

West Coast Regional Council

Review of Humping and Hollowing on the West Coast

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1 Executive Summary

The West Coast Regional Council has commissioned this review of humping and hollowing to collate what is known about: the effects of the activity, the resource consents issued by the Regional Council, and monitoring undertaken to date.

The key points are:

- While the effects of humping and hollowing can be divided into four main categories the effects cannot be considered in isolation as they are interlinked.
- The short term effects during development have the potential to result in adverse effects from erosion and sedimentation.
- The simplest requirement to avoid or mitigate adverse effects is to impose buffer/setback conditions.
- The monitoring requirements, as set out in resource consent conditions, need to be achievable.
- Consideration should be given to developing a layman's guide to humping and hollowing and the resource consent process.
- Records of consents issued should be kept up to date so that when making decisions on resource consent applications the cumulative effects can be considered.

2 Introduction

Farming practices on the West Coast are undergoing a noticeable change in scale and intensity. Earthmoving activities such as “humping and hollowing” and “flipping” are techniques used to improve land drainage and pasture production. These techniques are making development possible on lands where such development was once considered impracticable.

West Coast Regional Council has commissioned Opus International Consultants to prepare this review of humping and hollowing. The review covers:

- what is known about the effects of humping and hollowing;
- a summary of the resource consents issued over the last three years; and
- an assessment of monitoring requirements.

3 What is humping and hollowing?

Humping and hollowing (H&H) is a land development technique used in situations where vertical drainage through the soil structure is impeded by the soils low permeability or iron pan formations. The objective is to improve the soil drainage and structure by removing the low permeability solids, breaking through to the iron pan, and mixing and overlying soils with sand and gravel. A uniform surface is created with the hollows serving as a drainage path.

The work methodology has been described by Sinclair Knight Merz (Landcorp Farming Limited resource consent applications) as involving:

- excavation of pilot drains at uniform spacing across the development area. This establishes the depth and layout of the hollows and forms the drainage pattern for the H&H land;
- excavation and placement of the overlying soils in the “core” of the humps;
- excavation of iron pan and underlying gravel to form the hollow and build the hump;
- H&H land left unfinished to consolidate and drain;
- humps and hollows shaped and compacted by digger/bulldozer and roller; and
- fertiliser applied to land by ground application and grass seed sown.

A proportion of the land developed on the West Coast is flipped. Flipping is different from H&H in that the soil is turned as though the land was ploughed. The paddocks are left flat with no hollows. Soils are usually being flipped to a depth of 2 to 3 metres.

4 Statutory Framework

In terms of the effects of activities on land as it relates to H&H, section 30 of the RMA gives regional councils the following responsibilities in order to give effect to the purpose of the RMA:

- (a) *the establishment, implementation, and review of objectives, policies, and methods to achieve the integrated management of the natural and physical resources of the region;*
- (b) *the preparation of objectives and policies in relation to any actual or potential effects of the use, development, or protection of land which are of regional significance;*
- (c) *the control of the use of land from the purpose of-*
 - (i) *soil conservation;*
 - (ii) *the maintenance and enhancement of the quality of water in water bodies and coastal water;*
 - (iii) *the maintenance of the quantity of water in water bodies and coastal water;*
 - (iv) *the avoidance or mitigation of natural hazards.*

Section 9(3) of the RMA states that no person may use land in a manner that contravenes a rule in a regional plan or proposed regional plan unless allowed by a resource consent or it is an existing lawful use.

The Regional Council has chosen to regulate land disturbance in order to control soil conservation and manage water quantity and quality.

Under the Transitional Regional Plan, land contouring of any contiguous area over five hectares is a discretionary activity. It is intended that this provision be withdrawn when the Proposed Land and Riverbed Management Plan (PLRMP) becomes operative.

Under the PLRMP the following rules apply to humping and hollowing, flipping or V blading activities:

- Rule 8.1.1.1 – permitted activity outside of waterbody buffer margins subject to conditions, including that the area does not exceed 5 hectares per title per 12 months.
- Rule 8.1.5.1 – restricted discretionary where works do not meet the permitted rule or within a water body buffer margin where greater than 2 hectares.

The wording of the rules are attached as Appendix 1.

In the past the Council issued discharge permits for the discharge of contaminants (sediment) to land in circumstances where it may enter water. The H&H rules in the

PLRMP include conditions or discretion matters related to water quality. For this reason, conditions can be imposed on the land use consent to control the discharge of sediment and a discharge permit for the discharge to land is not required.

