Taihoro Nukurangi

Managing and adapting to coastal erosion on the West Coast: Granity

NIWA Client Report: HAM2006-153
October 2006

NIWA Project: EVL06201

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Prepared for

West Coast Regional Council

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Executive Summary

This report is one of a number being prepared for West Coast Regional Council (WCRC) to aid the decision-making processes associated with ongoing erosion problems at a number of locations in the region. The advice provided in this report and associated material focuses on Granity village and has been supported by the Foundation for Research, Science and Technology Envirolink fund set up to assist Regional Councils in accessing environmental advice from the various Crown Research Institutes.

The report outlines a number of potential measures, as a basis for future discussion between the Regional Council and Granity residents, that could assist in reducing the impact and/or slowing down the rate of coastal retreat of the gravel barrier along the village frontage, with particular emphasis on the most at risk section at the northern end of the village. The suggestions are intended to be achievable options, a number of which could be implemented by the local property owners and are based on the discussions held with a number of affected residents and staff at the Regional Council. Other suggestions are larger scale activities that would require contractors and coordination.

1. Introduction

1.1 Scope of the review

This report is one of a number being prepared for West Coast Regional Council (WCRC) to aid the decision-making processes associated with ongoing erosion problems at a number of locations in the region. The advice provided in this report and associated material focuses on Granity village and has been supported by the Foundation for Research, Science and Technology Envirolink fund set up to assist Regional Councils in accessing environmental advice from the various Crown Research Institutes.

As such these reports do not provide a detailed review, rather they are a summary of the observations made during a number of visits, discussions with West Coast Regional Council staff, various local residents at Granity, and due consideration of previous studies of coastal processes at these locations. Specifically the requirements are to provide overview advice on the potential options to reduce the impact and/or slow down the rate of coastal retreat of the gravel barrier along the village frontage, with particular emphasis on the most at-risk section at the northern end of the village.

Associated with this report, two public awareness brochures on coastal erosion are being developed, one specifically for Granity, and a general one for the entire West Coast region.

1.2 Visits and background information

Parts of the West Coast coastline, including Granity, have been inspected on a number of occasions over the last year (November 2005, May, August and October 2006) during visits associated with these specific studies and in conjunction with other ongoing work.

Discussions concerning the issues have been held with Chris Ingle, Wayne Moen, Simon Moran and Mary Trayes of WCRC. Mr Wayne Moen, Engineering Manager at WCRC, has assisted with a number of the site visits and he, and Mary Trayes, have provided much background information associated with the coastal changes in the West Coast region.

During the August 2006 visit to Granity, discussions have been held with a number of the local residents at the northern end of the village including, Mr & Mrs Shane Wratt, Mr Richard Jack, and Mr Bart Gillman, as well as Bill Milligan, a local contractor who has a long involvement in maintaining the outlets of the various streams for Buller District Council.

A list of previous studies which have been reviewed in the context of this report, are included in Section 4.

2. Coastal changes at Granity

2.1 Overview of the evolution of gravel barrier systems on the west coast

The coastline fronting the village at Granity is characterised by a single active gravel ridge backed by a low-lying swale which was historically an elongated lagoon or wetland area, with further relic beach barrier ridges landward of this. Much of the village of Granity is located on these relic ridges, although some property, particularly at the northern end is located in the relatively lower-lying reclaimed wetland areas.

Such gravel barrier systems, in most places around the world, are typified by long-term sediment starvation, (i.e., in the present geological age characterised by relatively stable sea levels over the last 6000 years there is insufficient fresh gravel entering the beach system to maintain their position), and they respond by migrating landward (Schulmeister & Rouse, 2003). This migration occurs in two ways:

- Washover: where gravel on the front face of the beach is progressively moved over the crest and on to the back face of the barrier due to episodic storm conditions where wave run-up reaches the crest, or overtops the barrier. Typically a gravel barrier, in a natural state, would experience wave overtopping of the crest around 2-4% of the time. Under more significant conditions larger volumes of overwashing can create localise washover fans, where gravel is washed down the backface of the barrier and spread out over the land immediately backing the barrier, or localised breaches of the barrier can occur.

- Overstepping: where the barrier is completely destroyed during a severe storm event and washed landwards simultaneously (Schulmeister & Rouse, 2003). This is more likely to occur if the barrier is backed by a lagoon rather than dry land.

Under a future with ongoing sea-level rise, such barriers tend to respond in two ways (Carter & Orford, 1993):

- The height of the barrier increases. This is the likely response where there is a wide and healthy gravel barrier to allow such a change in the beach profile to occur. The Blaketown beach, just south of the Tip Heads is one such area where such a response is likely.

- The barrier may break down and retreat shorewards. An increased rate of retreat, or even breakdown of the gravel ridge is the more likely response of many of the gravel barrier systems in the West Coast region which are presently less well nourished with gravel. As most of these systems are recessional, future sea-level rise will just exacerbate or accelerate this present day trend. This is the general situation at Granity although other local factors will also influence future evolution of the gravel barriers and are discussed.

These long-term patterns of landward retreat are not constant, cycles of short to medium term accretion and erosion patterns do occur depending on the particular complex interactions between wave climate variability, storm occurrence, storm track and storm sequencing (i.e., the impacts due to a particular series of storms), and river flood events (which are the dominant source of sand and gravel to the coastline).

2.2 Recent storm impacts

The West Coast region has experienced a number of storm events over the 2006 winter period which has caused overtopping, inundation behind, and noticeable coastal change of a number of beach barrier systems. The most significant events occurred on:

- 06 May - where a rapidly moving low pressure system south of New Zealand created a train of long-waves (see Appendix 1). This phenomenon is known as a rissaga, or “meteorological tsunami” as the wave conditions exhibit similar characteristics to a small tsunami. Large swell was also occurring that day, which would have produced very confusing seas and surging in and out at the coast. Wave run-up on the beach and overtopping is very sensitive to these long–period waves, with significant overtopping occurring at many locations in the West Coast region and also in Southland and Stewart Island during this event.

- 12 June – where large wave conditions coincided with a high Spring tide. The consequences, such as overtopping, of a storm event on the coast is highly dependent on the event coinciding with a high sea levels. This shows the importance of episodic events where large waves coincide with high tides, and in this case a high storm surge (up to 0.65 m), in causing coastal change along such gravel barrier systems. Conversely the visit to Granity in August 2006 coincided with a very high Spring tide, but only small waves, resulting in little change at the coastline.

The low pressure system on 12 June that created the strong winds and high waves crossed the South Island in a north-west to south-east direction (Appendix 2) resulting in winds and waves along the coast at Granity from the north-west. As the beaches on the West Coast tend to be more aligned with the dominant south-westerly swell, the effect of storm wave conditions from this direction resulted in more of a "shock" to the beach system.

Whilst overwashing occurred along much of the frontage at Granity during these two events the most significant impact occurred at the northern end of the village adjacent to Lover's Rock, Figure 1. Approximately 110 m of the gravel barrier in the lee, and to the immediate south of Lover's Rock, was breached filling the outlet of the Bradley Stream, (which has been artificially deflected about 270 m northwards running behind the barrier to discharge in the lee of Lover's Rock) and washing sand and gravel over the gardens and up and around the northern five houses on the seaward side of the road, Figure 2.

