Wharekirauponga Wetland Identification, Delineation & Hydrological Classification

Waihi North Project

OCEANA GOLD LIMITED

WWLA0996 | Rev. 6

4 February 2025

Photo: Brooke James

WWLA

Wetland Identification, Delineation & Hydrological Classification

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Contents

1. Introduction

The proposed Waihi North Project (WNP) will require deep dewatering in order to mine the vein system in the Wharekirauponga Catchment. Deep dewatering could have the potential to result in drainage effects in the shallow groundwater system and, therefore, potentially result in reduced surface water discharges to streams and wetlands. For that reason, OceanaGold Limited (OGL) have undertaken a program of works to identify wetlands that could be directly or indirectly groundwater supported, and a separate package of work focused on understanding the catchment stream flows and potential depletion.

To that end, Williamson Water & Land Advisory (WWLA) has been commissioned to undertake a variety of work related to the potential wetlands as summarised in **Table 1** which are now compiled into this single report.

Table 1. Summary of WWLA wetland work commissioned by OGL.

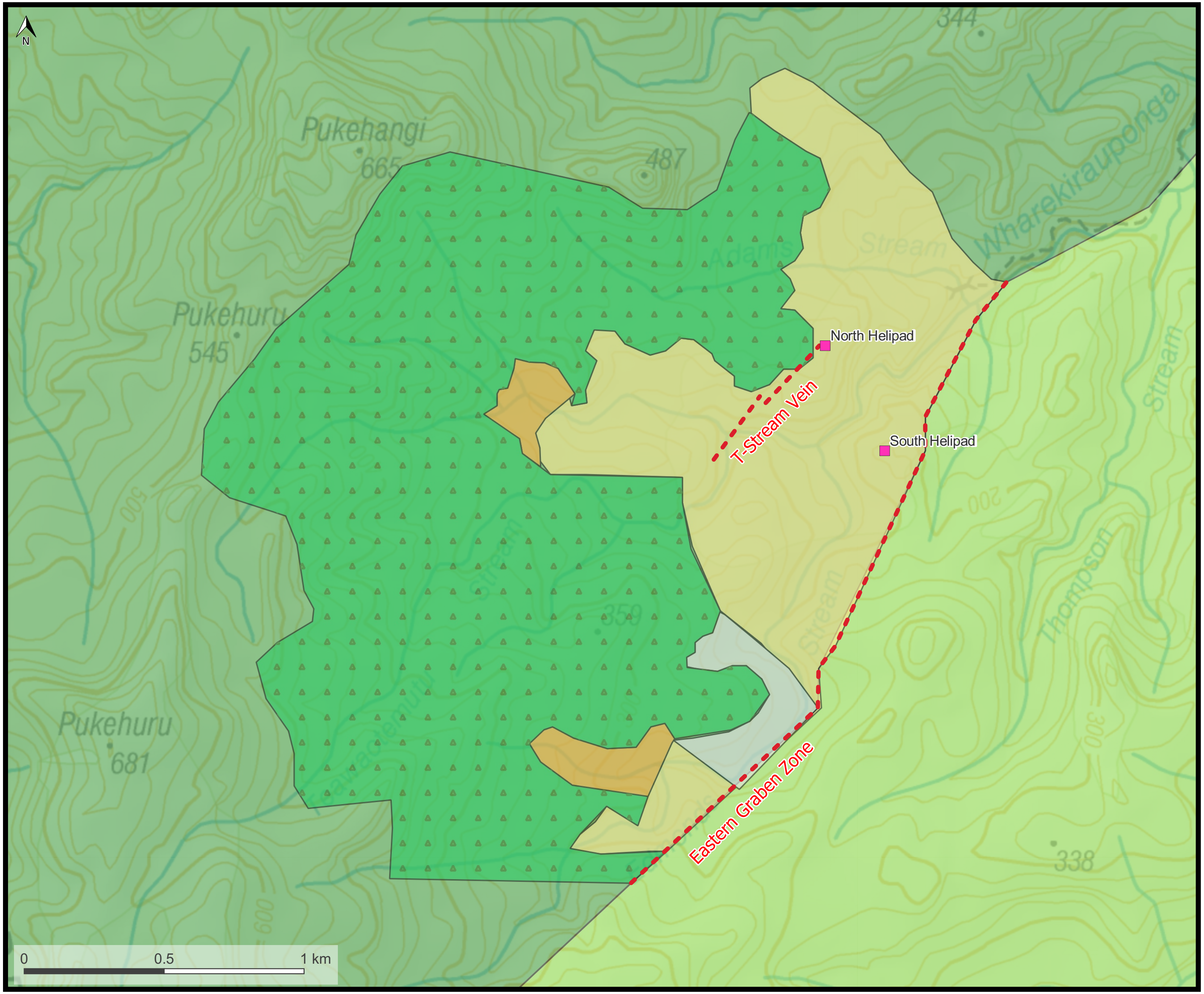
Report Reference	Description	Date Commissioned
WWLA (2023)	Closed Depression Analysis	November 2023
WWLA (2024a)	Hydric Soil and Wetland Hydrology Tool Assessments	December 2023
WWLA (2024b)	Dewatering Effects on Wetlands	May 2024
WWLA (2024c)	Wetland Hydrological Assessment (this report)	February 2025

1.1 Geology

Geology in the area comprises andesite flows at depth, overlain by flow banded / massive rhyolite and felsic lithic tuffs (Rhyolite volcaniclastic) that host the mineralised veins. Younger andesite flows cover most of the surface with Rhyolite volcaniclastics exposed only in the central project area. **Table 2** provides a description of the geologic formations within the catchment and a simplified geological map is provided in **Figure 1**.

Table 2. Geological Summary.

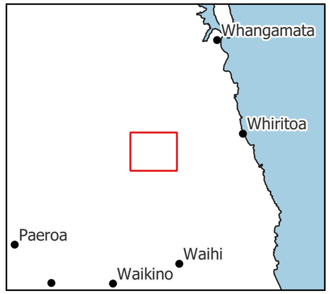
Geological Unit	Description
Pre-mineralisation Andesite Rocks	Part of the Waipupu Formation and is composed of porphyritic plagioclase flows. The andesite has a sharp upper contact with the overlying tuff sequence.
Rhyolite Volcaniclastics	Consisting of lapilli tuff containing rhyolite fragments, quartz grains in the ash matrix, and a variety of andesite and potential basement fragment types (sandstone, mudstone) showing textural homogeneity and similarities in fragment types.
Eastern Rhyolite Intrusive Dome, North, South Rhyolite Flow Dome, Western Rhyolite Dome	Each of these subunits are part of the Maratoto Rhyolite Formation. Dome-shaped intrusive bodies intruded into the tuff sequence and host mineralised vein systems.
The Eastern Graben Vein	The largest vein in WKP and dips towards the west. Is over 1000 m and host to most of the economic gold in the deposit. Towards the upper reaches, the vein becomes thinner or disappears, transitioning into clay alteration.
Post-Mineralisation Andesite Cover	Late phase andesite flows deposited at the surface on hilltops in western, south-western, and north-western portions of the project area. Forms the upper-most geological unit. The andesite flows were deposited on top of an erosional unconformity formed at the weathered surface of the mineralised deposits. Is expected to thin out near the edge of the deposits.



