IRBA

GEOLOGICAL ENGINEERING CONSULTANTS

Geotechnical engineering aspects of forestry operations, Uawa catchment

DRAFT

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for
Gisborne District Council

Project 1273

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1. Introduction

Ian R Brown Associates Ltd (IRBA) were engaged by Gisborne District Council to provide geotechnical engineering advice to support Council's investigation into possible non-compliance with resource consent conditions and the Resource Management Act (1991) generally in relation to forestry operations in the Uawa catchment near Tolaga Bay.

Intense and prolonged rain fell in the forestry areas during Queens Birthday weekend (2018), with runoff depositing forestry debris into the lower catchment.

On the morning of July 5, 2018, Ian Brown visited the Ernslaw One Ltd forests with Council staff and consultants (Murry Cave, Norm Ngapo, John Holst, Wiki Mooney) and Iain McInnes (Ernslaw).

The same group, but without a forestry representative, visited the PF Olsen forests on the afternoon of July 6. This followed an earlier induction at the company's Gisborne office.

On July 6, Ian Brown, with Norm Ngapo, John Holst and Wiki Mooney, visited the Hikurangi Forest Farms Ltd forests with company representative Todd Buchanan.

The three forests are shown relative to the Uawa catchment on Figure 1 (after Anon 2014),

2. Geological setting

The forests are located in an area of relatively steep topography west of Tolaga Bay (Figure 1).

The geology of the area has been mapped in detail by New Zealand Geological Survey and others. Mazengarb et al. (1991) cover the northern part of the forests (Infomap 260 1:50,000 Sheet Y16), and other unpublished data from that period of mapping is available for Sheet Y17 to the south.

The rocks exposed in the forests are part of the sedimentary Tolaga Group, comprising a sequence of alternating sandstone and mudstone with fine to coarse rhyolitic tuff, limestone lenses, massive sandstone, breccia, breccia-conglomerate and pebbly mudstone, and igneous conglomerate.

3. Geotechnical engineering background

Geotechnical engineering is a well established branch of civil engineering concerned with the behaviour and performance of earth materials. The current Wikipedia definition states:

Geotechnical engineering uses principles of soil mechanics and rock mechanics to investigate subsurface conditions and materials; determine the relevant physical/mechanical and chemical properties of these materials; evaluate stability of natural slopes and man-made soil deposits; assess risks posed by site conditions; design earthworks and structure foundations; and monitor site conditions, earthwork and foundation construction.

Forestry development requires geotechnical engineering input at various stages. At initial planning and planting, unstable natural slopes are able to be identified, and appropriate decisions made to mitigate any affects that long term instability might have on forest operations.

Prior to forest harvest, geotechnical engineering should play an important part in how earthworks are planned, and how earthworks construction is managed and monitored.

The need for geological studies associated with forestry (as a key input for geotechnical engineering) has long been recognised in New Zealand. We are aware of geological mapping carried out by government agencies through the 1970's to assist forward planning for forestry on the East Coast North Island. An example of such work that was subsequently published is a paper by Gage and Black (1979). The N.Z. Geological Survey mapping carried out in the area through the 1970s and 1980s was in response to the need for improved data to inform land use decisions.

We are not aware of the level of geotechnical engineering input that would typically be involved with forestry earthworks on the East Coast North Island. The NZ Forest Owners Association Inc. have published a comprehensive Road Engineering Manual (NZ Forest Owners Association Inc. 2011). The manual also covers earthworks associated with other forestry infrastructure, including landings. The 2011 publication is an update of earlier publications; we have been able to access similar titled publications dating back to 1999.

In the absence of any site specific geotechnical engineering studies for forestry earthworks, the 2011 Road Engineering Manual and its predecessor publications provide a good base line for how earthworks should be designed and construction managed.

4. Observations

During the site visits, we observed a number of issues that were relevant to the brief provided by Gisborne District Council. As the inspections progressed, it became clear that we were observing the same issues at many of the locations visited, and in all three of the forests.