Figure 1: Overwashed section of gravel ridge at the northern end of Granity village (Photograph taken by Prof. A Short, University of Sydney; 28 September, 2006).

Given the conditions during the two events identified above, the response of the coastline at the northern end of Granity was not all that unusual. The gravel barrier, particularly between Chair Rock and Lover's Rock is in a very poor state backed in sections by a thin stopbank, likely created from the excavated material from the northward diversion of the Bradley Stream, Figure 3. This, along with the location of the Bradley Stream running behind the beach, the general low lying nature of the area upon which the northern part of Granity village is located, and the outlet of the Bradley and Cooper Streams, all act to make this section of coast highly susceptible to overwashing and retreat of the barrier.

Along this breached section, the line of the old drainage channel which ran landward of the barrier is now over the upper part of the active beach. In the aftermath, this drainage channel was re-aligned further landward and the excavated material piled up to form a berm between the drain and the beach, Figure 4.

Figure 2: Looking south along the breached section of gravel ridge.

Figure 3: Narrow ridge between Chair Rock and Lover's Rock.

Figure 4: The re-aligned drainage channel and bund formed from the excavated material.

2.3 Future coastal change

There have been a number of studies of coastal change along the Granity and adjacent coastline including those of Mangin (1973), Gibb (1978), Neale (1989a, 1989b) with summaries and further interpretation provided by Hicks (1996), DTEC Consulting Ltd (2002) and Trayes (2006).

The main findings of these studies suggests that the shoreline at Granity "*shows evidence of short-medium term (1-20 years time-frame) cycles of accretion and erosion superimposed on a trend of long-term erosion. The short-medium term shoreline movements are characterised by accretionary "lenses" and erosion "bites" from several to 10 m in width and spanning 500-1000 m segments of shore*" (Hicks, 1996). Historic erosion rates identified over the last 50 to 100 years varies between the reports reflecting the different locations along the frontage and different time periods over which shoreline positions measurements were made. DTEC (2002) presented rates measured from the position of the coastline from aerial photographs between 1985 and 2002 at seven locations along the Granity frontage which were, with one exception, eroding at a rate of between 0.35 to 2.37 m/yr. At the northern end of Granity, the average rate of erosion over this period was around 0.6 – 0.8 m/yr. This is similar in magnitude to previous studies. Only immediately to the north of the Granity River mouth was there evidence of beach accretion over this period.

Continuation of this erosion trend will be an ongoing issue along the Granity coastline. Whilst there is no property presently at critical risk of being significantly damaged due to erosion caused by coastal retreat, such risk will increase over the foreseeable future as the coastline continues to retreat, particularly at the northern end of the village and at the school. However, occasional overwashing of gravel and inundation continues to provide a significant risk to property at Granity. Based on the various visits to the Granity frontage the following observations on future coastal response are made:

- Along the northern, breached, section it is unlikely that the barrier built from the excavated material from the re-aligned Bradley Stream outlet will withstand any significant wave action on a high tide. Whilst the gravel layer over the upper beach has re-established since the storm events in May and June and there has been a slow rebuilding of the gravel salient in the lee of Lover's Rock, reducing the impact of waves washing in behind at high tide, there is insufficient gravel to rebuild a natural storm ridge and provide any real protection to the land behind during stormier conditions. Given the low-lying nature of the land behind and the lowering of the beach crest that has occurred, overwashing and inundation of the land behind will become a more regular feature in the future. Given this susceptibility, the diversion of the Bradley Stream to an outlet behind Lover's Rock exacerbates this risk and it will become increasingly difficult to maintain an open channel immediately behind the beach. However, simply opening up a direct outlet to the sea further south for the Bradley Stream would result in lowering of the beach and the potential for considerable erosion adjacent to the outlet.

- Immediately south of the breached section, there remains a section of stopbank assumed to have been built from the excavated material from the northward diversion of the Bradley Stream, (Figure 3). The height of the stopbank has prevented the fillet of gravel on the upper beach from being washed over the stopbank. However, the volume of gravel is insufficient to prevent the stopbank from being cutback during storm conditions and when it finally breaches, the crest of the beach will be rapidly drawn down and overwashing become more frequent as has occurred to the north (and also along a section to the immediate south, Figure 5).

- Between Chair Rock and the outlet of the Granity River, and to the south of the river outlet, the beach is presently in a healthier state with a larger volume of gravel on the upper beach. Washover will still occur particularly along sections where residents have cleared the natural vegetation up to the back of the beach crest, Figure 6.

- The stopbank built to protect the school has now been breached at the southern end, Figure 7. Drawdown of the narrow gravel storm beach fronting the stopbank, or wave run-up over the gravel beach will further erode this protection. It is nearing the end of its serviceable life. There is now little room between the landward edge of the stopbank and the edge of the school buildings to re-build the stopbank, although this may be a short-term option. However, given the location of the school and swimming pool relative to the retreating beach, there needs to be serious consideration given to the landward relocation of these buildings/facilities. Past attempts at direct protection have not been successful and short lived, and more robust linear protection, e.g., a rock revetment on an open section of coast such as this, may well result in considerable exacerbation of erosion or outflanking at either end of the revetment.

Figure 5: Breached section of stopbank looking south towards Chair Rock.

Figure 6: A buffer zone of natural vegetation such as flax behind the gravel ridge helps reduce overwashing by trapping gravel washed over the beach crest. Clearing such vegetation allows a greater volume of gravel to be washed over increasing the rate of roll-over and hence coastal retreat.

Figure 7: Breach in the stopbank at the southern end of Granity School.

3. Managing the impacts of coastal change at Granity

Coastlines are dynamic areas and trying to control how coastlines change is typically a very expensive and often futile activity which in many cases exacerbates problems along adjacent coastal areas. Attempting to "hold the line" through for example the construction of a linear defence such as a rock revetment located over the upper active beach is unlikely to be a feasible option in the case of Granity primarily due to the associated cost (there would be a need for a substantial embankment to provide support to the revetment), and the potential for exacerbating the rate of erosion along adjacent unprotected sections of coast.

During the discussions with local residents a number of other engineering solutions were mentioned and discussed, including:

1. *Groyne field along the Granity frontage:* Groynes are commonly used in the UK to control the longshore transport of sand and gravel. However, as they trap sand and gravel moving along a coast they can cause quite some significant down-drift erosion impacts (i.e., exacerbated erosion along sections of adjacent coast). Where groynes are still used, they are used in conjunction with beach nourishment, i.e., sand or gravel placed to increase the width of the beach. The function of the groyne field is now not to trap sediment being moved along the coast but to hold the beach nourishment material in place. Given the paucity of gravel on this coast, and limited longshore supply (see Hicks, 1996, DTEC, 2002) groynes without associated gravel nourishment is not a feasible option.

2. *Groyne to Lovers Rock:* The intention of placing a groyne over the beach to Lover's Rock would again be to trap gravel being moved northwards along the coast and build up a beach on the southern side of the groyne. Whilst there is still some doubt over the direction of net gravel movements along this coast, the lack of gravel along this section of coast is insufficient to build up a sufficiently wide gravel berm to increase the protection to the land behind. The influence of Lover's Rock would generally reduce the potential impacts of any downdrift effects, although such impacts can not be discounted.

