water quickly spills across the flats which act as floodways. Infilled lowland channels are 12% of the sample. Sediment sources occupy 26% of their reach length.

Photo 2: Lowland channel infilled with alluvium

Valley-bottom channels incised in weathered rock or clay (Photo 3)

The upper reaches of tributary channels. Some drain to the lowland channels already described. Others flow direct to the Mahurangi estuary through valley bottoms in a block of rolling country that occupies the north-eastern catchment (Duck Creek, Hamilton Creek, un-named valley-bottom streams draining to Te Kapa Inlet). Valley-bottom channels also include those that discharge to the estuary from a block of steep country in the catchment's centre (Dyer Creek, Hepburn Creek, un-named stream draining the Parry Reserve); and from a block of rolling country that occupies the south-eastern catchment (un-named streams draining to Pukapuka Inlet).

These channels are small, typically 1 to 3 metres wide. They flow through pools that are almost zero gradient, separated by stepped rock bars of tuffaceous sandstone or volcanic grit. In this respect only, they resemble incised lowland channels. Their banks are completely different - typically 1 to 3 metres high, cut into footslopes that abut the channel. Bank angles are very steep - in the 35 to 60 degree range - but ease abruptly to undulating (8 to 15 degree) footslopes at top of each bank. Bank materials are variable. Sandy clay, weathered in situ from marine sandstone or siltstone, predominates. It is interspersed by bands of tuffaceous sandstone which appear as "rotten rock" in banks. Colluvium (sediment deposited on footslopes by sheetwash of soil from farther up) is also common. It appears in banks as lenses of sand and silt, with low clay content.

The channels carry slight low flows throughout the summer months. After heavy rain, they discharge appreciable flood flows, but volume is much less than lowland channels, simply because each stream has just a few square kilometres of headwater area to contribute runoff. Most floods are contained within the channel cross-section; only exceptional floods rise onto footslopes. Incised valley-bottom channels are 12% of the sample. Sediment sources occupy 35% of their reach length.

Photo 3: Valley-bottom channel incised in weathered clay

Valley-bottom channels infilled with re-worked colluvium (Photo 4)

Occur as reaches interspersed along incised valley-bottom channels.

Dimensions of the open channel are similar i.e. 1 to 3 metres wide, but it flows across an alluvial bed, formed where the stream re-works colluvium (sediment deposited on footslopes by sheetwash). The sediment has a high content of coarse grains, so is best described as sandy or silty clay. It contains sufficient clay particles for cloudy mud to rise and suspend in flowing water if the sediment is disturbed. Banks range from near-flat to short vertical scarps up to a metre high. They are bordered by narrow flats, rarely wider than 5 metres. The flats are swampy where vegetated by wetland or pasture. Where vegetated by native trees or planted trees, they are summer-dry, but may turn boggy in winter. In all these respects, infilled valley-bottom channels resemble infilled lowland channels. Where they differ, is that the flats are narrow, discontinuous, and in many places just on one side of a channel. The channel's other side is bordered by a footslope of weathered clay or colluvium, and a second footslope abuts the flat.

The channels have minimal flood capacity - they carry low flows but floodwater quickly rises to flow across the flats. Groundwater seepage through fill may augment low flows, but this cannot be confirmed in the absence of flow recorder data. Infilled valley-bottom channels are 26% of the sample. Sediment sources occupy 25% of their reach length.

Photo 4: Valley bottom channel infilled with re-worked colluvium

Hillslope channels incised in weathered rock or clay (Photo 5)

Distributed throughout catchment headwaters. Also on hillslopes descending to the Mahurangi estuary.

Incised hillslope channels are less than a metre wide. They descend hollows on hillslopes, initially at gradients exceeding 20 degrees, easing to about 5 degrees on lower slopes. Banks are steep short scarps less than a metre high, vegetated by grass in the open or forest groundcover species if beneath trees or scrub. Bed and banks are sandy clay, weathered from sandstone or siltstone, though can be solid rock where tuffaceous sandstone outcrops through a hillside, forming a cascade or waterfall.

The channels carry a trickle of low flow during fine weather, and dry entirely during summer droughts. Flood flows are small in volume and short in duration. Steep channel gradient enables them to scour and transport sediment. Incised hillslope channels are 13% of the sample. Sediment sources occupy 33% of their reach length.

