GeoSolve Ref: 230663
6 November 2023 Rev2

Otago Regional Council
Private Bay 1954
Dunedin 9054

Attention: Melanie White

## Mapping of sediment types
## Te Hakapupu – Pleasant River Catchment

Dear Melanie,

In accordance with our Agreement dated 28 September 2023 we have undertaken a desktop mapping exercise of sediment sources within the Te Hakapupu – Pleasant River Catchment. This report summarises the information used for the mapping exercise, methodology and results of the mapping.

## Introduction

We understand a restoration project is underway for the Pleasant River Catchment and Estuary to improve its environment condition. It has been reported that the ecological health of the estuary has been adversely impacted by sedimentation and nutrient runoff. A chemical review of sediment source within the catchment and estuary indicate the primary source of sediment within the river system is from subsoil and streambank erosion.

Therefore, to better understand and manage the sediment input into the catchment, stream bank and hill slope instability mapping has been recommended and the desktop aspect of this mapping has been carried out in this assessment.

## Sources of Information

GeoSolve have carried out a desktop mapping exercise using QGIS, mapping potential sediment sources within the catchment. The assessment has been carried out within the Te Hakapupu catchment extents as provided within the catchment file listed below. The assessment has been carried out using available aerial imagery, lidar, geological mapping and published reporting for the catchment. The assessment has used the following geospatial sources:

- Otago – Coastal Catchments LiDAR 1 m Digital Elevation Model (DEM) 2021 (sourced from LINZ data service). A slope model was also created from the DEM and used as an additional tool to identify features.
- Barrell DJA. Smith Lyttle B, Glassey PJ. 2017. Revised landslide database for the coastal sector of the Dunedin City district. Lower Hutt. (NZ): GNS Science. 29p. (GNS Science consultancy report; 2017/41).
- Otago 0.3 m Rural Aerial Photos - 2017-2018 (sourced from LINZ data service). Only partial coverage of workspace with aerial not covering the northern extents.
- Otago 0.4 m Rural Aerial Photo - 2013-2014 (sourced from LINZ data service)
- Otago 0.75 m Rural Aerial Photos - 2005-2006 (sourced from LINZ data service)
- Google Satellite Imagery (various dates)
- GNS Science 1:250,000 Scale Geological map. 2020.
- Ahika Consulting (2023). Initial mapping of sediment sources, movement pathways and deposition areas of the Te Hakapupu catchment, eastern Otago. Maps used include the following:
    - Te Hakapupu Catchment
    - Te Hakakpupu Historic Mass Movement
    - Te Hakapupu Waterways

No stereoscopic assessment of historical aerial imagery has been carried out.

## Assessment

GeoSolve have systematically worked through the catchment extents to identify sources of sediment that show evidence of active erosion or could be a source of past or future erosion. This involves identifying geomorphological features identified within DEM and slope layer and verifying with aerial imagery to determine the certainty of the feature identified.

We have categorised each erosional feature into six categories. These are as follows:

1. **Stream Bank Erosion (line feature):** Identified as erosion within river or stream channels/banks due to hydraulic processes. This has included areas where exposed subsoil on the stream bank is visible within aerials and where visible slumping has been observed.
2. **Large Scale Slope Instability (polygon):** Slope instability including deep seated landslides, and earthflows or areas containing high density of shallow slips in a small area.
3. **Shallow instability (point feature):** Shallow landslides, typically on steep slopes involving failure of overburden soils or under runner collapse structures.
4. **Roads/Tracks (line feature):** Areas of exposed soils or subgrade along private roads or tracks.
5. **Exposed soil/subgrade (polygon):** Non-road areas of exposed soils such as logging site, stock yards, exposed earthworks etc. Not including earthworks carried out in formation of roads/tracks.


 

6. **Geological/ Geomorphological (polygon):** Elevated risk of surficial erosion of vulnerable soil or rock types, steep slopes, or other susceptible landforms

Each feature identified has had four attributes classified to describe the sediment source in accordance with 1)Certainty, 2) Severity, 3) Connectivity and 4) Remediation Potential.

The definition of the classifications are outlined in Table 1 below.