This section of the report provides a summary of our observations, using a few of the sites as examples. It is beyond the scope of this report to provide a complete inventory of all the sites visited in the three forests.

4.1 Natural slope stability

The relatively steep topography in the forested area (need a slope angle map that can be referenced) shows slope angles between xxx degrees and yyy degrees. The steeper slopes where streams are deeply incised, combined with unfavourable geological structure and lithology, are potential locations of deep seated land instability.

We observed a number of landslides with composite failure mechanisms. In general, they have an arcuate head scarp with tension cracks behind the head scarp. The slope displacement appears to be controlled by a low angle surface (possibly bedding) with slide debris covering that surface and forming a low relief basin. These active landslides react to changes in groundwater, and hence pore water pressures in the slope. The construction of earth fills on these landslides has also led to further global slope displacement as shown by recent tension cracks at the surface. (add photographs)

These landslides are not recent features; they have been moving over a long period of time although changes to loading of the slopes due to earthworks, and increased pore water pressures have caused recent displacement. The landslides are able to be mapped; interpretation of vertical aerial photograph stereo pairs is an effective way to do this. However the photographs should have been taken before forestry planting obscured some of the more subtle landslide features.

We observed a number of mid-slope shallow landslides where the residual soil cover had moved down slope. We were told that these are naturally occurring, however we did not observe such landslides in any of the areas still covered with trees. Further work is required to understand the mechanism that caused these landslides. One possibility is that logs and debris left on the slope diverts and concentrates water flowing down the slope during high intensity rainfall. The localised high velocity runoff is able to erode and scour the shallow soils, leading to further concentration of runoff and more localised erosion.

4.2 Fill slope stability

Because of the generally steep topography in the three forests, extensive earthworks are required to form forest roads, and flat sites (landing, skid, platform) for harvesting and processing operations.

We have not sighted any engineering as built drawings or documents showing how fills in the three forests were constructed. We do not know if the foundations for fills were benched and cleared of soft materials before fill was placed. We have not sighted any records of fill placement, or quality assurance documentation regarding key soil parameters (moisture content, *in situ* density, shear strength).

At a number of sites, we could see that the fill at the edge of the site had been end tipped over *in situ* organic material. (add photographs) In some cases organic material had been incorporated into the fill. (add photographs) This is not good practice as the organic material is compressible, and with time will create voids that will weaken the fill and provide pathways for groundwater that could lead to internal erosion.

We visited one site soon after road maintenance had been carried out. The high moisture content soils excavated from the water table had been end dumped across the road. (add photographs) In places this uncompacted fill had failed and created a potential hazard for traffic on the road, as well as contributing to debris in the stream below. (add photographs)

We observed fill slopes supported by untreated timber pole structures. (add photographs) These structures should not be relied on to provide any long term support. They do not appear to have benefitted from appropriate engineering design.

Waste products from harvesting (logs, slash, bark) have been placed on the edge of some fill slopes. (add photographs) Where these slopes have failed and the waste products have been transported down slope, it is not clear whether the failure was due to erosion from surface water concentrated in that area. At the same time, a build up in pore water pressure in the fill together with an increase in loading due to the waste may have caused localised shear failure of the fill.

None of the fills we inspected showed evidence of engineering stabilisation structures as discussed in section 4.11 of the NZ Forest Owners Association Inc Road Engineering Manual.

4.3 Run off control

The lack of adequate control of surface water during high intensity rainfall has led to widespread erosion of earth fills across all three forests.

The water table drains along roads were often blocked with debris. (add photographs) Many culverts were blocked (add photographs) diverting runoff across the fill with subsequent downslope scouring (add photographs).

In some locations we observed culverts exiting directly on to a vulnerable slope without any diffusion of flow to reduce the erosional impact of water discharge. (add photographs)

5. Health and Safety

There are a number of sites that have well defined, and actively displacing tension cracks. These should be clearly marked and designated as areas to avoid approaching with any equipment unless under appropriate supervisory control.

