Aggregation in rivers and streams of the Taranaki Ring Plain

Photo 1 Stony River – upper ringplain – aggradation and erosion

Photo 2 Kaihihi Stream – Stony Walkway - bridge closed by bank erosion

Photo 3 Stony River – combined effects of deposition and erosion

Photo 4 Stony River – Vicinity of Egmont National Park boundary – bank erosion

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1. Purpose

The primary purpose of this report is to examine the condition of watercourses in the Taranaki ring plain with particular reference to bedload influence on channel condition. The report examines possible effects on land use and the need for Council to adjust existing policies and practices related to the management of gravels in watercourses.

2. Introduction

Heavy rainfall events centred on the Egmont National Park are a climatic feature of Taranaki and may result from cyclonic, frontal or orographic type systems. The main cone and the adjoining ranges are a prominent feature causing and attracting rainfall which may otherwise pass over the surrounding relatively low altitude landscape. The abruptness of these geographic features also stimulates rapid climate change, often resulting in unusually high rainfall intensities of relatively short duration. This type of event may result in high volume discharges from all or a small number of catchments draining onto the ring plain from the Egmont National Park.

Events of this type are not unusual and watercourse channels have been formed by these conditions. Since 1990 there appears to have been an increasing incidence of more intense storms effecting discrete or isolated parts of the Egmont National Park. This has resulted in some upper catchments channel stability deteriorating at a faster rate than others.

As all channels discharge through the occupied ring plain any changes in channel condition may affect adjoining property, public and private assets, infrastructure and communications. It is in relation to these matters that Council has statutory functions and responsibilities.

Storm event related channel deterioration over the last few years has resulted in Council taking action to provide assistance with some restoration and repair work on a number of occasions. It has also advised other public bodies of possible implications which may arise from deteriorating channel conditions. Council also commenced an investigation into a review of its policies relating to the management of and implications arising from rapidly increasing volumes of aggregate (bedload) within the ring plain watercourses

3. Background

3.1 Ring plain

With the exception of a small number, the rivers and streams of the ring plain rise from within the Egmont National Park (ENP) and the majority of these have their source on the volcanic cone of Mt Taranaki. The mountain slopes are naturally relatively unstable, steeply sloping and attract a high annual rainfall often delivered in high intensity short duration storm events. Watercourse channels are very steep in the upper reaches typically dropping over 1800 m in altitude over a distance of some 10 km to exit the ENP. The channels continue on a relatively steep and straight course across the ring plain with high energy forces capable of transporting significant volumes of gravel bedloads.

The ringplain is fairly uniform but has sectoral characteristics which are used to describe locations around the ring plain. These are shown in Figure 1.

Figure 1 Ringplain zones

Zones and catchments		
Northern	-	Waiwhakaiho to Maunganui
Eastern	-	Te Popo to Kapuni
Southern	-	Kaupokonui to Ouri
Western	-	Punehu to Werekino
Pouakai	-	Stony to Te Henui

3.2 Elevation

Elevation of Mount Taranaki, is 2518 m with shrublands occurring between about 1500 m down to the bushline at about 900 m, depending on aspect. The Pouakai summit is 1400 m and Patuha at 682 m is the highest point of the Kaitake Range.

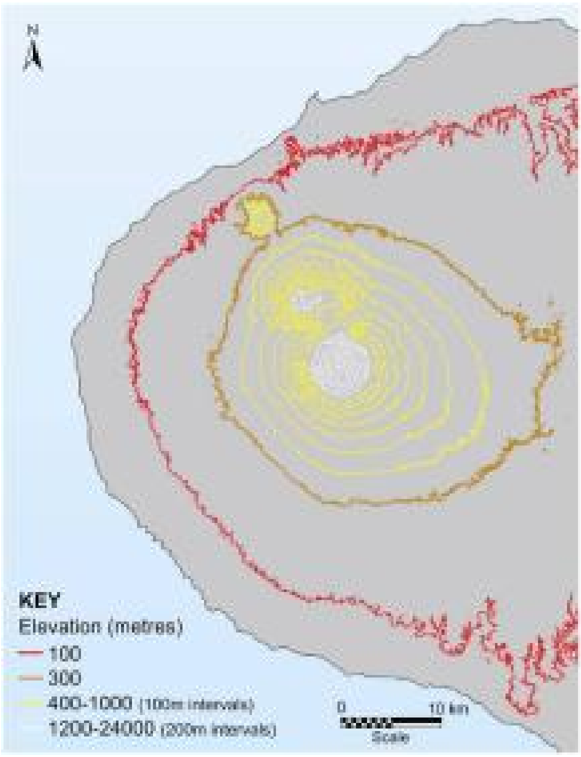

Figure 2 Elevation

The main part of the ring plain is generally 100 - 300 m asl in the west and south and 200 – 500 m asl in the east and north. There is a coastal strip of ring plain below 100 m asl between Oakura and Hawera.

3.3 Stability

The Kaitake Range is stable but in recent times landsliding has occurred on steeper southern slopes during high intensity rain storms resulting in downstream channel damage.

The Pouakai Range is also displaying evidence of more recently increased landsliding and some channel deterioration in the north-eastern area in the upper Oakura River catchment. The majority of the range is stable.

The least stable part of the mountain is around the Pyramid sub-catchment of the Stony River. This basin contains the most recently deposited material from volcanic activity and is comprised of deep beds of ash, sands and gravels. The most stable area is in the eastern sector between about East Egmont and Dawson Falls.

3.4 Rainfall

The mountain and ranges have a strong influence on rainfall by attracting orographic type events which are often associated with frontal systems and depressions moving through the Tasman Sea. Annual rainfall on the upper slopes of ENP is in excess of 6000 mm and ranges down to 3000 – 4000 mm on the western and southern slopes. The Kaitake Range receives 2000 – 3000 mm annually. The occupied northern and eastern areas rainfall range from about 1500 to 5000 mm, the western and southern areas 1250 mm to 3000 mm with a southern coastal strip receiving less than 1250 mm.