*Table 1: Sediment source classification scheme*

| Certainty | Certainty Description |
|---|---|
| Definite | Evidence of recent sediment movement that can only be result of erosional feature described |
| Likely | Sediment source that may be result of erosional feature described |
| Possible | No recent erosion visible but may be a source of past or future erosion |
| Severity | Severity Description |
| High | Large area with recent evidence of erosion (>100 $m^2$ source area) or large-volume/small area sources (active landslides, debris flows etc) |
| Medium | Small area of recent soil/rock erosion (<100 $m^2$).<br><br>Small area of recent erosion within a larger more stable feature. e.g prehistoric less active landslide complexes with activation of smaller lobe or small shallow failure |
| Low | No recent erosion visible but may be a source of past or future erosion, e.g. during major rainfall events. |
| Connectivity | Connectivity to Stream Network Description |
| High | Direct, ongoing connectivity to stream network. (i.e. within a stream channel) |
| Medium | Moderate potential of source connection to stream network – large storm events (in flood) (i.e. likely to be in contact with watercourse during flood event) |

| | |
|---|---|
| Low | Erosion source is only connected to stream system in exceptional circumstance |
| Remediation Potential | Remediation Potential Description |
| High | Erosion source can be remediated through simple erosion protection methods, i.e. vegetation development, alternative land use, riparian planting, buffer planting, bridges etc |
| Medium | Erosion source requires moderate remedial works, earthwork, vegetation establishment, rip rap protection. |
| Low | Erosion source requires significant remedial works i.e. large scale earthworks or slope stabilisation |

Remediation potential has been classified based on desktop observations of the erosional feature only and should be considered indicative. Remediation has been considered to a level that would reduce risk of further erosion and sediment movement occuring. In the case of landslides, remediation would not be to a level that would allow future development and or other landuses. Further site specific assessment is recommended if remediation of any particular feature is to be considered.

In additional comments have been added to the attributes table of some identified features to give an indication on how the feature has been identified and classified.

## Erosion Mapping Results

**Stream Bank Erosion**

Stream bank erosion has been mapped where there is visual or evidence within data reviewed that erosion of the stream bank is occurring. Where features were identified the following was generally observed:

- Exposed subsoils were visible on the bank;
- Over steepened stream banks were visible likely as a result of erosion and where exposed subsoils were likely present within the bank but were not observed; and
- Visible slumping was observed on the stream banks.

There are likely additional areas that are susceptible to alluvial erosion that have not been mapped such as where the stream meanders, where higher water energies would be present in floods or high flows. However, if no evidence of recent erosion is visible then the feature has not been mapped for simplicity. These vulnerable areas would be easily identifiable using the watercourse mapping already carried out for the catchment.

The mapped Stream Bank Erosion features are shown in Figure 1 below with the features mapped in terms of Certainty.

The map also shows the waterways categorised to relative flow as provided. From this it can be concluded that the visible erosion within the catchment is predominantly within the main stems of the catchments where higher flows are likely present.