Photo 5: Hillslope channel incised in weathered rock or clay

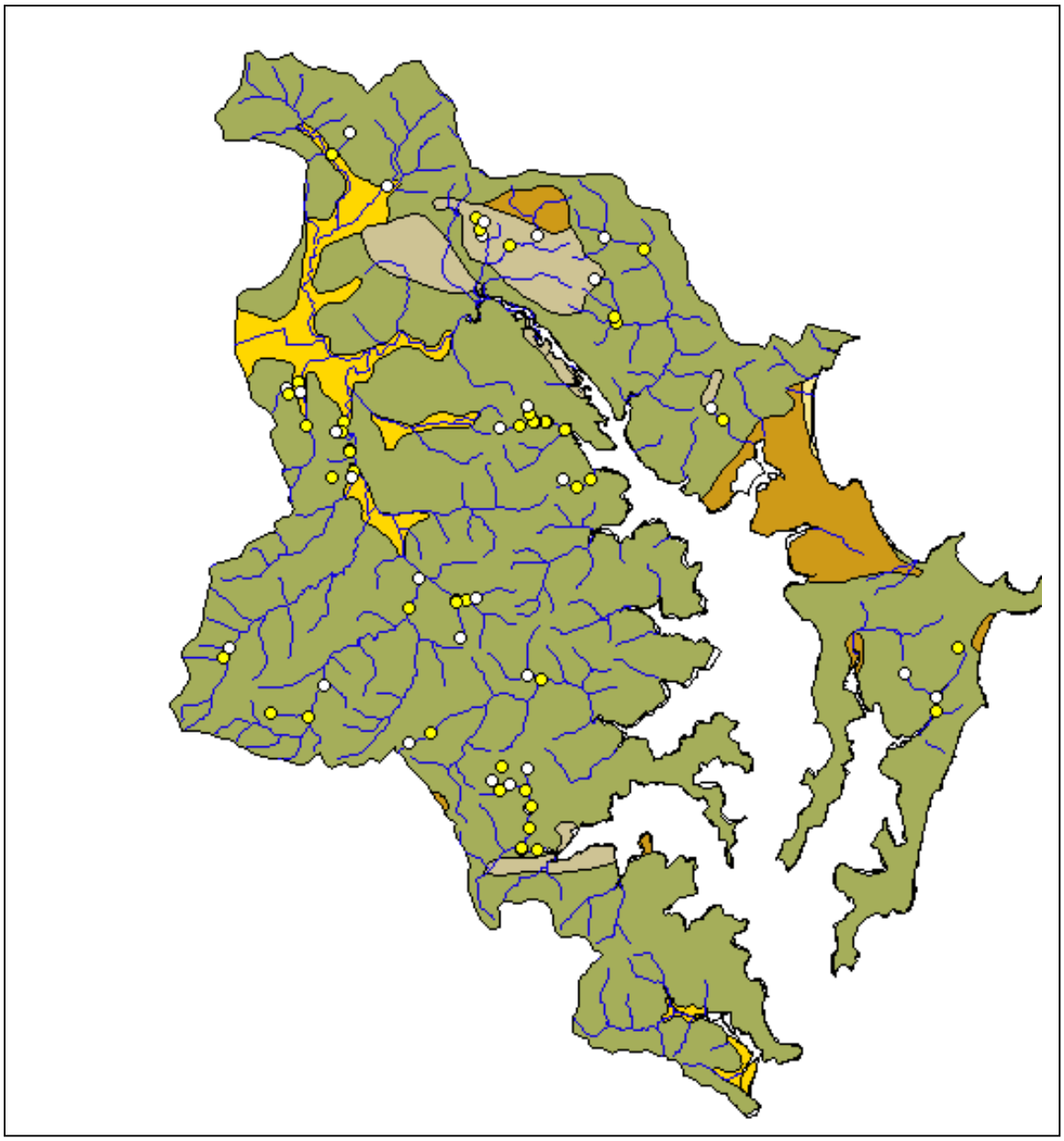
Hillslope channels infilled with colluvium (Photo 6)

Occur as reaches interspersed along incised hillslope channels.