Map Title:
Simplified Geological Map

Project:
Wetland Delineation

Client:
Oceana Gold



Legend

- **Helipad**
- **T-Stream and Eastern Graben Veins**
- **Dacite-Andesite Pyroclastic Sediments**
- **Omahia Andesite Cover**
- **Rhyolite Flow**
- **Rhyolitic Pyroclastics**
- **Omahia Andesite**
- **Whiritoa Andesite**

Data Provenance
Aerial imagery and land parcels from Land Information New Zealand

Drawn by: Jaide Derbyshire
06/09/2024

Layout Name
Geology (Chris) G:\Shared drives\Projects\Oceana Gold\WWLA0996_WKP Wetland Identification_Delineation\Technical\GIS\QGIS project files\OGL WKP Wetland Fieldwork.qgz

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Figure 1.

1.2 Hydrogeology

1.2.1 Conceptual Groundwater Model

The conceptual model for the groundwater systems at the Wharekirauponga site broadly divides the groundwater systems into two parts: a shallow groundwater system (nominally above 100 m depth) and a deep groundwater system (nominally below 100 m depth). The mine dewatering would only take place in the deepwater system.

Post-mineralisation andesite volcanics are present at the land surface, with those deposits overlying the rhyolite volcanics that host the vein system. The rhyolite volcanics are stratigraphically older and the surface of the units have been affected by clay alteration while the geothermal system was active. Further, the rhyolite volcanics were exposed at the land surface for millions of years before the andesite rocks were deposited and weathering of the units occurred, again transforming the parent rock to residual clay. The combined effects of alteration and weathering means that an aquitard (clay) layer exists between the andesite and underlying rhyolite. The shallow groundwater system is, therefore, mostly separated from the deep groundwater system due to the presence of the aquitard.

The deep groundwater system within the rhyolite rocks is observed to have strong downward vertical hydraulic gradients within and near the vein system. The groundwater piezometric levels in the vein system are observed to flow to the north north-east. Groundwater levels indicate that there is a natural drainage effect on the vein system with a discharge elevation of some 100 m RL. The outlet point of that drainage is considered to be within the lowest reach of the Wharekirauponga Stream.

The groundwater effects assessment undertaken has indicated that dewatering of the deep groundwater system has limited effect in the shallow groundwater system or the near surface. That means that mine dewatering is generally not expected to affect the inland wetlands. The exceptions are wetlands that are supported by the groundwater system in some way that occur either in the central Wharekirauponga Stream area or possibly in other isolate areas where there is some connectivity between the deeper and shallower groundwater systems. This report considers and assesses both situations where wetlands may or may not have deep groundwater contributions.

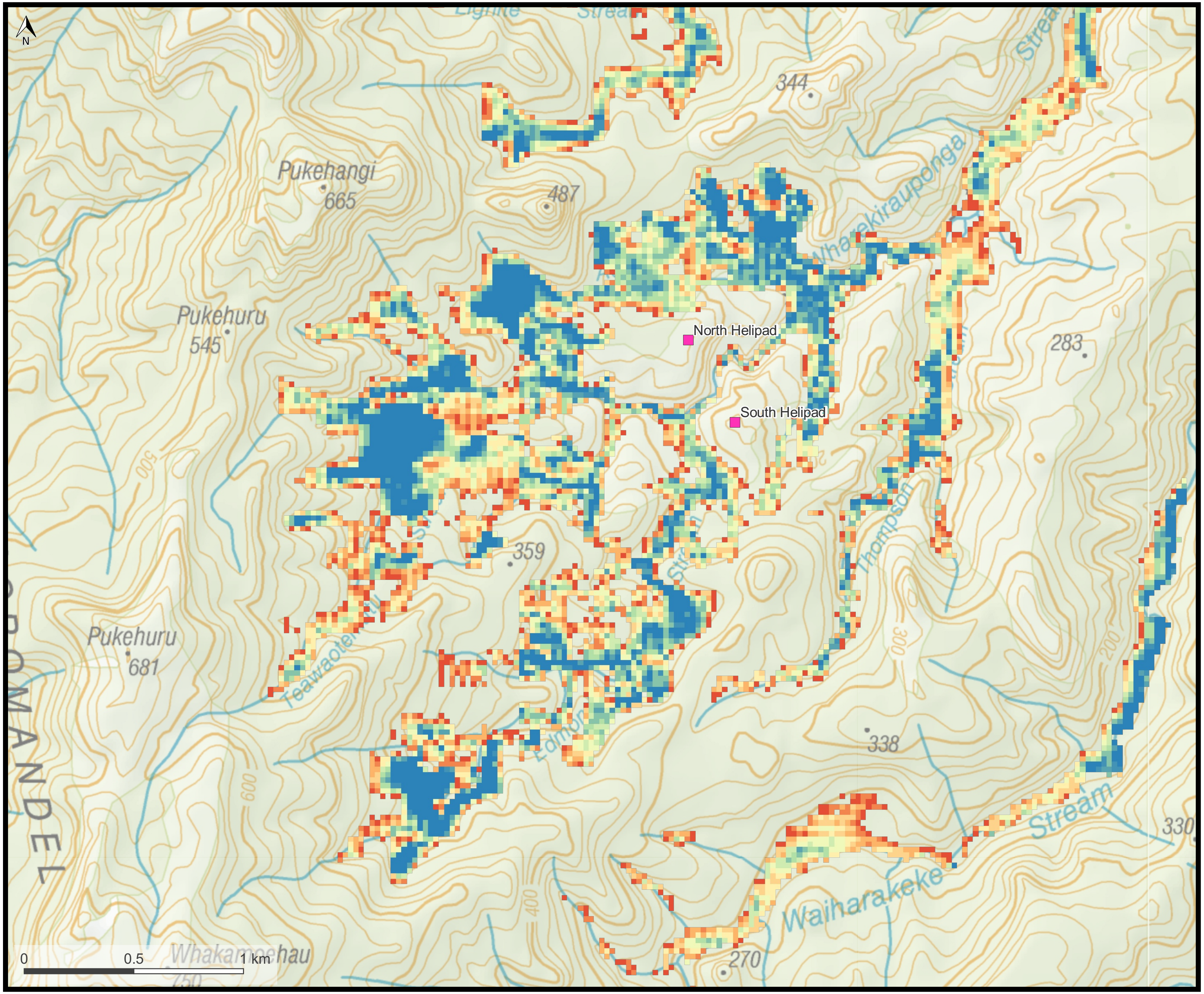
1.2.2 Depth to Groundwater

Groundwater modelling was undertaken by FloSolutions[1] for OceanaGold in November 2023 for the Wharekirauponga Underground project development. The aim of the modelling was to evaluate potential interactions between the proposed underground mine development and shallow groundwater and surface water. The code for the numerical model was MODFLOW-USG, developed by the United States Geological Survey.

