Detailed map of landslides in the Pukekohe area, southern Auckland

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DISCLAIMER

Use of Data:

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EXECUTIVE SUMMARY

This report documents a map of landslide features within a rectangular footprint that encompasses the wider Pukekohe area in southern Auckland. The landslide information comes from government-funded geological mapping datasets compiled by GNS Science in recent years. Under contract to Auckland Council, the landslide data were converted into a format suitable for upload to the New Zealand Landslide Database (NZLD) operated by Auckland Council. The project work comprised checking and refinement of a GNS Science archival (unpublished) digital detailed map of landform interpretations (geomorphology) that includes landslide information, extraction of the landslide component of the geomorphological dataset and making it compatible with the NZLD data structure, delivery of a report documenting the landslide dataset and data transfer to Auckland Council and upload to the NZLD.

The GNS Science Pukekohe detailed landslide map dataset is in a geographic information system (GIS) format and is provided as polygons and points. The polygon component shows the extent of each landslide. An accompanying point provides information (attributes) for each of these landslides, including interpreted characteristics of the landslide movement.

The detailed geomorphological map from which the mapped landslide polygons were extracted was compiled in a GIS on-screen by drawing expert interpretations over a high-resolution topographical basemap generated from LiDAR data (airborne laser-scanning of the ground). The mapping has an assigned resolution of 1:10,000-scale. The GNS Science geomorphological map-data structure differs from that of the NZLD. Selected attribute information from the geomorphological dataset was translated into the NZLD format and supplemented by information specific to the NZLD. The project brief required attributes for six specific information categories (fields), noting that data could be added to other NZLD fields where information was readily available and easily incorporated. As a result, most of the landslide features have attributes in up to 20 fields.

The Pukekohe detailed landslide map dataset is an inventory of landslides identified from evidence of land surface form (geomorphology). A total of 921 landslides have been mapped, most of which are in rugged hill country in the east of the map area. Individual landslides range in size from as little as ~200 m^2 to as much as ~500,000 m^2.

Interactive discussions between GNS Science, Auckland Council and Beca (NZLD facilitators) identified some refinements for the NZLD to improve its utility for documenting prehistoric landslide features and to supplement its existing utility for accommodating information on more recent landslides, for example, where movement was observed or can be readily identified from damage characteristics. Particularly useful is the addition of an information category that indicates the level of confidence that a landform feature is of landslide origin, rather than relating to some other landscape-modifying process (e.g. other types of erosion).

1.0 INTRODUCTION

1.1 Overview

The Institute of Geological and Nuclear Sciences Limited (GNS Science) has a government-funded project (part of the Nationally Significant Databases and Collections Programme) that is compiling new geological maps and geological data products for selected urban or urban-fringe areas of New Zealand (Urban Geological Mapping project). One of the targets for urban geological mapping in proximity to Auckland is the wider Pukekohe area of southern Auckland, within a specified rectangular map footprint (Figure 1.1).