From interpretation of tyre imprints along a road where the water table had recently been cleared, the plant operator was very close to the edge of the fill he was working on. There are two aspects to this – he could easily have driven over the edge, or the fill could have collapsed due to the increased tyre loading. (add photographs) It is recommended that a spotter is available to direct the operator in such cases so that a safe distance is maintained from the edge of steep slopes.

6. Conclusions and recommendations

There appear to have been a number of contributory factors that led to a large amount of forestry debris being transported through the Uawa catchment. Firstly, there was a significant rainfall event on Queens Birthday weekend 2018 that overwhelmed the surface runoff control measures that had been constructed around the areas of earth fill.

As the runoff control measures failed, water was discharged across earth fills causing subsequent erosion. The earth fills were further compromised by increased pore water pressures due to poor drainage leading to localised fill failure. Where forestry debris was located on the edge of fills, that may also have contributed to shear failure of the underlying fill.

At present the earth fills are generally in a vulnerable state. There is much work to do to reinstate, if not redesign, the runoff control measures to protect the fills from future high intensity rainfall.

We do not know if the fills have been built with the benefit of specific geotechnical engineering design, or whether the NZ Forest Owners Association Inc Road Engineering Manual has been followed. We recommend a review of forestry as built records, then select several representative fills for forensic investigation. This would involve test pits, core drilling, and cone penetration testing providing input to stability modelling.

This study would then enable an informed estimate of long term fill stability, and provide a guide to potential improvement of earthworks practice (design and construction).

Further work is required to understand how run off control measures have been designed, and how they might be reconfigured to provide an appropriate level of control during future high intensity rainfall events.

Where earth fills have been constructed across active landslides, further work is required to assess the vulnerability of these fills to ongoing landslide movement.

7. References

Anon (2014) The Uawanui project, building a shared vision for Uawa / Tolaga Bay. Booklet prepared by Allan Wilson Centre, Massey University.

Gage, M., Black, R.D. 1979 Slope-stability and geological investigations at Mangatu State Forest. Technical paper 66 O.D.C 114:116 – 014.1 Wellington. Forest Research Institute, New Zealand Forest Service.

Mazengarb, C., Francis, D.A., Moore, P.R. 1991 Geology of the Tauwhareparae area. Geological map of New Zealand 1:50,000 Sheet Y16 Tauwhareparae. New Zealand Geological Survey division of Department of Scientific and Industrial Research.

NZ Forest Owners Association Inc. 2011 NZ Forest Road Engineering Manual. www.nzfoa.org.nz

8. Applicability

This report has been prepared for the benefit of Gisborne District Council with respect to the brief given to Ian R Brown Associates Ltd. It may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Opinions and recommendations contained in this report have been derived from the information and data gathered during the course of our investigations.

No liability is accepted by Ian R Brown Associates Ltd nor by any Director, or any other servant or agent of the company, in respect of the use of this report (or any information contained therein) by any person for any purpose other than that specified in the brief.