Infilled hillslope channels are less than a metre wide. They descend hollows at comparable gradients to incised channels, but flow across colluvium which the stream re-works downslope. The sediment is a sandy or silty clay, derived in part from sheetwash of soil particles off the adjacent hillside, though a large fraction is mass movement debris - soil which has been transported downslope by slips and slumps, deposited in the channel, and re-worked downstream by flowing water. Fill extends a metre or two either side of the channel. Like infilled channels in valley bottoms, it is swampy where on open ground vegetated by grass or wetland. Beneath tree or scrub cover, it is dry for much of the year but can turn boggy after prolonged wet weather in winter, or after heavy rain in summer.

Like incised hillslope channels, low flows are a trickle, and flood flows are small. It is rare for low flows to cease entirely, possibly due to shallow groundwater seepage through springs at their heads. Infilled hillslope channels are 19% of the sample. Sediment sources occupy 38% of their reach length.

Geological Classes within the Mahurangi Catchment and Location of Stream Reaches



Alluvium
Limestone
Mudstone
Sand and dunes
Siltstone and sandstone

Map 2

Photo 6: Hillslope channel infilled with colluvium

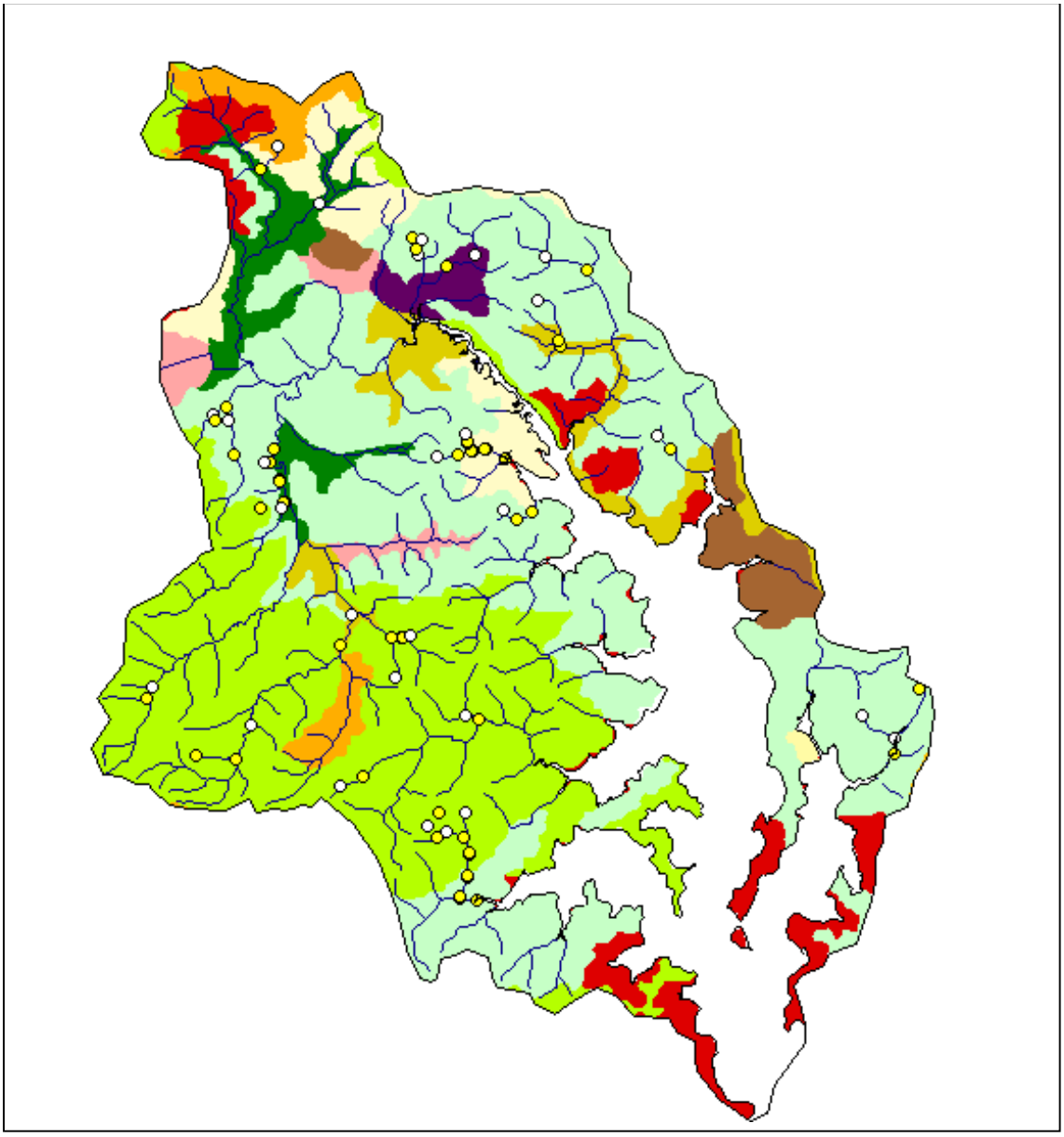
Discussion

Maps 2 and 3 depict the Mahurangi catchment's stream network relative to published geological and slope maps. The sample shows that :

- Lowland channels are located on Tauranga Group alluvium, dissected into undulating terraces (4 to 7 degree surfaces, steepening at terrace edges).
- Valley-bottom channels are located on Waitemata Group or Northland Allochthon sedimentary rocks, where these rocks form rolling downlands or footslopes (8 to 15 degree surfaces, steepening at stream banks).
- Hillslope channels are located on the same geological formations, where they form moderate to steep faces (16 to 25 degree upper slopes, steepening to 26-35 degrees at the base).
- Incised channels are found where solid rock, or clay weathered in situ from rock, or weathered sediment, outcrops in stream beds and banks.
- Infilled channels are found where stream beds and banks are recent colluvium or alluvium, mantling older sediment or rock.

Standard errors (Table 3a) give a high degree of confidence that each stream landform is present in proportions indicated by the sample; also that sediment sources occupy reach length in the proportions indicated.

Soil Classes within the Mahurangi Catchment and Location of Stream Reaches



