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TECHNICAL REPORT **0334**

ENGINEERING GEOLOGICAL REPORT ON INVESTIGATIONS NIHOTUPU AND HUIA FILTER STATION SITES

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1.0 INTRODUCTION

A written brief from the Auckland Regional Authority (ARA. ref 11/20/7 of 24/8/1988) asked for a geological investigation of the Nihotupu and Huia Filter Station sites. The brief called for a reconnaissance survey of the geomorphology, and an assessment of the stability of the two sites in the event of earthquake with respect to subsidence and earth slip. A verbal request was also made for comment on ground stability around the raw water feed conduits to both filter stations, and this was carried out for half a kilometre west of Huia Filter Station.

The ARA is looking at the feasibility of increasing the total capacity of the Waitakere Filter Stations, and favours the construction of further clarification units over the existing Nihotupu holding tanks.

2.0 REGIONAL GEOLOGY

Interbedded weak to moderately strong sandstone and mudstone of the Blockhouse Bay Formation (Kermode, 1982) occurs in the lower part of the Little Muddy Creek catchment. It is overlain by volcanic grit, sandstone and minor siltstone of Cornwallis Formation, which in turn is overlain by a well cemented gritty volcaniclastic sandstone facies referred to as the Swanson Member within the Nihotupu Formation. All three units are of Miocene age. The inter-relationship of the upper two units is unclear, and it is probable that regionally they interdigitate. However Swanson Member is only recognised in the headwaters of the catchment above 110 m ASL. Above this contour massive beds, up to 5 m thick, form bluffs which lie between equally thick units of interbedded sandstone and siltstone, each bed being less than 150mm thick. The strike of the beds within Swanson Member is variable and the dips are low throughout, most being less than 4°, but all have a northerly component. Cornwallis Formation is poorly exposed within the area surveyed, being seen only as small outcrops in the stream draining from Huia Filter Station, and at the top of the waterfall below Ngaio Rd. The strike and dip of the beds above the waterfall is consistent with that in the overlying Swanson Member.

Much younger unconsolidated sand, mud and clay has been deposited up to about 20 m ASL in the floor of Little Muddy Creek, and colluvium and slide debris has been deposited on the weathered surface of all three units.

3.0 PHYSIOGRAPHY

The arcuate bluffs at the head of the Little Muddy Creek catchment have, in the past, been interpreted as the headscarp of a major landslide. The evidence of parallelism between the near flat lying beds of the Swanson Member in the bluffs and the Blockhouse Bay Formation lower down in the sequence, and the existence of rock beneath the Huia Filter Station site, suggest that there is an unbroken rock sequence extending from the bluffs through beneath the Huia Filter Station to the waterfall below Ngaio Road, and therefore that the area south of the bluffs is not underlain by a massive landslide.

Geological and physiographic evidence suggests that Little Muddy Creek downcut its course, initially to a base level well above present sea level, to form a wide valley floor. Remnants of this valley are preserved above the 50 m contour across the head and western side of the valley. Headward erosion of the valley proceeded through the softer Cornwallis Formation rocks undercutting the more competent Swanson Member rocks to create the bluffs surrounding the head of the valley. A second period of downcutting followed, this time with a base level below present sea level, to produce a valley in valley form. The younger valley is deeply incised below Ngaio Road, and is also incised above Ngaio Road, to a depth of 15 m close to the road decreasing to a depth of 2 m at the boundary of the Huia site. The lower reaches of the new valley system were then flooded by a subsequent rise in sea level and back filled with sand, mud and clay to heights a few metres above sea level, before sea level dropped again to its present day level.

Several mounds, up to 12 m above the surrounding terrain, exist along the northern edge of the first formed valley (fig 1). The mounds are separated from the base of the bluff by poorly drained troughs which are partly backfilled with recent sediment. The mounds may represent erosional remnants from the first period of valley development, or more probably they represent remnants of debris from the bluffs at the head of the valley. It is suggested that such debris accumulation occurred during a period of active valley erosion, and are thus associated with the first stage of valley development.

4.0 SITE GEOLOGY

Both the Nihotupu and Huia Filter Station sites are considered for expansion. The geology of each site and its immediate surroundings, as well as that of the raw water feed conduits, are discussed.