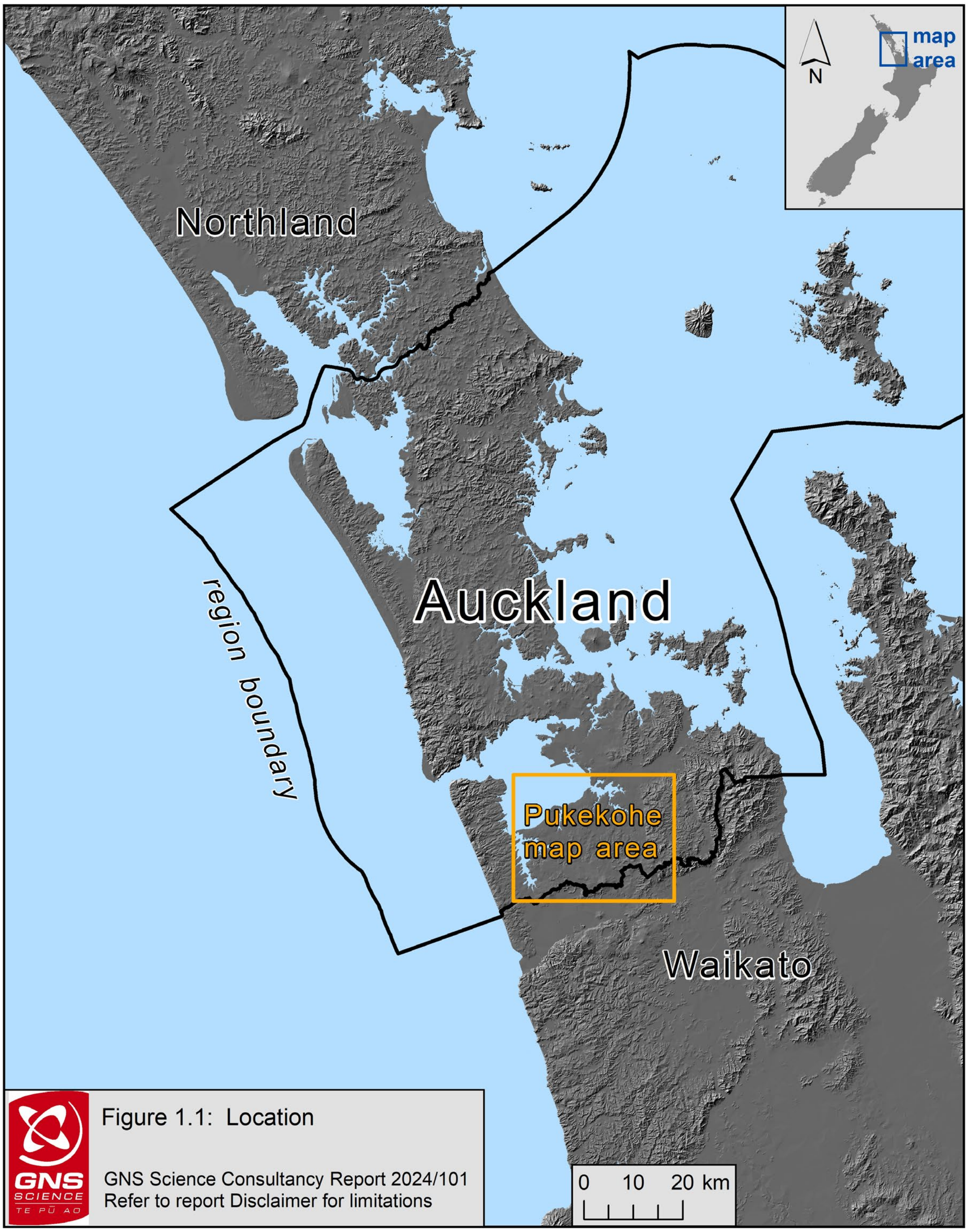

Figure 1.1 Location of the Pukekohe map area. The southern part of the map extends into the Waikato region.

The geological data products published for the Pukekohe map area as part of the GNS Science project, with some financial support from Auckland Council, include a borehole database (Hill 2019), a digital 3D geological model (Jones et al. 2022), a geological map and accompanying text (Bland et al. 2023a, 2023b) and a geomorphological map and text (Townsend et al., in prep.). Two companion publications provide a stratigraphic framework for the naming of the geological units (Bland et al. 2020; Barrell et al. 2021).

A key component of the methodology of compiling the geological and geomorphological maps was to first make a detailed interpretative map of geomorphological features, based on high-resolution topographic information from LiDAR data, which exists for the entire Pukekohe map area. This detailed geomorphological map, prepared at ~1:10,000-scale and including delineation of the extents of landslide features, is referred to in this report as a ‘record map’. The information from the record map was used as the basis for drawing two considerably simplified (‘generalised’) maps, one emphasising the geology (Bland et al. 2023a) and the other highlighting the geomorphology (Townsend et al., in prep.). The generalised landslide information forms part of the digital data for each of those map publications, but the detailed record map is stored by GNS Science as a digital archive and not published.

In discussion with Auckland Council, a project was developed to extract the landslide feature information (mapped as areas – ‘polygons’) from the record map dataset, to structure the polygon and descriptive information (‘attributes’) dataset to be compatible with the New Zealand Landslide Database (NZLD), operated by Auckland Council, and to get this uploaded to the NZLD. This report describes the work that was done and documents the information within the GNS Science Pukekohe detailed landslide map dataset (henceforth, ‘Pukekohe detailed landslide map’).

1.2 Work Programme and Deliverables

The following work components are set out in the project brief:

- Checking and, as needed, refining the detailed record map geomorphological polygons of the Pukekohe map area, including data attribution, peer review and quality assurance.
- Extraction of the landslide component of the geomorphological dataset and making it compatible with the NZLD data structure.
- Delivery of a report on the landslides (presented here), including documentation of the Pukekohe detailed landslide map digital data, data transfer to Auckland Council and upload to the NZLD.

1.3 Mapping Method

The detailed geomorphological record map was compiled using the ArcGIS geographic information system (GIS) by mapping on-screen over topographical basemaps by expert interpretation of landforms. The main resource of topographical information was high-resolution LiDAR datasets generated from airborne laser-scanning of the ground. The datasets that were used were issued in 2016 (Auckland) and 2010 (Waikato) and made available on a Creative Commons basis by Toitū te Whenua Land Information New Zealand (LINZ).

Further information on the geomorphological mapping method for the Pukekohe map area will be documented in Townsend et al. (in prep.).

