NIWA

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Impacts of stone-harvesting from the Houhou – Kaihinu foreshore

NIWA Client Report: CHC2003-090
August 2003

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D. M. Hicks

Prepared for

Stoneweavers Ltd, Hokitika

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National Institute of Water & Atmospheric Research Ltd
10 Kyle Street, Riccarton, Christchurch
P O Box 8602, Christchurch, New Zealand
Phone +64-3-348 8987, Fax +64-3-348 5548
www.niwa.co.nz

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Reviewed by:

Jeremy Walsh

Approved for release by:

Ross Woods

1 Introduction

This report was commissioned by Stoneweavers Ltd, Hokitika, to investigate possible environmental impacts of their proposed harvesting of stones from the beach face along a 3.5 km span of shore between Hokitika and the Arahura River. The stones are to be used by Stoneweavers to make doormats, ornamental furniture, and similar items for the purpose of sale. Stoneweavers are presently preparing a Consents Application for this harvesting.

1.1 Key points of consent application

- Consent to remove up to 50 cubic metres per year of stone from the beach face below mean-high water level from a 3.5 km span of shore approximately between Houhou and Kaihinu.

- The southern limit of the harvesting area is the groyne at the Hokitika oxidation pond; the northern limit is the southern boundary of the Maori Reserve on the southern side of the Arahura River mouth (Figure 1).

- The stone would be hand-picked from the beach during low tides and transported off the beach by 4WD vehicle. Beach access would be via two existing vehicle tracks: (1) the track adjacent to Stoneweaver's premises at Houhou; (2) the track at One-Mile Line Road at Kaihinu (Figure 1).

1.2 Issues

The issues associated with Stoneweavers' proposal are:

- that the stone resource on the shore may become significantly depleted

- that the removal of the beachface material may degrade shore stability along the harvested shore and adjacent coast

- that the associated beach access may degrade the beach environment and landscape.