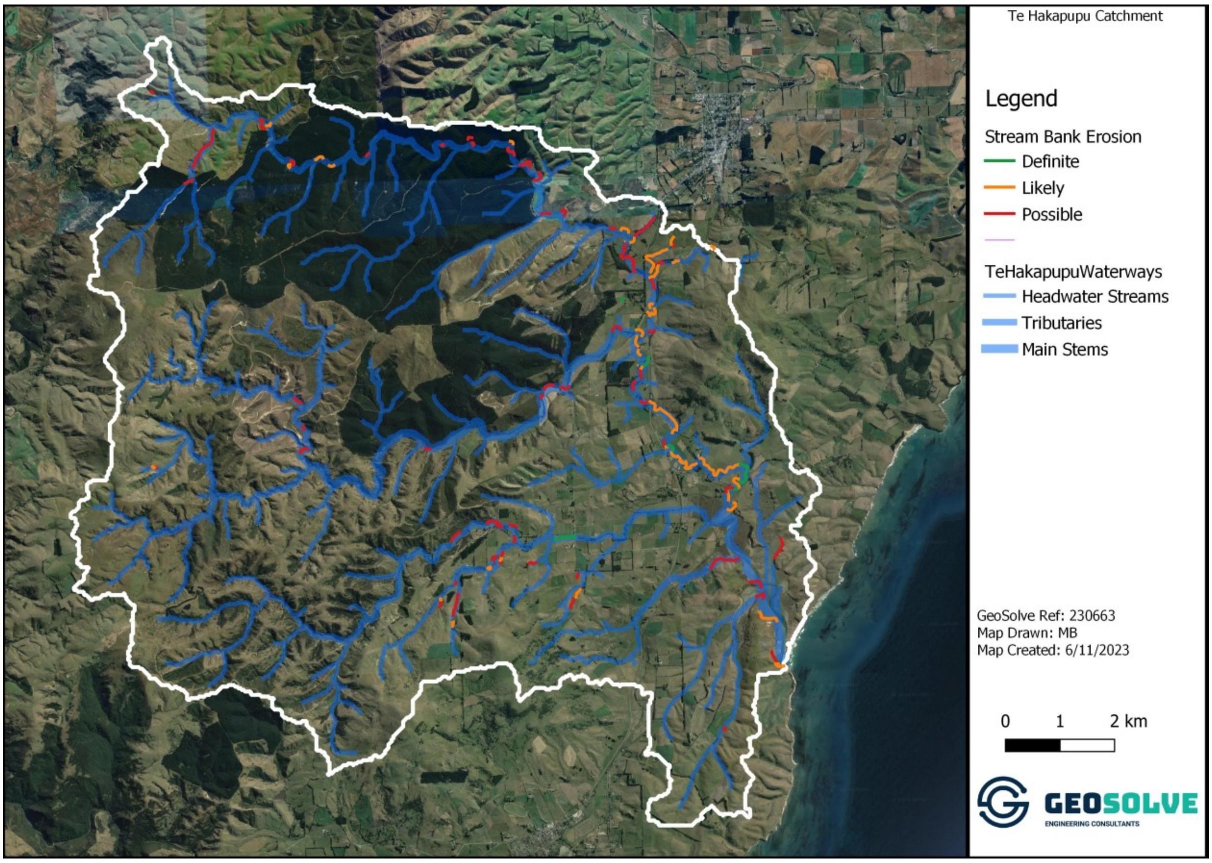


*Figure 1: Mapped Stream Bank Erosion*

## Slope Instability Mapping

We have carried out mapping of slope instability features within the catchment. The features have been mapped based on geomorphology and identification of exposed soils where recent movement has been observed. Typical geomorphological features used to identify slope instability include displacement at head and lateral scarps, accumulation of debris in toe area and hummocky or irregular ground within the feature.

Where the landslides are small features (typically shallow slips within overburden soils), the slip has been identified using a point feature located on the scarp of the landslide. Larger features have been mapped using polygons.

Where existing landslide mapping has been carried out (i.e. by GNS Science or supplied by Ahika Consulting) we have verified these features with the 2021 Lidar and where valid have included these within our mapping. Classification using the GeoSolve's scheme has been carried out for the GNS Science mapping. Existing attributes as defined by GNS Science have been retained and provide further information on some of the features identified using some differing sources as used in this study. There is some overlap between the GeoSolve and GNS mapped landslides as GeoSolve's mapping has identified the more defined more recently active zones.

The mapped instability is shown in Figure 2 below with each feature categorised into Severity. As indicated within Table 1, the severity is a direct correlation to the activity of the feature and whether any recent movement has been sited within the aerial imagery available back to 2005-2006.

We note that a low severity indicates that no recent movement has been identified within the available dataset. There is potential for future movement that would result in 'high' severity classification. Larger landslides commonly 'creep' during heavy rainfall events or prolonged wet periods and evidence of these creep movements may not have been identifiable from the lidar and aerials available.