   The storm events in May and June resulted in the breaching of the beach connection (tombolo) to Lover's Rock in the lee of the rock, allowing the sea to wash in behind. Whilst the breach is still present, and the sea washes in behind the rock on the upper half of the tide, at the time of the site visit in

August and again in October, the upper beach in the lee of the rock had begun to slowly build back out and it is likely that given time the high tide beach connection to the rock may well re-establish and therefore act as a "natural groyne".

3. *Artificial surfing reefs:* These are rock or sand filled geotextile structures typically built below the low water mark. They are designed to create a suitable peeling breaking wave for surfing. As they influence wave breaking offshore they can promote beach build up in their lee. However, at best the width of beach build up is generally no more than double the width of the structure. Given their location below low water, these structures need to be substantial, and hence are expensive to build with the resulting benefits in terms of increased beach width only occurring over a very localised area. For example a typical capital cost of such a structure would be of the order of $1 million plus ongoing maintenance with benefits in terms of direct protection and increased beach width only likely over an area of around 100 m or so. Exacerbation of downdrift erosion effects can also be an issue.

Whilst there are many other types of engineering structure that could be considered, in essence there are no real feasible options that are either affordable, or would not cause significant downdrift erosion effects for controlling the rate of change along the Granity frontage using engineering structures over the upper, intertidal or subtidal beach. Potential options that may be feasible are outlined in the next sections.

3.1 Gravel beach nourishment

To the south of Lover's Rock there is presently insufficient gravel to form a storm berm which has resulted in the lowering of the beach crest and increased susceptibility to overwashing. However, the location of Lover's Rock does provide an opportunity to build up a more robust gravel beach over a short length to the south (essentially a fillet of gravel along the 150 m section that was most severely overwashed and is presently most at risk) which would effectively be 'anchored' naturally by Lover's Rock.

This would require the placement of well sorted pebble to cobble sized river gravel to form a new gravel ridge of sufficient width and height to accommodate profile changes to the upper beach under storm conditions (rather than being overwashed). This is shown conceptually in the top panel of Figure 8. Whether there is a suitable source of such gravel is not known. The volumes required are also not known and will require a number of beach profiles to be conducted to allow the potential quantities, and hence costs to be established.

Whilst this may be a feasible option for a short length of coast adjacent to Lover’s Rock (which controls the longshore movement of gravel and hence helps keep the gravel beach in place), it is unlikely to be a feasible option along the coastline any further south where the gravel would be more mobile and therefore more difficult to constrain.

3.2 Reducing overwashing and slowing coastal retreat

If gravel nourishment is not an option at the northern end, at this location and along much of the rest of the Granity coastline, the future emphasis will need to switch to slow and adapt to the rate of retreat rather than trying to "hold the line". Even with small scale beach nourishment and implementation of some of the suggestions outlined below, relocation of a number of properties, primarily at the northern end of the village, may well become a necessity over the coming decades for a number of owners. Given the width of the current buffer between the property and the coastline, and the general long-term rates of coastal change, such actions are unlikely to be required in the immediate future, albeit that occasionally there will be events that cause washover or inundation up to and around the property in this location. However, property owners at the northern end of Granity should be mindful that the need to relocate property will ultimately be a reality and that planning an exit strategy over the coming decades would be advisable.

The discussions with a number of the property holders at the northern end of Granity village focussed on identify possible measures to help slow, as far as possible, the rate of coastline retreat, and reduce the magnitude of episodic overwashing or overtopping events. The discussions focussed on the following:

- Establishing as wide a buffer zone of natural vegetation as possible immediately behind the active beach.

- Backstop protection.

The planting of flax and other thick coastal vegetation helps considerably in reducing the rate that gravel is washed landward of the active beach when overwashing occurs. This is well demonstrated immediately to the south of the six northernmost property in Granity on an undeveloped section where a thick belt of flax is well established.

Although not a native, the clumps of bamboo that are found at a few locations elsewhere along the Granity frontage, once established are also extremely effective. Maintaining a continuous buffer zone of natural vegetation between the back of the beach crest and property is a fundamental activity in managing coastal retreat at Granity and is integral to any other activities carried out. The location of such vegetation buffers are shown conceptually as green zones in Figure 8.

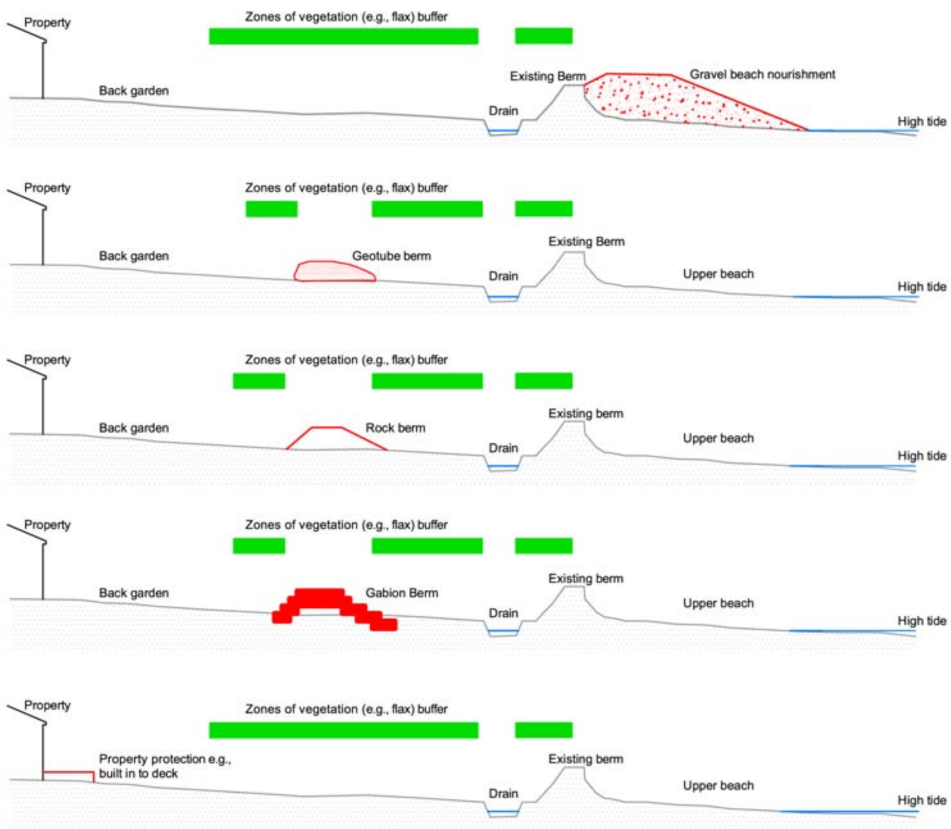

Figure 8: Conceptual profiles showing the layout for various options including gravel nourishment (top), geotube berm backstop protection, rock berm backstop protection, and property protection (bottom).

The use of traditional 'facines' to also help trap and hold overwashing gravel is also an option to assist the role flax and other vegetation plays. These have been used in other locations in New Zealand to help trap sediment (see Figure 9) using Manuka (i.e., tea tree – which has good rot resistance) stakes driven in to the ground, with Manuka branches woven between the stakes. At Granity these would be positioned behind the beach crest to <u>run parallel</u> with the beach to complement the re-vegetation to further trap overwashed gravel (see Figure 10).