- Atuanui steepland soil
- Waitemata complex and Otao silt loam
- Motatau clay
- Warkworth clay and sandy clay loam
- Whakapara and Whareora clay loam
- Whangaripo clay loam
- Whangaripo clay soil
- Kara silt loam
- Puhoi light brown clay loam
- Waikare silt loam

Map 3

Percentage of reach length occupied by sediment sources is significantly lower on lowland channels (both types) and infilled valley-bottom channels, than on incised valley-bottom channels or hillslope channels. That said, all percentages are high.

Overall percentages mask considerable variation from one reach to the next. Table 3b gives frequency distributions for sediment sources on each stream landform. Clearly a proportion of reaches have no sediment sources at all; most have moderate incidence; and a few have high incidence. The latter could have several causes, which will be examined in Sections 4 to 6. Meanwhile, the influence of geology, regolith and relief can be elucidated by comparing sample data only for stream landforms that still have natural bank vegetation, relatively undisturbed by livestock or humans (Table 3c)

The range of natural sediment sources is high on five out of six stream landforms. It increases with the transition from hillslopes, to valley bottoms, to lowlands; except for the low range on infilled lowland channels.

On hillslope channels the only natural sediment sources are scour of bed or bank, with associated deposition of sediment in the channel. Both are minor in dimensions. On valley-bottom channels, these sediment sources remain small but affect larger percentages of bank length, and are joined by sporadic bank collapses. On lowland channels, bank collapses become extensive and large, with similarly large sediment deposits in downstream pools.

These ranges are expected, as they accord with published geomorphological research about the role of slope processes in supply of sediment to headwater streams, the role of channel gradient in sediment transport by small channels, increases in sediment transport with increasing stream power, and greater erosivity of alluvial sediment compared with clay or rock.

Conclusions specific to this survey are that :

- Sediment entry into streams is a natural process in all parts of the Mahurangi's freshwater network.
- It affects a variable - often large - percentage of bank length, on all stream landforms.
- There is an increase in range, variety and size of natural sediment sources, moving from hillslope through valley-bottom to lowland channels.
- The range is further increased by non-natural sources, on all types of stream landform.

