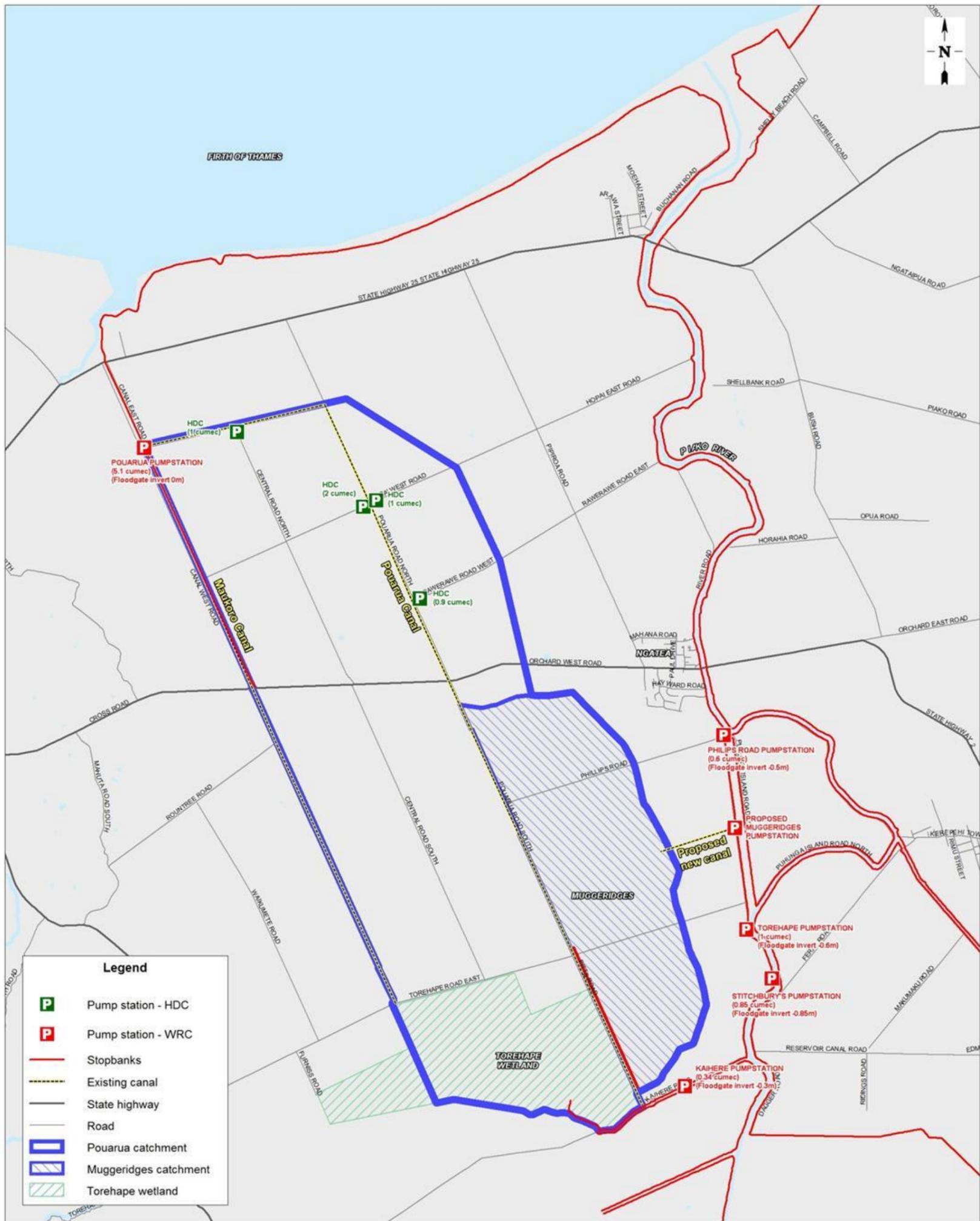
Activities involved in the monitoring processes are listed below

- Feedback from the farmers
- Complaints from the public

- Getting new LIDAR information
- Checking the performances of the drains
- Reviewing pumpstation operations- peak discharge, start/stop level
- Review of catchment area
- Topographical survey.

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Pouarua Catchment and Mugeridges Catchment Location