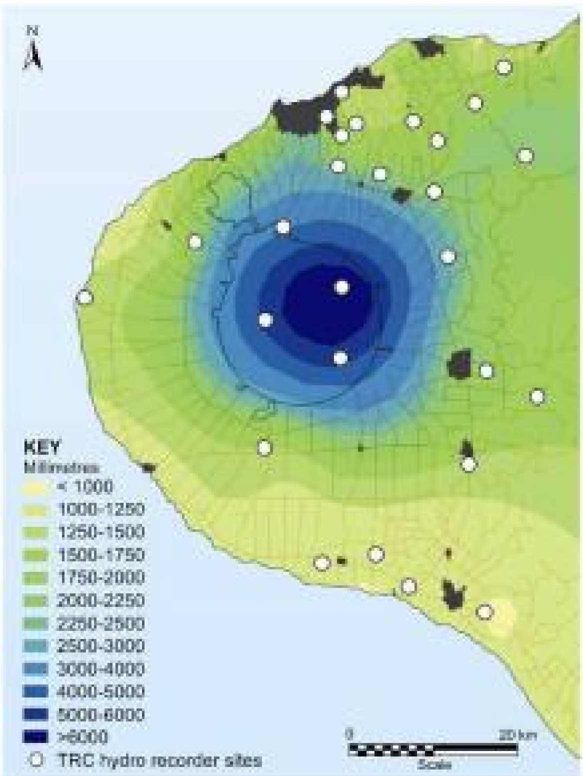

Figure 3 Average annual rainfall and ringplain hydro recorder sites

Although the annual totals are quite high, the way in which rainfall is delivered is more significant. Short duration, high intensity bursts of rain occurring during a storm event are potentially much more significant in terms of run off generated and related damage within the catchment and watercourse channels. Council rainfall recorders located at mid-altitude within ENP frequently record intensities in excess of 50 mm per hour and it is likely that higher intensities occur. The amount and rate of run off generated by rainfall is also influenced by slope and ground conditions. Bare, wet and steep slopes produce higher rates of run off.

3.5 Run off

The nature and characteristics of run off once it becomes flow in watercourse channels is dependant on a number of features irrespective of size. The slope or grade of the bed is a major factor controlling rates (speed) of flow. The speed and volume of flow has an influence on channel width and depth which may be changed naturally by bank erosion or bed aggradation. Faster flowing water in a steeper graded channel has more energy (power) to transport bedload (gravels) and to enlarge its channel width by bank erosion. As the channel grade flattens the speed of flow reduces with consequential effects. As flow rates slow a given volume of water will require a larger channel size. This is usually obtained by bank erosion and the development of berm or floodplain flow. With flatter grades, the power to transport bedload diminishes and gravel is deposited in the channel as aggradation, which in turn increases the slowing, deposition and erosion processes. Additionally, loss of channel capacity may lead to an increasing incidence of outflows, flooding and attendant deposition.

3.6 Channels

The diagrammatic representations of selected watercourses in Figure 4 illustrate the influence of channel slope/grade against distance. Typically, the upper most parts of the catchments (where channels are less defined) are located between the summit at 2518 m asl and 1800 m asl over a distance of about 1 km, a grade of say 700 m per km. Between the 1800 m contour and the boundary of ENP the channel grades range between 130 – 160 m of fall per kilometre. Channels in the upper ring plain have grades of about 20 m/km while the lower ring plain is about 10 m/km reducing more closer to the coast, particularly in the longer channels.

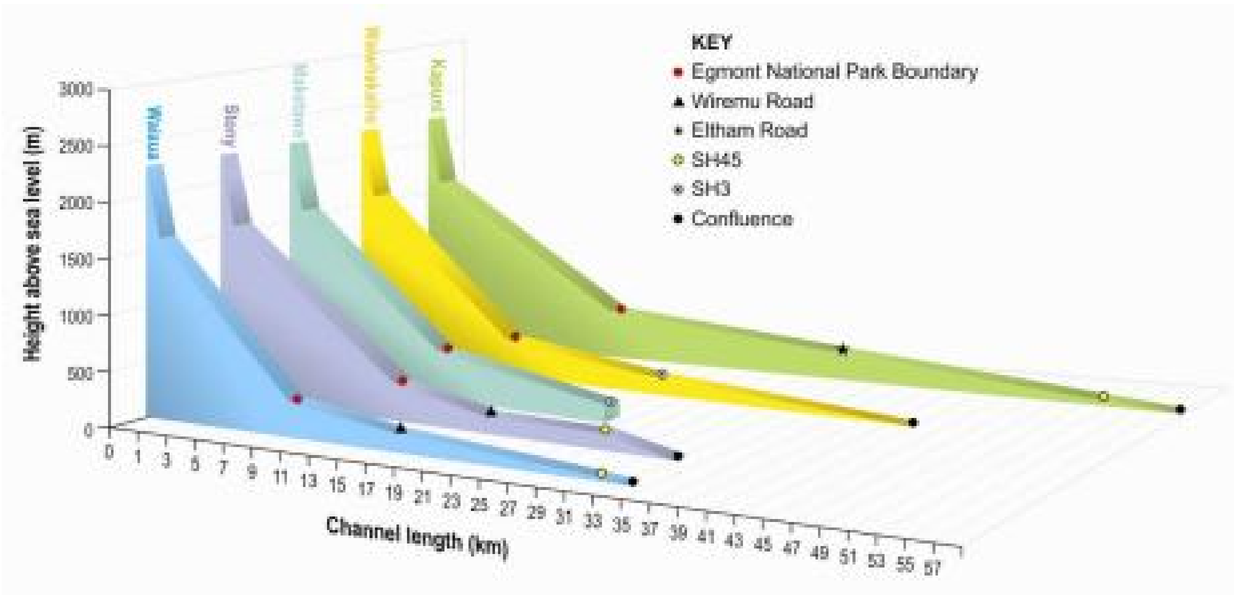

Figure 4 Schematic representation of selected watercourses

For purposes of comparison the much larger main channel of the Waitara River which rises at about 450 m asl, has a channel length of some 200 km and has an overall grade of 2 m/km. In the lower reaches the grade between Tarata (at 40 km upstream) to the mouth, is about 1.7 m/km and about half of that over the lower 10 km reach. In the steeper upper tributaries channel grades are typically in the 10 – 20 m/km range.