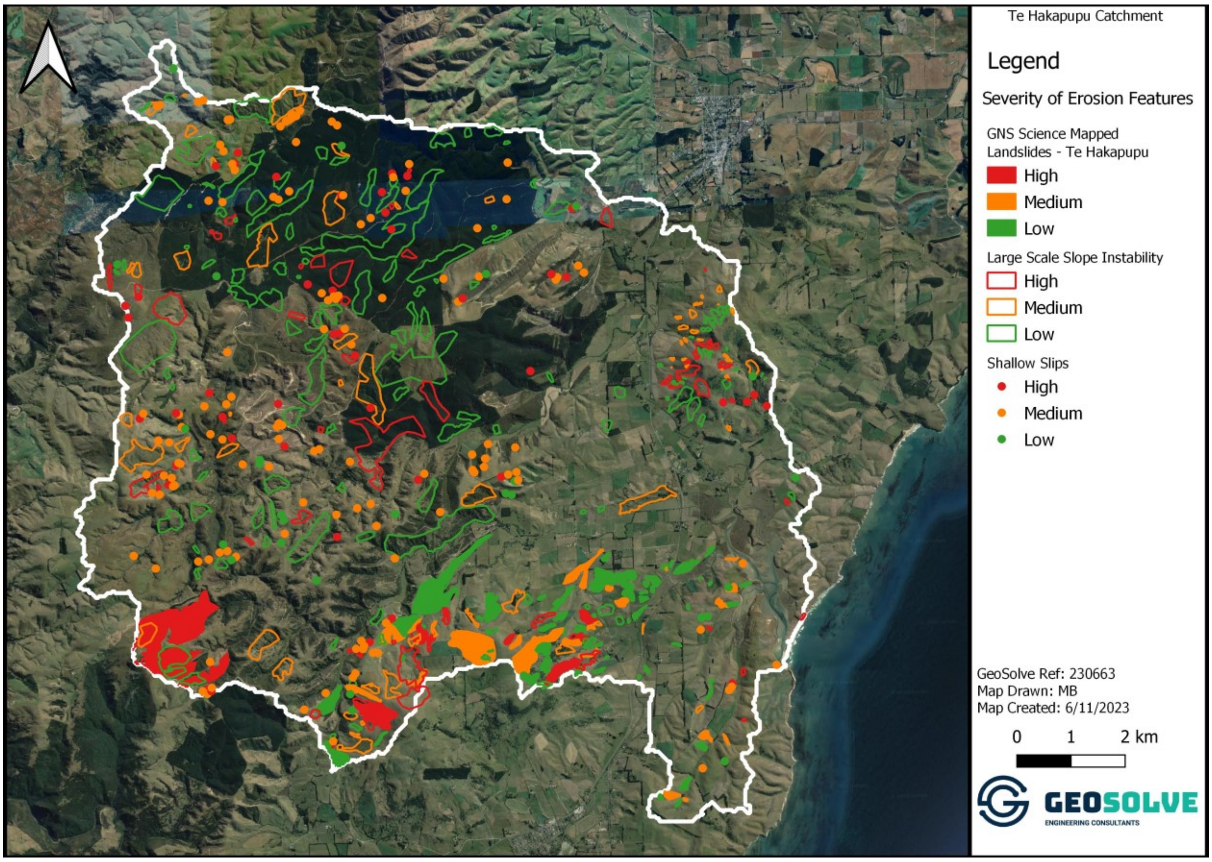


*Figure 2 – Mapped slope instability identified in the figure with Severity.*

Following the mapping exercise it can be concluded that the catchment is vulnerable to slope instability. This is largely due to the geology of the area and the presence of weak tertiary aged rock types that can be prone to instability where present on steep slopes or where groundwater regimes allow pore water pressures to become elevated.

Areas that are most susceptible to slope instability and mass movement are where volcanic rock types have cross cut Late Cretaceous to Paleocene Mudstones of the Onekakara Group. In particular large mass movements are mapped adjacent to the geological contact between the two units. This can be seen in Figure 3 below which overlays the mapped slope instability feature over GNS Science's 1:250k geological map. A high density of Large Scale Slope Instability is mapped near the boundary of the purple (Dunedin Volcanic Group) and brown units (Onekakara Group mudstone). These areas have also been identified as mass movement zones within GNS Science's geological mapping.

Slope instability is also common near the geological contact between the Late Cretaceous Taratu Formation (green unit below) and the underlying Otago Schist (grey unit below). Taratu Formation rock/soils types can become unstable on steep slopes whereas the schist is relatively stable at steeper angles. This commonly results in landslides where the Taratu Formation can become unstable on gully margins where slopes steepen.