0 1 2 3 4 5
Kilometres

Scale - 1:55,000 at A3

A3

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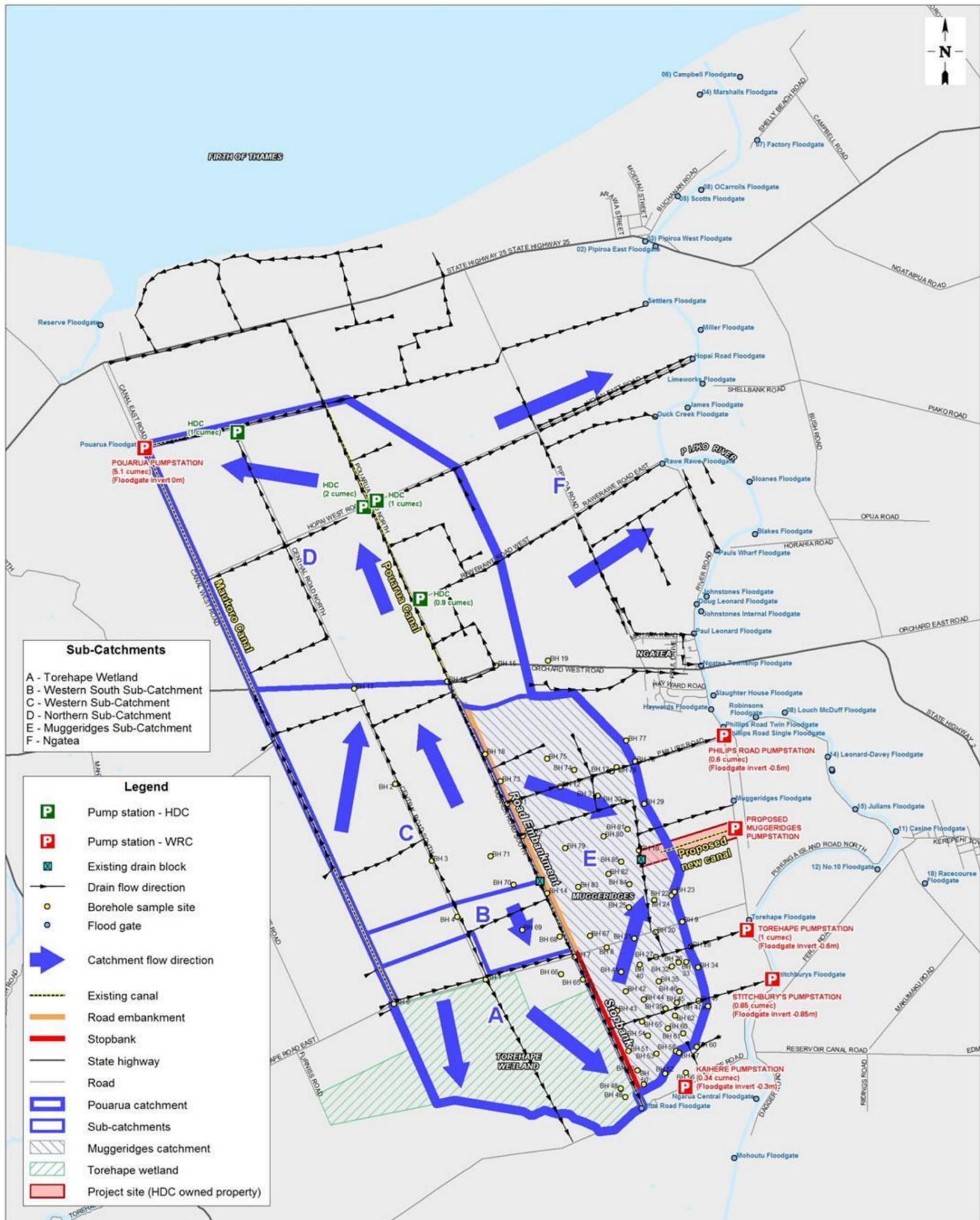
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Figure 1 Location of Pouarua and Mugeridges catchments



Pouarua Catchment Surface Hydrology

0 1 2 3 4 5
Kilometres

Scale - 1:55,000 at A3

A3

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Figure 2 Pouarua catchment drainage pattern