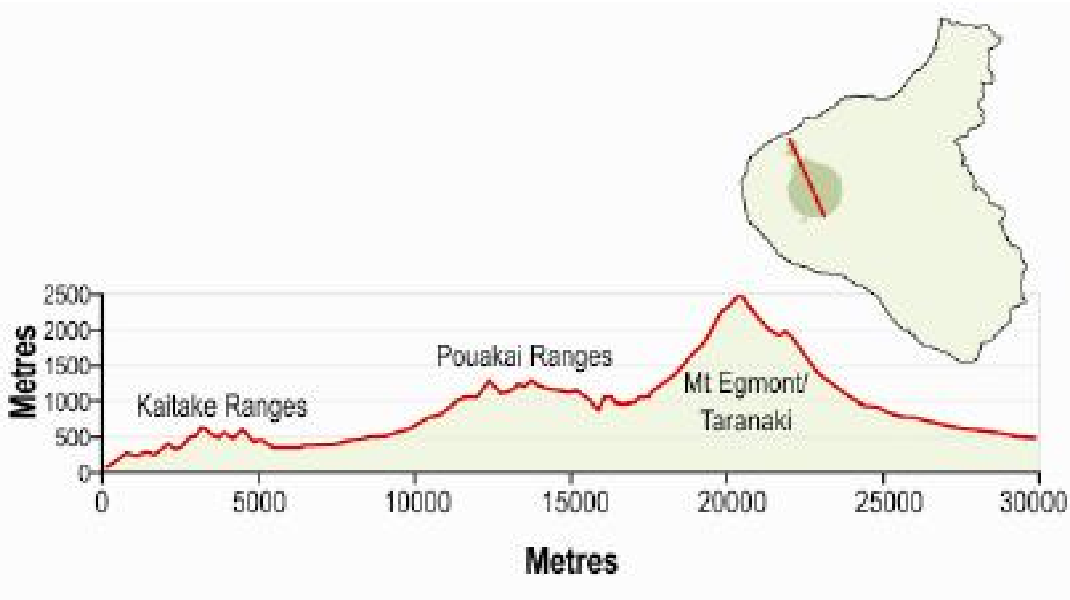

Figure 5 Elevation profile through Egmont National Park

4. Legal status and background

4.1 Ownership

'Sand and Gravel' is a Crown owned mineral included within the 'Interpretation' section of the Crown Minerals Act 1991 under 'Industrial rocks and building stones'.

Mining of Crown owned mineral restrictions **do not apply** where the mineral exists naturally in land owned or occupied by the person, for reasonable use on the property or is sand, shingle in the bed of a river, lake or in the coastal marine area. But this **does not remove the need to comply with other applicable Acts etc.**

4.2 Control

Extraction of gravel and sand for commercial purposes is subject to a mining permit and to the payment of royalties under the Crown Minerals Act 1991.

Dry land quarry operations for commercial extraction would also initially be required to comply with territorial authority land use provisions of the district plan.

Any extraction of sand or gravel from the bed of a river, lake or coastal marine area is required to comply the relevant regional plan.

The Taranaki Regional Freshwater Plan (RFWP), has allowed landholders to take up to 15 cubic metres a year from watercourses within their properties, for use on their properties, and provided it is not taken between May and October and not from areas covered in water. (This volume represents an area 5 m x 15 m covered to a depth of 0.2 m).

Removal of gravel from watercourses is allowed for Council controlled river control purposes.

4.3 Land ownership

Land ownership in and around waterbodies is a crucial factor in relation to activities in these areas. It can be confusing and is often misunderstood giving rise to much debate. A brief description of the situation as it occurs in Taranaki follows.

Private land
Parcels of land are defined by surveyed boundaries but where adjoining a water body its bank may be adopted (without survey). The waterbody may be a reserve of some type under the control of central or local government.

Where there is no such reserve the adjoining title enjoys *ad medium filum aquae rights* under a common law principle conferring presumed ownership of the bed to the middle of the stream. This does not apply to tidal or Coal Mines Act 1925 'navigable' rivers.

Crown Land
There are many types ranging from land without title (unalienated) through a variety of reserve classifications including roads. A high proportion of reserves are

vested into local government. Most reserves have at least one surveyed boundary and the extended 'ownership' provision applies.

4.4 Catchment authorities

During the late 1940's and early 1950's the main block of catchment authorities were established under the provisions of the Soil Conservation and Rivers Control Act 1941 (SCRCA). Catchment boards were set up in districts with a combination of duly elected and appointed representatives. Boards had statutory powers (including rating) and functions to administer the control of damage by floods and erosion. Districts were established by local request which resulted in partial national coverage.

By 1960 legislation change enabled catchment commissions to be established. These bodies comprised members appointed by territorial authorities to represent those authorities together with a minority of government appointees. Commissions administrative funding was obtained by agreed levies on each territorial authority.

Catchment authorities administered national policies at a local level and accessed government grants to support and undertake their functions and work programmes. Their linkage to central government was to an appointed national council.

4.5 Regional Water Boards

By 1970 further statutory change introduced water management and control and caused catchment authorities (boards and commissions) to also become regional water boards to administer the Water and Soil Conservation Act 1967 (WSA) and where no authority existed they were deemed to be established to administer both statutes.

Taranaki Catchment Commission and Regional Water Board was established in 1971.

4.6 Control of gravel extraction

In 1974 the Taranaki Catchment Commission used powers in the SCRCA to create a by-law to regulate shingle extraction from any watercourse. The purpose of the by-law stated at the time "*is not to restrict the winning of metal but to protect the streams from the effect of uncontrolled exploitation. Some streams already show evidence of overworking with consequent damage to stream bed resulting in loss of future supplies, danger to bridge structures and some erosion of river banks*".

Provisions of the WSCA (as amended) were used to attain protection of the Stony River in its natural state by a Local Water Conservation Notice in 1985. This effectively precluded any activities within the river other than those required for river and flood control purposes.

The enactment of the 1988-1989 central and local government review and reorganisation processes caused many significant organisational changes including the establishment of Regional Councils and their assumption of catchment authority responsibilities. Further changes occurred with the introduction of the Resource Management Act 1991 (RMA) and the abolition and amendment of related statutes.

The management and control of activities within watercourses have since become primarily regulated by plans and rules prepared under the RMA.

5. Geology

The geology of the ring plain is dominated by past and present volcanic centres with a large Pouakai ring plain being overlaid by formations arising from the present cone. Layers of conglomerates, breccia and tephra have been deposited over lahars and debris flows. Some of these formations have resulted from substantial collapse of part of the cone.