The Proposed Water Management Plan covers the discharge from any drain to water (Rule 12.4.2) as a permitted activity subject to conditions. The rule is intended to cover the discharge from any drain to *surface* water. With H&H numerous drains will be formed or existing ones utilised. Any discharge from drains that enter surface water will have to meet the permitted conditions or a discharge permit will have to be applied for.

Rule 12 from the Regional Plan for Discharges to Land is being relied on by applicants for the application of fertiliser. The rule permits the application of fertiliser in a manner that does allow contaminants to enter water.

5 What are the issues and current knowledge?

As the objective of H&H is to improve the soil structure and improve land drainage, there are a number of effects of the activity that need to be considered. The effects of H&H can broadly be divided into four main categories:

- (i) changes in soil structure
- (ii) changes in catchment hydrology
- (iii) the discharge of contaminants
- (iv) modifications to habitat

Within these four categories the effects cross more than one category as, for example, changes in hydrology can modify habitat value and the discharge of contaminants can affect habitat.

Figure 1 lists the matters that need to be considered when looking at H&H activities, and the following sections explain these matters in more detail.

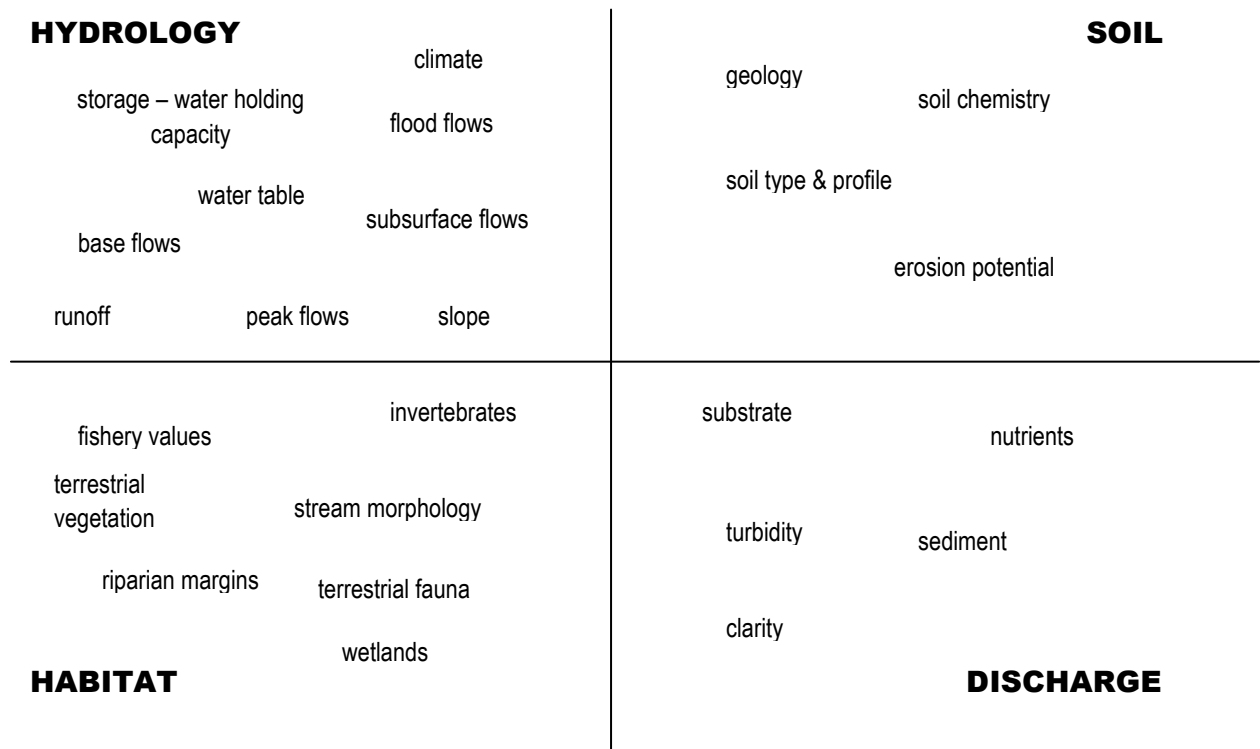


Figure 1: Matters to consider with H&H activities

5.1 Soil

During earthworks and for several months following H&H the ground surface is bare, making it susceptible to erosion and sediment transport. Given this, the type of soil will to some extent govern the risk of erosion.