2.0 DATASETS AND CHARACTERISTICS

The GNS Science geomorphological map-data structure uses an ArcGIS platform and attaches all of the landslide descriptive information as attributes to each polygon. The NZLD takes a slightly different approach, whereby each landslide is primarily represented by a data point at about the source area of each landslide. The data point contains the attribute information for the landslide and is linked to other geographic features, such as landslide polygons, by a Globally Unique Identifier (GUID) value.

The Pukekohe detailed landslide map was made compatible with the NZLD by supplementing polygons from the source dataset with point data (Table 2.1). The point dataset provides each landslide with attribute information on interpreted characteristics of the landslide movement. Points for each landslide are placed at approximately the centroid of the associated vacated source or landslide area polygon (see Section 2.2). The accompanying polygon dataset shows the extent of each area interpreted to have been involved in landslide movement.

Table 2.1 Key components of the Pukekohe detailed landslide map dataset. The third column indicates the link to the geomorphologic feature type in the archival GNS Science geomorphological record map dataset. Italicised text indicates the attribute fields within the two datasets, and terms in inverted commas denote the equivalent attributes.

Data Geometry	This Dataset	GNS Science Geomorphological Map Dataset
Point	Centroid of ‘Source area’ or ‘Landslide area’ polygon	Not part of the GNS Science geomorphological map dataset structure
Polygon	*Landslide_polygon_type* • 'Source area' • ‘Debris area’ • ‘Landslide area’	*GeomorphologicFeatureType* • 'landslide vacated' • ‘landslide terrain’ • ‘landslide terrain inferred’ or ‘landslide terrain’ (without differentiated source and debris areas) or ‘landslide terrain’ (identified as debris only)

2.1 Landslide Polygon Dataset

The locations of landslides in the Pukekohe detailed landslide map are shown in the context of the Pukekohe map area at 1:125,000-scale in Figure 2.1, while Figure 2.2 gives a representative close-up illustration of the mapped landslides in the area southeast of Bombay at 1:10,000-scale.

The geomorphological record map from which the detailed landslide map was extracted has a data structure developed by GNS Science for its Urban Geological Mapping project. For the Pukekohe area, the data structure will be outlined by Townsend et al. (in prep.). For most of the landslides, the record map and derivative detailed landslide map differentiate the vacated part of the source area (from which some, or all, of the displaced material was removed during landslide movement) and the debris area (where the displaced material resides and/or has accumulated).[1] Together, these components represent an area affected by landslide movement. Where differentiation has not been made, a single polygon called ‘landslide area’ has been mapped. ‘Landslide area’ polygons are of two types, identified in the *landslide_polygon_description* field of the polygon dataset. One type comprises polygons

1 The term ‘debris’ is used here generically to refer to material that has been displaced by landslide movement; it encompasses material that has been translated largely intact through to material that has been highly disrupted and fragmented during movement.

that encompass both source and debris areas. Reasons for non-differentiation include displacement not having been sufficient to delineate an exposed source area at the 1:10,000-scale of mapping, or where satisfactory interpretation could not be made of the relative extents of the source and debris area. The other type is where a source area could not be satisfactorily identified and the polygon encompasses only a debris area characterised by hummocky ground. It thus denotes a minimum extent of that landslide.