Figure 9: Use of Manuka 'facines' to help trap sand and raise beach levels in front of dunes at Raglan. The branches woven between the poles have now been covered with trapped sand.

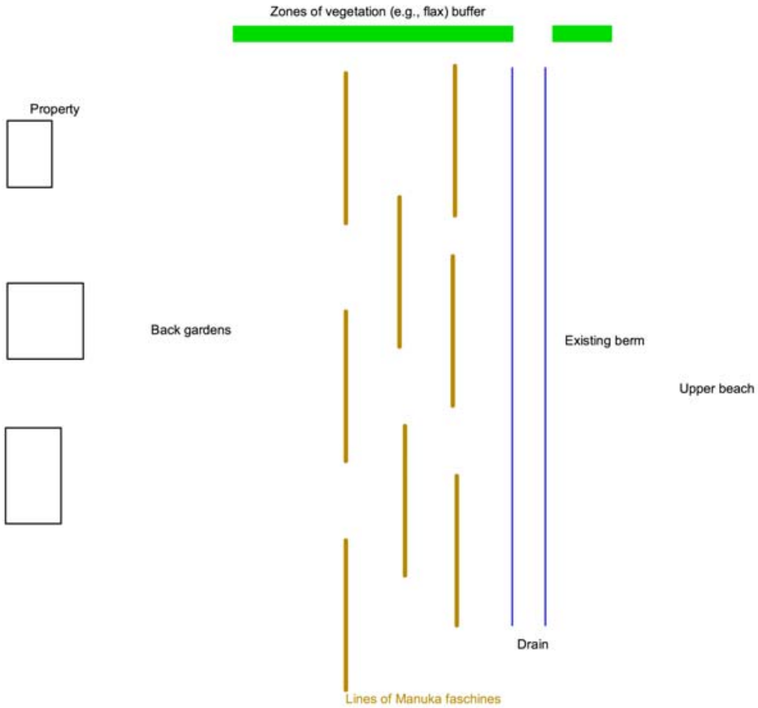

Figure 10: Conceptual plan layout showing possible location of facines.

In addition to the role a well vegetated buffer zone plays, the next level of option would be to install some form of backstop protection works landward of the drain to: 1) reduce the landward extent of overwashing when it occurs; and 2) provide additional protection to the property from inundation. This would essentially involve creating a stopbank or berm which would become less effective as the beach crest continued to retreat and ultimately roll back over it. However, as it would restrict how far gravel was washed inland during overwashing events, it would slow this rate of retreat. There are a number of options for construction to create such a berm, for example:

- Geotubes, i.e., sand filled geotextiles (Figure 8, second panel): Geotubes could be installed relatively quickly as an emergency measure but would require specialist assistance for filling them. As a medium term solution there is still some concern with regard to UV degradation of the geotextile (although they are much more stable now than previously). An option would be to cover the geotube with topsoil and plant vegetation over it.

- Rock rubble berm (Figure 8, third panel): This was an option being explored by a number of the residents using waste material from a neighbouring coal-mine. If such an option was progressed the same design considerations should be taken in to account as any rock revetment type structure. For example the following is recommended:

    - 1:2 minimum seaward slope, 1:3 preferable.

    - Largest rock placed at the toe of the structure and the toe keyed well in to the underlying substrate – ideally up to a 1 m below the land level.

    - 3 rocks wide at the crest.

    - Smaller sized rock used in the core of the structure.

- Gabions (Figure 8, fourth panel): Whilst gabions are not recommended for coastal defence works on an open coastline exposed to wave action, as backstop protection located well back from the beach crest and only acting to block occasional overtopping or overwashing they are potentially an option. The main problem with using gabions is that the land back from the beach crest is low-lying. Hence to create a berm with a crest height of 1 – 1.5 m above that of the adjacent land levels would require a wide crest (3 - 4 m wide or greater) for structure stability resulting in a relatively high cost per metre of defence. If gabions are used it is suggested that the wire be galmac and PVC coated as this is more durable in a marine environment. **Cobbles for filling the baskets should be sourced from a suitable quarry and not taken from the beach.** The toe of the gabion would also need to keyed in well to the underlying substrate. A geotextile filter would be required between the gabions and the underlying strata.

At present it is suggested that the backstop protection extend along the front of the five northernmost properties on the seaward side of the road at Granity, from the undeveloped section at the southern end to beyond the northern most property. At the northern end the protection should curve landward to help prevent inundation at the stream outlet from flowing around the end of the protection. Whilst there will be a desire to locate any backstop protection close to the landward edge of the drain (i.e., as far seaward as possible), the defence will be more effective and longer-lasting the further landward it can be located. The backstop protection works could also be extended southwards in the future if required.

Creating a stopbank from compacted fill or gravel only (e.g., as was carried out in front of the school) is also an option. However, as such a structure would be more prone to being eroded and breached as the coastline retreats, and as such is less of an attractive option than the above.

For the six properties at the northern end, simple flood protection walls, e.g., built as foundations for a raised deck, may also be an option to provide additional protection to property from inundation due to overwashing water, (Figure 8, bottom panel).

Finally a further option that may need to be considered is the re-routing of the drainage channels from along the back of the beach, e.g., Bradley Stream. Given the fragile nature of the beach crest between Lover's and Chair Rocks, the location of these diverted drains which now run immediately behind the beach reduces the stability of the beach crest. Whilst it is advantageous to maintain the outlet of these streams behind Lover's and Chair Rocks, the potential for diverting the streams further landward to the points of discharge, e.g., along the landward side of State Highway 6 should be explored. The existing drains could then be filled and re-vegetated.

3.3 Further considerations and implementation

Outlined above are a number of potential measures for reducing the rate of coastal retreat along the Granity frontage. They are based on the brief discussions held with a number of affected residents and staff at the Regional Council. Most will require further discussion between the residents, District and/or Regional Council as well as further investigation, e.g., quantities and costs weighed up with benefits.

None of these measures will 'solve' the problem, rather they are a way of adapting to and managing the erosion issues at Granity, and in the case of the residents at the northern end of the village, provide increased protection and time to implement plans for relocating these buildings over the coming decades. Nor are the options to be considered alternatives, i.e., implementing them all is an option. However, developing and implementing these options will need to be either led by the community or the District/Regional Council, with the table below providing a suggestion of where the onus for each option may lie.