On the West Coast the soils can be divided into three broad categories: alluvial river flats, terraced areas; and pakahi soils. The best soils, from a farming perspective, are the alluvial river flats. These soils can pug but will dry relatively quickly. It would be unusual for these soils to be the subject of H&H. On terraced country, that once had natural vegetation of beech, stony silt loams are found. The final main type of soil found on the West Coast is pakihi terrace soils. These soils had natural vegetation of silver pine (kahikitea), manuka, moss and fern. They have low natural fertility, poor drainage, and iron pans. It is these soils where the majority of H&H has occurred to date.

Changes in the soil profile - H&H

Following H&H the soil profile will have been altered so to improve the drainage characteristics. It is usually the existence of an “iron pan” that means the soil has poor drainage characteristics.

Iron pan formations have a low permeability and impede water percolation. With H&H the iron pans are usually removed entirely from the hollows and re-worked into the

humped areas. Breaking the iron pans and reworking the surface soils removes the barrier to water infiltration at the surface. The drainage then becomes 'controlled' by the permeability of the underlying materials.

Deeper percolation of water to the groundwater table is governed by the permeability of the underlying geology – this is unchanged by H&H. Large proportions of the areas that have been, or are likely to be, H&H will comprise underlying geology of gravels that are moderately compacted with moderate permeability that is unlikely to restrict deeper vertical drainage.

Following H&H any sandy soils are exposed at the surface in hollows and placed on the surface of humps. This increases the infiltration and drainage characteristics. The surface soil should result in a high gravel and sand content, with a reduction in clayey silts and organic matter. It is noted that gravel is resistant to erosion, while sand is easily eroded.

Changes in the soil profile - flipping

The other, but not so common, technique is to flip the soils. The objective of flipping soils is the same as H&H: to improve the drainage of the land. The process is to bury what is usually pakihī soils and bring as much of the sands/gravels to the surface as possible. The depth of the soil flipping is usually between 2 and 3 metres depending on the depth of the underlying material and iron pan. By burying the top layer of soil that has poor water movement and loosening up the underlying soil, the water holding capacity of the soil is increased.

Erosion and sedimentation

Erosion and sedimentation are the key environmental concerns during earthworks. Once mobilised, it is the fine silts and clays that are difficult to control. The factors that influence erosion are: the soil type, slope, rainfall and the way in which the work is undertaken. The effect of soil type has been covered above, while slope is considered in the Hydrology section.

The time taken from commencement of excavation until grass is established, to a point the erosion potential is reduced, varies through the seasons. The optimum time of sowing grass seeds is during autumn and spring, with the time taken for grass to establish typically being six to eight weeks. The timing of earthworks therefore becomes an important factor if erosion is to be avoided or mitigated.

The risk of at least one, if not more, significant rainfall events while the soil is exposed is high even if the area to be H&H is small. Generally on the West Coast there is a rainfall surplus, ie. greater rainfall than evaporation, throughout the year, resulting in saturated soil conditions.

While the risk of erosion/sedimentation needs to be determined for each H&H proposal, the method in which work is undertaken will have a significant influence. Some examples of best practice include:

- staging earthworks – do not expose more land than can be revegetated within timeframes;
- minimise the gradient of hollows;
- use cut-off drains etc to divert runoff from areas not being developed;
- maintain buffers around waterways including riparian planting and fencing; and
- use and maintain sediment control devices.

The effects of erosion/sedimentation on land are temporary, lasting until grass has become established. But sediment that enters waterways can have longer lasting effects.

Soil chemistry - flipping

At Cape Foulwind the Regional Council requested Landcorp to provide an assessment on the changes in soil pH that could occur following large scale flipping (1,450 ha) of the soil. The concern was that acid sulphate material would be released and cause acidification.

Any potential acid sulphate material would be present in the iron pan or below it. As flipping improves the soil aeration any sulphides present may be progressively converted to sulphuric acid (SKM, February 2003). High levels of organic matter, as found at Cape Foulwind, give soils low pH (5.2 –4.4) and significant amounts of sulphate in an oxidised form.

Testing of the soil was carried out to determine if any potential acid sulphate material was present. Soils were tested where flipping and occurred and on undeveloped land.

The results of the testing showed that:

- The presence of sulphides that could be converted to acid sulphate were found at levels below detection limits.
- The iron pan did not contain acid generating material. This means that there was no risk of water contamination associated with redistributing the iron pan layer through the soil profile.
- Detectable acidification is confined to surface, organic horizons. The acidification is minor and would occur gradually over a long period of time.
- Any acidity produced by the surface organic horizons can be readily treated with lime.

While this investigation was to look at any changes that might occur with the soil chemistry from flipping, the results would be equally applicable to H&H when given the right soil conditions.