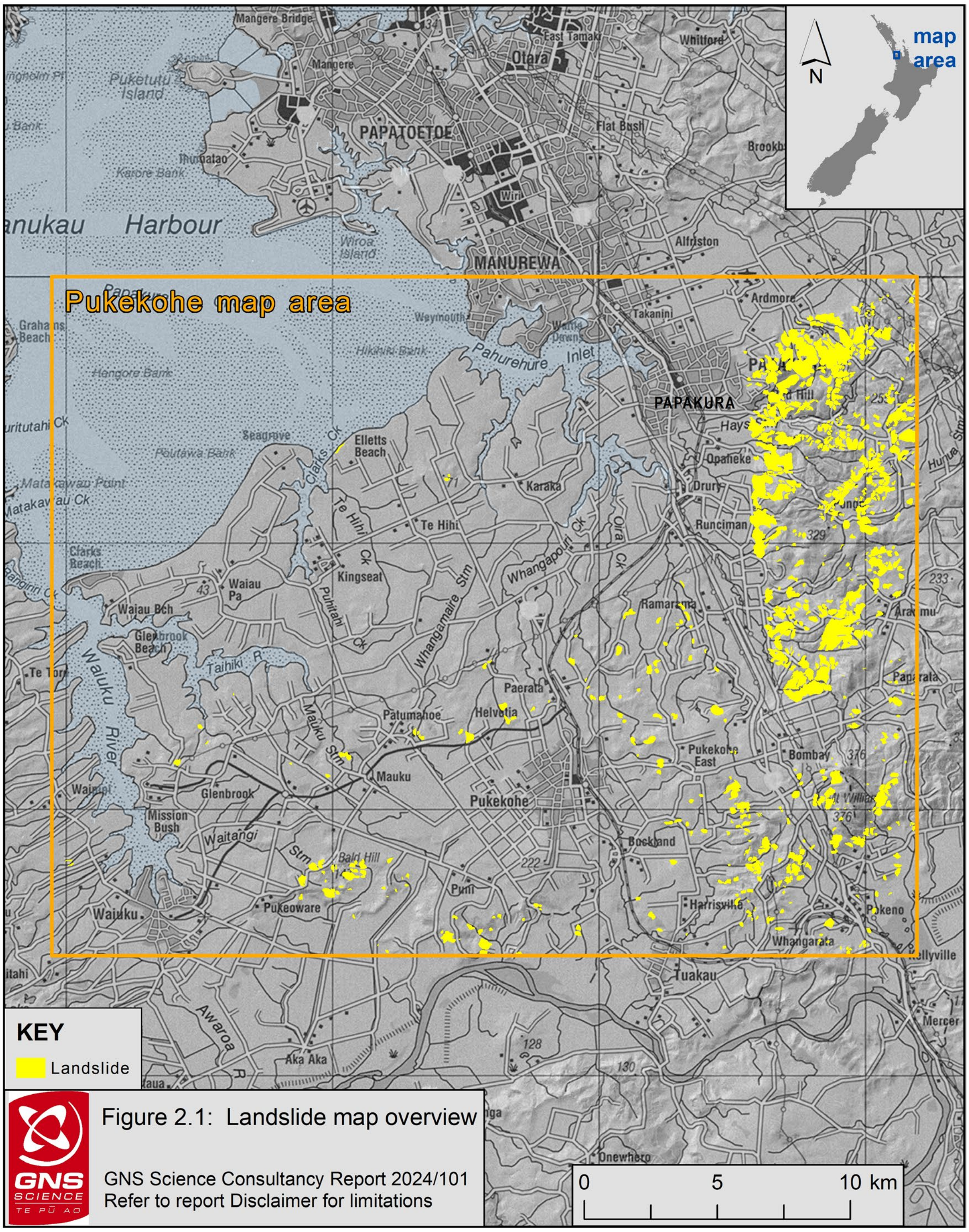

Figure 2.1 Landslide map overview. This shows just the landslide polygon dataset. Most of mapped landslides are in the generally rugged hill country that lies east and southeast of Papakura, with lesser concentrations of landslides in areas of more subdued hill terrain around Pukekohe, mainly at the fringes of an elevated volcanic plateau.