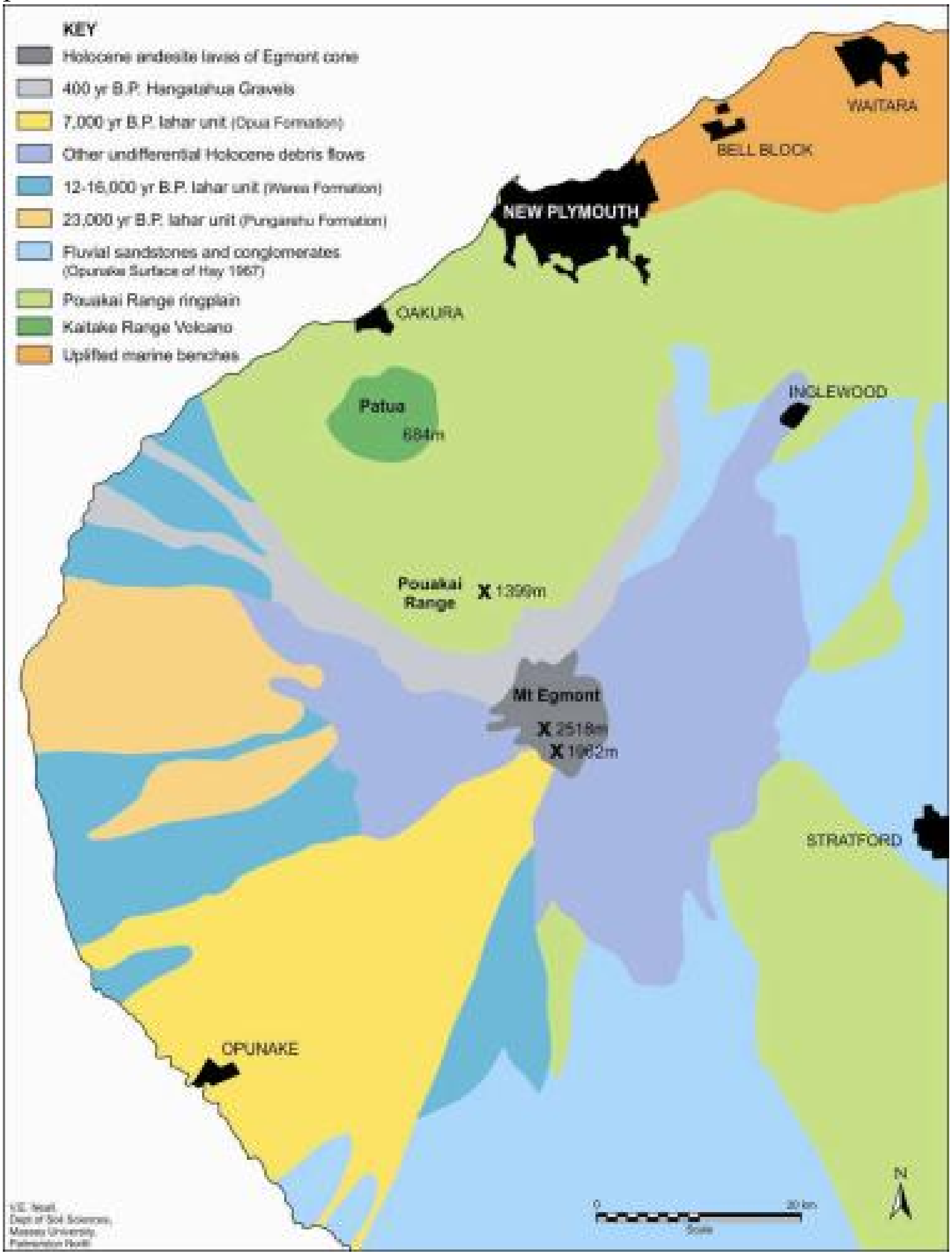

Figure 6 Elevation profile through Egmont National Park

The laharic deposits are very mixed and vary from concreted blocks through to uncompacted sands. Boulder content is variable with a greater percentage generally occurring nearer to the source. Older formations are usually more compacted. Andesitic lava flows are present on the cone above 900 m asl.

6. Watercourses

Watercourses on the ring plain became entrenched to varying degrees as they formed their channels through the volcanic formations. Lower reaches of watercourses draining larger catchments are often within a flood plain of a wider valley.

The variability of the material within the volcanic formations contributes to the susceptibility to erosion. Gravels and sands are readily transported within high velocity watercourses. Steeply sloping channels have even more energy to transport larger volumes, and size of bedload. Large boulders are often exposed in watercourses which were not transported as bedload but were deposited as a part of the formation and play an important control effect within the channel.

All ring plain watercourses transport gravel and sand as bedload. Within the last two decades a series of heavy rainfall events has caused increased erosion in the upper catchments. This has led to an increase in bedload within watercourses which has induced instability within channels resulting in damage to riparian lands and assets within or adjacent to floodways.

Photo 5 Stony River SH45 bridge, flood flows of about 200 cumecs

Photo 6 Stony River aggrading channel downstream of SH45

Photo 7 Stony River narrow incised channel upstream of SH45 with large gravel deposit in wider section beyond

7. Event/effect relationship

The Egmont volcanic cone is a very unstable structure in that it is comprised of successive layers of uncohesive deposited layers occasionally further destabilised by over steepening as a result of cone collapse. Only at the higher levels above 900 m does the andesite lava rock become evident.

Over time there have been a number of events centred within the Egmont National Park that have been a cause for concern to occupiers within the downstream ring plain. Events are usually associated with severe rainfall causing failure of slopes in the upper catchments. These may result in abnormally high flows, avalanches, lahars or channel damage all of which may result in adverse effects downstream.

One such event took place in the 1950's when a blockage caused a flow diversion from the upper Oaonui Stream into the upper Waiaua River. A similar but more substantial rockfall in the same locality resulted in a more significant diversion during a 1998 event. On this occasion there was significant damage experienced in the Waiaua River which included the Opunake Water Supply intake, the Opunake hydro plant and erosion and deposition on river frontages.

Photo 8 Lower Waiwhakaiho River downstream of SH3 with floodflow of about 350 cumecs

Similar events occur periodically around the mountain and they are now appearing to happen with increased frequency. The events are natural and they are triggered on the mountain, within the Egmont National Park. Little can be done in a practical or affordable sense to limit or restrict onsite damage. The effect will be transported downstream to cause damage to public and private assets on the occupied ring plain.

It is possible to provide some form of relief by intervention with river engineering in some instances. The questions of affordability, economic justification and effective permanence of the solution need to be considered.

The general situation is that aggradation is occurring in parts of most of the ring plain watercourses. Where it is happening it usually results in; elevated bed levels, channel blockage and diversion, bank erosion and possible increased flooding with attendant deposition and damage to assets. Accelerated rates of aggradation can only be managed by controlling the rate of bedload input into the watercourse. The prospect of any reduction of bedload material being contributed from sources within the Egmont National Park, is entirely dependant upon a significant change in current and predicted weather patterns.

8. Management of aggrading channels

8.1 Process

Aggradation is a process where bedload is deposited in the channel of a watercourse. The deposited material occupies channel space making less available for stream flow. It also flattens the grade of the bed of the channel and tends to divert flows often resulting in bank erosion. The end results are channel enlargement or an increased incidence of overflow from the channel and most frequently a combination of both.

8.2 Control

As it is usually not possible to readily arrest the process of aggradation, channel training works are usually undertaken to maintain an effective channel through the affected area where this is justified and affordable.

Controlled removal of deposited material is also an option but this has a number of pre-requisites to be effective. The most important of these include, type and quality of material, potential use and demand, volume, location and access. It is significant that the large proportion of aggregate material produced for industrial and commercial purposes in Taranaki for many years has been won from quarries located in lahar deposits and river terraces.

Additionally, local rock does not meet required specifications for highway sealing chip and railway ballast. As a result the product required to meet these demands are imported into the region.

It is unlikely that there will be any success in promoting gravel/aggregate extraction from regional watercourses as a means of managing the rate of increasing aggradation. Some opportunities may be occasionally available and more often in sites closer to centres of population.