The modelled area encompasses the entire Wharekirauponga catchment and is limited by the Otahu Stream in the north and the Waiharakeke Stream in the south. The model was calibrated to match data collected from the Wharekirauponga area. Data included surface water flows captured by continuous flow gauging stations, and groundwater level data from piezometers. The representative geology was from a geological model provided by the OceanaGold geology.

The groundwater model simulated the water levels and trends for both the shallow and deep groundwater systems, estimated mine inflows, baseflow reduction, and spatial responses to simulated stresses. For the purposes of this study, the simulated water levels are utilised to give an estimation of depth to groundwater from the land surface and drawdown levels. OceanaGold provided WWLA with the depth to water (DTW) model 324, shown in **Figure 2,** the DTW model provides insight into which wetlands may have groundwater input or springs.

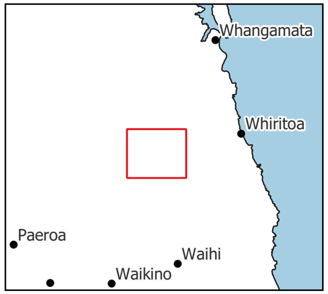
[1] FloSolutions. November 2023. FY2023 Hydrogeology Support for WUG, OceanaGold NZ Limited.



Map Title:
Depth to Water Model 324

Project:
Wetland Delineation

Client:
Oceana Gold



Legend

Helipad

DTW_324 (m)

- **<= 0.0**
- **0.0 - 0.5**
- **0.5 - 1.0**
- **1.0 - 2.0**
- **2.0 - 3.0**
- **3.0 - 4.0**
- **4.0 - 5.0**
- **5.0 - 6.0**
- **6.0 - 7.0**
- **7.0 - 8.0**
- **8.0 - 9.0**
- **9.0 - 10.0**
- **> 10.0**

Data Provenance
Aerial imagery and land parcels from Land Information New Zealand

Drawn by: Jaide Derbyshire
08/10/2024

Layout Name
Depth to Water G:\Shared drives\Projects\Oceana Gold\WWLA0996_WKP Wetland Identification_Delineation\Technical\GIS\QGIS project files\OGL WKP Wetland Fieldwork.qgz

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Figure 2.

1.3 Closed Depression Analysis

In November 2023, WWLA were commissioned by OGL to undertake a closed depression analysis in the Wharekirauponga Catchment. The aim of this work was to identify potential wetlands at a desktop level. The GIS exercise used three overlays:

- Identification of closed depressions in the land surface using lidar data;
- Depth to groundwater obtained from outputs of a groundwater numerical model developed by FloSolutions and then calibrated by Intera[2] as discussed in **Section 1.2.2**.
- The maximum drawdown extent associated with mine dewatering from the numerical model.

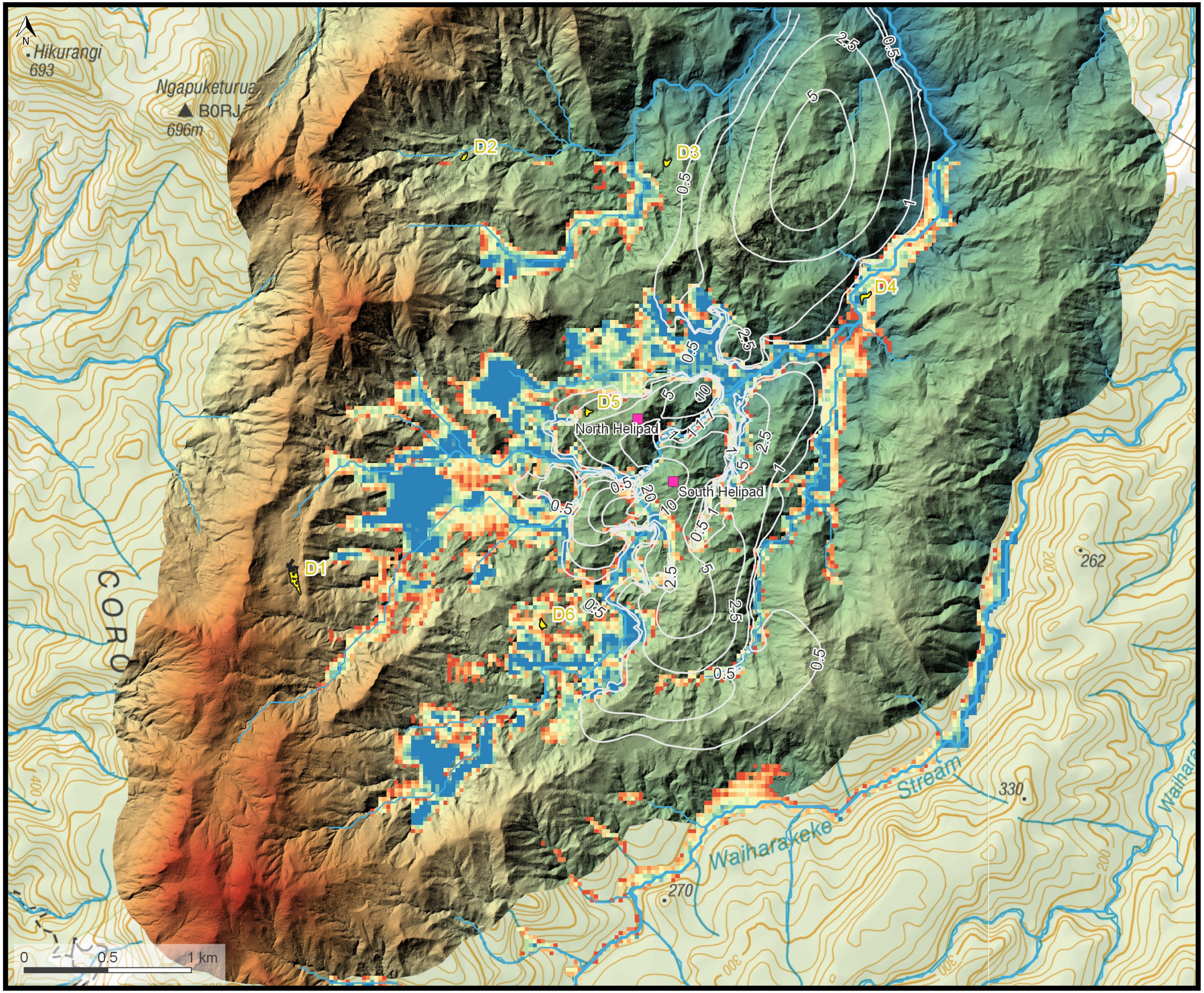
The exercise presented six potential wetlands in the catchment area (**Figure 3**), with only site D4 being situated in an area of shallow groundwater depth (< 1 m). The remaining depressions were located at higher elevations and were situated generally well above the groundwater elevation and/or are outside the potential drawdown extent.