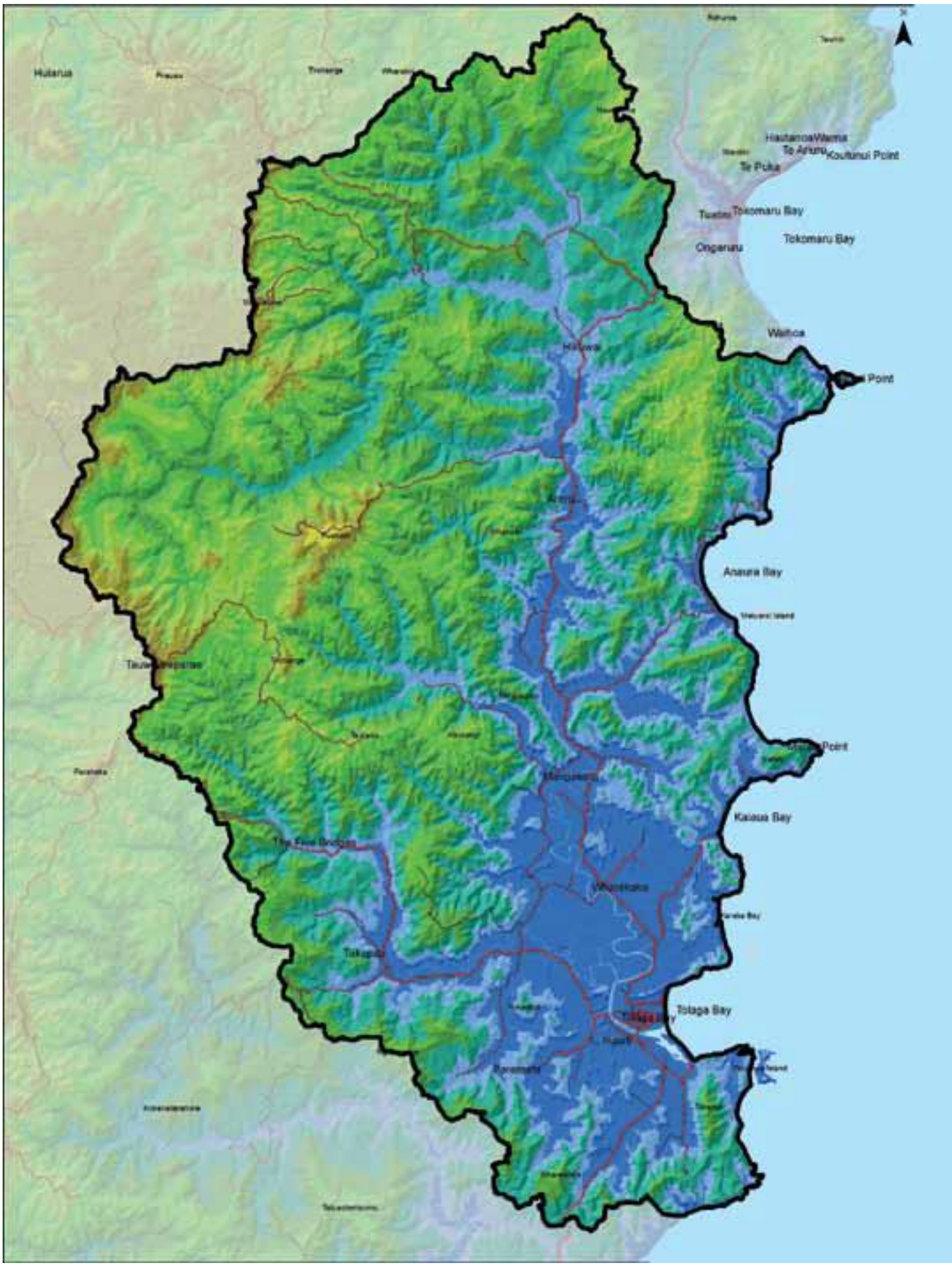

Figure 1   Uawa catchment elevation

Need to add three polygons with outlines of forests visited.