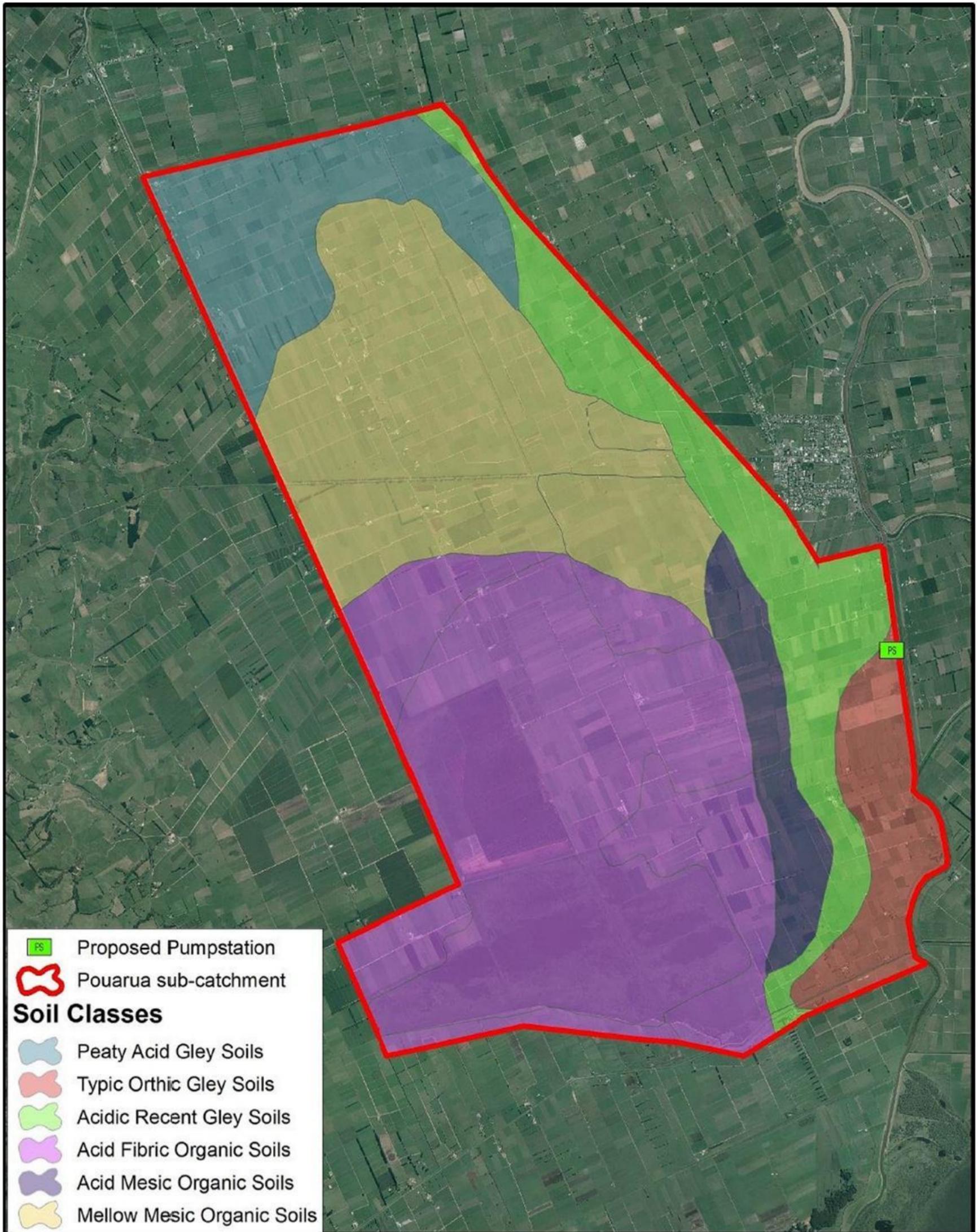


Figure 3 Soil classification of Pouarua catchment

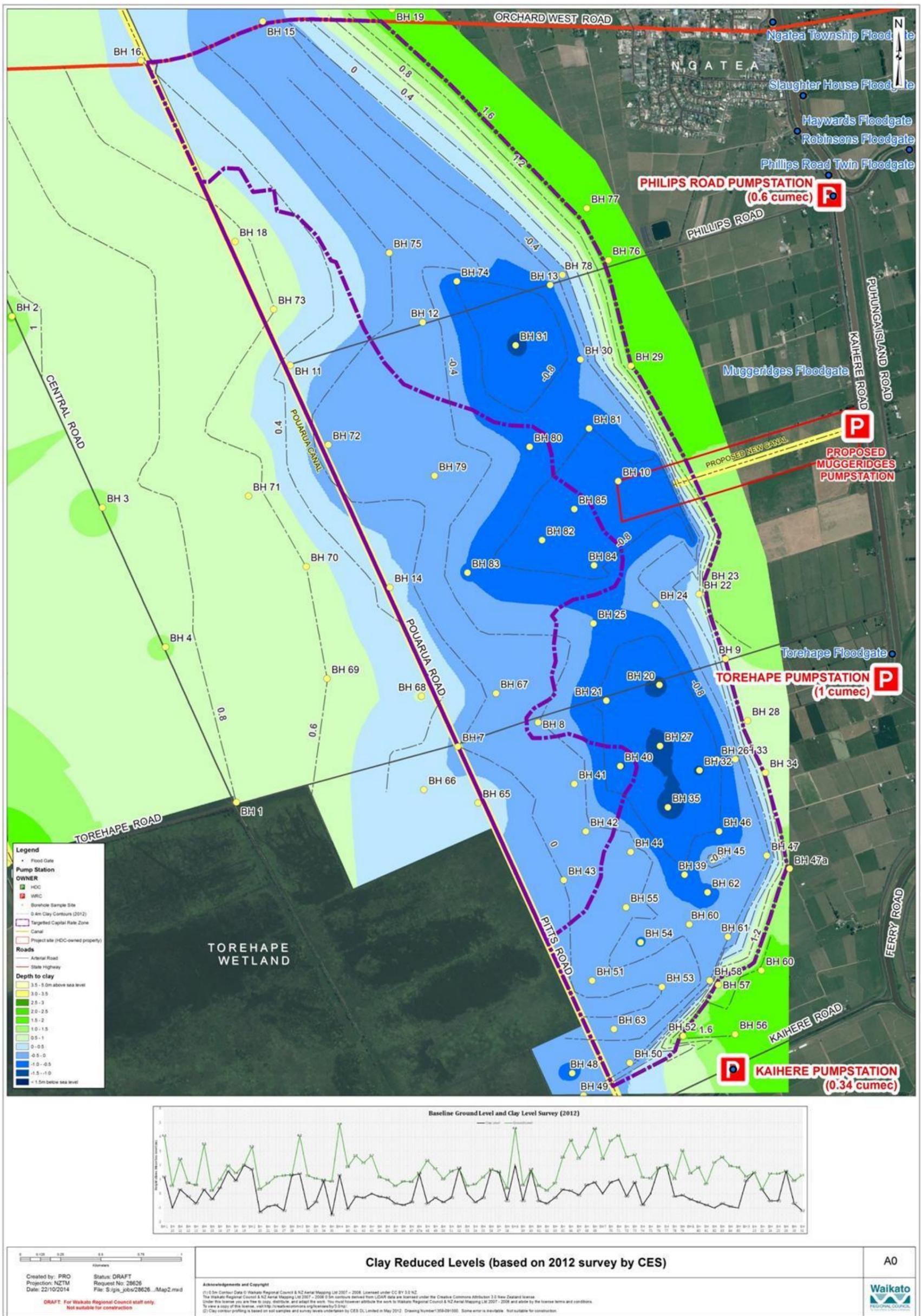