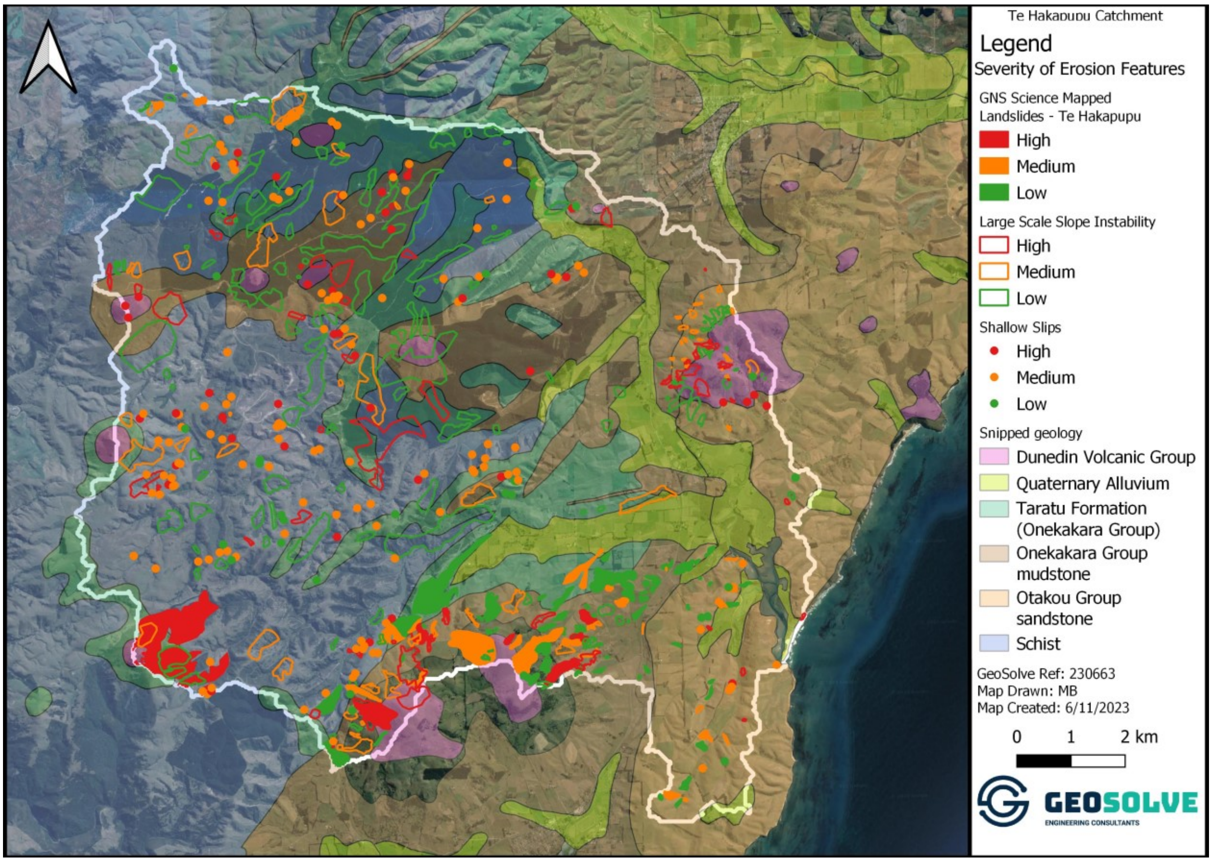


*Figure 3: Mapped slope instability overlaying GNS Science 1:250k mapping.*

**<u>Exposed Soils and Tracks or Roads</u>**

Exposed soils and roads/tracks that have the potential to be a sediment source were mapped. These features were identified using available aerial maps. Public roads were excluded as these spatial data is already available from LINZ for these locations.  These features were typically associated with the land current land use i.e. informal access to farmland or forestry ares, logging sites, stock yards etc.

A number of the tracks mapped are likely to be temporary access for forestry harvest and often have involved steep cut and fill earthworks. These areas will be vulnerable to erosion.

The mapped areas of exposed soils and road/tracks are shown in Figure 4 below.