Long term effects

While H&H as a practice has been around for some time, there are a couple of unknowns about the long terms effects on the soil. It is unknown whether the iron pan would reform and essentially leave the farmer in the same situation as before the land was developed with poor draining soils. With flipping there is some concern that sand and clay soils may not be suitable to flip, as these soils may 're-seal'. Given that iron pans form due to bacteriological processes over a geological time scale, any reforming of the iron pan would not occur over a short to medium term

5.2 Hydrology

As H&H is designed to convert poorly drained land into productive land, there will be changes to the hydrologic regime. A number of concerns have been expressed about whether the changes have positive or negative effects, and what the long-term implications might be.

The following is a list of perceived issues on what effects H&H might have on the hydrology of the area H&H:

- higher water velocities;
- changes in the water table;
- changes in flow regime;
- bases flows would be lower;
- providing well defined drainage lines would increase storm runoff;
- the new resulting landscape configuration would drain more rapidly and have little storage;
- low flows will be reduced with undesirable instream effects ie. the instream environment would be comprised;
- improved pasture might transpire more;
- improved drainage networks will increase peak flows causing drainage problems and/or damage downstream, including the need to provide larger culverts; and
- what is the duration of any effects - long term or permanent - are there differences in the elevated peak flows of H&H vs v-blading.

In 2001 Landcorp Farming Limited (Landcorp) lodged a number of resource consents to H&H or flip large areas land on the West Coast. The Mawheraiti farm (RC01301) and Nelson Creek farm (RC01302) resource consents required that pre-development and post development monitoring of the hydrological effects is undertaken. At both catchments v-

notch weirs, tipping bucket rain gauges and water level records were installed five months prior to earthworks beginning. At Mawheraiti 28% of the catchment area was to be H&H, whereas at Nelson Creek it was to be 20%. In total, 16 months monitoring was undertaken.

The study results show that H&H has resulted in little change to the hydrological regimes due to the dominance of rainfall in one catchment and excessive drainage to groundwater in the other. At Mawheraiti prior to H&H there was high rainfall and poor drainage, now with normal drainage the land is saturated most of the time. This results in a large proportion of any rain running off and sustaining low flow. At Nelson Creek the hydrological cycle is dominated by excessive drainage to groundwater. The rainfall is intense enough to produce surface runoff but ceases soon after the rain stops. The results from the Nelson Creek and Mawheraiti investigations are presented in Table 1 below.

Table 1: Summary of resulting hydrological characteristics at Mawheraiti and Nelson Creek.

Parameter	Ephemeral (Landcorp - Nelson Creek)	Continuous flow (Landcorp - Mawheraiti)
Water balance	Earthmoving either increased or maintained runoff Established pasture runoff decreased 5mm/day during autumn and winter	
Baseflows	Greater at earthmoving compared to before H&H Post H&H slightly higher than before H&H Site baseflows and low flows not adversely affected	Post H&H decrease compared with prior to
Flood volumes	Prior to, and during earthmoving and pasture the same Post H&H decrease by 25%	No change in runoff between before and after H&H
Flood peak flows	Similar for prior to H&H and earthmoving periods Post H&H flood peaks most likely to be lower before development, especially for high intensity rainfall	Little difference between before development and earthmoving Flood peaks lower after H&H than before

It is important to note that the conclusions of the study could have been compromised by the short period of monitoring. But it is clear that the earthworks have not had a gross effect on the hydrology (NIWA, 2003).

The potential change in hydrology from H&H need to be considered in light of the percentage of the catchment that is proposed to be H&H.

Effect of slope on runoff

Land slope influences the proportion of runoff resulting from rainfall and the surface runoff velocity. Steeper slopes will result in increased flow velocities, reduced infiltration potential and a higher proportion of runoff. If the land being developed has a gentle gradient, H&H will increase the slope from top of the humps to the base of the hollows. The slope of the hollows though will usually remain unchanged, thus not altering the runoff velocity within the hollows from that of pre-development levels.

To determine whether land slope will affect runoff, it is necessary to look at the average catchment gradient prior to development. It is likely that pre-development there will be low runoff velocities, given it is gently to rolling land that is usually developed.

Hydrological changes due to flipping

The largest area of land to be flipped to date has been by Landcorp at Cape Foulwind. When the resource consent application was being lodged the Regional Council requested further information on the likely hydrological effects of the activity. The likely effects were modelled by Sinclair Knight Merz and are reported in their further information response and in a February 2003 report. The effects are summarised in Table 2 below:

Table 2: Summary of predicted hydrological effects resulting from flipping.