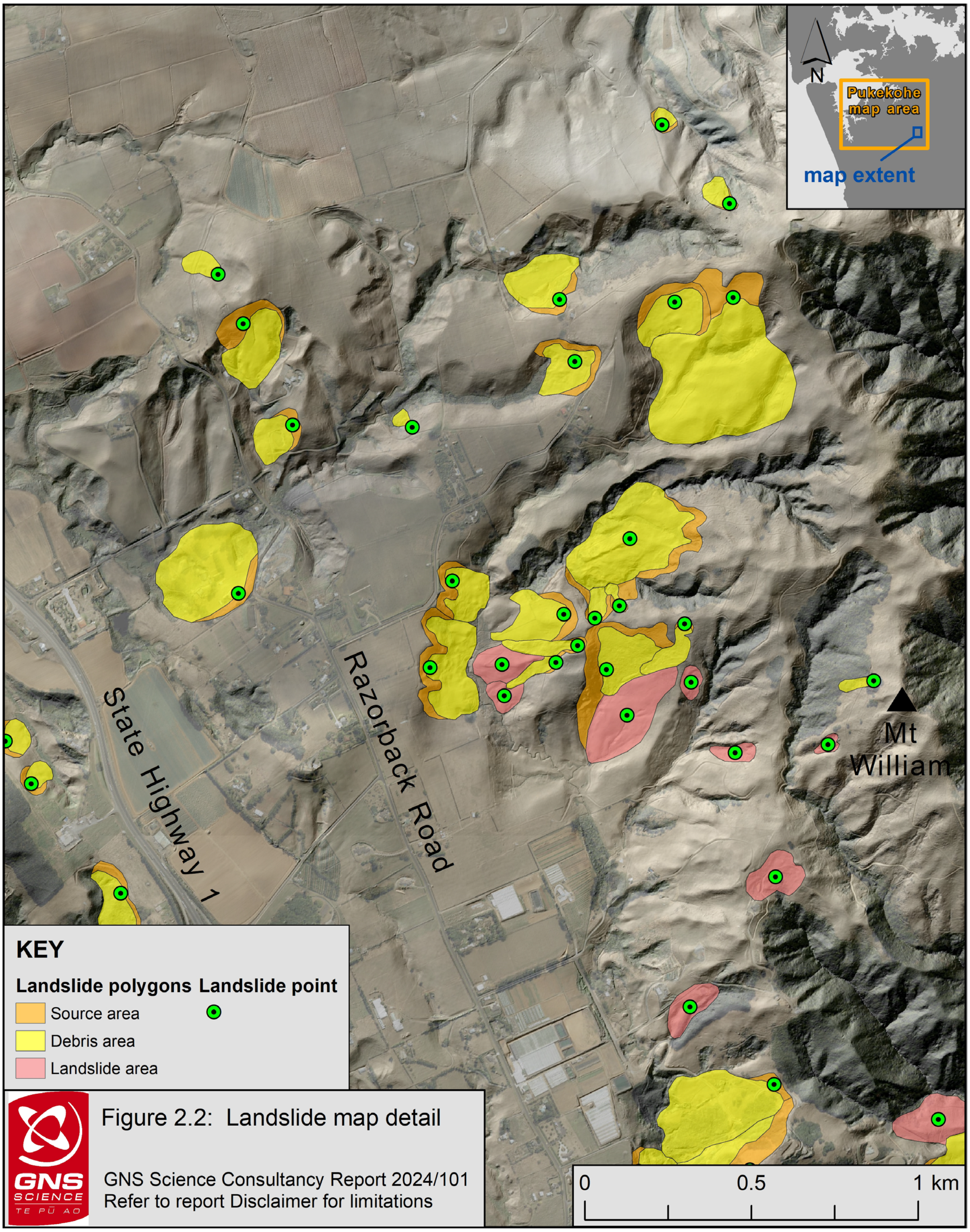

Figure 2.2 Landslide map detail. A sample illustration of the Pukekohe detailed landslide map (points and polygons) southeast of the Bombay area (see Figure 2.1). For most landslides, the polygons distinguish the source (vacated) area from the debris area. The remainder are represented by a single landslide area polygon (see text). The background comprises a LiDAR digital elevation model draped transparently over vertical imagery from the ArcGIS basemap service.

2.2 Landslide Point Dataset

A point dataset was produced for this project to match the NZLD approach. The NZLD specifies that the point representing each landslide be positioned in the centre of the zone of depletion of the landslide. The zone of depletion is where net loss of ground-forming material downslope occurred due to the movement and conceptually is partnered by a zone of accumulation where there was net gain in ground-forming material. Determining the centroid of the depleted zone would necessitate topographic-geometric profiling of each landslide. This is difficult to use for prehistoric landslides, which comprise most of the landslide features in this dataset, due to a lack of direct information on the configuration of the slope prior to movement. In contrast, for historically observed landslides, there may be topographical information pre-dating a slope movement. For simplicity and consistency in the dataset described here, a point was generated at the geometric centre (centroid) of each source area polygon or, for undifferentiated landslide areas, the centroid of each landslide area polygon. Pending the upload of the Pukekohe detailed landslide map dataset to the NZLD, a provisional GUID (‘gns_GUID’) has been created to link each associated entity of the polygon and point components of the dataset.

Due to the pre-established rectangular shape of the Pukekohe map area, some landslides straddle the map area boundary. It was agreed in discussion with Auckland Council not to include truncated polygons in the detailed landslide map dataset, as that would create an incomplete depiction of the full extent of each landslide. Instead, a point was generated for the centroid of each landslide’s truncated source area, or landslide area where undifferentiated, to indicate the presence of a landslide, whose full extent would need independent evaluation should more information be sought.

2.3 Landslide Characteristics

The NZLD has many attribute fields, as set out in its operational manual.[2] A subset of these fields, suitable for use in desktop geomorphological mapping work, has been used in the Pukekohe detailed landslide map point dataset and populated with attributes as per the manual (Table 2.2).

The field attributes assigned in this dataset were either adapted from the geomorphological record map dataset or generated for the Pukekohe detailed landslide map dataset via expert interpretation, or other information, as noted in the digital dataset. An *Aspect* attribute was generated for each landslide point location from a digital slope map by calculating the azimuthal direction towards which the slope faces (‘aspect’). The project brief only required the populating of six specific fields with attributes but acknowledged that entries may be made in any other NZLD fields where suitable information was readily available (Table 2.2). As a result, for most landslides documented in this dataset, attributes were entered in 21 fields.

2 https://landslides.nz/nz-landslides-database-manual/; accessed 2024 Oct.

Table 2.2 Data fields and attributes compatible with the New Zealand Landslide Database for the Pukekohe detailed landslide map point dataset. Where a field has a restricted list of attributes, we include the list as specified at the time of report preparation. The six fields required to be populated with attributes are asterisked.

