Landform mapping of Waikereru Ecosanctuary

Authors: Mike Marden & Anne Seymour 2022

Goal: Produce a GIS-based map of landform units present at Waikereru Ecosanctuary.

Method: Landform units were identified on aerial photography flown in 1953 (SN 818, Run 2161, prints 16 & 17). Using a mirror stereoscope and a mapping pen, each unit was delineated onto the photographic prints as a 'closed' polygon. Each polygon was then digitized from registered images of the photographs to provide a GIS-based data set for use in MAPINFO (Map 1). In total, 115 polygons were mapped, and each was assigned a discreet number. An accompanying spreadsheet lists each polygon for which a measured area (ha) and Land Use Capability (LUC) class is provided. The LUC units together with contours and parcel boundaries are shown on Map 2 which is an aerial view of the ecosanctuary flown in 2017. Both maps are at a scale of 1:5000. Descriptors for the LUC units are provided in Table 1.

Landform units:

Three of five landform units were mapped across moderately steeply dissected hill country comprising undifferentiated, fossiliferous mudstone and tuffaceous sandstone of Pliocene age (Mazengarb & Speden, 2000). The remaining two landform units include Quaternary-aged fan gravels and Holocene-aged alluvial terraces the youngest of which have been inundated by flood deposits since European settlement times.

ST- Stable ridgelines and slopes with little sign of slope instability. Coverbed materials including forest topsoil overlying layered tephra (volcanic ash) are likely to be quite thick and relatively in-tact (i.e., undisturbed). Classed as Typic Orthic Allophanic Soils (Hewitt 2010) they comprise a silt loam (~20 cm thick) below which there will be multiple tephra-fall beds erupted from the Okataina and Taupo volcanic centres located within the Taupo Volcanic Zone (TVZ). Tephra potentially present at these sites include the: Taupo 1718 ± 10, Waimihia 3382 ± 50, Whakatane 5542 ± 48, Mamaku 7992 ± 58, Rotoma 9472 ± 40, Opepe 10,004 ± 122, Karapiti 11,501 ± 104, Waiohau 14,018 ± 91, Rerewhakaaitu 17,209 ± 249, Okareka 23,545, Kawakawa 25,358 ± 162. (Ages are based on Hopkins et al. (2021). Okareka Tephra age based on Peti et al. (2021)).

Tephra thickness and their grain size characteristics have a significant influence on drainage. While the coarser-grained and friable Waimihia Tephra is well-drained, many of the older mid-Holocene aged tephra are fine-grained and compact (e.g., Whakatane, Mamaku and Rotoma Tephra) and thus impede drainage. Signs of poor drainage, and possible periods of prolonged saturation, include mottling (i.e., rusty colouration) and the presence of black manganese nodules at shallow depths ~0.5-1.0m.

SL-Shallow landslide scars. Predominantly located on steeper valley slopes between 21-35°, landsliding generally results in the stripping of all the **original coverbed** materials to expose the underlying bedrock lithologies. **Present-day coverbed** materials are therefore likely to be thin and skeletal (i.e., a high percentage of angular clasts of sandstone and siltstone mixed with minor finer-grained sediment dislodged from the slopes above the original landslide scar). Vestiges of preserved volcanic tephra are possible but will be thin and of limited aerial extent. Though porous, the Typic Orthic Recent Soils typically associated with land that has been eroded or has received sediment as a result of slope processes (Hewitt 2010) are well drained but dry out quickly and are low in fertility.

SLU-Rotational slump. Deeper-seated failures where the displaced material has slumped *en-masse* while remaining largely in-tact. Some of the slumps likely occurred before European settlement, while others have failed in more recent times. The surface of slumped blocks, though inclined, is considerably less steep than the surrounding hill slopes. Upon the body of the slumped mass, the same volcanic ash and pumice beds as listed above are likely present, though they have possibly been buried by the accumulation of debris generated during more recent storm-initiated shallow landslide failures triggered on the slopes above and surrounding the original slump. Drainage characteristics will vary considerably between different slump blocks, across individual slump bodies, and will reflect the thickness and mix of tephra present.

F-Alluvial fan. Sloping landscape units located at the base of steep slopes and representing zones of accumulation of material displaced by slumping and shallow landslides from steeper slopes above. Fan material consists of thoroughly mixed forest soil, tephra, but predominantly comprise angular clasts of bedrock. Fans often display stratification that represents multiple episodes of landsliding and deposition of coarse-grained material at times of heavy rainfall during past storm events, separated by intervals of soil formation and accumulation of airfall tephra. With the retention of soil moisture for longer periods after rainfall, alluvial fans tend to more fertile than the landslide-scarred slopes from which the fan material originated. Most of the better-preserved alluvial fans have accumulated on alluvial terraces at the base of slopes flanking the true right bank of the Waimata River. Over time, the toe slopes of several of the older fans (i.e., those closest to the base of the hillside), and of younger alluvial fans emanating from the side tributaries draining the ecosanctuary, have been truncated as the Waimata River incised in response to tectonic uplift.