4.1 Nihotupu Site

Nihotupu Filter Station is sited on the corner of Scenic Drive and Waima Road and faces south. The site is backed on the northern side by a spur of Swanson Member sandstone. On the southern side two benches, together some 25 m wide, carry Waima Road and the access to Exhibition Drive. These benches separate the Nihotupu Filter Station site from a 15 m high 1:1.5 slope above a sediment trap which feeds into a tributary of Little Muddy Creek. Highly weathered material occurs in the face between the two benches. It is probable that the 15 m high slope is composed partly from fill dumped from the excavation for the filter station.

At the western end of the existing buildings slightly to moderately weathered coarse sandstone is exposed. At the eastern end a less weathered sandstone is exposed behind the holding tanks. The sandstone forms a 4 m high bluff some 10 m above ground level and above a debris slope of 35°. Two drillholes at the south west corner of the filter station located interbedded sandstone and siltstone at a depth of 2 m.

The exposures and sub-surface information suggest that the foundations at the western end are very close to unweathered to slightly weathered rock, but it is probable that slightly to moderately weathered sandstone and siltstone appear in the foundations at the eastern end.

Apart from minor pavement and curb failure on the outer edge of the pavement in front of the filter station, no indications were found to suggest failure or deformation within the weathered material.

4.2 Huia Site

This site is on undulating terrain some 150 m from the bluffs at the head of the valley and 250 m south west of the Nihotupu site. Examination of data from 31 drillhole logs supplied by ARA, plus surface mapping, indicates a mantle generally between 10 m and 14 m thick of clay, silty clay and clayey sand over unweathered bedded gritty sandstone, sandstone and mudstone. The surficial material ranges from a soft to firm plastic silty clay or clay near the original ground surface to a stiff clay at depth. Relict fabric in some surface exposures suggest much of the material is residual soil developed from in situ weathering, but some colluvial deposits are suspected, particularly near the stream draining the site, and possibly also near borehole 4624 in which peaty clay was recorded at a depth of 4.9 m beneath firm clay.

Natural soil moisture contents are well above the plastic limit for the material over much of the site, particularly east of the standby generator house. Surface seepage was noted north east of No 2 Lagoon. Although no positive evidence was seen, soil creep is possible where such wet conditions exist, particularly on steeper ground, or above unsupported cut faces. Surficial slides displacing up to 50 cu m of material were noted in the banks of the stream, both inside and outside the Huia site enclosure.

4.3 Raw water conduit tracks

Nihotupu Filter Station is fed through a cast iron pipe laid along Exhibition Drive. Massive unweathered to slightly weathered sandstone form bluffs above Exhibition Drive which are transected by steep drainage paths or shoots. The steep drainage shoots are underlain by slightly to moderately weathered sandstone and colluvium. Below the drive there is a steep apron of debris through which bluffs of fresh sandstone are exposed. The development and position of the bluff, both above and below Exhibition Drive, is dictated by joint orientation.

The Huia feed water conduit is built across the mounds mentioned above as probably remnant hummocks of rock fall debris, and also across residual soil or colluvium, developed on the older valley floor. Both deposits comprise soft to firm sandy clay or clay.

5.0 ENGINEERING GEOLOGY

5.1 Foundation materials

Nihotupu Filter Station: Based on surface exposures and interpretation of the two drillholes available, slightly to moderately weathered material is suspected where the extensions are proposed at the eastern end. The thickness of the weathered zone is unknown, but it is thought unlikely that it is greater than 5 m below ground surface adjacent to the holding tanks, but presumably thickens to the south. Further investigations are necessary to determine the extent and suitability of this weathered rock as a foundation material.

Little surface or subsurface information is available from the alternative site of proposed extensions at the start of Exhibition Drive, but it is thought probable that part of that site is on fill.

Huia Filter Station: Moderately to completely weathered rock and colluvial deposits, both as soft and stiff clay, silty clay and clayey sand form a layer, generally between 10 m and 14 m thick over the entire site. Drillhole data suggests there is a transitional zone into bedrock. The bedrock surface approximates to a valley plunging south beneath the washwater tank and No 1 lagoon. The fresh rock, although probably slightly weaker than that found at the Nihotupu site, is thought to be adequate as a foundation material. Further assessment of the suitability of the weathered rock and colluvium as a foundation material is recommended.