9. Science interests

9.1 Massey University

The Egmont Volcanic Centre has attracted much scientific interest for many years. There is geological interest as well as the specialist volcanology interest and the acknowledged authority in both fields is Professor Vince Neall of Massey University. He has had a long association with the mountain and has authored and been associated with a vast range of papers, research and reports related to pedology, geology and volcanology of Taranaki. He has prepared a number of reports for Council, especially relating to the Stony River and plays an active part in the Egmont Scientific Advisory Group. A number of his colleagues and students have completed and continue to undertake projects and research in the area. All of this work provides an excellent information base.

9.2 Waikato University

In 2010 Nicola Cowie of the Coastal Marine Group, University of Waikato, made a presentation of Council of a sponsored report co-authored with Terry Healy and Peter McComb "Monitoring the Coastal Sand Wedge Outbreak from the Stony River". The work was based on the analysis of cross sections of the channel between 1995 – 2007 particularly in the Pyramid sub-catchment. It concluded that some 14 million cubic metres of material was discharged into the river of which some 3 million remained in the channel, a further 3 million to the sub-areal beach and 7 million being transported offshore.

It is possible that this work did not take into account the full extent of the effects of erosion, scour and aggradation affecting bedload movement within the channel during high flow events and may therefore be a little conservative.

9.3 Landcare Research

During 2009, Council investigated the possibility of obtaining some quantification of the rate of erosion of channels within the Egmont National Park and to establish some measure of the nature, extent and volume of bedload likely to be discharged into the occupied ring plain. This resulted in Landcare Research being contracted to undertake an analysis of available aerial photography of the Stony River catchment to test the method. Massey University joined in partnership to complete the project. Two extracts from the completed report follow.

Photo 9 Pyramid Stream. Erosion in upper catchment which discharges into Stony River within Egmont National Park

1 Introduction

Landcare Research (NZ) Ltd was contracted by Taranaki Regional Council (TRC) in 2009 to map areas of severe erosion and deposition in the upper Stony River catchment, Egmont National Park. The Stony is the most extreme example of a number of catchments draining Mt Taranaki/Egmont that are experiencing severe, and apparently worsening, erosion in their headwaters, presenting consequent aggradation problems to farming and infrastructure lower down on the Taranaki ring plain".

6 Conclusions

Mapping of bare ground in the study site in this study has indicated the following:

- *As of 1979, analysis of bare ground showed that the study site appeared to be in the early stages of recovery from a possible earlier period if disturbance, with decreases in both erosional and aggradational bare ground by 1994. The Stony River channel appeared little changed over this period, with low terraces up to and including the confluence with Pyramid Stream remaining largely intact by 1994 with a vegetation cover becoming well established. Measurement of bare ground along 19 cross-sections distributed throughout the channel system in the study area also documented this apparent stabilisation.*
- *Significant changes occurred between 1994 and 2007 with a particularly large increase in the area of active aggradation in the channel of Pyramid Stream and the Stony River. This clearly resulted from accelerated erosion and expansion of the large gully system in the Pyramid Stream sub-catchment, which dumped as much as 14.3 million cubic metres of debris into the channel system between 1995 and 2007 from a relatively small part of the sub-catchment. This rapid change in channel condition was also recorded by significant increases in active channel width along the cross-sections measure, particularly downstream of the Pyramid Stream gully system.*
- *Available rainfall data suggest that the accelerated erosion in the study area between 1994 and 2007 may have been triggered by a series of particularly large storms in the second half of 1998 which caused significant damage to many catchments on Mt Taranaki and probably left them predisposed to higher rates of erosion during subsequent storms.*
- *Storm intensity, not just storm magnitude, is considered by Neall et al. (2008) to be a significant factor in determining how much erosion occurs within a catchment during a storm event. Analysis of peak stream-flow data in this study suggests the frequency and intensity of storm events may have been increasing on Mt Taranaki since at least 1980, which, if such a trend is established and continues into the future, has implications for further severe erosion and aggradation in the study area – and, of course, other vulnerable catchments on Mt Taranaki.*
- *Since the last date of photography mapped in this study, further significant erosion has occurred in the study area and in other catchments on the mountain, most notably in response to a particularly intense storm event in April 2008 which caused the Stony River to notch up its highest flood peak on record. Elsewhere on Mt Taranaki, rain-triggered lahars during this event also caused major damage to the Maero and Maketawa Streams. It is clear that the trend of increasingly severe erosion, perhaps linked to increasing storm frequency and intensity as noted above, has continued beyond 2007 and may do so into the future.*
- *The detailed mapping of erosion and aggradation from sequential aerial photography in this study offers a consistent, objective and accurate means of assessing changes in catchment condition over time. The advantage of mapping from aerial surveys is that imagery can be acquired shortly after significant storm events and mapping results can be made available quickly, offering the opportunity for rapid measurement and*

> *reporting on the effects of significant storm events soon after they happen. Modern colour aerial imagery can be flown at very high resolutions, which offers the potential for even higher levels of spatial accuracy than achieved from the older imagery used in this study.*

The results of this project attracted national media attention.

9.4 Geological and Nuclear Sciences

The "Landcare Report" generated the interest of the Institute of Geological and Nuclear Sciences (GNS) who proceeded with a separate work. GNS work is centred on *'mapping the existing landslides on Mt Taranaki using satellite imagery and information from a recently completed Landcare report (October 2010). This mapping will then form a baseline for assessing the rate at which landslides occur on Mt Taranaki in the future….. This mapping will then be used to identify sites for field inspection to collect samples and information such that the material properties of the rocks and soils of Mt Taranaki can be determined. These material properties will be used directly in current research activities on Mt Taranaki looking at the potential for large scale sector collapse".*

9.5 Options

Other methods are available to obtain quantative information about the location extent, rate and volume of deterioration occurring within Egmont National Park. One such method is Lidar surveying involving laser scanning capturing vertical detail down to about 0.2 m. Regular monitoring (repeat flying) is necessary to capture change and derive the information sought. This type of activity is being adopted in some regions to replace manual surveying in managing channels and flood plains of major rivers.

10. Conclusions

10.1 Upper catchments

The Egmont National Park contains the Egmont Volcanic Centre and the headwater catchments of most of the ring plain rivers and streams. The Kaitake and Pouakai Ranges which are remnant extinct volcanoes much older than the main cone, are more stable than Mt Taranaki. There is a lack of uniformity and cohesiveness in the materials forming the steeply sloping mountain. As a consequence of this it is inherently unstable, prone to slope failure, landsliding and erosion of watercourses.

10.2 Weather effect

As a physical feature the mountain attracts and receives heavy rainfall in terms of both intensity and totals. Severe events on the upper slopes may result in falls of 50 mm or more per hour and 200 mm or more in 24 hours. It appears that severe events are becoming more frequent in the last two decades. Such events destabilise catchments and may cause significant erosion. Channels draining from the Egmont National Park are damaged by high energy torrent flows, by erosion and aggradation. Flooding and deposition may occur in the lower reaches.