Figure 4 Underlying clay layer in the Mugeridges catchment

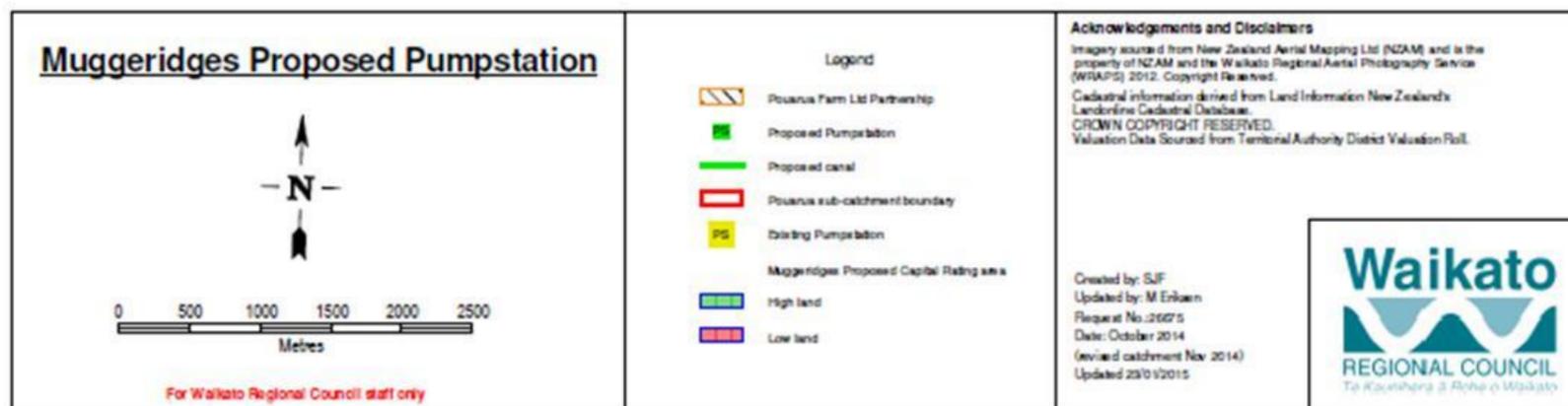
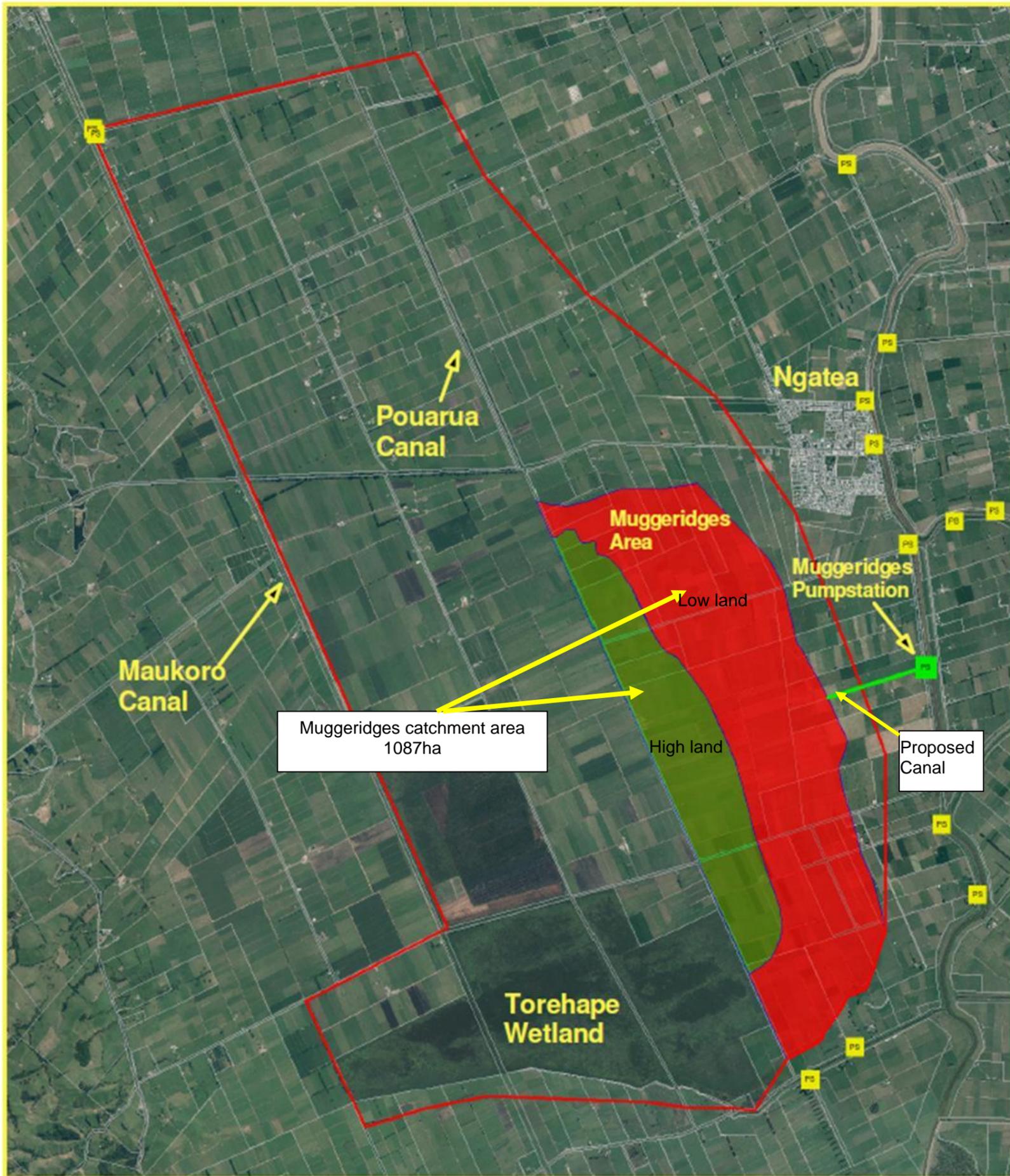