Parameter	Predicted Effect
Flow duration	Reduction in low flow occurrence Reduction of high flow occurrence
Catchment Discharge	Reduction of high flow rate Increase in low flow rate (base flow)
Catchment Water Balance	Slight increase in soil evaporation (due to deeper active zone) Surface runoff likely to decrease (due to higher infiltration) Groundwater percolation likely to increase (due to breaking of iron pan)
Instantaneous peak discharge	32% to 35% reduction in peak instantaneous flows

From: Sinclair Knight Merz, February 2003

5.3 Discharges

There will always be a risk of runoff during, and for a period, following earthworks. The main contaminant that is discharged during H&H is sediment. Other contaminants may include fertiliser and nutrients. There is essentially a contaminant 'pathway' that needs to be considered.

Sediment

High levels of suspended solids in water bodies can lead to sediment deposition. The deposition of sediment can reduce invertebrate abundance and diversity by: smothering them; reducing their food supply or quality; and blocking interstitial spaces and reducing available habitat. This in turn can affect fish, as invertebrates are a major food source for them.

High levels of suspended solids also affect the water clarity and can change the habitat values of a watercourse.

The only monitoring data that has been reported to date is from the initial H&H carried out by Landcorp at their Weka and Nelson Creek farms. At the Weka Farm (RC01268) four pairs of monitoring sites were established each with an upstream (US) and downstream (DS) site. There was also an additional downstream site and control established. Monitoring was to be carried out at Pairs 1-3 three monthly within six months prior to the commencement of work in the catchment, once within the first month following work commencement, and three monthly thereafter. At Pair 4 the monitoring was to be carried out once within one month prior to the commencement of work in the catchment, three monthly for one year and then six monthly. Water samples were taken and suspended solids levels measured along with an assessment of substrate. The results are presented in Tables 3 and 4 below.

Table 3: Suspended solids and clarity results to date at Weka Farm.

Date	Suspended solids (g/m ³)						Clarity (cm)					
	Pair 3 - Weka E		Pair 4 - Deep Creek		Weka D & Control		Pair 3 - Weka E		Pair 4 - Deep Creek		Weka D & Control	
	US	DS	US	DS	DS	control	US	DS	US	DS	DS	control
8/1/03			<3	<3		5			77	100		42
13/2/03	<2	dry	<2	<2		3	63		88	>100		66
13/3/03	3	dry			dry		75					
8/4/03	<3	5			<3	<3	86				82	82
15/5/03	<3	<3	<3	<3	4	<3	>100	>100	>100	>100	85	>100
19/6/03					24						23	

The results from the earthworks at Weka Farm show no overall change in the level of suspended solids. In all cases the clarity is the same or better downstream.

Table 4: Suspended solids and turbidity results to date at Nelson Creek.

Date	Suspended solids (g/m3)					Turbidity (NTU)				
	Pair 1		Pair 2		Additional site	Pair 1		Pair 2		Additional site
	US	DS	US	DS		US	DS	US	DS	
18/12/02	<3	<3	<3	<3	<3	1.0	1.25	0.82	1.15	1.36
8/1/03	<3	<3	<3	11	3	1.78	1.28	1.59	22.7	7.01
13/2/03	<2	<2	2	<2	3	1.7	2.4	3.6	2.4	1.4
13/3/03	7	<3	<3	<3	<3	3.4	0.81	1.04		1.19
15/5/03	<3	<3	<3	<3	<3	1.98	2.05	1.18	1.43	1.09

The Nelson Creek results show both increases and decreases in suspended solids and turbidity downstream. There is one result (8/1/03) where the downstream results are clearly higher compared with the upstream. Both the suspended solids and turbidity readings are elevated. Otherwise it is not clear that the earthworks have had a measurable adverse effect on water quality.

The difficulty with the way the monitoring schedule was set up in the conditions, is that sampling times were not tied to the different phases of the earthworks. If there was a significant difference between upstream and downstream results, there would be no way of knowing whether the difference was due the earthworks or some other factor. It may be possible to tie a result to works on site if Landcorp kept records of what was occurring on the site on a regular basis. For these reasons the monitoring schedule was re-written for the second phase of consents that Landcorp sought.

Nutrients

Runoff from soil can also contain nutrients. Small increases in stream nitrogen (N) and phosphorus (P) levels can increase the stream productivity without degrading conditions, but higher increases can increase algal growth. If it becomes extensive, algal material can deplete the oxygen in the water, choke out other forms of biota, and significantly alter the animal communities present. Pasture streams typically export 3–10 times more nitrogen and phosphorus than forest streams (NIWA research – No8 Wired, TV3 show 28 October 2001).