	Smaller scale activities able to be conducted by residents	**Larger scale activities requiring contractors and coordination**
Gravel nourishment over 150m length of coast south of Lover's Rock		▬
Backshore flax planting	▬	
Facine installation	▬	
Backstop protection	▬	▬
Property protection	▬	
Drainage re-direction		▬

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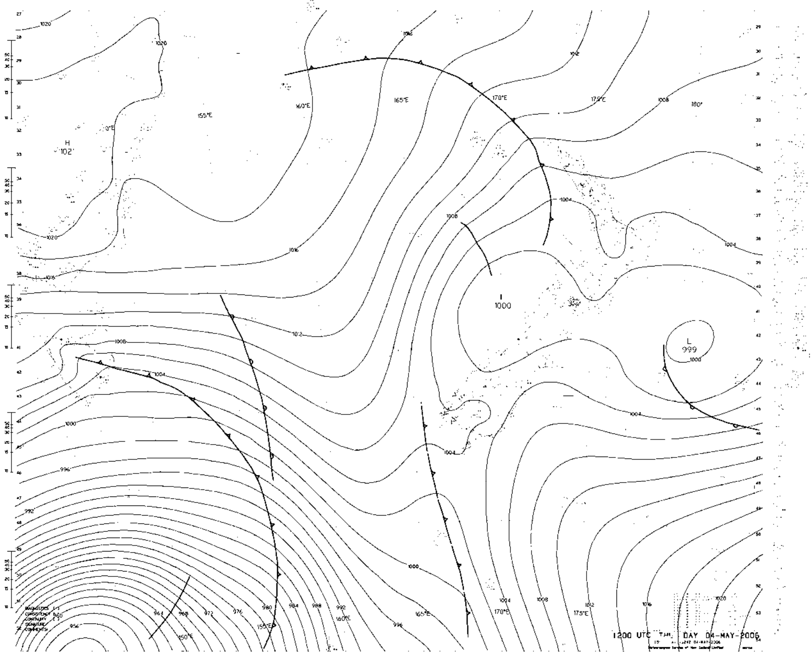
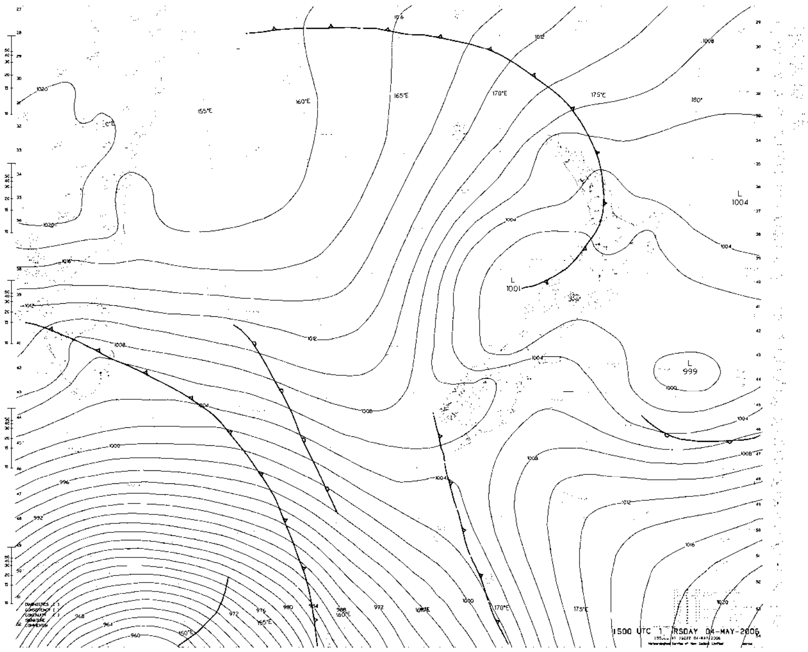
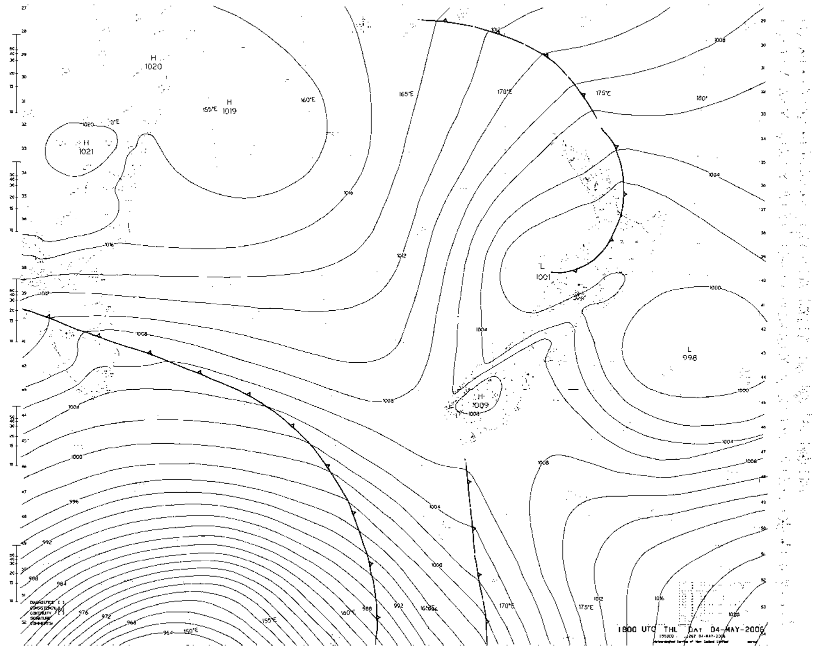
5. Appendix 1: Mean Sea level pressure maps showing the slow-moving low pressure system tracking to the south of New Zealand over the period 4-6 May 2006.