10.3 Damage

High value intensive agricultural production dominates the occupied ringplain which has a dense natural drainage pattern of permanently flowing streams. Most properties have at least one watercourse flowing through it causing some impact on farm management. Public roading networks and other infrastructural utilities operation and maintenance are also effected by the large number of watercourses.

10.4 Long term effects

The combination of the increasing incidence of severe rainfall events, destabilisation and erosion and the associated change of flow and channel characteristics is showing increasing adverse effects in the watercourses in the occupied ring plain. These effects include: aggradation, lateral bank erosion, elevated high flow levels, flooding, deposition, damage to public and private infrastructural assets and disruption. Setting aside the climatic influence, the primary cause of the physical damage is the loss of channel capacity due to aggradation or deposition of gravels within the channels. This initiates the cycle of compounding inter related problems.

10.5 Management options

Managing an overabundance of bedload gravels in a watercourse and controlling the related effects is complex and more difficult when the primary source of the material cannot be controlled.

- Diversion of gravels into storage areas adjacent to the channel is a method that has been used successfully in isolated cases in other regions. This is not an option here in high value agricultural land.
- Removal of surplus material by managed gravel extraction for commercial and industrial purposes is a satisfactory method widely applied in most regions. However, unless the site to be managed contains high quality aggregate in large volumes and is relatively close to centres of demand, larger longer term operations are unlikely to be established.

In the Taranaki situation, ring plain rivers and streams are relatively short and upper reaches have substantial riparian vegetation. Erosion rates in the high energy watercourses result in a significant amount of wood being mixed with gravels arising from the instream grinding processes while timber and gravels are transported downstream. This is an impurity for many end uses and is difficult to eliminate. As a consequence quarrying of laharic based aggregate at a site where a processing plant is established becomes a favoured alternative.

Generally a minimum amount of processing is required on site in watercourse extraction of gravels. The size of ring plain streams determines the relative volume and availability of aggregate which together with processing, access, land tenure, distance to market and transport are reflected in product cost. These considerations again tend to favour fixed site operations.

Taranaki sourced aggregate does not meet the abrasive strength test specification standards for both state highway sealing chip and railways ballasting. Those potential markets are therefore not available.

The grading range of naturally transported gravels in the relatively short ring plain channels has a high percentage of larger stone size. There are few uses for 'run of the river' gravels so some processing by screening is generally required either on site or at a facility elsewhere. This limitation can be overcome by site selection to some degree. But the economics of the activity would be determined by the end use of the product, processing and transport costs.

The vast majority of aggregate users obtain the product from supply specialist operators. These operators have fixed processing facilities based on quarry sites using laharic and terrace deposit resources. There is a very high capital investment required for processing machinery which is increasingly expensive to operate with rising energy costs.

For the foreseeable future it would appear that usual demands for aggregate can be met from a continuation of currently favoured supply methods. Any exceptional additional demand is likely to be project related and probably located in the vicinity of a population centre. In this event suppliers adjust to meet the circumstances, as they have in the past.

There appears to be no commercial advantage for aggregate suppliers to change the base operations from quarrying to extraction of river gravels from ring plain watercourses in situations other than advantageous sites in relative close proximity to established plants.

10.6 Egmont National Park

The headwater catchments of most ring plain rivers and streams are located within Egmont National Park. The cornerstone of management policy of land, fauna and flora within national parks is founded on naturalness. Management interventions have objectives of protection and preservation of naturalness or to promote and assist public access to and enjoyment of that naturalness.

Lands within Egmont National Park are being affected by climatic event related destabilisation of an already fragile geologic structure comprised of the extinct Kaitaki and Pouakai volcanoes and the presently dormant main Egmont cone. Public enjoyment of Egmont National Park relates to features of; landscape, recreation, flora, fauna and visual appreciation. There are elements of strong scientific interest with volcanology and stability of the main cone attracting particular attention due to the natural hazard and public safety associated aspects.

It can be expected that management of the Egmont National Park will continue to focus on naturalness which would preclude consideration of any intervention measures interfering with natural processes.

Continued activity by the scientific fraternity can be expected. Opportunities should be taken to obtain relevant information as it becomes available and where appropriate to join with and promote studies and investigations. Monitoring of catchment condition within Egmont National Park will provide essential and vital information to facilitate the management of ringplain river and stream channels.

11. Obstructions to flow in watercourses

Barriers of various types interrupt the natural flow of watercourses. Some barriers are natural and usually of a short term while others may be man made with a planned long term purpose. Any interruption to flow reduces naturally occurring energy and the watercourses ability to transport sediment and bedload.

11.1 Natural barriers

These may include restrictions resulting from streambank collapse, damming by log jam or aggradation from accelerated introduction of bedload into the channel. The very effect of interruption to flow promotes aggradation which may or may not be cleared by successive high flow events where the watercourse attempts to return to natural state and processes.

11.2 Man made barriers

Structures such as; dams, weirs, fords, bridges, culverts interrupt natural flow. The only exception is a structure that has no part within the channel or on the floodway or berm and is sufficiently high to be clear of the highest flood flow.

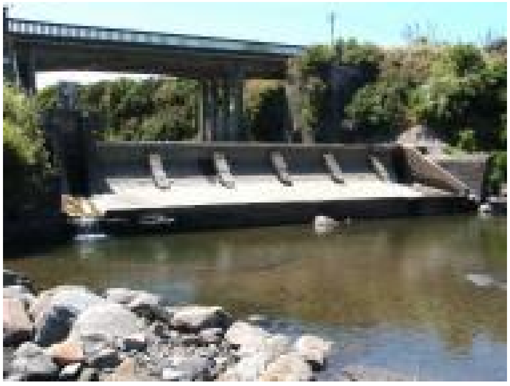

Photo 10

Photo 11

Photo 12

Photo 10, **Photo 11**, **Photo 12** Waiaua River at SH45 Weir to divert flow for electricity generation. Local clearing required by consent. Deposition extends upstream

TRC has investigated barriers to fish passage and reports "Dams and Weirs and Fish Passes in Taranaki" May 1995 and "Dams, Weirs and Other Barriers to Fish Passage in Taranaki" May 2001 contain detailed site records. Following on from the 1995 report Council commenced a programme to remove redundant structures which would restore fish passage and importantly restore natural characteristics including bedload transport. Structures had caused aggradation, bank erosion and elevated flood level upstream while depleted bedload transport had resulted in channel deterioration and erosion downstream. After work had been completed at some relatively minor sites to remove redundant and remnant structures, intervention by the Historic Places Trust caused the programme to be stopped.

The 2001 report identified 63 consented structures that were barriers to fish passage (with all but one on the ring plain) and of these 26 required remedial action. A further 45 structures (with 5 outside the ring plain) were identified that were not consented. Ten met fish passage requirements, 30 needed attention and 5 were classed for removal.