5.2 Slope stability

Instability may be triggered by natural erosion, ongoing weathering, precipitation, changes in vegetation cover or construction, or by seismic activity. The potential for large failures in this area is not great, unless seismically triggered. Such failures are discussed separately within this section.

5.2.1 Landslide

Nihotupu Filter Station: No historic failures were seen in the weathered material at this site, but could occur in debris slopes behind the station. Such failures are unlikely to dislodge more than a few cubic metres of material, and can thus be tolerated. It is recommended however that, to keep the possibility of failure low, vegetation not be removed from the slope behind the filter station.

Examination of aerial photograph stereo pairs suggested slope failure may have occurred on the south side of Waima Road opposite Nihotupu Filter Station prior to its construction. To reduce the potential for failure of the slope it is recommended that the ponded area, developed as a sediment trap, below Waima Road be drained. It is also recommended that the stability of the slope above the sediment trap be investigated.

Huia Filter Station: Recent slope failures in weathered material and colluvium were observed both inside and

It is recommended that a topographic and detailed geological survey be made of the spur behind the Nihotupu Filter Station to investigate further the potential for, and possible volume of, slope failure which could affect the filter station.

Nihotupu Raw Water Feed pipe: Minor rock falls have occurred by collapse from above onto Exhibition Drive since its construction in 1925. These falls have only involved a few cubic metres of rock and do not appear to have affected the pipeline. The position and size of the failures is controlled by the spacing and orientation of joints and bedding. The position and orientation of the bluffs is dictated by one set of joints, but the orientation of the conjugate joint set, and of the bedding, is into the bluffs. Such defect orientation reduces the potential for block or wedge failure.

The bluffs have developed on a joint set striking between 075° and 120°, dipping 80° to 90° south. The second set of joints is not so well developed, and strikes between 330° and 045°, and dips approximately 80° to the east. The beds dip at 2° to 5° into the bluff.

The bluffs below Exhibition Drive are either covered by slope debris or occur as massive sandstone faces, and the potential for a failure undercutting the pipe is considered minimal.

Huia Filter Station and Huia Raw water feed: Both the filter station and raw water feed are remote from bluffs, and are unlikely to be affected by rockfall.

5.3. Large seismically triggered collapses.

A seismic event of sufficient magnitude could initiate larger failures than those discussed above. The greatest impact would be on the Nihotupu Filter Station and raw water conduit as a result of collapse of the bluffs and steep debris slopes above and below them. Slope failure above the filter station could bring down debris on to the filter station partially filling the sand filter bays and filtered water storage tanks. Seismically induced failure on the slope between Waima Road and the ponded area below it is less likely to affect the filter station, but such a failure would disrupt the filtered water conduit from Huia Filter Station.

outside the Huia site adjacent to the stream, but confined to areas where slopes are greater than 25°. These failures do not at present appear to threaten the site. Additional geotechnical investigations to determine stability are required if extensions are planned, particularly at the eastern end of the site.

Raw Water Conduits: Minor landslides have occurred in the steep drainage paths transecting the bluffs above Exhibition Drive. The volume of material dislodged varies between 10 cu m and 50 cu m, and further landslides can be expected to deposit debris on the Nihotupu raw water feed pipe. The potential for damage to the pipe however is considered to be low.

There is evidence of incipient slumping in the debris apron below Exhibition Drive. The slumping appears to be confined to fill tipped over the outer edge of the road during its construction. The road is cut back into unweathered rock, and the pipe is laid three to four metres in from the edge of the unweathered rock, and thus any failure in the fill is unlikely to affect the pipeline.

It is recommended however that as a protection, vegetation is retained both above and below Exhibition Drive.

No evidence of recent slope instability was seen affecting the Huia raw water conduit.

5.2.2 Soil creep

Soil creep is possible at the Huia site, particularly on steeper gradients. With time such creep could reduce lateral support to some structures. No evidence was seen to suggest soil creep was affecting the Huia raw water conduit.