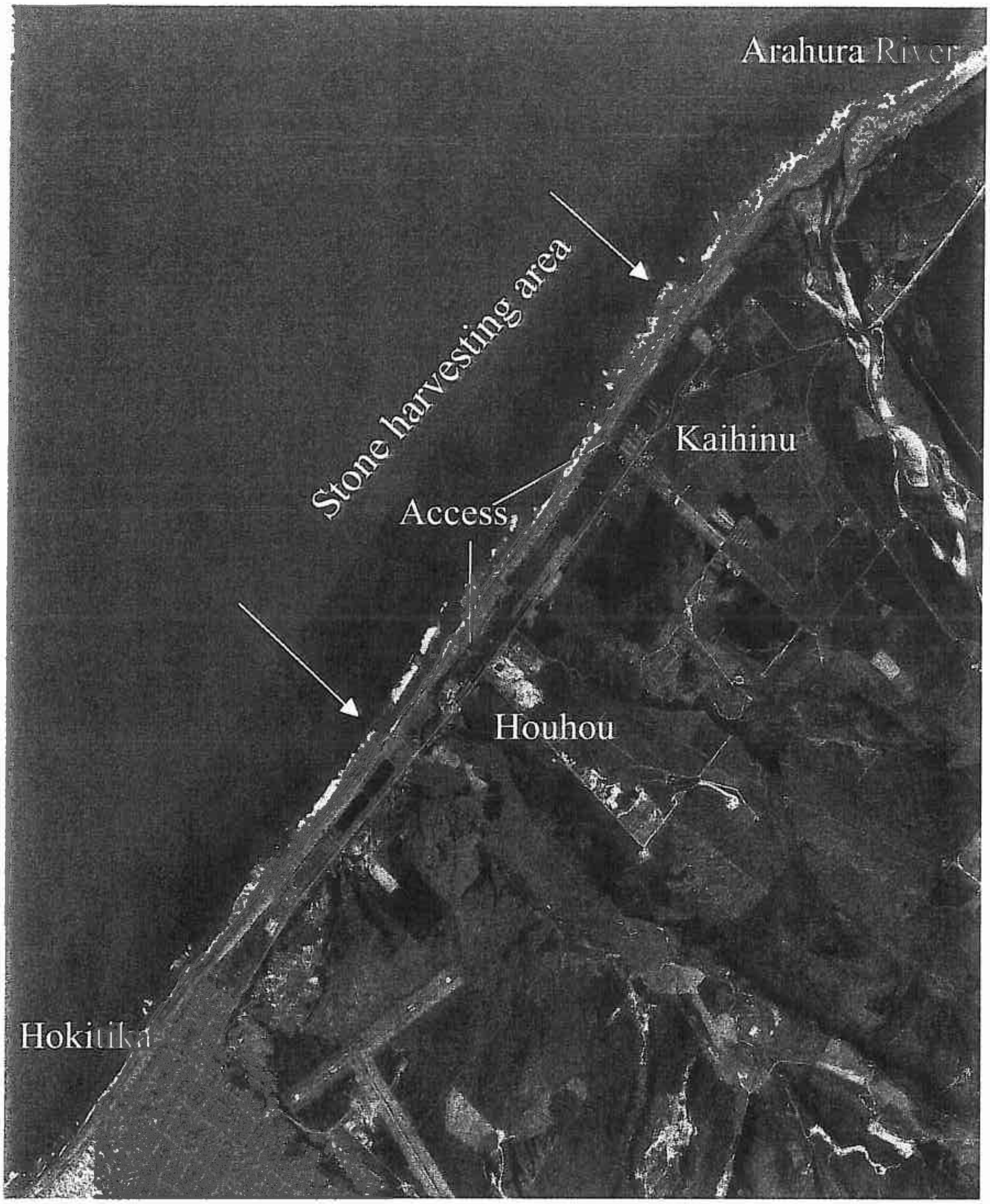

Figure 1: **The shore between Hokitika and the Arahura River. The proposed stone harvesting span of shore is marked between arrows.**

The stone resource could be significantly depleted if the harvesting rate exceeded the natural average rate of re-supply or if there was negligible natural re-supply and the harvesting significantly depleted the existing storage. Thus key questions are:

- What is the existing stone resource along the study shore?
- What would the resource life be assuming no natural re-supply?
- What is the natural rate of re-supply?

The proposed harvesting area lies within Coastal Hazard Zone 14, as mapped in the Regional Coastal Plan for the West Coast (West Coast Regional Council, 2001). This zone, as originally defined, extended from the Arahura River south to the Hokitika River. There is currently a proposal by the West Coast Regional Council to extend the southern limit to 1.5 km south of the Hokitika River. This zone was drafted into the Coastal Plan by Mr Craig Welsh, a consultant to the West Coast Regional Council. Although the technical basis for establishing the hazard zone is not mentioned in the Regional Coastal Plan, my discussion with Mr Welsh indicated that the main basis for setting up the zone was information presented in reports (notably Gibb, 1987; Benn and Neale, 1997), local knowledge, and feedback on the draft Coastal Plan.

Gibb (1987) noted, with regard to the shore of Hokitika Borough, that while the shore was in a state of long-term "dynamic equilibrium", it experienced short term cycles of erosion and accretion over 10-30 year periods. By mapping historical shoreline positions from cadastral survey plans and aerial photographs, Gibb showed that since 1867 shoreline fluctuations of up to about 100 m have occurred between the Hokitika and Arahura Rivers (Figure 2). He considered that the cycles stemmed largely from fluctuations in the direction of the Hokitika River outflow channel, which encouraged littoral drift bypassing (and so a healthy beach) when it was directed northwards but resulted in littoral drift starvation to the Hokitika shore when it was directed south. The situation creates a hazard mainly during phases of shore recession, when Hokitika becomes vulnerable to erosion and flooding by storm waves. As a result of Gibb's recommendations, rock groynes were placed at Richards Drive in 1986 and at the oxidation pond in 1991. Essentially, these act as "check dams" and locally retain sediment on the beach at key locations.

Benn and Neale (1997) confirmed that the major hazard facing the Hokitika shore was short-term erosion. They noted erosion phases in 1868, 1914, 1943, and the 1980's. They trace the cause of these to a variety of effects, natural and man-induced.