Pasture soils build up more nutrients because clover and legumes fix atmospheric nitrogen and because farmers add N and P fertiliser. Pasture is also more prone to erosion and surface runoff. This can carry phosphorus to waterways. NIWA research has shown that when rain occurs, in the first few days after fertiliser application, significant amounts of phosphate can be washed away in a single runoff event.

The discharge permits issued along with land use consents for H&H relate only to the discharge of sediment. While any soil eroded will contain a level of nutrients, the question is whether the effects of nutrient runoff from H&H is more closely related to the runoff resulting from fertiliser application. If this is the case the Regional Council permits the application of fertiliser to land under Rule 12 of the Regional Plan for Discharges to Land. To be permitted the application of fertiliser shall not contaminate water. How this condition would be measured is unknown, but compliance with the Code of Practice for Fertiliser Use would be a useful best practice tool.

Through the Sustainable Farming Fund the Ministry of Agricultural and Forestry has funded a project being run by Landcare Trust called “Solutions from runoff from West Coast land conversions”. The project is intended to:

- Determine the effects of humping and hollowing land management on nutrient runoff;
- Provide practical solutions for mitigating nutrient runoff; and
- Interact with farmers to assess the social and economic costs and benefits of humping and hollowing land conversions – informal interviews to gain good understanding so that solutions are practical.

The project is still in its early stages with water sample analysis still in progress. Samples are being taken from hollows. In addition, hydrological information is being collected with weirs having been installed in hollows. The results of the study will be useful in understanding the effects of runoff from land development.

The only monitoring data that has been reported to date is from the initial H&H carried out by Landcorp at their Weka and Nelson Creek farms. The ammoniacal nitrogen, total nitrogen and nitrate results are reported in Table 5 below.

Table 5: Nutrient results to date from Weka Farm.

Date	Pair 3 - Weka E						Pair 4 - Deep Creek					
	Ammon-N		TON		Nitrate		Ammon-N		TON		Nitrate	
	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS
8/1/03	0.01		0.009		0.009		0.01	0.01	0.006	0.087	0.005	0.087
13/2/03	0.02		0.007		<0.00 2		<0.01	<0.01	0.018	0.097	0.015	0.096
13/3/03												
8/4/03												
15/5/03	0.093	0.093	0.093	0.046	0.092	0.044	0.02	0.02	0.042	0.136	0.041	0.136

From the limited data above there appears to be no measurable increase in nutrient runoff as a result of earthworks. It is important to note that while the dates the samples were

collected on are known, it is not known what phase of the works were occurring at the time.

As periphyton monitoring was also required at Nelson Creek and Weka Farm, this would provide an additional indicator of whether there has been a change in nutrient concentrations, as elevated levels of nutrients can increase the growth of periphyton.

The percentage cover of various groups of periphyton had to be measured using method RAM 1 from the Stream Periphyton Monitoring Manual by Biggs & Kilroy, 2000. The results from Nelson Creek and Weka do not suggest that there were any discernable changes in periphyton.

Monitoring of periphyton presents a number of problems. Smaller ephemeral watercourses are often dry, so periphyton cannot be monitored, and dry spells disrupt growth. Before setting conditions that require periphyton monitoring it is therefore important to know whether the watercourse is ephemeral. It must be remembered that periphyton growth is also influenced by water temperature and flow. Higher temperatures can encourage growth while changes in the flow can cause material to be dislodged. It is for these reasons that the value of periphyton monitoring needs to be questioned.

5.4 Habitat

If H&H is proposed to be carried out within a water body buffer margin resource consent is required as a discretionary activity under the PLRMP (Rule 8.1.3.2). A water body buffer margin is an area of land of varying width related to land slope type adjacent to a water body, which contributes to the maintenance and enhancement of soils and bed stability. It is noted though that water body buffer margins do not apply to ephemeral water bodies. Changes in the margins around waterways can affect instream habitat.

The terrestrial habitat also needs to be considered as the clearance of vegetation can alter the habitat and biodiversity.

The habitat issues that need to be considered are:

- The reduction of wetland area can change the hydrology and reduce biodiversity.

Instream habitat

- lower base flows can result in loss of wetted bed area and potential loss of habitat for aquatic organisms.
- the stream bed substrate composition can be altered.
- The discharge of fine sediment from soil runoff to streams can block up spaces between stones in the creek. This would result in the loss of habitat for invertebrates and fish.

Riparian habitat

- loss of streamside vegetation and habitat for fish, as most fish require woody debris in streams and whitebait need overhanging vegetation.
- the loss of riparian vegetation can change the natural character.
- riparian vegetation can provide a filter for sediment runoff.