5.2.3 Rockfall

Nihotupu Filter Station: The potential for rock fall from bluffs above Nihotupu Filter Station is small. The slope behind the filter station rises, at the western end, some 40 m above road level but is only 6 m high at the eastern end. The bluffs within the slope are only 3 m to 4 m high with slopes at 35° above and below. The potential rockfall would be small, with falls only bringing down a few cubic metres of rock, but a larger collapse could initiate a landslide in the slope above.

Damage to the raw water conduit along Exhibition Drive by large, seismically induced failures is more likely to result from undercutting, withdrawing support from the pipeline, than by impact of debris from above.

Huia Filter Station is afforded some protection from large rock falls from the bluffs by the mounds described above. However localized failures in the weathered material adjacent to the stream could be expected, which could remove lateral support from the foundations.

6.0 SEISMIC HAZARD

Seismic hazard can be of two main types; tectonic ground deformation accompanying displacement along a fault plane, or strong ground motion from local or distant seismic activity. Secondary hazards are slope stability, as discussed above, liquefaction and subsidence.

6.1 Ground Deformation.

Information supplied by Geophysics Division of DSIR indicates that no earthquake of magnitude greater than 2.0 on the Richter scale has been recorded instrumentally as originating in the Waitakere area.

No active faults are recognised in the Waitakere area, and thus tectonic ground deformation is not considered as a potential hazard to either site. Hochstein et.al. (1986) plotted several active faults within the Hauraki Rift, a zone extending from the Taupo Volcanic Zone to Whangarei. The nearest active fault within the rift lies some 65 km east of the filter stations. The nearest active fault recognised onshore is the Kerepehi Fault, some 110 km to the south east.

6.2 Ground motion.

The information supplied by Geophysics Division also indicates that no earthquakes of felt intensity greater than MM 6.0 are known to have been felt in the greater Auckland area since written records commenced in 1840. There is an unsubstantiated report of an event with felt intensity MM 8.8 having occurred in 1835, but as the only report of the event was made overseas some 60 years after the event, and there is no other corroborative evidence, the report is considered to be of doubtful reliability. The highest reliably recorded felt intensity is assessed at MM 5.9, which resulted from the Port Waikato earthquake of 1891.

Smith and Berryman (1986) plot return periods for events of different felt intensities throughout New Zealand, and discuss the limitations of their assessment. For Auckland they suggest the return period for an event giving a felt intensity of MM 6.0 is 62 years, which is less than half the period of historic records. They calculate a return period of 260 years for felt intensity MM 7, and 1400 years for MM 8.

6.3 Liquefaction.

Liquefaction results from the sudden build up of pore water pressure in saturated, generally cohesionless, sediments. Most engineering soils seen on site in surface exposure, or recorded in the drill logs provided, are clays or clayey materials, and hence are unlikely to be susceptible to liquefaction. However the existence of cohesionless soils cannot be ruled out for the Huia site. Cohesionless soils are unlikely to exist beneath the Nihotupu site.

6.4 Subsidence

Low density soils were not recognised on either site, and hence subsidence through dynamic consolidation is unlikely.

7.0 SUMMARY

The data available indicates better foundation conditions for Nihotupu Filter Station site and its raw water conduit than for Huia Filter Station and its raw water conduit, with the former being close to, or on unweathered rock, while the latter is on weathered material or colluvium.

Potential geological hazards affecting the Nihotupu and Huia Filter Stations are landslide, rock fall, and the loss of lateral support for foundations through soil creep. Under normal conditions, the impact of landslide and rockfall are considered to be minor, and loss of lateral support by creep is a localized problem.

The impact of landslide and rockfall could increase if an earthquake of sufficient magnitude were to occur. Nihotupu Filter Station is considered more susceptible to damage from rockfall, and Huia Filter Station could suffer damage through lateral loss of support leading to foundation failure.

The probability of an earthquake of sufficient magnitude to trigger such slope failures is considered to be low.