Following this exercise, a team of ecologists visited each of the sites to confirm the natural inland wetland (NIW) status. It was concluded after the site visit that none of the closed depressions were NIW based on hydrophytic vegetation testing. Whilst this outcome was anticipated for the depressions at higher elevations, it was unexpected for site D4. based on its location and potential shallow groundwater depth.

It became clear, given the D4 outcome from the Closed Depression Analysis, that the wetlands would need to be identified on foot by the team of ecologists. To provide direction on where to focus, eight catchments were identified as areas of greatest interest based on geology and depth to groundwater and are as follows (**Figure 4**):

- Otahu Stream;
- Wharekirauponga (WKP) Stream;
- Teawaotemutu Stream (T-Stream);
  - T-Stream North
  - T-Stream South
- Adams Stream;
- Edmonds Stream;
- Tributary R (Trib R);
- Thompsons Stream, and;
- Waiharakeke Stream.

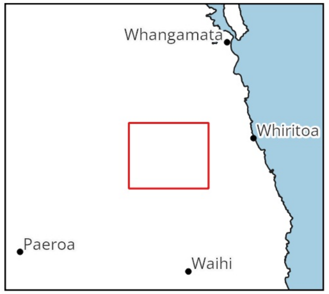
[2] Intera. September 2024. Groundwater Modelling for the OGC Waihi Project: Predictive Uncertainty Quantification.



Map Title:
Closed Depression Analysis

Project:
Wetland Delineation

Client:
Oceana Gold



Legend

- Helipad
- Drawdown Contour (Model 324)
- Depressions |>0.1 ha

Depth to Water (m)

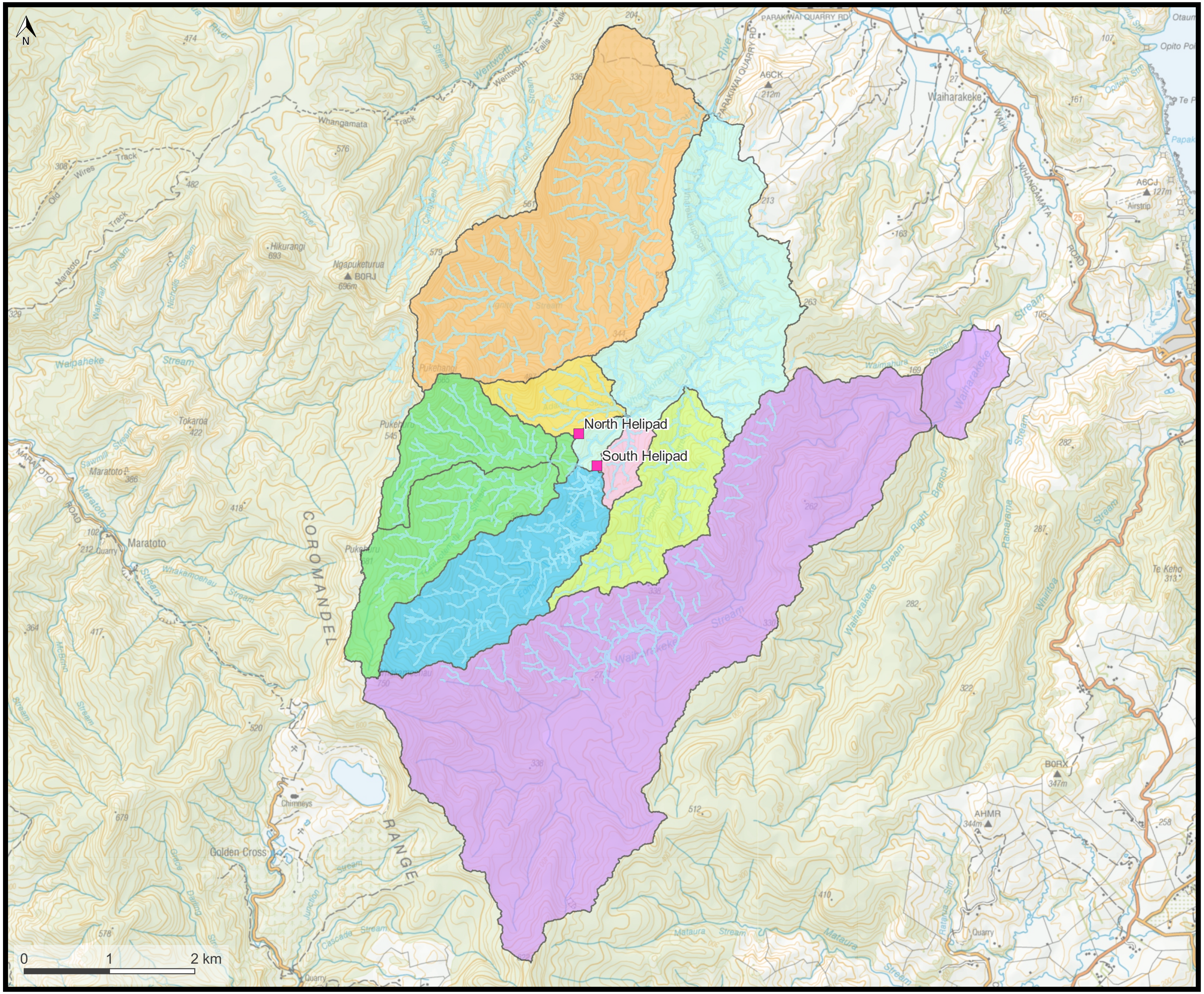
- <= 0.0
- 0.0 - 0.5
- 0.5 - 1.0
- 1.0 - 2.0
- 2.0 - 3.0
- 3.0 - 4.0
- 4.0 - 5.0
- 5.0 - 6.0
- 6.0 - 7.0
- 7.0 - 8.0
- 8.0 - 9.0

Data Provenance
Aerial imagery and land parcels from Land Information New Zealand

Drawn by: Jaide Derbyshire
06/09/2024

Layout Name
Closed Depressions G:\Shared drives\Projects\Oceana Gold\WWLA0996_WKP Wetland Identification_Delineation\Technical\GIS\QGIS project files\Oceana Gold WKP Desktop Wetland Identified Analysis.qgz

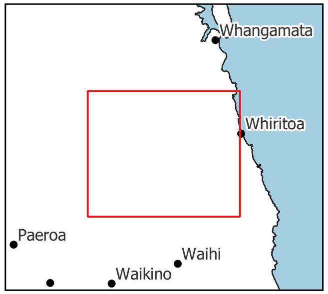
Figure 3.