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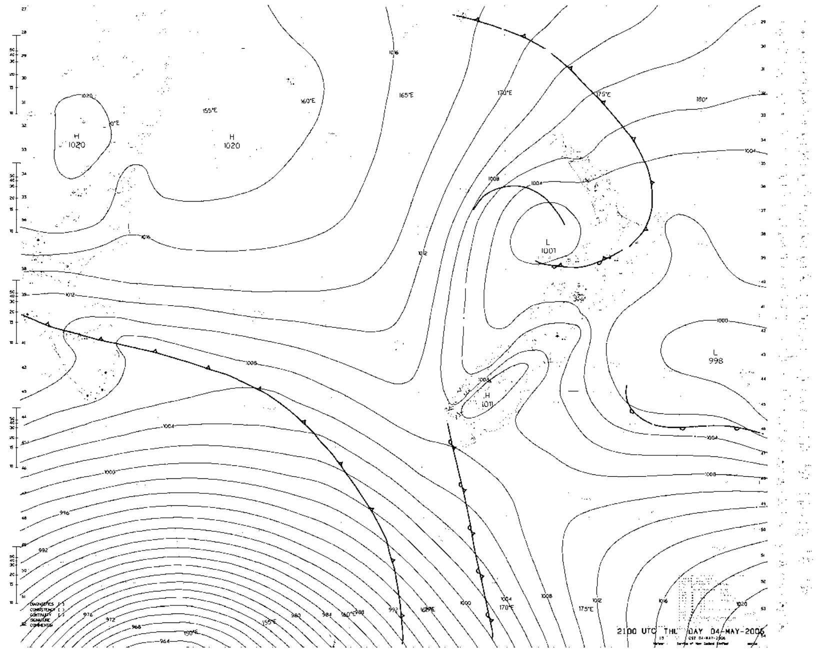
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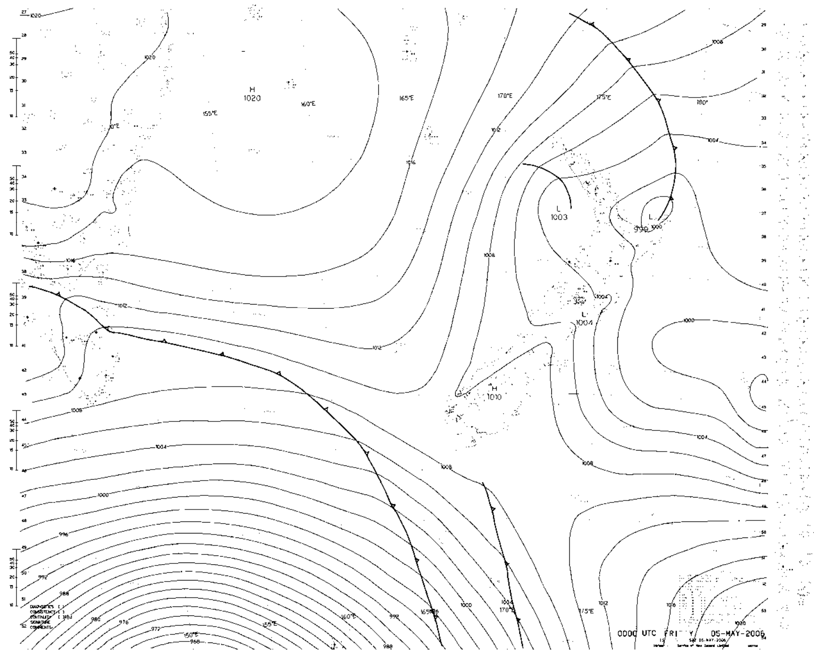
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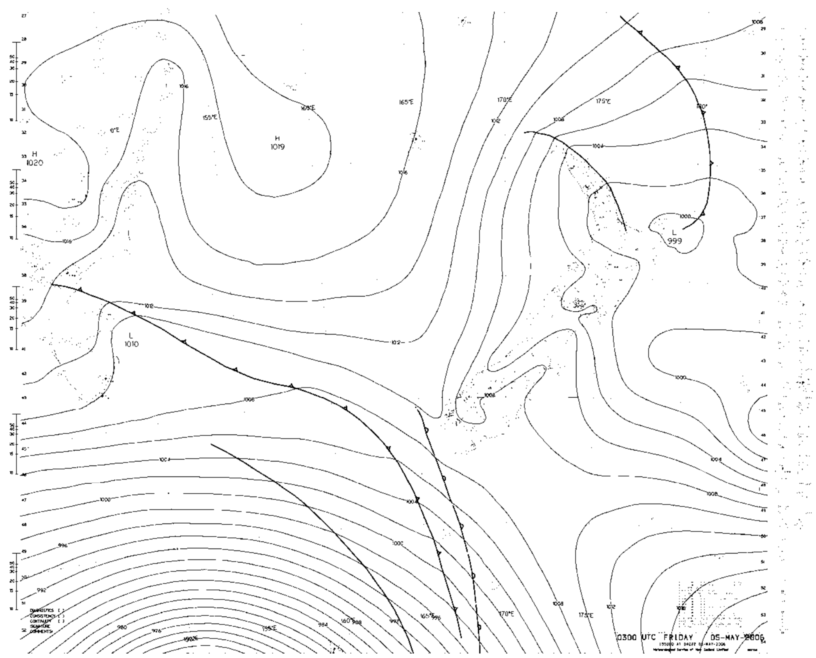
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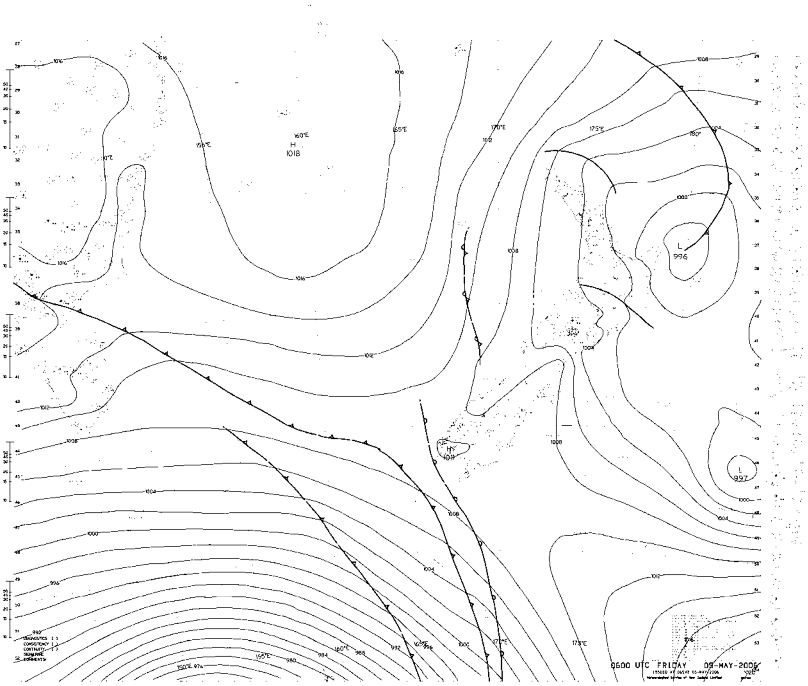
1020
H
1019
L
999
L
1010