Field Name (Field Identifier Code)	**Attribute Type**	**Comment**
Identifier (gns_GUID)	GUID	Provisional identifier (gns_GUID) links the data point and associated polygons for each landslide.
Landslide name (crf02_landslide_name)	Text	A common identifying attribute used for every data point 'GNS Pukekohe 2024'
Has the landslide been active in the last 1000 years? ('crf02_activityrecent')	Text-restricted list (five options: Certainly, No, Probably, Probably Not, Unknown)	'Unknown' is used most commonly in this dataset. This acknowledges that LiDAR-based mapping rarely provides information on whether there has been recent activity. 'Probably not' is used where ground-surface form suggests displacement is relatively old.
Landslide activity ('crf02_activitytype')	Text-restricted list (five options: Active, Inactive, Reactivated, Suspended, Unknown)	'Unknown' is used in all cases because assessment of landslide activity is not possible with the desktop methods used in this project.
Aspect (crf02_aspect)	Text-restricted list (representative octants: North, North-East, East, South-East, South, South-West, West, North-West, Unknown)	Value generated from digital slope map. 'Unknown' is not used in this dataset.
Source of landslide information (description) (crf02_landslidesourcetype)	Text-restricted list (three options: Desktop, Detailed, Intermediate)	'Desktop' used for every point in this dataset.
Estimated error in location recording method (crf02_locationaccuracy)	Text-restricted list (eight options: <1m, <10m, <100m, <500m, <1km, <2.5km, <25km, Unknown)	'<10m' used throughout as a representative value, signalling that all of the mapping is based on good quality LiDAR.
Complexity of mass movement (crf02_movementstyle)	Text-restricted list [four options: Multiple Events, Multiple Styles (Composite); Multiple Events, One Style (Multiple/Successive); One Event, Multiple Styles (Complex); One Event, One Style (Single)]	Representative value assigned based on expert interpretation of LiDAR information.
Primary movement type (crf02_primarymovement)	Text-restricted list (11 options: Erosion, Fall, Flow, Not collected, Other, Retaining Wall Feature, Slide, Slope Deformation, Spread, Topple, Unknown)	Representative value assigned based on expert interpretation of LiDAR information.
Centre of source (crf02_XCoordinate, crf02_YCoordinate)	Two integers: NZTM easting and northing.	Centroid of each source-area or landslide-area polygon for undifferentiated landslide features.

Field Name (Field Identifier Code)	Attribute Type	Comment
Comments (crf02_comments)	Text	Mostly left blank.
Project name/number (crf02_project_id)	Text	'GNS Consultancy Report 2024/101' used for every data point.
Date of first movement (crf02_dateoccurrence)	Date: dd/mm/yyyy	Landslides interpreted as prehistoric have a default value of 01/01/1000 applied.
Estimated date of most recent movement (crf02_recentdateoccurrence)	Date: dd/mm/yyyy	Landslides interpreted as prehistoric have a default value of 01/01/1000 applied
Geological setting (crf02_geology)	Text	Value taken from GNS Science data field 'geomorphologicRelation', which registers the inferred geological substrate of the source area, e.g. 'Kerikeri Volcanic Group'
Accuracy of dating method (crf02_datingmethodaccuracy)	Text-restricted list (11 options: Second, Minute, Hour, Day, Month, Year, Decade, Century, Millennia or more, Unknown, Not Recorded)	'Millennia or more' applied to almost all landslide features, as these are interpreted as prehistoric.
Is the age of the most recent movement able to be estimated quantitatively? (crf02_recentagequantifiable)	Yes/No	'No' was applied to landslides in this dataset, with a few exceptions.
Is the age of the initial movement able to be estimated quantitatively? (crf02_initialagequantifiable)	Yes/No	'No' was applied to landslides in this dataset, with a few exceptions.
Estimate the most recent movement age using qualitative descriptors (crf02_recentagequalitative)	Text-restricted list (five options: Pre-Holocene, Holocene, Old, Recent, Unknown) (see Appendix 1 for definitions)	A default of 'Unknown' has been adopted for all landslides other than those that were determined quantitatively.
Estimate the initial movement age using qualitative descriptors (crf02_initialagequalitative)	Text-restricted list (five options: Pre-Holocene, Holocene, Old, Recent, Unknown)	As above, defaults of 'Unknown' have been applied.
How confident are you that the mapped feature is a landslide? (crf02_landslideconfidence)	Text-restricted list (four options; 4 – Very high, 3 – High, 2 – Moderate, 1 – Low) (see Appendix 1 for definitions)	'3 – High' applied to all features where source and debris areas are differentiated; '2 – Moderate' applied to undifferentiated landslide area polygons (see Table 2.1 and text).