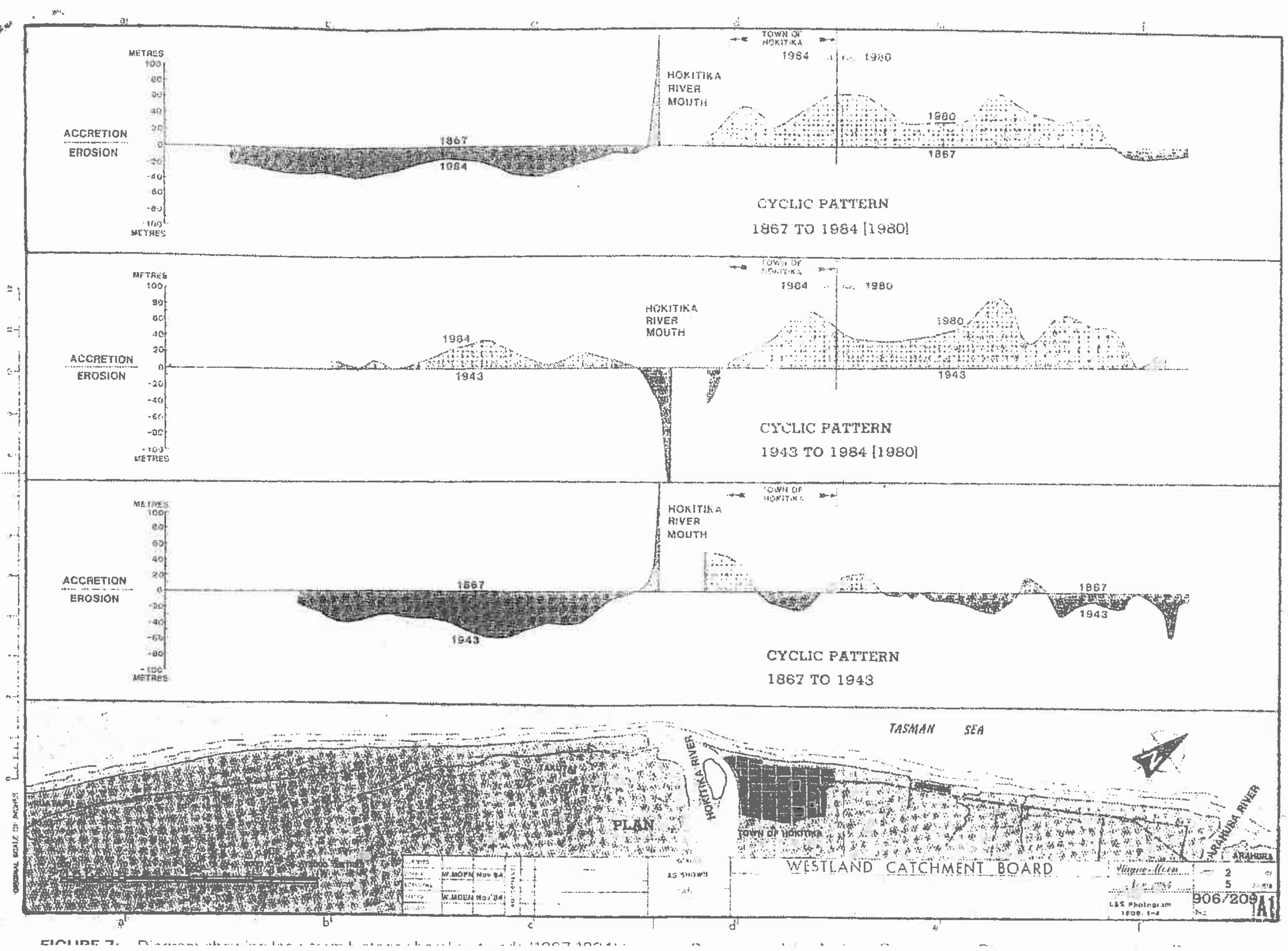

Figure 2: **Historic shoreline shifts between Ruatapu and the Arahura river mouth (Figure 7 from Gibb, 1987).**

Naturally-driven erosion phases relate to combinations of Hokitika River discharge (and sediment supply), mouth dynamics, and sea conditions. The 1914 erosion phase resulted largely from the construction of training works on the Hokitika River's south bank. These trapped littoral drift, starving the shore north of the river.

It has been observed (Gibb, 1987; Rob Daniels, Westland District Council, pers. comm.) that the erosion phases advance northwards along the shore as 'bites' or troughs. The bite that was at Hokitika in the 1980's has now advanced to the Houhou-Arahura shore, while the shore fronting Hokitika is now building out again. Indeed, the size of the sand-slug currently sitting on the north side of the Hokitika River mouth suggests that the north Hokitika coast, including the stone harvesting area, should be relatively healthy for the next decade or so (Rob Daniels, pers. comm.).

Thus the main hazard associated with CHZ14 is periodic shore erosion and an associated vulnerability to sea flooding. As well as the decadal-scale 'short-term' fluctuations, however, the shore is also very dynamic on a day-to-day basis. Storms can shift large volumes of sediment around in a matter of hours, exposing gravel patches one day and covering them with sand drifts the next.

Removal of sediment from the beach face could significantly influence shore erosion if the annual rate of removal was comparable with the average annual re-supply from littoral drift and/or with the volumes exchanged seasonally between the foreshore and the nearshore due to wave action (the nearshore lies below mean low water level while the foreshore lies above). Thus key questions are:

- What is the bulk rate of supply of sediment by littoral drift?
- How much beach sediment is exchanged between the foreshore and nearshore on a seasonal basis.

With regard to impacts on the beach landscape/natural character, key questions are:

- Will the harvesting leave visible holes in the beach?
- Will the access leave tracks above the high-tide level (except at the access points)?

I have sighted a communication from the Department of Conservation (DOC) to the WCRC (ref. RCO 0011 of 18 December 2001) regarding a previous application for consent to extract 2000 cubic metres per year of gravel from much the same area.

Since DOC's concerns/recommendations remain relevant to the existing proposal, I summarise them as follows:

- that an expert assess the situation
- that the existing beach profile data from the area be looked at
- that an assessment be made as to whether the rate of extraction was sustainable and did not increase the coastal hazard
- that the effects of the extraction be monitored by resuming past beach profile surveys and by monitoring textural changes in the beach sediment
- that several conditions be applied to beach access and extraction methods to ensure that the natural character of the beach was preserved.