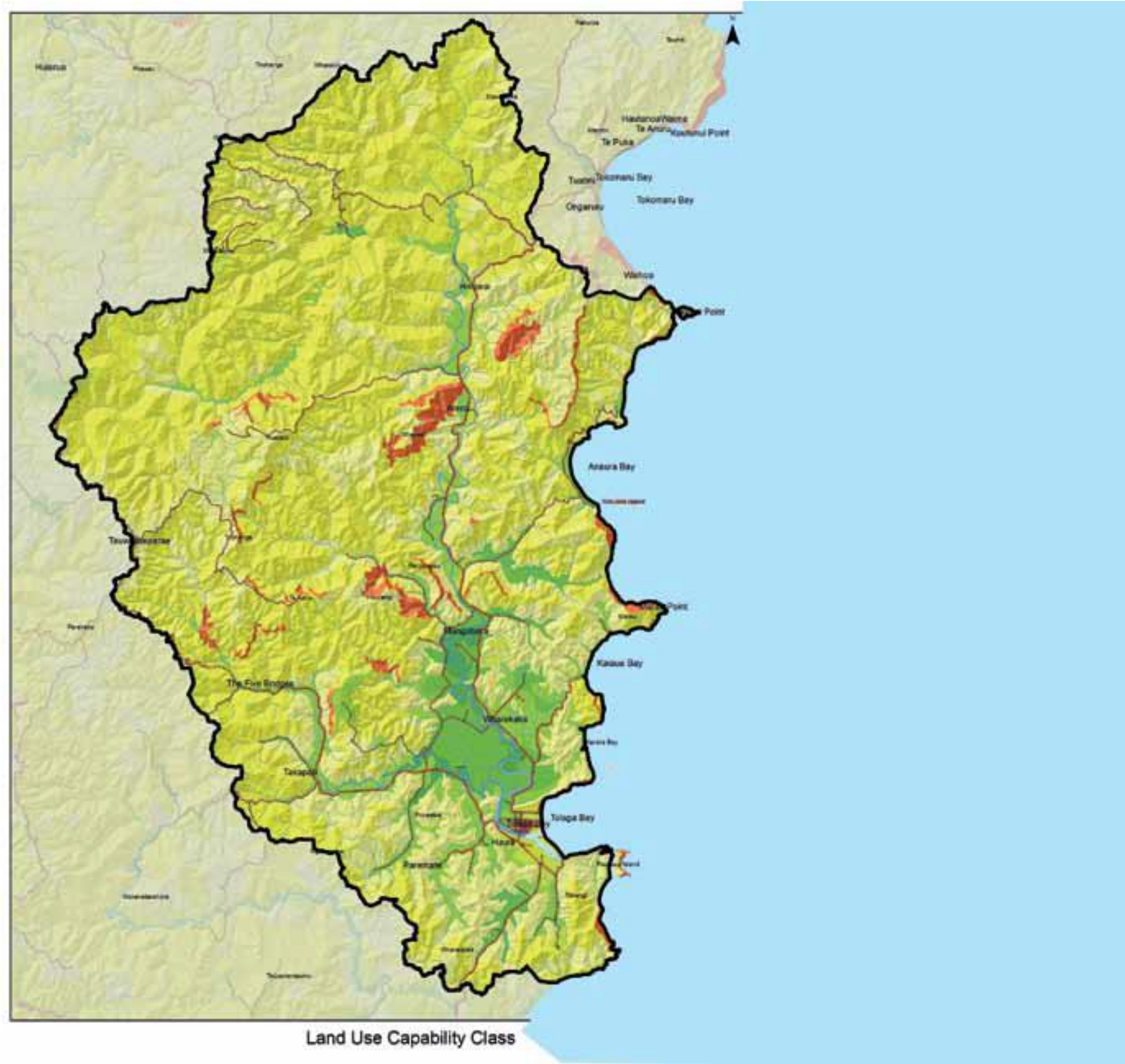

Figure 2 Uawa catchment land use capability class

Orange – Class 7. Land is limited and low producing for pastoral farming, often with major erosion issues. It is best suited to forest cover. The largest portion of the catchment is class 7 land, some 32,000 ha or 57% of the catchment.

Red – Class 8. Land includes cliffs and rocky areas best managed for biodiversity, soil and water protection under conservation management. There are some 1200 ha, or 2% of the catchment, in class 8.

Need to add three polygons with outlines of forests visited.