T-Alluvial terrace. These are best preserved along the true right bank of the Waimata River. Terrace coverbed material comprises a basal layer of gravel topped with layers of fine-grained alluvial sand, silt, clay, and reworked tephra deposited during successive floods. While the lowest and youngest of two flights of alluvial terrace remains vulnerable to flooding, the highest terrace may not have been inundated for some considerable period. If a layer of tephric airfall is present, its identification would establish when this terrace was last flooded. At the confluence of side streams with the Waimata River, gravel-sized material (e.g., clasts of silt and sandstone bedrock), excavated and transported from older alluvial fan deposits present within these side streams, will likely be more prevalent.

Table 1: Descriptors for Land Use Capability Units present at Waikereru Ecosanctuary.

Unit	Area (Ha)	Description	Slope (degrees)	Rock type	Soil type	Erosion potential	Other limitations
3W3	11.98	Narrow alluvial terraces and fans	0-8	Recent alluvium	Recent alluvial soils-silt loams.	Bank erosion	Occasional flooding

6e10	11.52	Moderately steep hill country	21-35	sandstone	Yellow brown earth	Slight to moderate shallow landslides	Low fertility
7e4	133.07	Moderately steep to steep hill country	21-35	Mudstone/argillite	Yellow brown earth	Moderate to very severe gully, slight to severe flow and moderate shallow landslides	Medium natural fertility

Of the 5 landform units mapped across an area of 156.48 ha, shallow landslides initiated during multiple storm events since European occupation have impacted 54% (85.04 ha) of the steepest slopes while stable ridges and old rotational slumps little affected by more recent failures comprise 22% (34.45 ha). Rotational slumps displaying more recent signs of slope instability comprise 6% (9.8 ha) while alluvial fans make up 11% (16.58 ha) and alluvial fans 7% (10.61 ha) of the ecosanctuary area.

By LUC class, the most extensive of the hill slope classes is 7e4 covering 85% of the ecosanctuary area (133.07 ha), 6e10 makes up 7% (11.52 ha) & 3W3 comprising alluvial terraces and fans make up 8% (11.98 ha).

General observations

Most of the larger and likely older of the slope failures in the form of rotational slumps, together with the more recently failed shallow landslides, occur on north-facing slopes. Although not all slope failures are the result of intense and/or prolonged rainfall during storm events, their predominance on north-facing slopes is typical for this region and reflects the direction of approach of many of the previous landslide-triggering storms, including Cyclone Bola (Marden et al. 1991, Marden & Rowan 1993). Conversely, although slopes on the sheltered south-facing leeward side of ridges were already heavily vegetated by 1953, it is evident that slope failures were fewer and less extensive than on north-facing slopes. Thus, as the in-situ coverbed materials (i.e., forest soil & tephra) are likely to have been better preserved over extensive areas and as they will be thicker, and therefore less prone to summer drying, these factors likely contributed, at least in-part, to the early establishment of a dense cover of indigenous vegetation on south-facing slopes.

References

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Legend for landscape units-Waimata ecosanctuary

ST- Stable ridgelines and old rotational slumps. Coverbed materials include layered tephra (volcanic and ash) of variable thickness plus forest topsoil. The coverbeds are in places likely to be quite thick and in-tact (i.e., undisturbed).

SL-Shallow landslide scars. Predominantly located on steeper valley slopes. Landsliding generally results in the stripping of all coverbed materials to expose the underlying bedrock lithologies. Present-day coverbed materials are likely to have been dislodged from the slopes above the original landslide scar and hence will be thin and skeletal (i.e., a high percentage of angular clasts of sandstone and siltstone mixed with minor finer-grained sediment). Vestiges of preserved volcanic tephra are possible but will be small in aerial extent.

SLU-Rotational slump. Deeper-seated failures where the displaced material is displaced *en-masse* but has remained largely in-tact. Some of the slumps likely occurred before European settlement, while others have failed in more recent times. The surface of slumped blocks, though inclined, is considerably less steep than the surrounding hill slopes. Upon the body of the slumped mass, volcanic ash and pumice beds are likely present, though possibly buried by debris generated during more recent storm-initiated shallow landslide failures triggered on the slopes above and surrounding the original slump, accumulating on the surface of the original slump block.

F-Alluvial fan. Sloping landscape units located at the base of steep slopes. Fans represent zones of ccumulation of material displaced by slumping and shallow landslides. Coverbed materials consist of thoroughly mixed landslide debris. Angular bedrock clasts predominate, possibly with some evidence of water-sorting during deposition, thus some stratification representing multiple episodes of landsliding and deposition during past storm events may be present. Over time, the drainage channels have incised in response to tectonic uplift, thus the toe slopes of several of the older fans have been truncated, including those fans located at the base of slopes flanking the true right bank of the Waimata River.

T-Alluvial terrace. Best preserved along the true right bank of the Waimata River where in past times this river has truncated alluvial fans emanating from the side tributaries draining the Ecosanctuary. The coverbed material comprises fine-grained alluvial sand, silt and clay deposited during successive floods. In places, particularly at the confluence of the side streams and the Waimata River, coarser-grained material (e.g., silt and sandstone clasts), excavated and transported from existing alluvial fan deposits present within the side streams, will also be present.