Map Title:
Catchments

Project:
Wetland Delineation

Client:
Oceana Gold



Legend

- **Helipad**
- **Stream**
- **Otahu Stream**
- **Wharekirauponga Stream**
- **Teawaotemutu Stream**
- **Adams Stream**
- **Edmonds Stream**
- **Trib R**
- **Thompsons**
- **Waiharakeke Stream**

Data Provenance
Aerial imagery and land parcels from Land Information New Zealand

Drawn by: Jaide Derbyshire
10/10/2024

Layout Name
Catchments G:\Shared drives\Projects\Oceana Gold\WWLA0996_WKP Wetland Identification_Delineation\Technical\GIS\QGIS project files\OGL WKP Wetland Fieldwork.qgz

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Figure 4.

1.4 Hydric Soil and Wetland Hydrology Tool Analysis

WWLA was commissioned by OGL in December 2023 to undertake Hydric Soil and Wetland Hydrology Tool Assessments for 18 potential NIW sites in the Edmonds Catchment. Following a field assessment, those features were identified as wetlands in accordance with the guidance documents (Landcare Research, 2018[3] and MfE, 2021[4]).

In addition to being confirmed NIW based on hydric soils and hydrology assessment, an interpretation of the water source supporting each feature has been made.

1.5 This Report

The commission was extended in August 2024 to visit all the potential NIW across the project area. The sites were initially identified based on hydrophytic vegetation and later confirmed by WWLA as NIW based on hydric soils and hydrology assessments. Furthermore, additional data that would assist in understanding the hydrological functionality (i.e. source of water) for each wetland was obtained. As part of this, surface water samples were collected for chemical analysis and detailed land surveys were undertaken in certain locations to enable a more detailed geomorphological assessment.

[3] Landcare Research, 2018. Hydric soils – field identification guide. Consultancy report prepared for Tasman District Council under Envirolink Grant: C09X1702. June 2018.

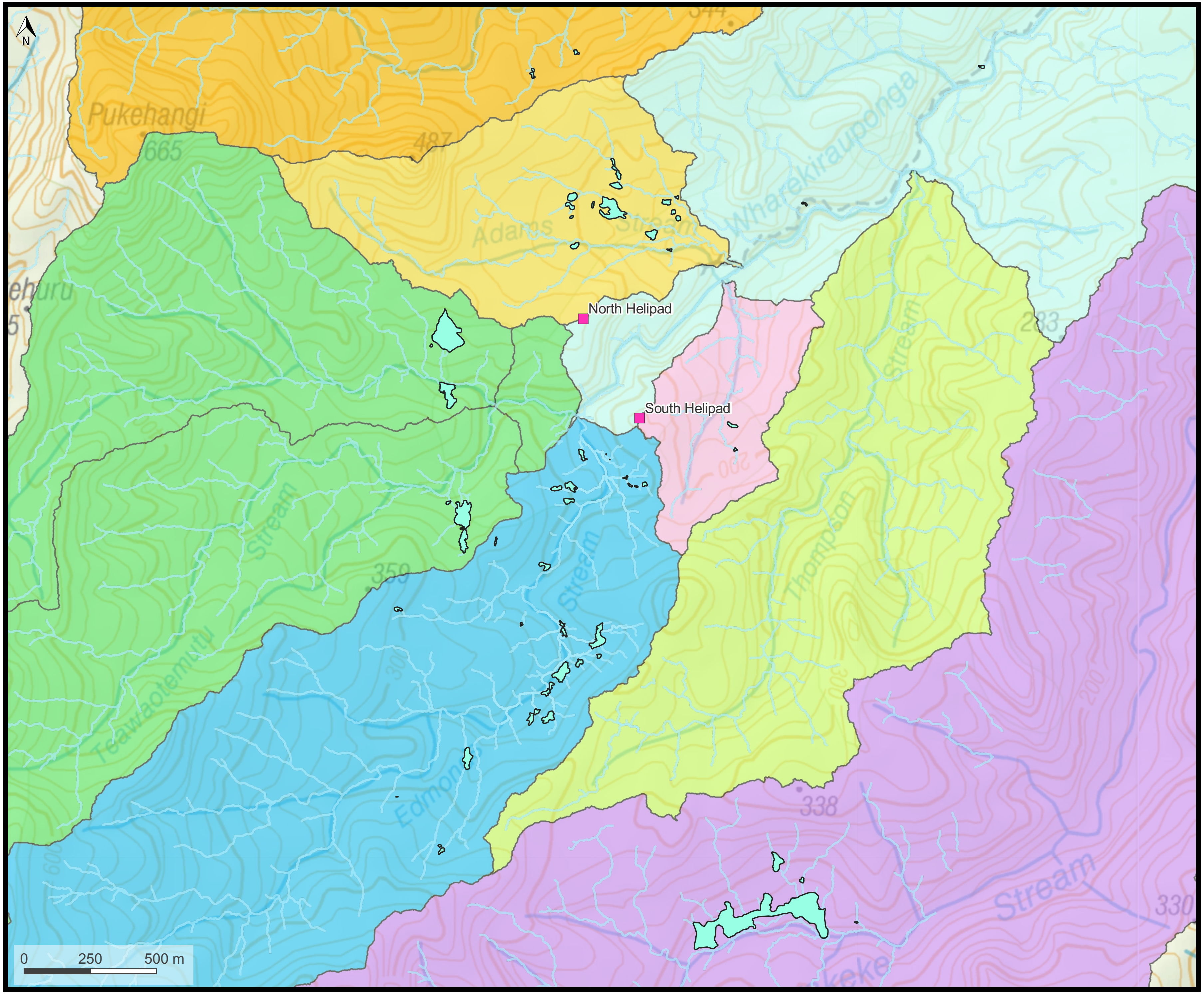
[4] Describing a colour requires three components: hue, value, and chroma. Hue refers to the colour (e.g. red, orange, yellow), value describes how light or dark the colour is, and chroma rates how bright or vibrant the colour is.