Figure 5 Mugeridges pumpstation catchment boundary

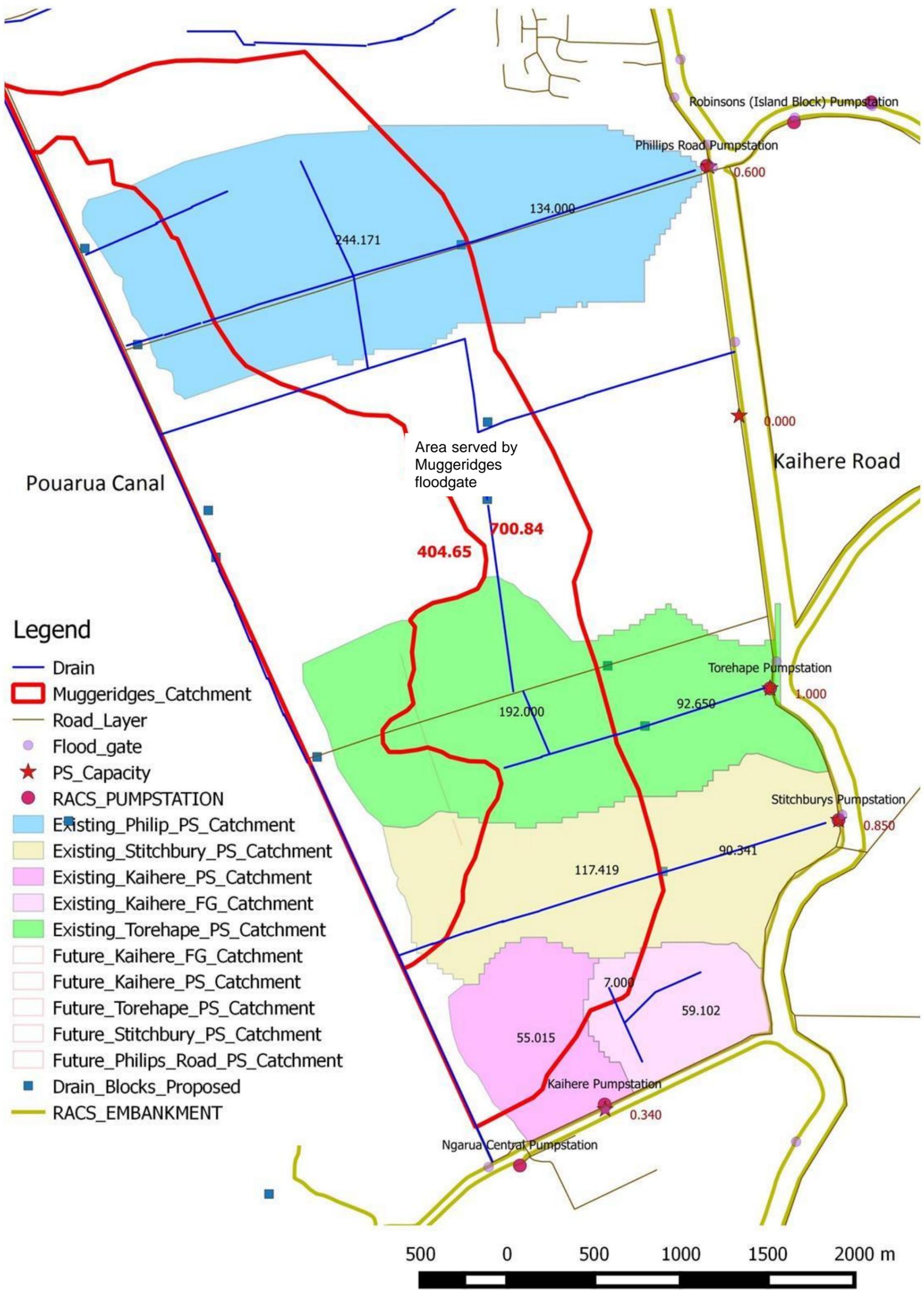


Figure 6 Catchment areas of the existing pumpstations and overlap with the proposed Muggeridges pumpstation