Terrestrial habitat

- clearance of terrestrial vegetation can alter habitat and biodiversity, especially in the case of remnant bush areas.

All the issues above relate to loss of or change in habitat.

It is usually 'wet' land that is H&H and some of these wet areas can be classified as wetlands. Those wetlands that remain on the West Coast are at risk of being drained. Farmers do not often see the ecological role that wetlands play. Wetlands can support a wide variety of birds (particularly waterfowl), fish and plants. Another reason to protect wetlands is to preserve the biological diversity of the area. Wetlands can be incorporated into a developed by providing 'treatment' of runoff and storage. It is noted that the Regional Council are currently compiling an inventory of wetlands.

The margins of water bodies play an important role in stream morphology, habitat and overall stream condition. For these reasons buffer zones play an important role in H&H practice. In avoiding potential adverse effects the requirement for a buffer zone is seen as essential. In reviewing the consents issued date, the majority of them stipulate buffer zones, or they have already been identified by the applicant and marked on the development plan. It is also noted that a significant number of the H&H incidents reported to the Regional Council refer to those who have not complied with buffer zone requirements.

While the majority of H&H that has occurred to date has not involved the clearance of indigenous vegetation, the West Coast District Plans contain rules covering the clearance of vegetation. While a large number of resource consent applicants leave remnant bush areas, there are instances where indigenous vegetation is cleared. The clearance of terrestrial vegetation can alter habitat and biodiversity.

6 Cumulative Effects

Assessing the cumulative effects of any activity is not simple. The two key areas where the cumulative effects of H&H will be more obvious are changes in hydrology and landscape.

As the percentage of individual catchments developed by H&H increases, depending on the hydrological characteristics, there is the potential for changes in the catchment hydrology. The greatest influence will be when wetlands are drained.

The cumulative effects on the landscape will depend on the perceived values people have of the area. This is not a matter that the Regional Council has direct jurisdiction over.

Records of consents issued should be kept up to date so that when making decisions on resource consent applications the cumulative effects can be considered.

Without detailed information on the extent to which landowners are relying on the permitted activity rule, any cumulative effects from this cannot be determined.

7 Resource Consents

7.1 Consents issued and trends

Resource consents issued over the last three years have been examined as part of this review. As of June 2004, 35 consents for H&H have been issued and are current, 4 issued and have already expired, and 11 applications are still being processed. A summary table of the consents and a copy of the consents can be found in Appendix 2.

Approximately half of the consents issued are for areas covering less than 100 hectares.

Area Developed	Number of consents issued
> 200 ha	15
100 - 200 ha	6
50 - 99 ha	4
20 - 49 ha	6
< 20 ha	8

Table 6: Broad Locations of current and expired consents:

Area	No. of consents
Karamea to Waimangaroa	2
Westport/Cape Foulwind	4
Inangahua/Reefton	2
Mawheraiti	3
Rotomanu-Bell Hill-Haupiri- Nelson Creek	14
Coal Creek	1
Kumara/Taramakau	2
Hokitika area	5
Harihari/Whataroa	5

The largest scale H&H to occur is that by Landcorp. The following resource consents for H&H have been issued to Landcorp:

RC02168, RC01300, RC03280	Weka Farm
RC01270, RC01302, RC03240	Nelson Creek
RC01299	Cape Foulwind
RC01267, RC01301	Mawheraiti
RC01269	Blair Farm, Bell Hill
RC03205	Mallinsons
RC03222	Raft Creek, Kokatahi
RC03259	Caroline Terrace
RC04023	Burkes Farm, Reefton

7.2 Information requests

Fifty percent of the consents issued had official information requests for further information under section 92 of the RMA. Information required to process the consents was also gained during site visits. A site visit is considered crucial to determining the effects of the proposal and whether buffers and other mitigation measures proposed are suitable.

As an example of the type of information that was being requested a copy of guidelines produced in 2003 by Regional Council consent staff is in Appendix 2.

All s91 RMA requests for further consents were for discharge permits. It is noted that some s91 requests include work associated with H&H such as culvert installation and stream protection or realignment works.

7.3 Consent conditions

The level and type of monitoring, and prescriptive conditions that have been required as part of consents issued over the last three years has varied greatly. The requirements have included:

- the supply of work programmes;
- hydrological measurements pre- and post development;
- nutrients and periphyton monitoring;
- substrate, suspended solids, re-suspended solids, turbidity, and clarity monitoring;

- implementation of sediment control devices;
- requirements for buffer zones;
- compliance limits specified but no monitoring required; and
- the need to meet s107(1)(c)-(g) of the RMA – after reasonable mixing test.