2. Wetland Identification

Following the identification of the catchments of interest, a team of ecologists conducted fieldwork to locate any NIW in the project area. They walked along the main streams and tributaries in each of the catchments looking primarily for wetland vegetation. This process resulted in the identification of 50 NIW throughout the area including the sites identified in the previous round of fieldwork (**Figure 5**).

The majority of the wetlands are located in the Edmonds Stream catchment, but some were also found in the Otahu, Adams, T-Stream, Trib R, WKP, and Waiharakeke catchments.

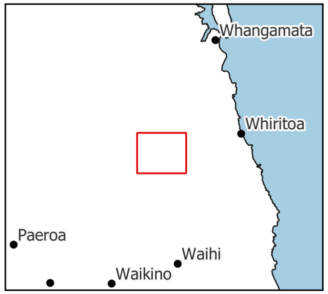
No wetlands were identified in the Thompson's Stream catchment.



Map Title:
Natural Inland Wetlands

Project:
Wetland Delineation

Client:
Oceana Gold



Legend

- **Helipad**
- **Stream**
- **Wetland**

Catchments
- **Otahu Stream**
- **Wharekiraupoinga Stream**
- **Teawaotemutu Stream**
- **Adams Stream**
- **Edmonds Stream**
- **Trib R**
- **Thompsons**
- **Waiharakeke Stream**

Data Provenance
Aerial imagery and land parcels from Land Information New Zealand

Drawn by: Jaide Derbyshire
21/10/2024

Layout Name
Catchments G:\Shared drives\Projects\Oceana Gold\WWLA0996_WKP Wetland Identification_Delineation\Technical\GIS\QGIS project files\OGL WKP Wetland Fieldwork.qgz

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Figure 5.

2.1 Types of Wetlands

There are four main types of wetlands observed in the project area. Each of the types are illustrated and described below.

2.1.1 Closed Depression

This type of wetland is located within a closed depression, commonly at the base of slopes (**Figure 6**). They are supported by surface run-off during rainfall and there are no extraneous sources of water or outflow. The water table is at depth, typically exceeding 3 m below ground level (mBGL), and these wetlands are surface water, or direct rainfall supported.

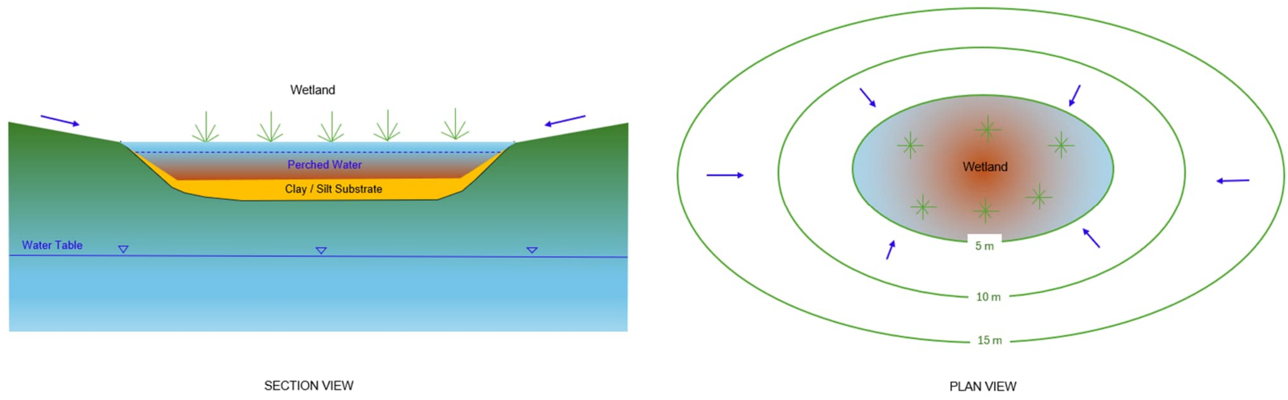


Figure 6. Closed depression wetland.

2.1.2 Depression with Hydrology Feature

This type of wetland is located in a depression, commonly at the base of slopes or within a valley (**Figure 7**). There is a hydrology feature running through the wetland and consequently they are supported by surface run-off during rainfall. The water table is at depth, typically greater than 3 mBGL, and these wetlands are surface water supported, with direct rainfall support.

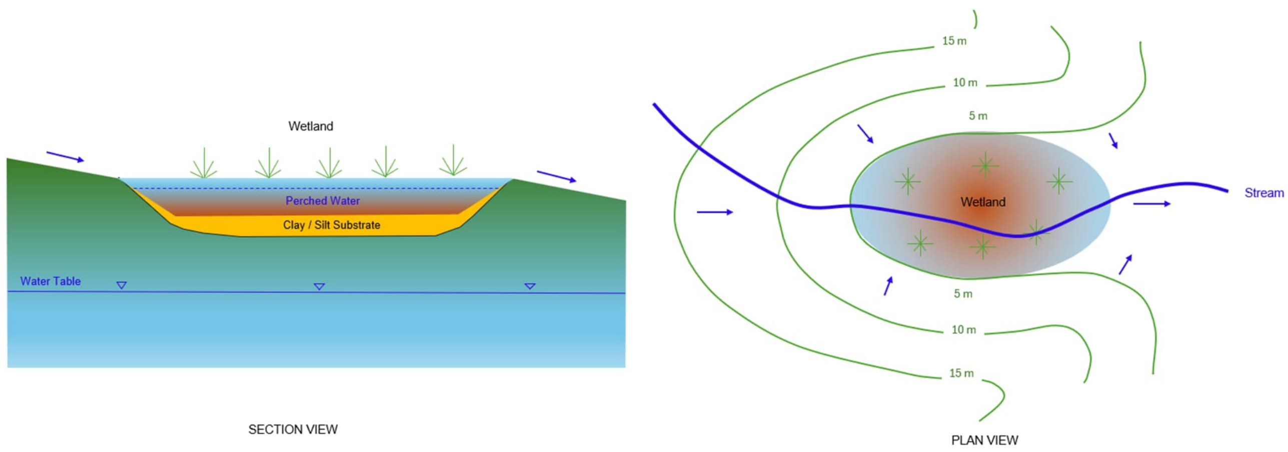


Figure 7. Depression with hydrology feature wetland.

2.1.3 Depression with Interflow

This type of wetland is located in depressions, commonly at the base of very steep slopes (**Figure 8**). They are supported by surface water run-off during rainfall and supported by interflow (shallow sub-soil water flow) through the steep slopes. The water table is at depth, typically greater than 3 mBGL, and the wetland is surface water-supported with interflow and direct rainfall support.