Fish passage can be affected by the construction of a bypass or ladder but such facilities do not provide for the passage of bedload. It is noted that all of the structures referred to in the reports may not be located in watercourses with gravel bearing bedloads. It is also noted that the lists may not reflect the total or current situation.

Structures creating impoundments eg dams capture bedload until the reservoir is full. The reduced flow velocity is reflected upstream causing bedload to drop and shoal upstream of the reservoir area. Downstream of the structure the energy contained within flows is not dampened by the transport of bedload. These higher than natural levels of energy result in bank erosion and channel and bed scour as the energy is dissipated in reaches downstream of the structures.

The abundance of ring plain watercourses gives rise to an abundance of structures for purposes of crossing and the opportunity to take and use water in an intensively occupied area.

TRC statutory functions and responsibilities require that its priority for attention is directed to the occupied lands of the ring plain beyond the boundary of the ENP. In respect of the range of issues relating to an accelerated rate of aggradation occurring within a high proportion of ring plain watercourses priority must be given to promoting awareness of the actual and potential hazard of damage to public and private assets. Damage by flooding and erosion will occur to an increasing degree as the incidence and severity of intense rainfall events increase as an anticipated result of forecast climate change effect.

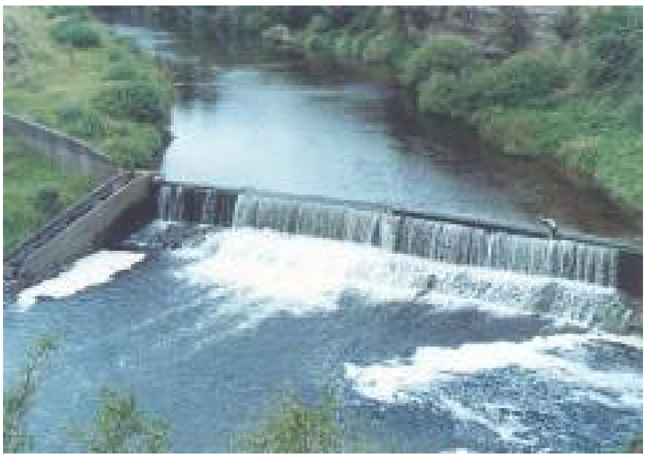

Photo 13 Kaupokonui Stream Weir build for dairy factory water supply at Glenn Road

Watercourses transporting gravel dominated bedloads will be the most affected. Where channels are incised and the highest flows are contained within steep banks natural grades are likely to continue to facilitate bedload movement without significant aggradation.

Where channels are less contained and higher flows occupy adjoining berms or floodplains velocities will be lower and aggradation, erosion, deposition and flooding will impact on attendant lands and facilities.

The variability within ring plain watercourses generally is such (with few exceptions) that problems arising from or related to increased rates of aggradation are not likely to occur throughout the entire channel length. The Stony River channel is one such exception where aggradation related problems occur throughout its length. This is due to exceptionally high erosion rates occurring in very unstable headwater catchments which are prone to receiving high intensity rainfall and bedload is being introduced to the channel at rates well in excess of its ability to transport it.

12. Policy considerations

Council statutory functions and responsibilities in relation to the management of aggregate or gravels in watercourses are derived from the RMA and the SCRCA. Policies adopted from RMA requirements are contained within the RFWP while those relating to the administration of river and flood control functions are from the SCRCA.

12.1 Resource Management – Regional Fresh Water Plan

The RFWP generally restricts activities undertaken "*on, under or over the bed of a river*" and provides for activities undertaken for river and flood control purposes. Various rules apply in different circumstances and an activity may be permitted or require a consent which would be subject to conditions. Removal of gravels would usually be subject to a consent.

Gravel is a Crown owned mineral and the Crown Minerals Act enables adjoining landholders to extract gravel from waterbodies for use on their property under *ad medium filium aquae* rights, subject to the provisions of any other Act. Council's RFWP allows adjoining landholders to take up to 15 m^3 annually and may permit larger volumes and other uses through a consenting process. The allowed 15 m^3 is a very small amount and river gravels (unless screened) are largely unsuitable for use on dairy farm races or yards, accepting that dairy farms are generally the adjoining occupiers of ring plain watercourses.

Raising the allowed limit is unlikely to have any significant effect upon volumes of gravels extracted from watercourses.

12.2 River and flood control

Existing Council policies enable river and flood control activities to be undertaken by the Council or by others for the benefit of the community or individual landholders where the purpose is for the prevention of damage by floods and erosion.

Increasing rates of aggradation and deposition of gravels in watercourse channels results in reduced channel capacity, the attendant increase of overflow from channels and lateral channel erosion. Structures such as; bridges, culverts, water supply intakes, fences and buildings are subject to damage and inundation. Flood plains or berms of ring plain watercourses are usually very small where they exist and increase in size only slightly in the lower reaches. The impacts of increasing loss of channel capacity structures and lands within and adjacent to those channels will accelerate the rates of deterioration of and damage to public and private assets.

Public assets that will be subject to damage will be dominated by roading with reserve lands and water supply also being affected. Commercially operated public services of; energy supply (gas and oil pipelines, electricity generation and reticulation) and telecommunications may also be damaged.

There is a need for increased awareness of the impacts that accelerated watercourse channel aggradation will impose upon managers of riparian related assets. Resource managers in local government must take the issue into account through planning and regulating processes to ensure that public risk and hazards are avoided.

Photo 14 Stony River – Establishing a diversion cut to re-align a channel through an aggraded area

Council should increase its level of activity in promoting awareness of the deteriorating channel stability conditions within ring plain watercourses. There should be an increase in the level of advice and assistance provided to asset managers and to landholders adjoining these rivers and streams.

Council has undertaken selected channel management works directly and also by contribution to works for flood damage restoration, river control and flood control purposes in a range of circumstances. The more significant Council direct projects to include:

Stony River	channel training adjacent ENP boundary and Blue Rata Reserve
	channel training vicinity SH 45
Kaihihi Stream	channel clearing and training adjacent Okato township
Mangatete Stream	channel clearing vicinity Oxford Road
Waiaua River	channel training upstream of SH 45
Waiwhakaiho River	channel training upper reaches adjacent to Alfred Road

Council contributions to shared river and flood control projects have occurred at various sites throughout the ringplain largely following flood events but also including other works where off site community benefit values were present. The majority of these works have been undertaken in the western and southern zones of the ring plain.

There is an opportunity to extend the number of managed reaches of key sections of selected rivers to implement programmed works for community and local benefit.

Photo 15 Stony River – Heavy rock training work to divert channel into new alignment

The continuation and extension of managed programmes for river and flood control purposes include the above referenced watercourses. Further attention should be applied to the Stony River with a view to reducing the risk of right bank overflows into the Kaihihi Stream upstream of Okato and other outflows upstream of SH 45.