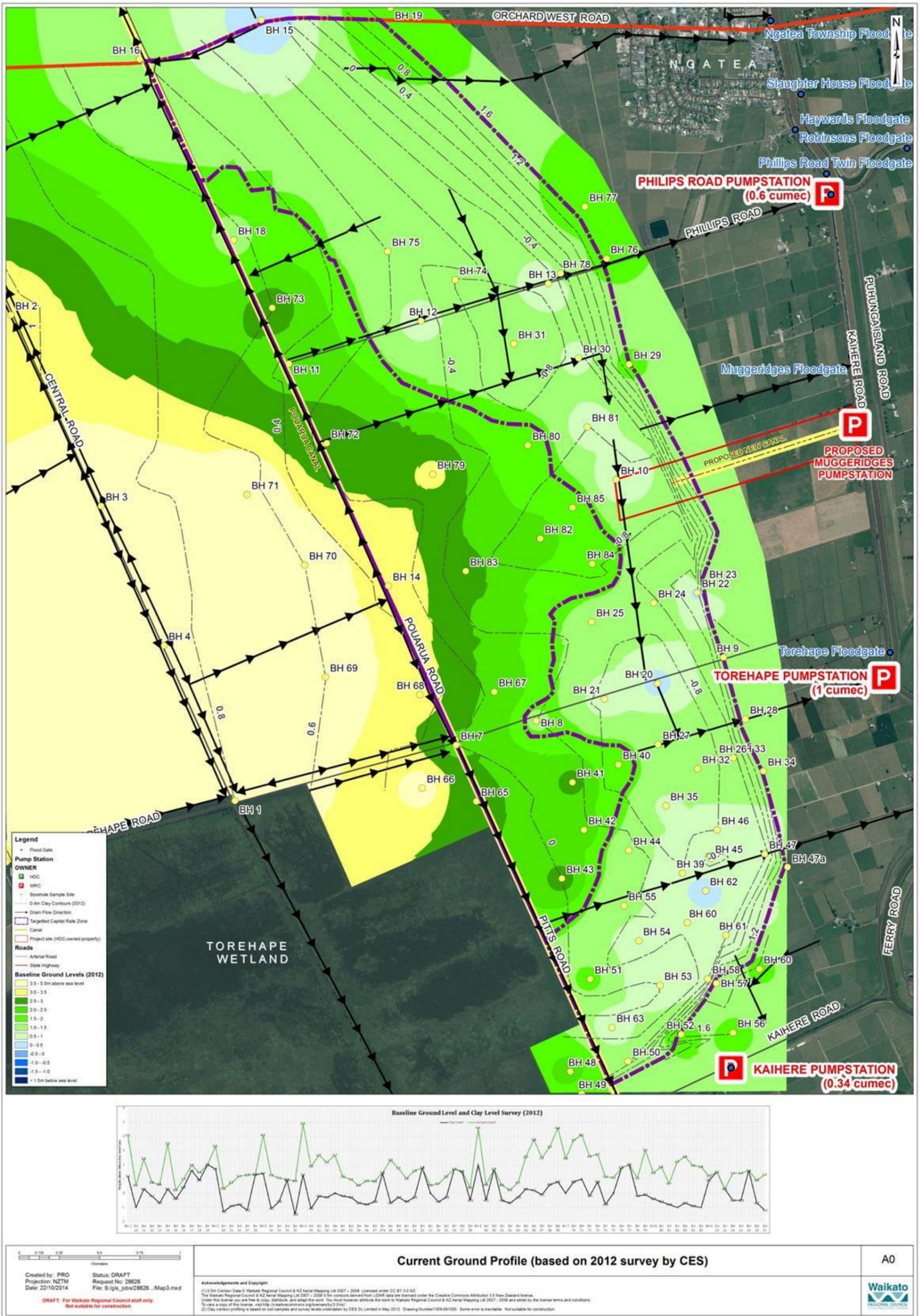


Figure 7 Existing ground contours of the Mugeridges catchment

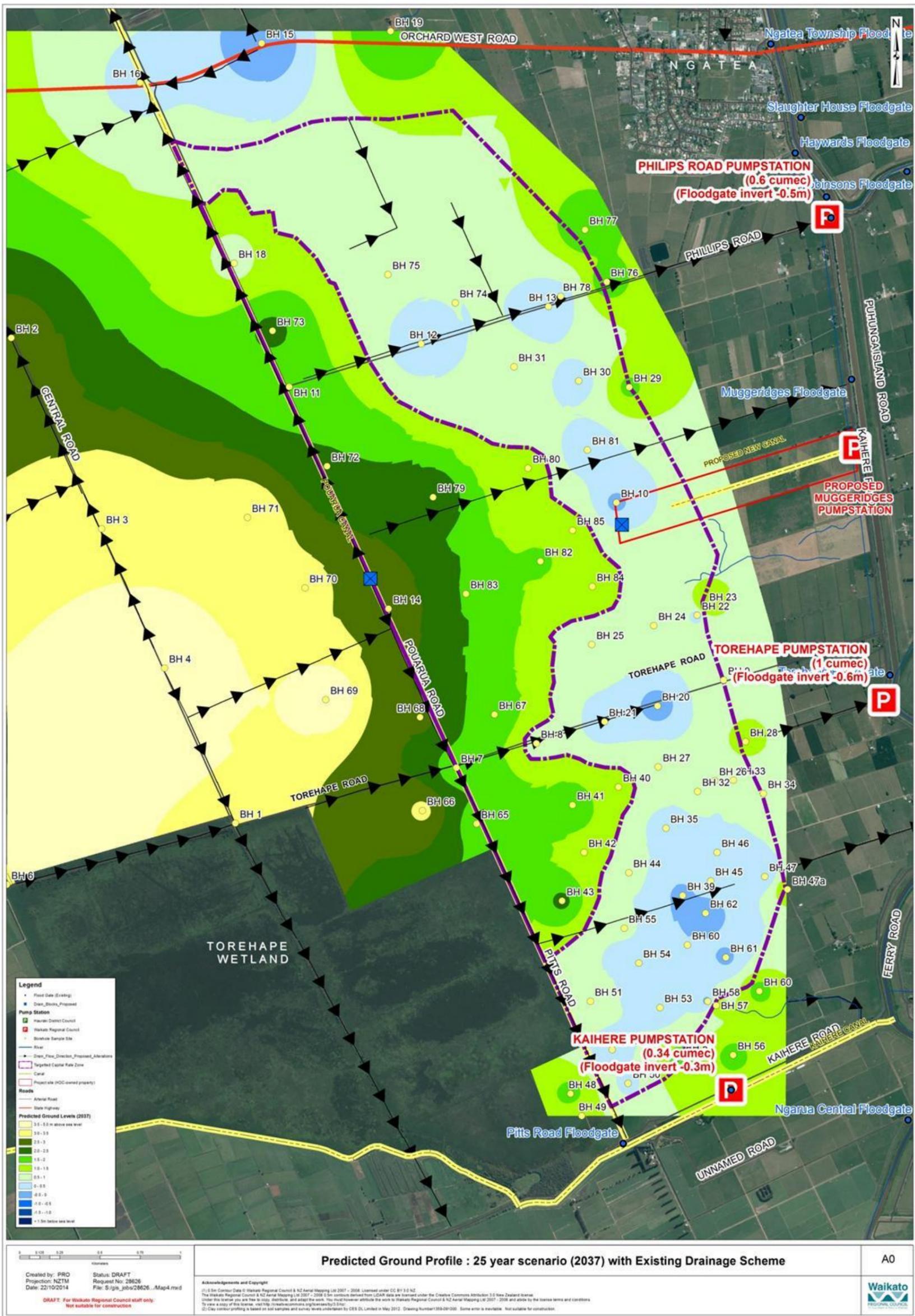