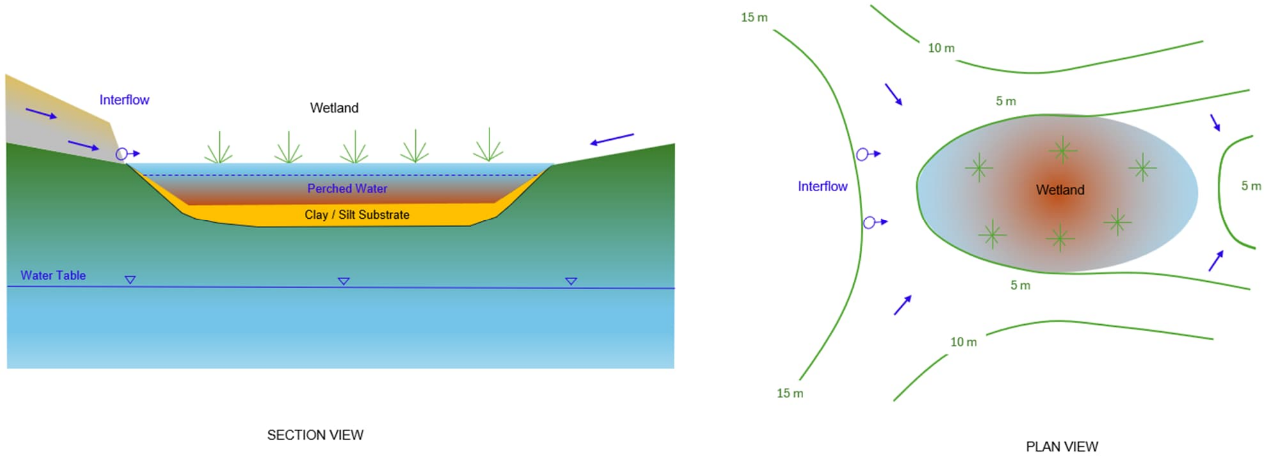


Figure 8. Depression with interflow wetland.

2.1.4 Groundwater Supported

This type of wetland is located in depressions, commonly at the base of steep slopes (**Figure 5**). The groundwater table is at the surface; hence groundwater ingress is a primary source of water. Due to the topography, there will also likely be an aspect of surface water support from run-off during rainfall. These wetlands are considered to be groundwater-supported with surface runoff and direct rainfall support.

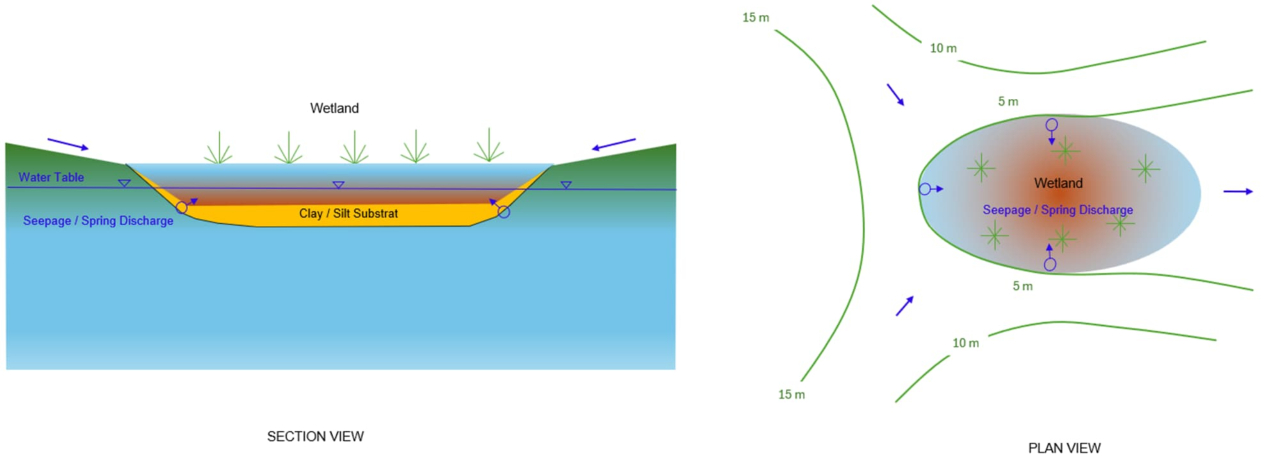


Figure 9. Groundwater supported wetlands.

2.2 Summary of Wetlands

Appendix A presents WWLA's observations for each of the wetlands based on the Hydric Soils and Hydrology Tools Assessment as set out in the Wetland Delineation Protocols by the Ministry for the Environment (MfE). All of the wetlands identified by the ecologists based on hydrophytic vegetation were confirmed to be wetlands using the Hydric Soils and Hydrology Tools Assessment.

2.2.1 Edmonds Catchment

A total of 25 wetlands were found within the Edmonds catchment (**Figure 11**). All four types of wetland were identified in this catchment with characteristics varying slightly between the surface water-supported wetlands and the groundwater supported catchments.