The Mangatete Stream channel between its confluence upstream to about Oxford Road has a very high volume of gravel bedload mobilised during flood events which seriously restricts channel capacity and discharges into the Kaihihi Stream.

Bedload added to the Kaihihi Stream impacts on channel efficiency leading to flooding and erosion upstream of SH 45 while there is a growing need for channel management downstream.

Typically the ringplain watercourses will present pressure points where channel grade flattens e.g. upper Waiwhakaiho River below the ENP boundary and the Waiaua River upstream of SH 45. Although the western and southern sectors have presented a higher risk to date there is evidence of a deteriorating situation in the northern sectors. Loss of channel capacity and condition results in damage by erosion and flooding and management of those effects necessitates ongoing intervention and maintenance programmes.

Photo 16 Stony River – Completed diversion and new channel to mobilise and increase gravel movement and reduce deposition

There is a need to access, gather and obtain information from relevant sources so as to enable Council to monitor, manage and quantify the overall situation then to target and act in areas of higher need, risk and hazard together with those affected by the hazard.

13. Structures in watercourses

Matters associated with obstruction of fish passage by structures have been addressed by Council. Policy has been adopted and procedures are in place to deal with known existing structures and to apply appropriate conditions during the consenting process of proposed structures.

The legacy of effect on channels caused by bedload impounding structures has not been addressed. When considering a few structures in the past the option of removal has been thwarted by the practicalities involved in managing the impounded gravels.

Many of the structures are that old that the downstream modified channels have almost become accepted as "natural state". Despite an apparent "permanence" there remains a risk of failure and the associated hazard downstream. The level of hazard is largely determined by its location, height, volume of impounded solids and condition of the structure. In the event of complete structural failure it is likely that only in the case of smaller barriers would there be a complete sudden release of impounded solids. In other cases while there would be an initial pulse of material released successive freshes would rework and regrade the material and the stream channel with some adverse effects occurring.

It would be appropriate for Council to ensure that owners of structures in watercourses which impound sediments or bedload are aware of potential hazards and liabilities. Contingency planning for management of the structure incorporating removal of redundant or high risk structures. Strategic removal of impounded material is a management option. Consideration of these matters could be addressed as a programme or at the time of resource consent renewal.

The processing of applications for the consenting of new structures within watercourses should include both short and long term effects of the structure on channel condition and dynamics. Also, consideration of impacts in relation to the retention of sediments and bedload and how such accumulations may be managed.

Photo 17 Dam dropping. Waingongoro River Normanby Weir diversion for electricity generation

14. Summary

14.1 Situation

During the last twenty years an increase in the incidence of severe rainfall events has been experienced around the mountain and ranges of the Egmont National Park. Short duration high intensity rainstorms have particularly affected unstable slopes at higher altitudes. Less intense but still severe rain has fallen on lower slopes. Collectively these events have caused significant deterioration of channel condition in a large proportion of catchments discharging through rivers and streams in the occupied ring plain. Erosion has resulted in high volumes of gravels being added to bedloads. Watercourses have reduced ability to transport them through the channel and as a consequence channels capacities and efficiency are being reduced by aggradation and deposition. Deteriorating channel condition leads to increased bank erosion, flooding and damage to riverine assets.

The primary problems are sourced within the Egmont National Park where management principles of such lands preclude intervention to manage adverse effects of natural processes. (Realistically, little measureable beneficial impact could be expected within the bounds of economic practical reality). The greatest impact will be felt in the channels below the Egmont National Park boundary in the occupied ringplain where public and private property and infrastructural assets will be subject to damage. It is in these locations where Councils' statutory functions and responsibilities will require implementation which gives rise to the need to develop appropriate strategies, policies and programmes.

14.2 Management and control options

- Based on the range of information available it is reasonable to assume that the periodicity of episodic severe and intense rainfall events occurring with Egmont National Park, has become more frequent in the last two decades. This has resulted in accelerated rates of erosion within the steeper and less stable catchments. Intervention to attempt management of natural processes within the Egmont National Park is not practical, affordable or in accord with National Park management philosophy. Any opportunity for intervention exists within and adjacent to watercourses downstream of the Egmont National Park boundary where increased bedloads are impacting on the management of assets and resources.

- Where aggradation and deposition of bedload gravels is occurring within watercourse channels of the ring plain the incidence of stream bank erosion and damage to adjoining lands and structures by inundation, flooding and deposition during storm events will increase. This damage and its effects will have a significant cost to the community. The opportunity for practical and affordable physical intervention by engineering methods will have very limited application at localised sites. These would be for the protection of assets or the management of deposition to maintain floodway capacity by enhancing bedload transport.

- Bedload gravels, as aggregate are a commodity of wide use and demand where they exist in larger volumes, are of good quality, suitable for processing to multiple uses and generally located closer to centres of demand. With a small number of notable exceptions, ring plain watercourses radiating out from Egmont

National Park passing through private property do not possess all of those attributes. As a consequence more permanent quarrying operations based on laharic and river terrace deposits are more favoured from a commercial view point. It is unlikely that present operations will change to an extent that managed increased aggregate extraction from watercourses will influence the presently existing deteriorating condition of ring plain watercourses. Opportunities that may foster some localised benefit should be encouraged.

- Council's existing policies within the RFWP are focused on the management of river gravels to; limit volumes extracted by adjoining landowners, prescribe dry beach operation and to protect instream aquatic life and water quality. The very modest amount of gravel extracted by adjoining landowners for use on their properties has proven to be of neither detriment or benefit.

- The matter of ownership responsibility of structures which impound and obstruct the transport of bedload should be addressed to ensure that appropriate contingency and management plans are in place.

- The likelihood of periodic flooding of the limited floodplains and bermlands adjacent to ringplain watercourses is a recognised natural hazard. Deteriorating channel conditions, especially the reduction of capacity as a result of aggradation, will increase both the incidence and severity of the hazard. The future use, management and control of activities in these hazard areas require to reflect the hazard and impose appropriate restraint.

- Council should continue to provide core advisory services for river and flood control to landholders. Enhanced levels of assistance including some cost sharing where appropriate, as follow up to damage of a community benefit nature following significant storm events should also be continued. Similarly the adoption of managed reaches of selected watercourses of key community importance particularly within the western, southern and northern zones, should be continued and expanded where appropriate.

- There is a need to capitalise upon the continuing and growing level of academic and scientific interest in the broad subject of stability of the main cone of the Egmont Volcanic Centre. Research and project related activity will provide further information of benefit to Council. Liaison and co-operation may lead to obtaining data upon which future management strategies may be developed.

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16. Acknowledgement

A large number of individuals have contributed information by providing time to share their knowledge, views and opinions about the geological structures and features within the Egmont National Park. Discussions have included aspects of the ring plain, its land use and particularly as to how rivers and streams should be used and managed. There are and will always be conflicting views reflecting individuals particular interests.

The contributions made by others in numbers too large to record, are acknowledged.