Figure 8 Projected ground contours of Muggeridges catchment - 25 years

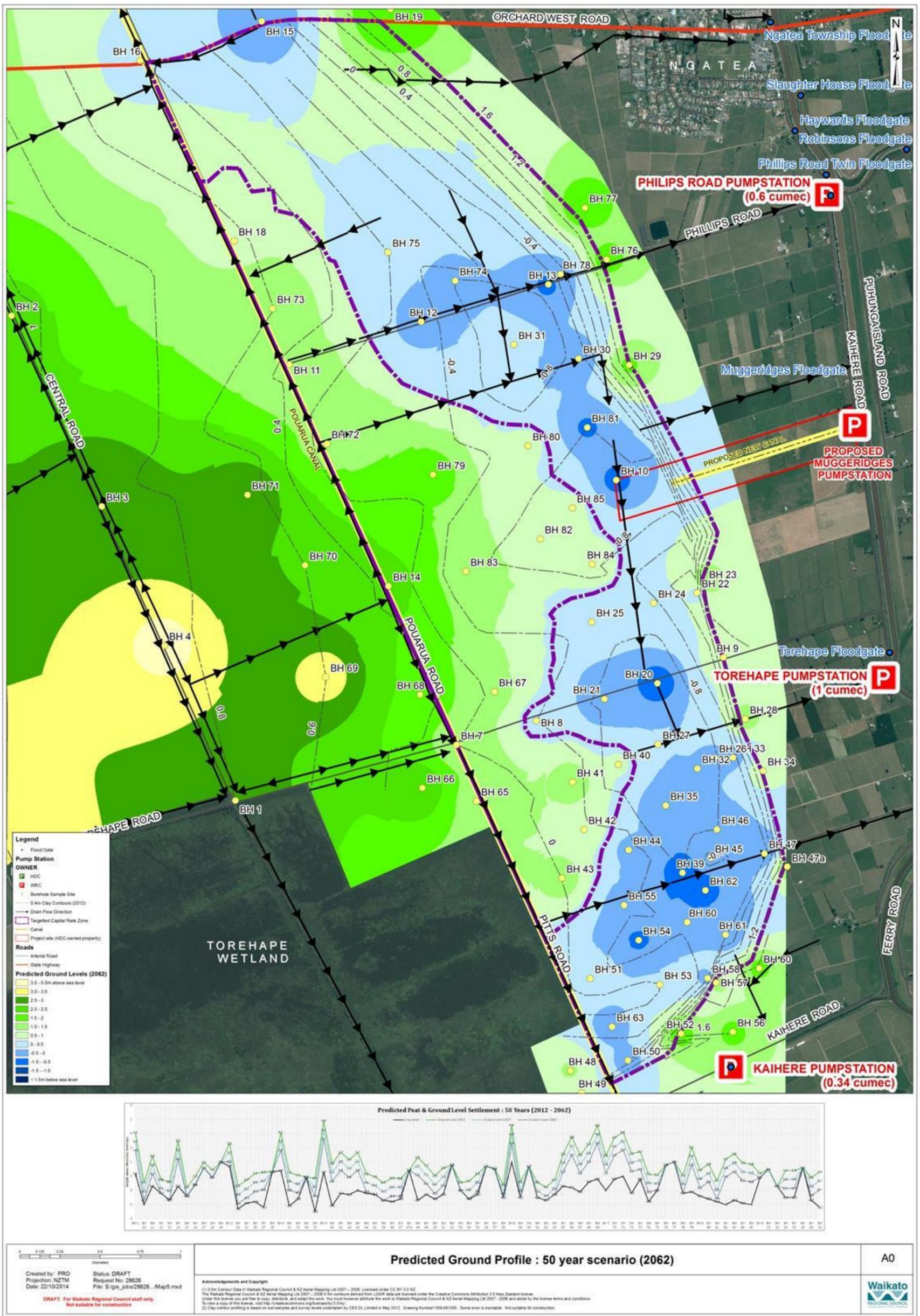
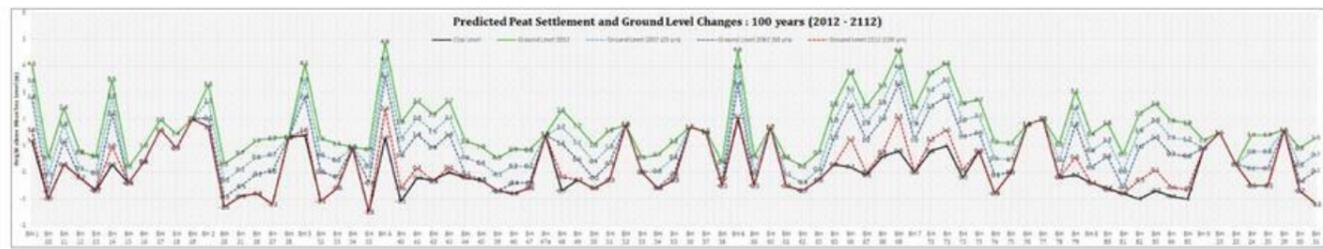
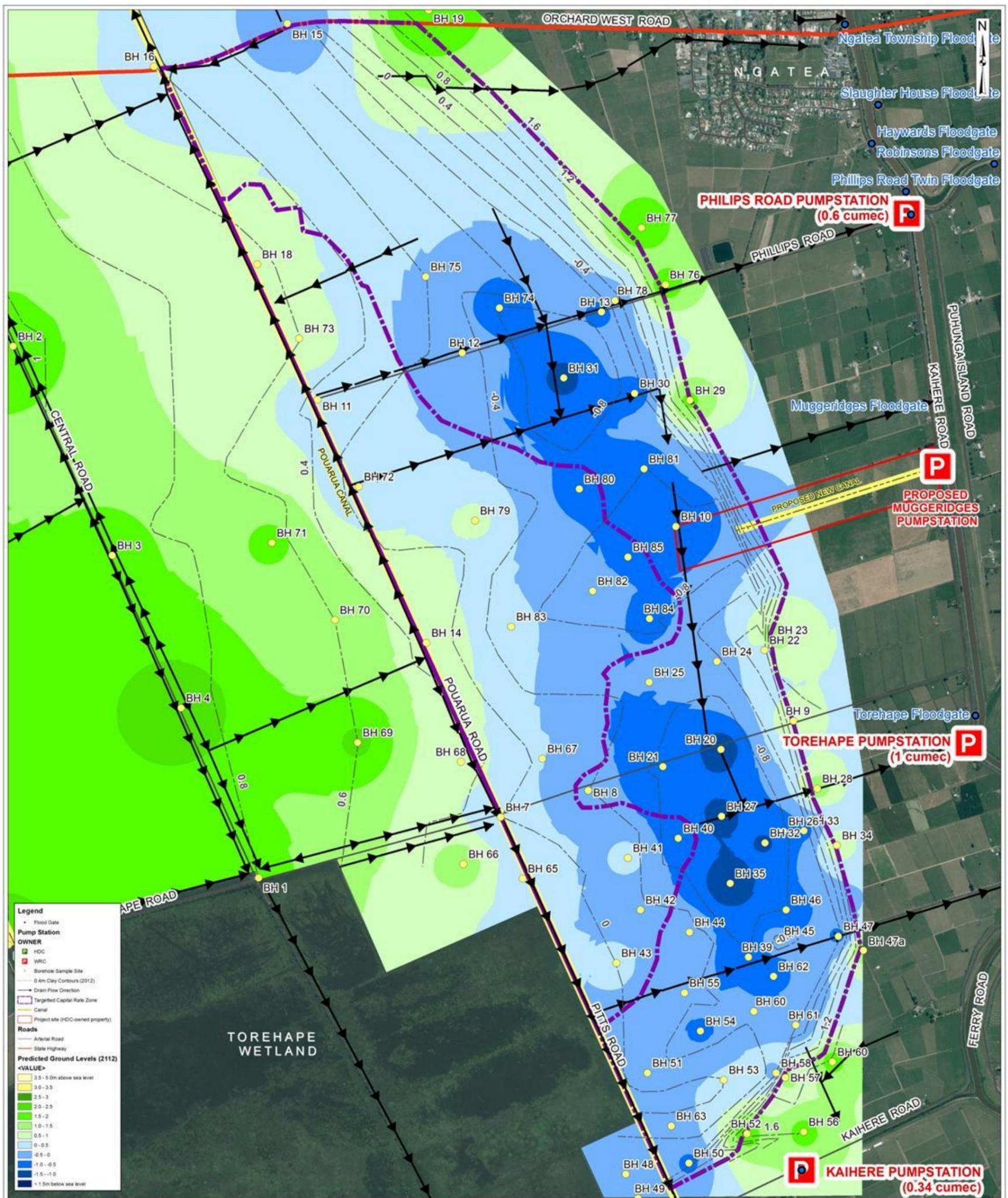