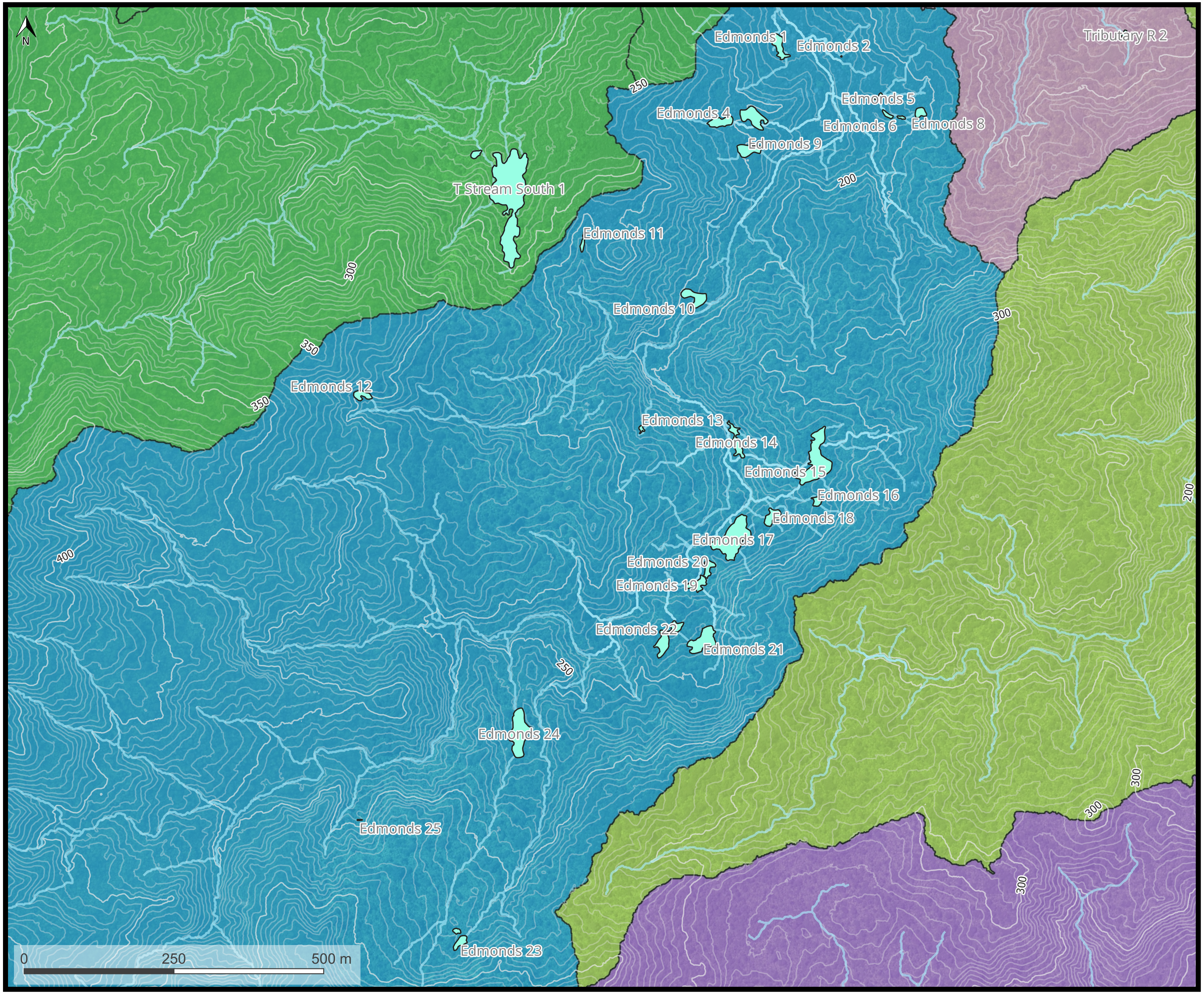
As indicated by the definition above, the surface water-supported wetlands were typically located at the base of slopes or valleys where surface water streams formed or passed through, and they were covered by dense vegetation limiting light and heat from reaching the ground (**Figure 10 – Photo 1**). The streams could often be seen fanning out or meandering to create ponding and highly saturated soils over the width of the depression.

Both the topsoils and subsoils in surface water-supported wetlands were observed to be very dark brown, or black, but no peat was identified. This is likely due to the steep surrounding topography which creates a fast-flowing, flashy catchment. As a result, the movement of water into the wetland is preventing any peat from forming. Between rain events, the water in the wetland becomes somewhat stagnant. This is likely limiting the oxygen in the soil resulting in the dark brown, or black soils observed.

The groundwater-supported wetlands were also located at the base of slopes, and some had stream supporting them. These wetlands were also covered by dense vegetation limiting light and heat from reaching the surface. The streams in these groundwater-supported wetlands were often observed only supporting part of the wetland (such as the downstream end) or were located at a lower elevation than the wetland area, indicating lesser importance as a water source than groundwater. Seepage was observed coming from some of the steep slopes, and this could be a mix of groundwater or interflow. In some of the wetlands, upwelling was observed centrally during the low-flow summer months.

The topsoils in the groundwater-supported wetlands were generally also dark brown or black, but in some cases a bright orange soil was observed (**Figure 10 – Photo 2**)caused by a slimy, iron-oxidising bacteria giving the orange colouring. The naturally occurring bacteria takes dissolved iron within groundwater and oxidises it to produce an iron-oxide deposit. Along with the orange slime, an oily biofilm was observed. This is produced by bacteria called Leptothrix Discophora which oxidises dissolved iron and manganese from groundwater, secreting proteins and carbohydrates. The biofilm floats on the surface and shatters when touched, unlike oil which sticks together (**Figure 10 – Photo 3**).

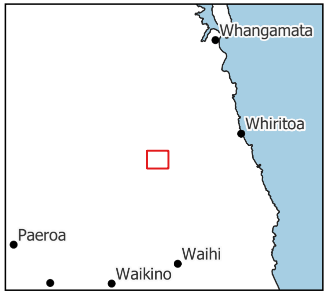
Figure 10. Edmonds catchment photos.



Map Title:
Edmonds Stream Catchment

Project:
Wetland Delineation

Client:
Oceana Gold



Legend

- **Stream**
- **Contour (m)**
- **Wetland**
- **Teawaotemutu Stream**
- **Edmonds Stream**
- **Trib R**
- **Thompsons**
- **Waiharakeke Stream**

Data Provenance
Aerial imagery and land parcels from Land Information New Zealand

Drawn by: Jaide Derbyshire
04/10/2024

Layout Name
Catchments G:\Shared drives\Projects\Oceana Gold\WWLA0996_WKP Wetland Identification_Delineation\Technical\GIS\QGIS project files\OGL WKP Wetland Fieldwork.qgz

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Figure 11.

2.2.2 Waiharakeke Catchment

A total of four wetlands were identified in this catchment, all of which were classified as depressions with hydrology features.

Three of the wetlands were located at the base of steep valleys where streams were flowing through or starting to form. The fourth, and largest wetland, was located on a flat area at the base of the steep slopes and was bound by the Waiharakeke Stream at a lower elevation. This wetland had several surface water streams running through the area. Two large slips were found along the north-western border of the wetland (**Figure 12 – Photo 1**) and some interflow was observed here.

For the most part, dense vegetation covers the wetlands limiting light and heat from reaching the ground, but centrally in the large wetland, there was an area of wetland grass where there were no shrubs or trees and the light level was much higher (**Figure 12 – Photo 2**). There was significant ponding across this area.

Both the topsoils and subsoils in the wetlands were observed to be dark brown (**Figure 12 – Photo 3**), and no peat was identified. This is likely due to the steep surrounding topography which creates a fast-flowing, flashy catchment. As a result, the movement of water into the wetland is preventing any peat from forming.

A small amount of orange slime was observed in the west of the large wetland (**Figure 12 – Photo 4**), but this was sporadic and there was no clear evidence of groundwater upwelling at the surface. It is likely that this was the result of a nearby slip which may have mobilised metals into the wetland.

Figure 12. Waiharakeke catchment photos.