3.0 DISCUSSION

The Pukekohe detailed landslide map dataset is an inventory of landslides identified from desktop evidence of land-surface form (geomorphology). There are 921 data points representing the mapped landslides. Most lie in the relatively high and rugged topography in the east of the map area. There is also a cluster in the hill country just north of Taukau. A few others occur around the fringes of the volcanic plateau approximately centred on Pukekohe, where there are also a few small collapses of tuff ring crater walls (see Bland et al. [2023] and Townsend et al. [in prep.] for further information).

Mapped types of landslides comprise: 'Erosion' (1), 'Other' (1), 'Unknown' (3), 'Flow' (33) and 'Slide' (871). Their aspects are distributed around all direction octants but with slightly fewer facing towards the east (N = 141, NE = 113, E = 87, SE = 117, S = 125, SW = 100, W = 115, NW = 123).

Quantifying the range of extents of individual landslides is not a simple calculation because most landslides are divided into source-area and debris-area couplets, which would need amalgamating to obtain an overall extent. However, debris-area polygons are typically the considerably larger component of each couplet, so each approximates a minimum extent for each landslide. Data derived from the GIS show that 'Debris area' polygons range from 185 m^2 to 409,784 m^2, 'Landslide area' polygons range from 1823 m^2 to 176,233 m^2 and 'Source area' polygons from 170 m^2 to 51,120 m^2.

It is difficult, based on desktop evidence alone, to make robust interpretations of when a landslide was initiated, whether it involved single or multiple movement events and how recently it last moved. The approach taken with the Pukekohe detailed landslide map is that, unless there is information to support a specific age classification, each landslide's age of initial movement and age of the most recent movement are assigned as 'Unknown'. This signals that virtually all of the landslides represented in this dataset have very little known about them, apart from LiDAR-based interpretation of their extent and surface form.

Despite extensive use of the default attribute 'Unknown' for landslide age in this dataset, the topographic settings and surface form of most of the mapped landslides suggest that their initiation was likely at least several hundred years ago (i.e. 'Holocene' or 'Pre-Holocene' by the definitions in Appendix 1). As their initiation likely preceded human settlement of New Zealand, we use the informal term 'prehistoric' as collective shorthand for discussing landslides with assigned qualitative ages of 'Unknown'. Their formation likely relates to natural evolution of the landscape, linked to the underlying geological substrate and erosive processes operating within valleys or gullies that have increased slope angles and encouraged slope instability.

During this project, discussions between GNS Science, Auckland Council and Beca (operators of the NZLD) resulted in proposed refinements to some aspects of the database. The main purpose of the refinements is to improve the utility of the database for accommodating prehistoric landslide features. A landslide mapper has a limited basis for reliably estimating details of movement characteristics for prehistoric landslides, in contrast to landslides that have occurred recently, for example, where the movement was observed or where details can be ascertained from damage to built features. In the existing NZLD fields for initial movement and most recent movement, apart from the few landslides that can be identified from aerial imagery, etc., as having occurred historically, the same date (01/01/1000) is applied in both existing fields.

It was proposed in the GNS Science / Auckland Council / Beca discussions that five new fields be added to the NZLD to allow improved characterisation of landslides. The dataset described in this report has been structured accordingly in anticipation of the implementation of these changes to database structure. The proposed new fields (see Table 2.2) include:

- Is the age of the most recent movement able to be estimated quantitatively? (Yes/No)
- Is the age of the initial movement able to be estimated quantitatively? (Yes/No)
- Estimate the most recent movement age using qualitative descriptors. (Restricted list)
- Estimate the initial movement age using qualitative descriptors. (Restricted list)
- How confident are you that the mapped feature is a landslide? (Restricted list)

The restricted lists and definitions are provided in Appendix 1.

The first four of the new fields are conditional fields that are used if another field is filled in a particular way. For example, if the 'Is the age of the most recent movement able to be estimated quantitatively?' field has an attribute of 'Yes', then a date value will be entered into the 'Estimated date of most recent movement' field. There are only four landslides in the Pukekohe detailed landslide map dataset for which a date has been estimated. In all cases, the date is bracketed by dates of aerial imagery, with an earlier image where the landslide is absent and a later image where it is present. The assigned date value is midway between the image dates, and the value in the 'Accuracy of dating method' field indicates the range. Qualitative age descriptors are used where quantitative values cannot be applied (see Appendix 1). For this dataset, default values of 'Ancient' were applied to landslides where source and debris areas are differentiated, and 'Pre-Holocene' was used for undifferentiated landslide area polygons. 'Prehistoric' in this report encompasses both the 'Ancient' and 'Pre-Holocene' categories.