1.3 Investigation

The aim of my investigation was to address the issues and questions listed above. The work involved a field inspection, discussion with Mr Ray Oliver regarding his harvesting techniques and 'stoneweaving' operations, discussions with staff at West Coast Regional Council, Westland District Council, and Department of Conservation, and examination of past reports and relevant beach profile information.

The field inspection was undertaken on 6-7 August 2003. For this I:

- walked the beach for the complete length of the harvesting area
- inspected Houhou Creek and Little Houhou Creek behind the beach to assess if they contributed gravel to the beach
- sampled the beach material at mid-tide level along a representative 900 m of the harvesting area using the 'Wolman' method. (This involved measuring the intermediate-axis size of whatever grain lay under my toe every 10 m along the shore. Grains finer than 2 mm were simply classed as sand.)
- inspected the beach at several access points between the Hokitika River mouth and Kumara to gain a wider-scale impression of the 'health' of the shore and the relative occurrence of gravel and sand

- measured the size characteristics (A, B, C axes) and estimated the lithology of a random sample of 40 stones from a bin at Stoneweavers.

2 Results

2.1 Stoneweaving operations

The stone-weaving operation involves creating doormats and other ornaments from flat, rounded stones collected from the beach. The stones are hand-picked around low tide from patches or 'rafts' of gravel than collect on the middle foreshore, between high and low tide levels. The hand-picking means that the stones are taken only from the beach surface and selectively over a broad area, so no holes or excavation scars are left. Once collected, the stones are removed from the beach with the aid of a 4WD vehicle driven along the foreshore below high tide-level. The dynamics of the beach are such that vehicle tracks disappear between tides. At the factory, the stones are mechanically sorted by thickness. Unused stones are returned to the foreshore, where they are spread around during the next high tide.

From the stone count (Table 1), the stones have an average B-axis size of 40 mm, long-axis size of 57 mm, and thickness (C-axis) of 9 mm. The B-axis ranges between 25 and 65 mm. This classifies them as pebbles bordering between "very platey" and "very bladed" in shape. They range between "rounded" and "well rounded" on Powers' roundness scale. The sample was composed mainly of greywacke/semi-schist (incipiently foliated schist of psammitic origin), with subordinate schist and quartz and traces of granitic and other material.

Table 1: Range and average dimensions from the random sample of 40 harvested stones.

	A-axis	B-axis	C-axis
Average (mm)	57	40	9
Minimum (mm)	39	25	5
Maximum (mm)	83	65	16

Table 2: **Lithology of the random sample of 40 harvested stones.**

Lithology	Count
Biotite-garnet schist	1
Biotite schist	7
Greenschist	1
Greywacke/semischist	13
Hornfels schist	3
Myonlinite	1
Diorite	1
Granite	1
Phyllite	5
Quartz/banded schist	8

2.2 Beach inspection

The beach from the Houhou (oxidation pond) groyne towards the Arahura River varied from dominantly sandy to a more mixed sand-and-gravel type. At the oxidation pond groyne, the foredune on the north side was set back 17 m landward compared to the southern side, reflecting the effect of the groyne in damming sand on its southern side and starving the beach immediately north. The foredune had recently eroded back as far north as Houhou Creek, but the beach was dominantly sandy (medium-coarse grade).

Greater concentrations of gravel occurred from the Houhou Creek outlet north to the next groyne, and this area was also a collection zone for driftwood. This may reflect the slight northward pivoting of the shore at this location. The foredune location and the berm width indicated that this area undergoes at least several 10's of m of short-term advance and retreat. The beach in front of the Creek outlet is particularly dynamic, with the outlet shifting rapidly from tide to tide, and rapid turnover of beach material by waves and scour by the creek outflow. The bank cut by the creek showed that the beach face was composed of alternating lenses of sand and gravel (Figure 3). I estimate that gravel makes up about 20% of the beach volume in this general area, and more in the immediate area of the stream outflow.

Further north, past Kaihinu, the beach was again more sandy overall, but it still contained intermittent gravel patches on the middle foreshore. Often, but not always, these patches sit on the horns of cusps and are concentrated there by swash processes. The relatively finer patches appear to be associated with gravel slug movement and can be very dynamic – appearing with one tide and disappearing the next, or being buried by sand layers. Coarser patches appear to have formed more as lag deposits following beach scour events or simply by the reworking of the rafts by swash. It appears that more mobile slugs of sand can quickly and easily bury the gravel patches.