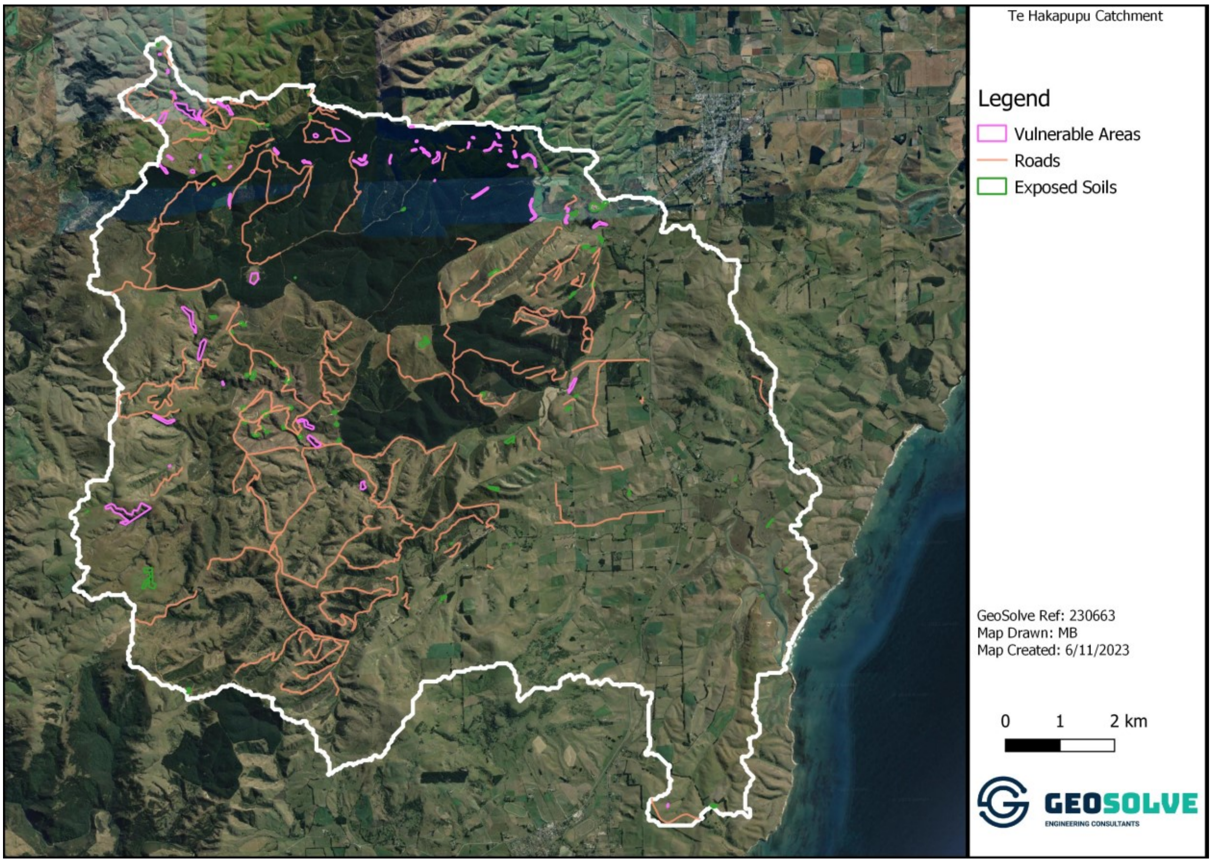


*Figure 4: Mapped Track/private roads, exposed soils and vulnerable areas.*

## Vulnerable Areas

Vulnerable areas mapped are areas that may be at higher risk of erosion but may not have active erosion visible. These were typically steep slopes or rock faces. Further assessment of these areas could be considered to determine whether these features are a sediment source. These features will typically have low remediation potential due to the large or steep nature of the areas.

Mapped vulnerable areas are shown as purple polygons in Figure 4 above.

## Limitations

The mapped erosional features or sediment sources have been mapped based on available desktop information and features observed within the aerial imagery and lidar data available. No ground truthing has been carried out. The assessment has made classification in terms of the certainty of each feature and where unsureness is present appropriate classification has been made (i.e. likely or possible classification).

The assessment has used Lidar to analyse terrain and identify geomorphological features. These feature have then been cross checked using aerial imagery. However, we note aerial imagery available is limited to 2018 and visual confirmation of more recent features was not possible. Recent erosional features are generally obvious within the DEM and where identified with DEM only, have been included within the map. We note that shallow small area/volume slips are not as easily identifiable from Lidar and where these have occurred recently, mapping may have been missed.

## Datasets Provided

Six GIS datasets have been generated as part of the erosion mapping and provided to the Otago Regional Council as an attachment to this report. These are as follows:

1. Stream Bank Erosion Shapefile (line)
2. Large Scale Slope Instability (polygon)
3. GNS Science Mapped Landslides_Te Hakapupu (polygon)
4. Shallow Slips (point)
5. Roads/tracks (line)
6. Exposed Soils (polygon)
7. Vulnerable Areas (polygon)

## Use of the Erosion Mapping Datasets

The datasets developed have been developed to determine potential erosion sources within the subject catchment. This data has been provided to aid catchment management and determine potential remedial options for reducing sediment runoff into the catchment system.

The data should not be used or relied on (in whole or part) by anyone else, or for any other purpose or in any other contexts, without our prior review and written agreement.

## Applicability

This report has been prepared for the sole use of our client, Otago Regional Council with respect to the particular brief and on the terms and conditions agreed with our client.

Yours faithfully,

Matthew Bruce

Engineering Geologist

GeoSolve Limited

Reviewed and authorised for GeoSolve Ltd by: Mark Walrond (Senior Engineering Geologist)