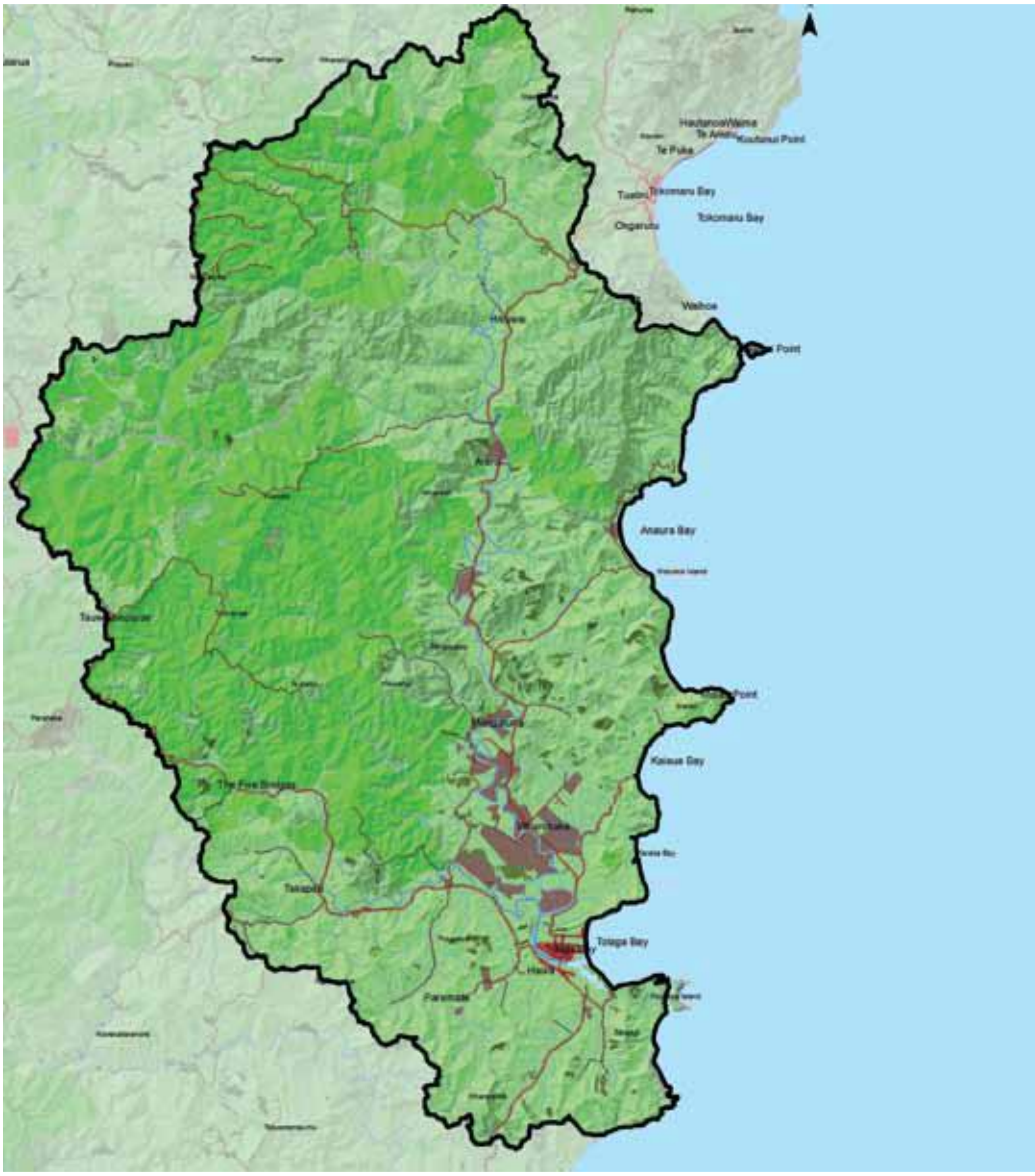

Figure 3 Uawa catchment land cover

Dark green – planted forest and shelterbelts

The land cover shown is from the 2002 land cover database satellite imagery (LCDB2). This shows around 22,400 ha or 40% of the catchment area is planted in exotic forest. The location of forestry land cover appears to be broadly matched to the land use capability class 7 land.

Need to add three polygons with outlines of forests visited.