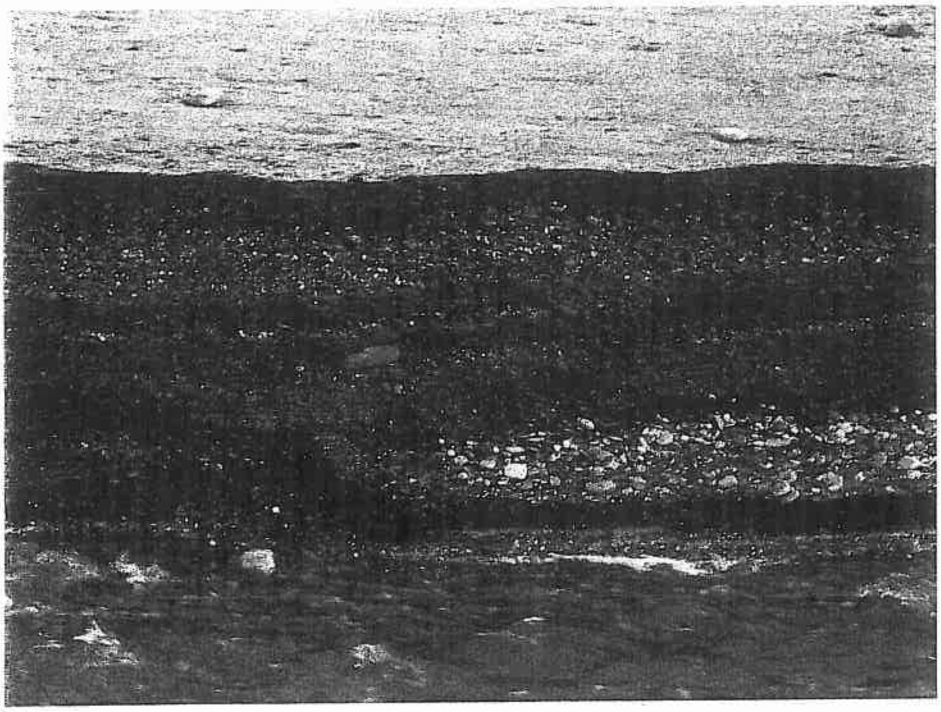

Figure 3: **Houhou Creek outflow channel across beach face. Note gravel lenses within the beach and sparse gravel on the surface.**

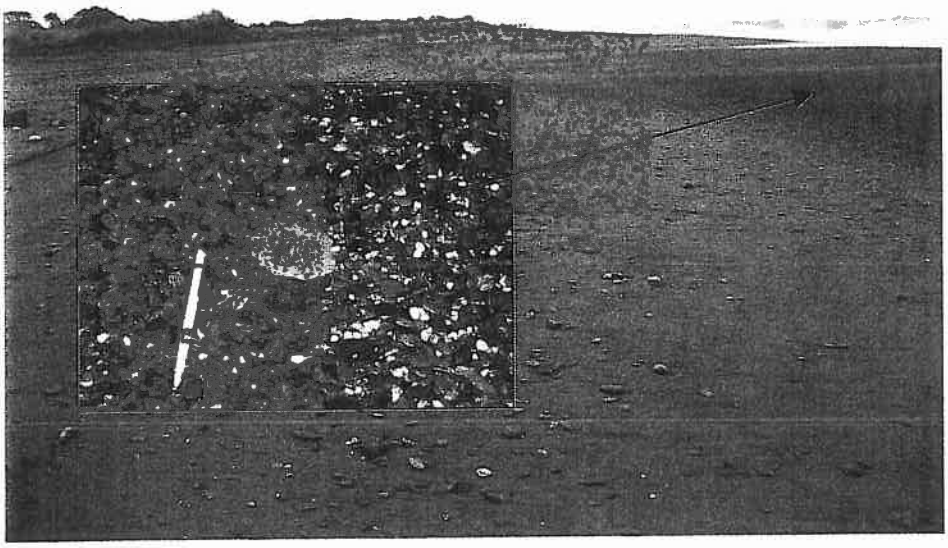

Figure 4: **Gravel patches below high tide level at Kaihinu. Inset shows detail of patch surface.**

The 'Wolman' count of grain B-axis size along 900 m of beach at mid-tide level (Figure 5) showed that 51% of the beach surface at mid-tide was composed of gravel and 49% sand. Of the gravel, the average B-axis size was 21 mm, while 36% was in the 25-65 mm B-axis size range of the sample of harvested gravels (Table 1). This indicates that approximately 18% of the middle foreshore surface contains gravel suitable for harvesting. In other words, if one were to walk along the proposed harvesting area at mid-tide level, one should encounter a suitable grain every fifth step on average.

Estimating conservatively that the between-tide portion of the beach where the gravel concentrates is 30 m wide, that the dynamic swept prism of beach material worked over by waves is 1 m thick (see following section), and that 18% of the beach volume is gravel of suitable size, then the harvestable gravel resource along the 3.5 km length of shore is approximately 19,000 m^3. Thus even without any replenishment by longshore drift, the resource life would be 380 years if extracted at the proposed rate of 50 m^3/year.