There is clearly a tier of requirements that are/have been used:

- (i) large scale: work programmes, buffers, nutrient and periphyton analysis, substrate, clarity, pre- and post development hydrological investigations, compliance limits and a monitoring timetable. (Note: only two Landcorp consents have required this level)
- (ii) as for (i) above but without the hydrological investigations;
- (iii) medium-large scale: work programme, buffers, substrate, clarity, suspended solids, compliance limits and a monitoring timetable;
- (iv) no monitoring but specifies sediment control devices, buffer zones and compliance limits; and
- (v) no monitoring but specifies sediment control devices, buffers and compliance with section 107(1) of the RMA.

The requirement for a work programme depends on the scale of the activity and term of consent granted. The short term consents (1-2 years) do not necessarily require a work programme as the H&H is usually completed in one stage.

The requirement for buffer zones and sediment control devices has been specified in over 90% of the consents assessed.

Examples of conditions can be found in Appendix 3.

7.4 Consent Compliance

To date little monitoring information has been supplied to the Regional Council. This partly reflects the wording of consent conditions in requiring monitoring data to be supplied on completion of the works. Monitoring information that has been supplied, other than work programmes, is from Landcorp.

Compliance matters that need to be considered are:

- It is questioned whether the periphyton, substrate and suspended solids monitoring on consents issued to individual landowners will actually be carried out. To improve the chances of this happening a laymans guide to the conditions would be required and follow up compliance monitoring by Regional Council compliance staff.

- The key matter that needs to be considered when considering compliance monitoring is the availability of staff and resources. Should compliance monitoring be undertaken it is also suggested that the Regional Council prioritise consents.
- If someone makes a H&H enquiry to Consents, and the proposal is permitted, information should be passed to Compliance staff.
- The Regional Council needs to be liaising with District Councils to avoid potential conflicts over buffer requirements as differences in requirements can lead to non-compliances.

8 Incidents

Incidents relating to H&H activities that have been reported from 2000 to now (April 2004) have been analysed. There are 36 complaints that directly relate to H&H registered in the Council's incidents database (see Appendix 4). Of those that have an outcome recorded against the complaint, the action required, or not, falls into four main categories:

- (i) abatement notice issued;
- (ii) consent to be applied for;
- (iii) need for a buffer zone around a water body; or
- (iv) compliant activity.

Council staff have stated that a significant number of the non-compliances resulted from landowners being ignorant of buffer requirements.

The incidents do cluster around three main areas: Harihari, the Grey Valley and north of Westport. This reflects the locations in which consents have been issued, but also the areas in which dairy farming is carried out on the West Coast.

9 Summary

The Regional Council commissioned this review of H&H to considered the effects of H&H, the resource consents issued by the Regional Council and monitoring undertaken.

The effects of H&H can be divided into four main categories:

- (i) changes in hydrology;
- (ii) changes in the soil profile;
- (iii) effects of discharges to water; and
- (iv) effects on habitat values

Within these categories the effects are not isolated, rather changing one parameter can influence another.

Of the 35 resource consents issued over the last three years for H&H the majority of the applications relate to land in the Grey Valley with the largest scale development having been carried out by Landcorp Farming Limited.

The consent conditions imposed and the monitoring information supplied to date suggests that monitoring needs to be tailored to each application to ensure that data can be collected and that it relates to the effect of the activity.

As H&H is an activity that will continue to be undertaken on the West Coast, the Regional Council should consider developing a layman's guide that includes:

- information required to be submitted with consent applications;
- a summary of the effects of H&H on soil, water and habitat;
- best practice during earthworks; and
- how to undertake monitoring.

It is also recommended that records of consents issued are kept up to date so that when making decisions on applications the cumulative effects can be considered.

10 References

NIWA (August 2003), The effects of humping and hollowing on the hydrological regime, north Westland, NIWA report CHC2003-085.

Sinclair Knight Merz (August 2002), West Coast Farms Hump & Hollowing Project. Assessment of Hydrological Effects at Mawheraiti Farm. Report prepared for Landcorp Farming Limited.

Sinclair Knight Merz (February 2003), Cape Foulwind Farm Acid Sulphate Soils Assessment. Report prepared for Landcorp Farming Limited.

Sinclair Knight Merz (October 2003), Hump and Hollow Consents, Assessment of Effects on the Environment Weka Sheep and Beef Farm, Resource consent application prepared for Landcorp Farming Limited.