Figure 9 Projected ground contours of Mugeridges catchment - 50 years



Predicted Ground Profile : 100 year scenario (2112)

<p>Created by: PRO Projection: NZTM Date: 22/10/2014</p> <p>Status: DRAFT Request No: 28626 File: S:\gis_jobs\28626_Map6.mxd</p> <p><small>DRAFT: For Waikato Regional Council staff only. Not suitable for construction.</small></p>	<p style="text-align: center;">A0</p> <p style="text-align: right;">Waikato REGIONAL COUNCIL</p>
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Figure 10 Projected ground contours of Muggeridges catchment - 100 years

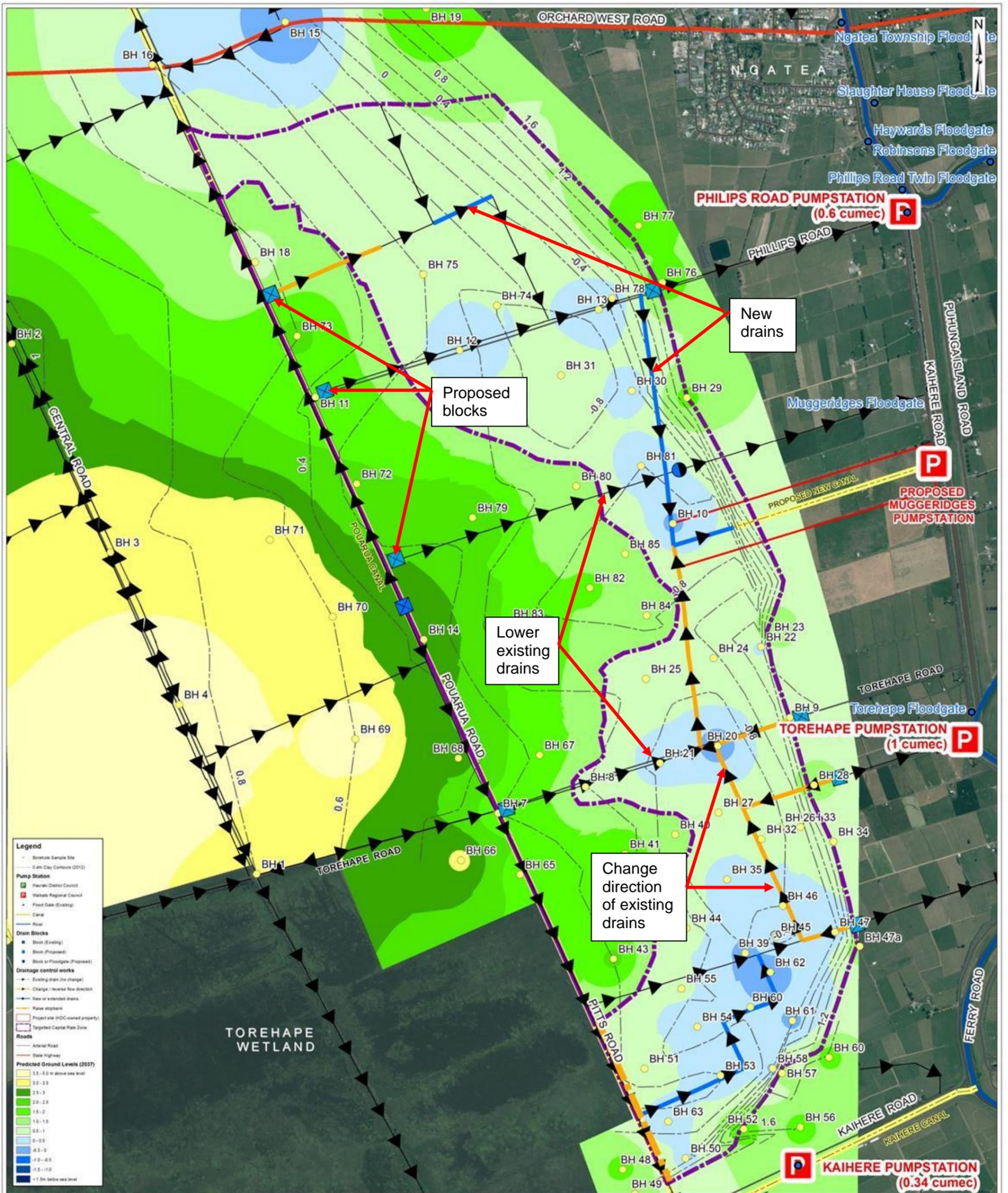


Figure 11 Proposed internal drainage layout in Mugeridges catchment