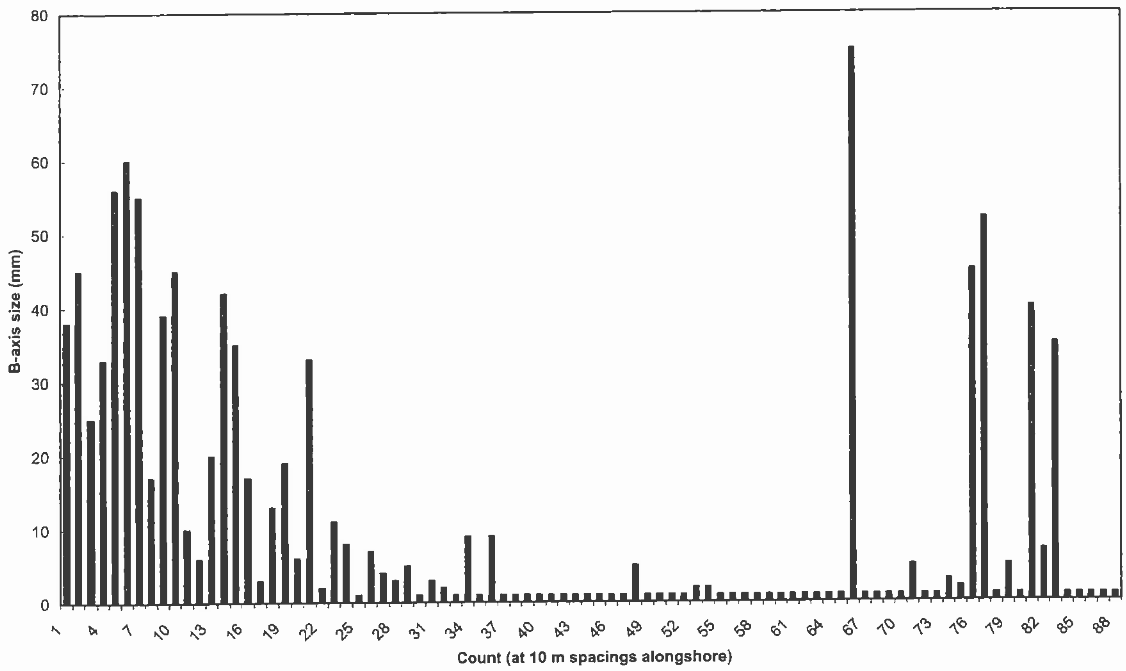

Figure 5: **Grain B-axis size from Wolman count of sediment encountered at 10 m intervals along 900 m of shore at mid-tide level. Sand grains assigned a size of 1 mm.**

Both Houhou and Little Houhou Creeks follow low-gradient, meandering paths as they approach the coast. Inspection of their channels immediately behind the beach showed muddy beds, therefore, they do not appear to be significant sources of beach gravel.

Beach inspections further afield showed that gravel patches/drifts occurred intermittently on the beach face all the way between Hokitika and Kumara (Figure 6).

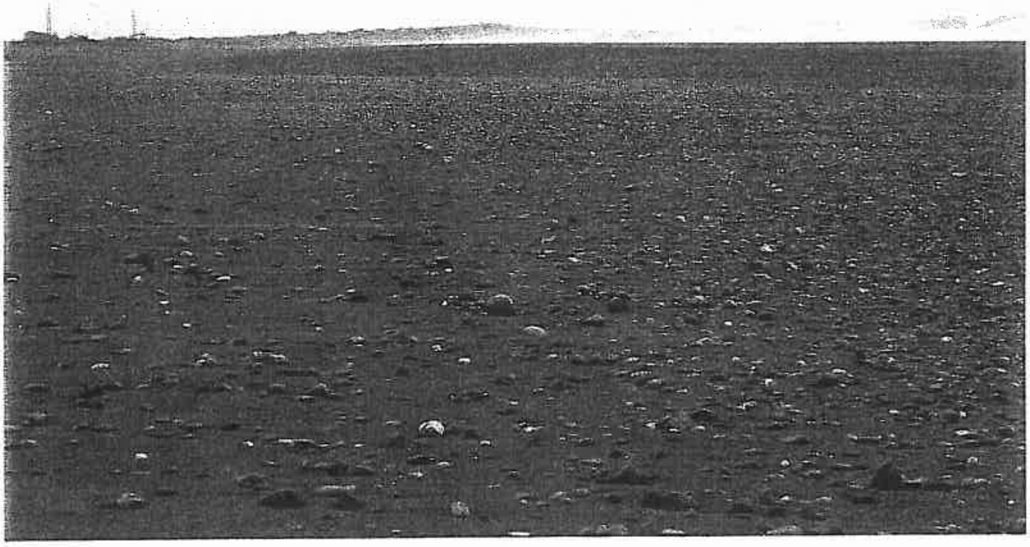

Figure 6: **Gravel on the beach face at Hokitika. River mouth groyne in distance.**

2.3 Gravel supply from the Hokitika River

It is clear that there is a strong and dominant northward littoral drift up the coast past Hokitika. This is expected from the W-SW wave climate (Figure 19 in Gibb, 1987) and evidenced by seaward offsets of the shoreline on the south side of groynes (where sediment is trapped) and landward offsets on their northern sides (where sediment is eroded). Gibb estimated that about 93% of the gross longshore drift was directed northwards. Thus it is expected that coarse sediment (sand and gravel) delivered to the coast by the Hokitika River should be transported north, along with sediment being transported alongshore from further south of Hokitika. While these supplies may be interrupted and stored at the river mouth for extended periods, eventually it is released onto the beach north of the river. Based on his observations of beach dynamics and composition at Hokitika, Gibb estimated that the rate of northward longshore transport of gravel and coarse sand on the beach above MLWS was about 230,000-250,000 m^3/yr. He estimated that the northward transport rate of medium and fine sand below MLWS may be about ten times this.