8.0 REFERENCES

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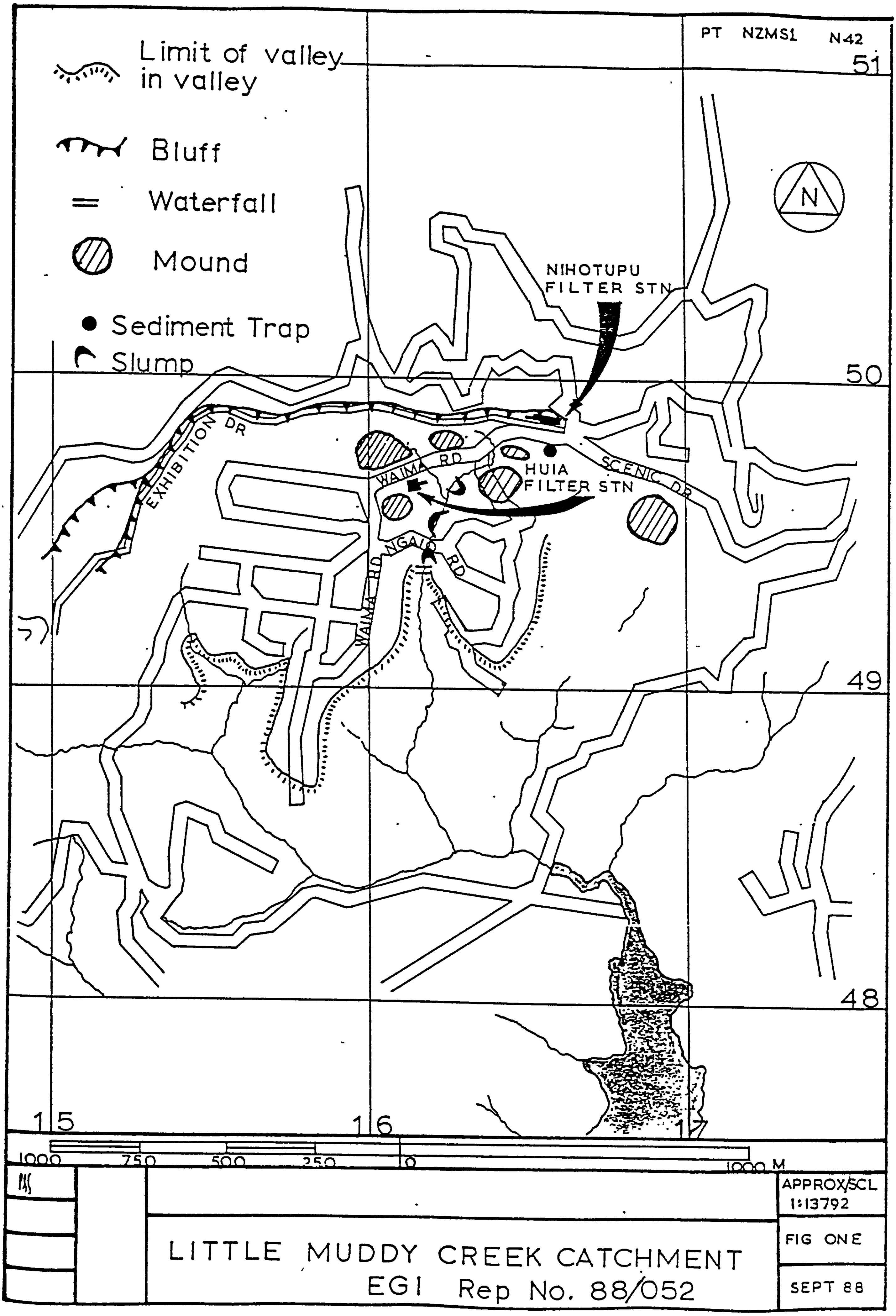

PT NZMS1 N42
51
50
49
48
15
16
17
Limit of valley in valley
Bluff
Waterfall
Mound
Sediment Trap
Slump
NIHOTUPU FILTER STN
HUIA FILTER STN
EXHIBITION DR
WAIMA RD
NGAIO RD
SCENIC DR
N
1000 750 500 250 0 1000 M
APPROX SCL 1:13792
FIG ONE
SEPT 88
LITTLE MUDDY CREEK CATCHMENT
EGI Rep No. 88/052