0300 UTC FRIDAY 05-MAY-2006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1018
L
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L
997
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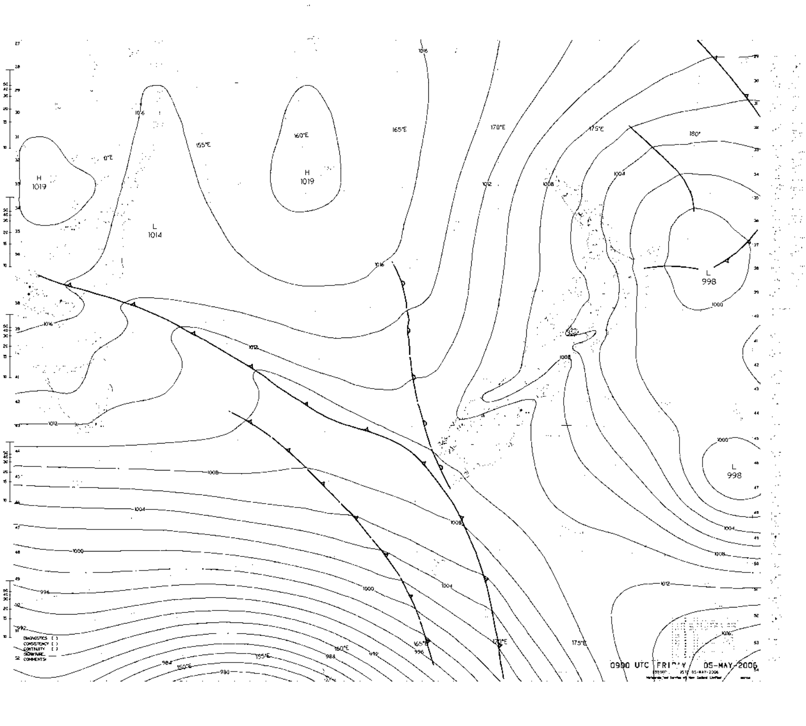
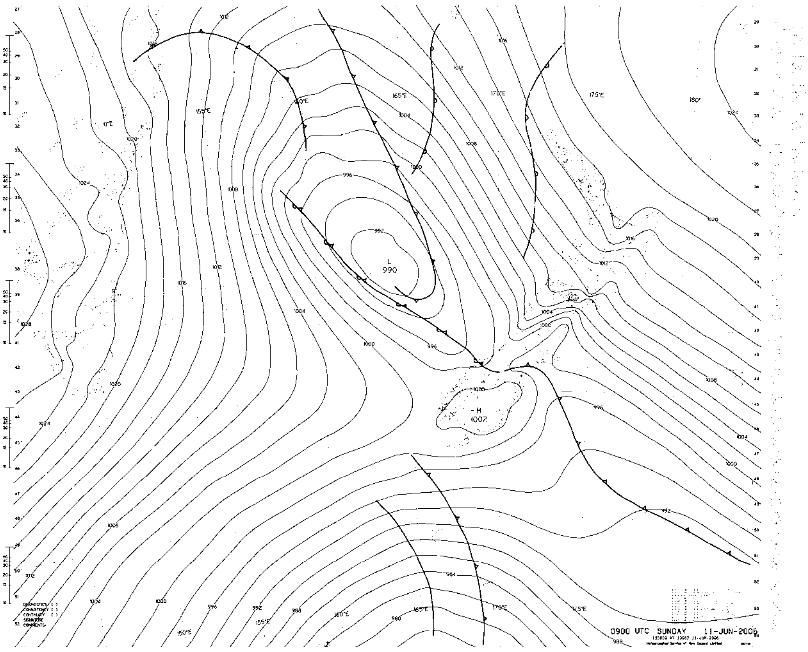
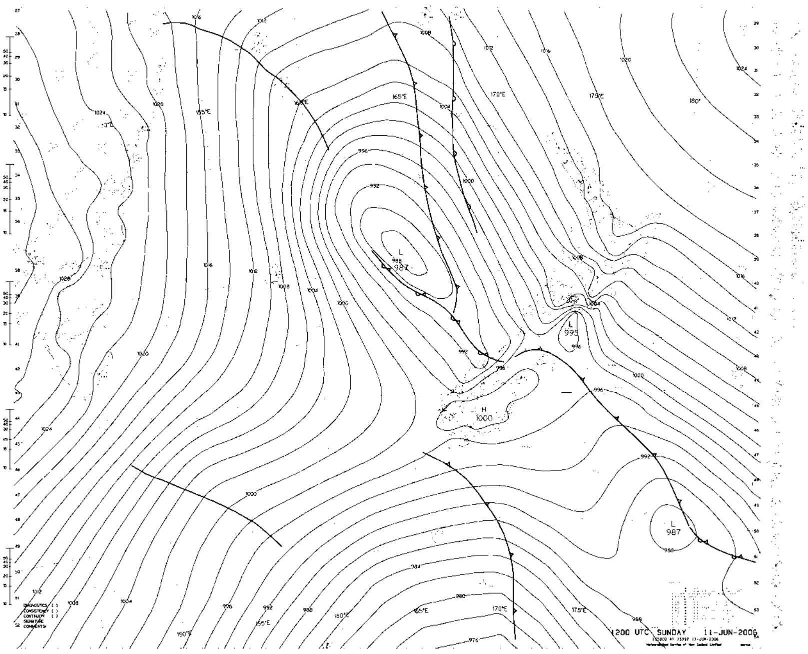
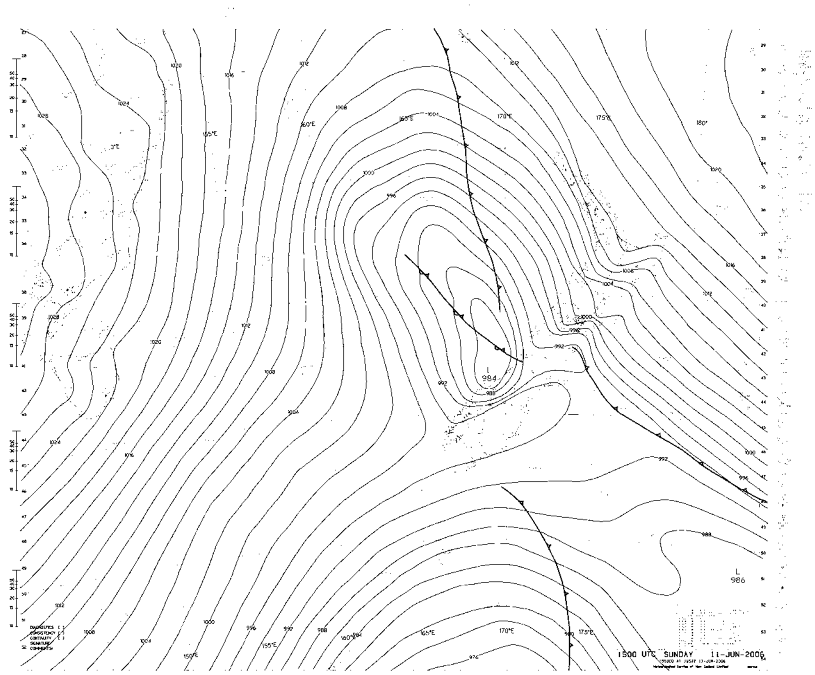
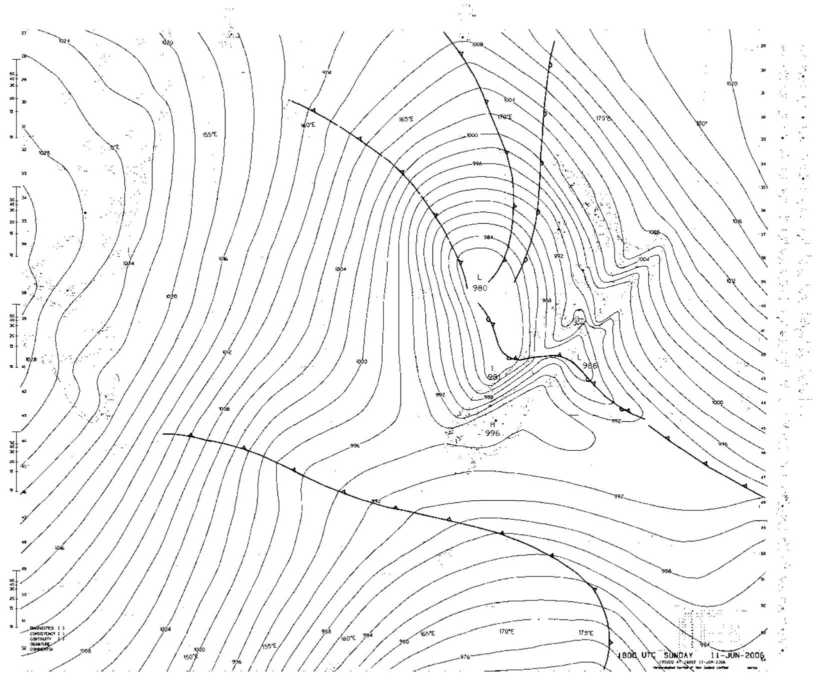