Gibb (1987) also made observations of beach and river gravel composition in the area. He noted that serpentinite and greenstone could be used as a tracer for littoral drift because it was found in the Hokitika and Arahura Rivers but not in the Totara River (16.7 km south of Hokitika). He found these two lithologies everywhere along the beach between the Hokitika and Arahura Rivers but no more than 600 m south of the Hokitika River. This confirms the northward dominant drift and continuity of transport along the Hokitika-Arahura shore. Gibb (p.30) further observed "*large waves of fine beach gravels and coarse sands separated by troughs of coarse lag gravels and angular boulders*".

From recent research of my own (Hicks and Shankar, 2003), I have calculated an average suspended sediment yield from the Hokitika River of 6.2 million tonnes per year. Based on particle size analyses of suspended load in other rivers, I estimate that approximately 35% of this should be very-fine to medium sand. Also, based on bedload to suspended load ratios in other rivers, I estimate that the coarse-sand and gravel bedload yield of the Hokitika River should be equivalent to about 5-10% of its suspended load. Assuming a bulk density of 1.6 t/m^3 for sand and gravel, these figures suggest volumetric outputs of approximately 1.4 million m^3/yr of medium and finer sand and about 190,000-390,000 m^3/yr of coarse sand and gravel. These figures agree reasonably well with those of Gibb, considering that sand at least is supplied from south of the Hokitika River as well as from the river.

Conservatively assuming that gravel makes up only 10% of the Hokitika River's bedload, then a gravel supply of approximately 20,000-40,000 m^3/yr is indicated. Some of this will be reduced by abrasion as it is transported the 4 km between the river mouth and Houhou. Using abrasion coefficients reported by Gibb and Adams (1982) for cobbles on the Canterbury beaches, I estimate that something like 20% of the gravel supply at Hokitika might be ground away to mud grade before it reaches Houhou. This indicates, very roughly then, an average gravel supply to the beach at Houhou from alongshore of about 16,000-32,000 m^3/yr. The proposed stone harvesting rates are only 0.3-0.6% of this gravel supply rate or approximately 0.8-1.6% of the supply rate of the 25-65 mm fraction targeted by the harvesting (assuming this is 36% of the beach gravel, as estimated in the previous section). Therefore, I conclude that, for the purpose of the proposed stone harvesting:

- the 50 m^3/yr harvesting rate can be regarded as sustainable

- the harvesting will make negligible impact on the overall beach volume – that is, the harvested volumes will be trivial compared with the volumes that are exchanged across the beach by tide and storm waves during storms and seasonally and with the volumes that are deposited and eroded over decades in association with the passage of longshore-migrating sand slugs and erosion troughs.

2.4 Beach profiles and beach dynamics

Two beach profiles in the proposal area were surveyed by Don Neale from DOC on four occasions between 15/6/89 and 28/7/93 (Don Neale, DOC, pers. comm.). These were located at Kaihinu. One was located at the site of a mining claim, the other was located nearby (at Fred's) as a control. I have plotted the profile changes at the control site, which should give a better indication of the natural beach changes. Figure 7 shows that the foredune toe retreated 13.5 m over the survey period, mostly between 15/6/89 and 12/5/92. The steepness of the 15/6/89 dune face indicates that the erosion started before that date. The area of the 'dynamic swept prism' (i.e., the area of beach profile subject to either cut or fill) was 42 m^2 (or 42,000 m^3 per km of beach length). This gives an idea of the transfers of sediment occurring on the whole beach above low tide level. Over the middle beach face (towards the seaward end of the profile), which didn't undergo much net change over the monitoring period, the swept prism was approximately 1 m thick. Thus the part of the beach profile subject to the proposed stone harvesting experiences cuts and fills of the order of 1 m on a regular basis.