The fifth new field (landslide confidence) is a useful addition for inventory mapping of pre-historic landslides because it allows a mapper to assign a level of confidence that a feature was formed by slope movement (Appendix 1). Landslide confidence has been assigned default values in the dataset based on landslide type criteria from the geomorphological record map. Each 'Landslide area' polygon for which there is no corresponding mapped 'Source area' polygon (96/921) has been assigned a value of '2 – Moderate'. All other landslides (825/921) have been assigned a confidence value of '3 – High'.

When the project was set up, it was anticipated that any LiDAR-delineated landslides in the Pukekohe detailed landslide map dataset that were already represented in the NZLD would be linked via a common unique identifier (GUID) value. However, comparative inspection of the data, in consultation with Auckland Council, revealed that the newly mapped landslides are relatively large landscape features, whereas the existing NZLD entries are generally small historic failures that are different occurrences to the newly mapped, mainly prehistoric, landslides. Even where an existing landslide (point or polygon) in the NZLD coincides with the location of a newly mapped landslide polygon, it is likely that the two records represent different landslides. For this reason, a new identifier (gns_GUID) was created for every landslide in the Pukekohe dataset.

The mapping methodology identifies the areas where landslide movement is recognisable in the landscape but does not provide any information on the current stability of those landslides. It is expected that the landslide map datasets may have utility in future work using new techniques such as InSAR ground deformation surveying, which may be able to determine whether any detectable landslide movement is occurring.

4.0 ACKNOWLEDGEMENTS

We are grateful to staff from Auckland Council and the Beca Auckland office for discussions in developing the project brief, provision of information on the New Zealand Landslide Database and in refining some aspects of the database. Internal reviews by Sam McColl and Julie Lee of GNS Science provided useful feedback.

The geomorphological dataset from which the Pukekohe detailed landslide map was derived was compiled as part of the GNS Science Urban Geological Mapping Project, supported by the New Zealand Government though public research funding (Strategic Science Investment Fund) from the Nationally Significant Databases and Collections Programme.

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APPENDICES

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APPENDIX 1 DEFINITIONS FOR NEWLY DEFINED FIELDS

A1.1 Landslide Qualitative Age Descriptors

These definitions were refined in discussion with Auckland Council to provide improved relative age estimation for the proposed new fields of ‘Estimate the most recent movement age using qualitative descriptors’ (field identifier code: crf02_recentagequalitative) and ‘Estimate the initial movement age using qualitative descriptors’ (field identifier code: crf02_ initialagequalitative) (see Table 2.2). Restricted list values (in **bold**) and definitions are:

- **Pre-Holocene:** Geomorphology suggests movement pre-Holocene.
- **Holocene:** Geomorphology suggests Holocene movement but no significant movement within a few hundred years.
- **Old:** Geomorphology suggests movement within a few hundred years but not within the last few decades.
- **Recent:** Geomorphology suggests movement within last few decades.
- **Unknown:** Not known or specified.

A1.2 Landslide Confidence

The Qualitative Landslide Confidence field – ‘How confident are you that the mapped feature is a landslide?’ (crf02_landslideconfidence) – was developed in discussion with Auckland Council to provide a parameter expressing the degree of confidence that the mapped feature was formed by landslide processes. It applies only to the identification of the landslide and not to other characteristics such as type of movement, whether multiple or single, etc. Restricted list values (in **bold**) and definitions are:

- **4 – Very high:** There is no doubt that the feature was formed by landslide movement. This typically applies where landslide identification and extent mapping are based on detailed field observations and/or expert analysis of high-resolution topographic data or aerial imagery, or where a landslide was observed to have occurred (first-hand or in time sequences of imagery).
- **3 – High:** High confidence is applied where there is a small possibility that the feature may have at least in part been formed by processes other than landsliding (e.g. other types of erosion or human ground modification). This typically applies to mapping using detailed field observations and/or expert analysis of high-resolution topographic data or aerial imagery where the original ground surface is obscured to some extent by vegetation cover or has been affected by human ground modification. This level of confidence may also be applied when the evidence is from good-quality maintenance records or newspaper reports, which sometimes mis-identify other similar hazards as landslides.
- **2 – Moderate:** Moderate confidence is applied where it is reasonably possible that the feature was formed by processes other than landsliding (e.g. other types of erosion or human ground modification). A landslide origin is equally or more likely than not. Typically applied where diagnostic landslide landform characteristics are ambiguous (e.g. subtle or discontinuous) because the ground is largely obscured by tall vegetation; extensively modified by human activity, including intensive urbanisation; or the landslide is very old. It may also apply where mapping is based on limited information, such as distant or reconnaissance field inspection, lower-resolution imagery or topographic maps.

- **1 – Low:** Low confidence indicates that the feature was possibly formed by landslide movement but is more likely to have formed by processes other than landsliding (e.g. other types of erosion or human ground modification). Typically applied where few diagnostic landslide landform characteristics are present or are very subtle in their expression.

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