H
1019
H
1019
L
1014
L
998
L
998
0900 UTC FRI 05-MAY-2006

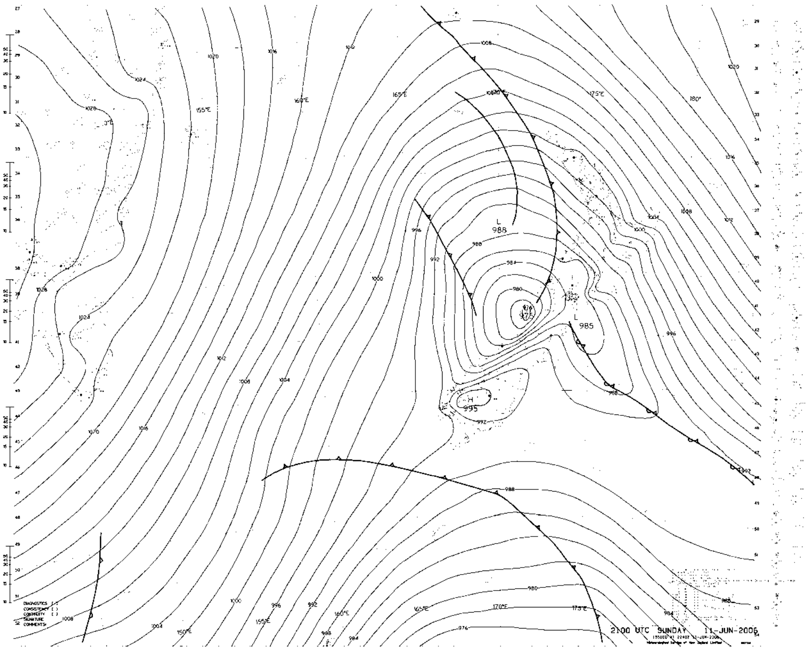
6. Appendix 2: Mean Sea level pressure maps over New Zealand for the period 11-12 June 2006.






L
984
L
986
1500 UTC SUNDAY 11-JUN-2006


L
980
H
996
1800 UTC SUNDAY 11-JUN-2006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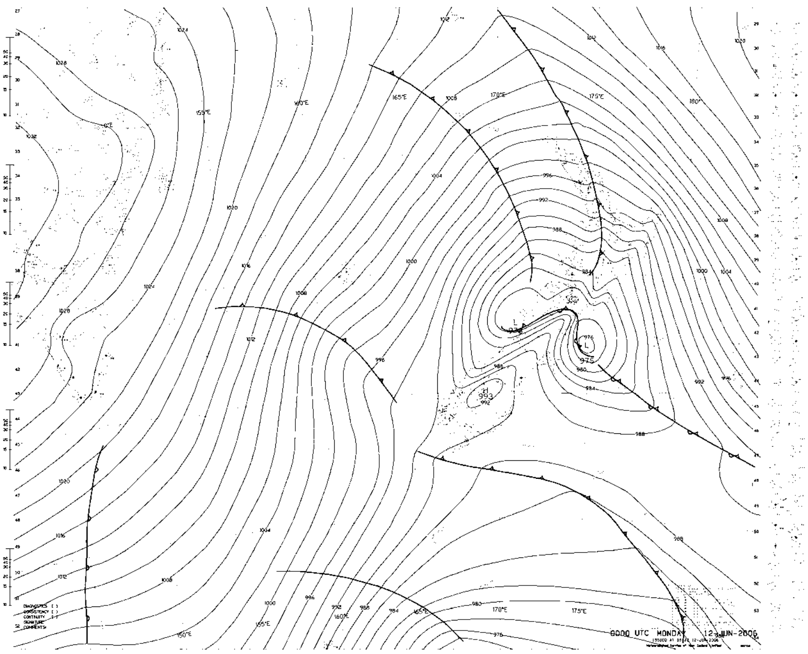
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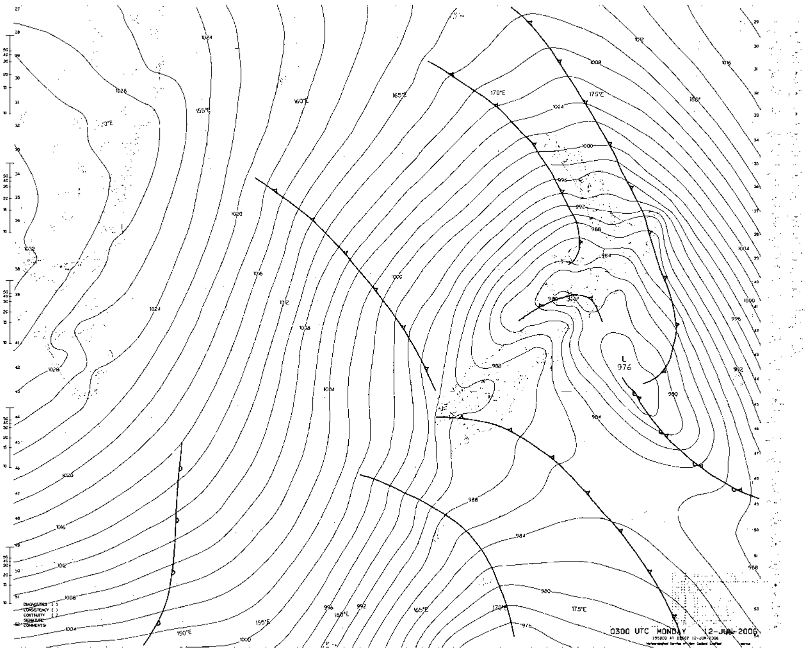
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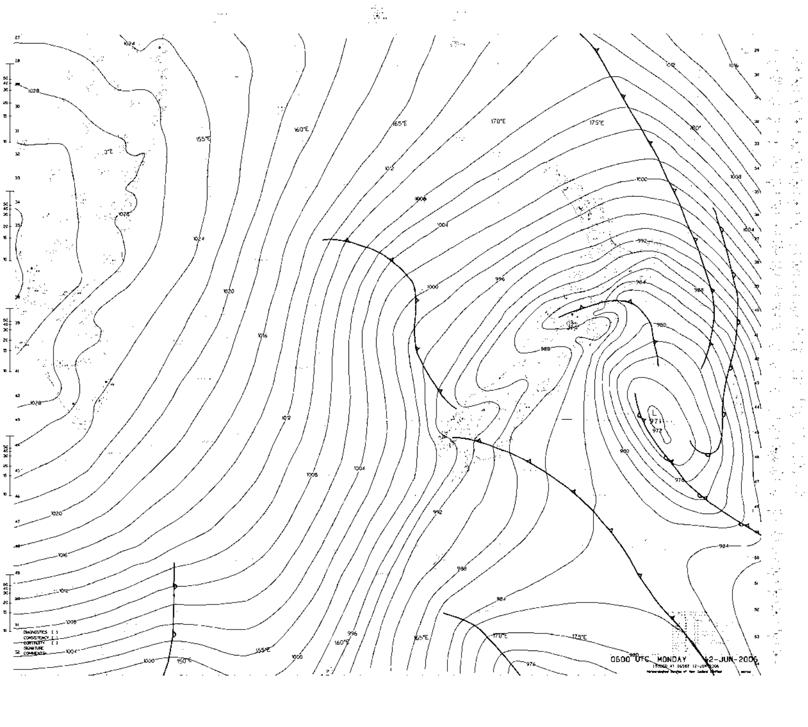
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