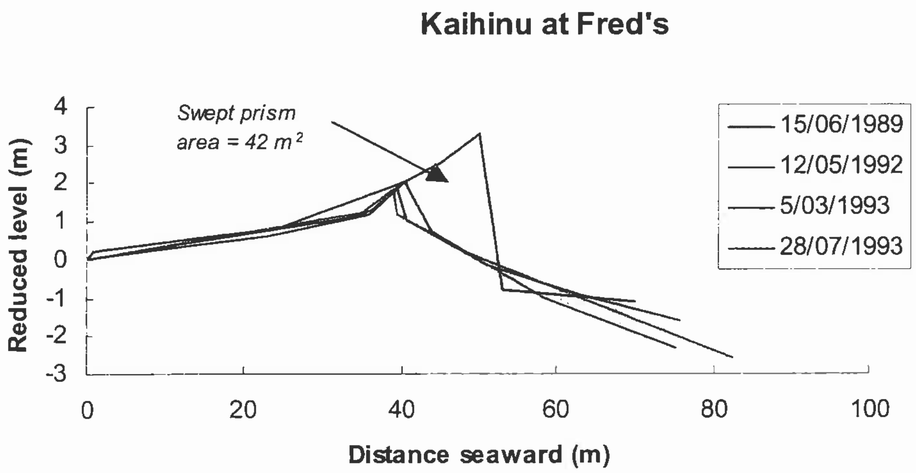

Figure 7: Beach profile changes at Kaihinu at Fred's, 1989-92. The reduced level is to an arbitrary datum.

Beach profiles have also been surveyed since 2000 along the Hokitika foreshore by Westland District Council (Rob Daniels, pers. comm.). Plots were obtained for profiles at Richards Drive on either side of the groyne, at Spencer Street, and at Tudor

Street. Between July 2000 and February 2002 the maximum beach level fluctuation at these profiles ranged from 1.4 m to 2.9 m in association with phases of cut and fill. It was observed (Rob Daniels, pers. comm.) that gravel tended to become more concentrated on Hokitika Beach when the sand was cut away.

These figures on profile change illustrate how dynamic the beach is within the general area. In comparison, the changes in beach level that would be associated with the proposed stone harvesting are trivial (less than 1 mm or less than one layer of sand grains per year with the harvesting spread along the 3.5 km of shore).

3 Summary and conclusions

- Stoneweavers Ltd propose to remove up to 50 cubic metres per year of flat stones of pebble size grade from the beach face below mean-high water level from a 3.5 km span of shore approximately between Houhou and Kaihinu. The stone would be hand-picked from the beach during low tides and transported off the beach by 4WD vehicle. Beach access would be via two existing vehicle tracks.

- The proposed harvesting area lies in a Coastal Hazard Zone. The hazard zone was established to flag a history of shoreline fluctuations that have seen the shore erode and then accrete by up to about 100 m over decadal time scales. These fluctuations appear to relate mainly to coastal storms and intermittent bypassing of littoral drift sediment past and from the Hokitika River mouth. Stone harvesting has the potential to exacerbate the shore erosion hazard if it were to significantly reduce sediment volumes on the beach, particularly during phases of natural sediment depletion.

- The shore is replenished with gravel and sand mainly from the Hokitika River, and the proposed harvesting rate amounts to only 0.3-0.6% of the estimated gravel supply rate. Even with no replenishment of the harvested gravel by littoral drift, the resource life of the stones in the harvesting area is estimated as 380 years. On this basis, the proposed stone harvesting may be regarded as sustainable.

- Beach profiles indicate that the foreshore levels rise and fall by up to several metres in association with wave-driven cut and fill events on a daily to annual basis. In contrast, the harvesting, when spread along the 3.5 km span of shore, would lower the beach face by less than the equivalent of one layer of sand grains per year. On this basis, the proposed stone harvesting should not degrade shore stability and therefore should not exacerbate the existing coastal hazards along the harvested shore and adjacent coast.

- The proposed stone collection and beach access should not degrade the beach environment and landscape since existing access points will be used, vehicle tracks on the beach will be removed by the following high tide, and hand-collecting spread along the 3.5 km of shore will ensure that no holes are left on the beach.

4 Recommendations

4.1 For monitoring

Given the small volume of the stone harvesting compared with the volumes of beach material that are moved across and along the beach by waves, it would be impossible to detect any effects of the harvesting by surveying beach profiles. If profiles were surveyed and erosion was detected, any stone-harvesting signal could not be isolated from the large natural noise.

Similarly, because the beach face sediment composition naturally varies alongshore and over time, I would expect that any surveys of beach material sediment size would be too 'noisy' to identify any trends in gravel depletion.

My suggestion is that records simply be kept of the volume of harvested stones. Stoneweavers Ltd might also be encouraged to take regular photographs of the harvesting shore from fixed locations (perhaps at monthly-annual intervals). While this should not show up effects of their operations, it will nonetheless provide a useful record of the shore dynamics in the area.

4.2 For minimising impacts

The proposed harvesting approach should be adequate to minimise effects on the coastal landscape, thus no further recommendations are made.

5 Acknowledgements

I thank Rob Daniels (Westland District Council, Hokitika), Don Neale (Department of Conservation, Hokitika), Craig Welsh (Resource and Environmental Management Ltd, Nelson), Vanessa Scott and Lilley Sadler (West Coast Regional Council, Greymouth) for discussion and information. Thanks to Ray Oliver and Colleen Leywood (Stoneweavers Ltd, Hokitika) for information and accommodation.

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