TABLE 3b: FREQUENCY DISTRIBUTIONS FOR SEDIMENT SOURCES ON STREAM LANDFORMS						
% of reach affected	Incised hillslope	Infilled hillslope	Incised valley	Infilled valley	Incised lowland	Infilled lowland
0-	0.10	0.13	0.20	0.16	0.03	0.07
1-10	0.31	0.18	0.10	0.31	0.16	0.26
11-20	0.14	0.13	0.10	0.12	0.19	0.07
21-30	0.17	0.11	0.10	0.12	0.26	0.26
31-40	0.07	0.18	0.17	0.12	0.10	0.11
41-50	0.03	0.00	0.17	0.12	0.03	0.11
51-60	0.03	0.11	0.10	0.00	0.10	0.00
61-70	0.03	0.02	0.03	0.00	0.10	0.04
71-80	0.00	0.04	0.00	0.02	0.03	0.04
81-90	0.03	0.00	0.00	0.00	0.00	0.00
91-100	0.07	0.09	0.03	0.02	0.00	0.04
Totals:	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 3c: RANGE OF SEDIMENT SOURCES ON STREAM LANDFORMS					
Stream landform	Relief	Geology	Regolith	% of length affected (all reaches)	(reaches in natural condition)
Incised hillslope	steep	rock	clay	0-100	0-35
Infilled hillslope	steep	rock	colluvium	0-100	0-37
Incised valley-bottom	moderate	rock	clay	0-100	0-48
Infilled valley-bottom	moderate	rock	re-worked colluvium	0-100	0-57
Incised lowland	flat	sediment	weathered alluvium	0-78	1-65-
Infilled lowland	flat	sediment	fresh alluvium	0-92	0-25

4 STREAM BANK VEGETATION IN THE MAHURANGI CATCHMENT

Introductory comments

Recording bank vegetation, enables reaches in a natural condition to be separated from reaches that have been disturbed by land use. The records also indicate how bank vegetation has been modified by different land managements within a particular use. Table 4a summarises sample data relative to bank vegetation. Bank vegetation was recorded :

- from the water's edge to the top of bank, where banks are clearly defined (incised channels),
- from the water's edge to the edge of fill, where there are no distinct banks (infilled channels).

Wetland

Wetland vegetation is present on 31% of stream banks in the Mahurangi. Intact flax swamp, raupo swamp, or sedge-rush swamp is absent. Somewhat modified wetland (Photo 7) has been recorded along 3% of sample banks. Disturbed wetland, vegetated by sedges and rushes intermingled with exotic pasture grasses and water weeds (Photo 8) is more common, occupying 11% of banks. Degraded wetland, dominated by exotic pasture grasses but containing remnant clumps of sedge or rush (Photo 9), is also common, occupying 17% of banks.

Within wetlands, sediment sources are present on :

- 5% of reach length where somewhat modified,
- 30% where disturbed and grazed,
- 19% where disturbed but now fenced,
- 39% where degraded,
- 3% where degraded but now fenced.

TABLE 4a: SEDIMENT SOURCES AMONGST BANK VEGETATIONS

			Reaches (number)	Length (paces)	% of sample	sample error (+-2 s.e.)	Sediment sources (paces)	% of sub-sample	sub-sample error (+-2s.e.)
Wetland	modified		7	800	2.9	0.2	37	4.6	1.5
	disturbed	grazed	16	2300	8.4	0.3	697	30.3	1.9
	disturbed	fenced	7	620	2.3	0.2	115	18.5	3.1
	degraded	grazed	25	3801	13.9	0.4	1478	38.9	1.5
	degraded	fenced	8	914	3.4	0.2	31	3.4	1.2
Pasture	open	grazed	17	2065	7.6	0.3	1112	53.8	2.2
	open	Grazed & rank	12	2192	8.0	0.3	600	27.4	1.9
	open	rank	15	1633	6.0	0.3	346	21.2	2.0
	with scrub	scattered	2	241	0.9	0.1	45	18.7	4.9
	with bush	scattered	3	380	1.4	0.1	180	47.4	5.0
	with scrub	open canopy	4	264	1.0	0.1	77	29.2	5.5
	with bush	open canopy	12	1882	6.9	0.3	887	47.1	2.3
Scrub	regenerating	fenced	2	180	0.7	0.1	73	40.6	7.2
	successional	grazed	1	56	0.2	0.1	30	53.6	13.1
	successional		9	909	3.3	0.2	185	20.4	2.6
Bush	regenerating	fenced	13	1688	6.2	0.3	440	26.1	2.1
	mature	grazed	1	204	0.7	0.1	109	53.4	6.8
	mature		17	2122	7.8	0.3	559	26.3	1.9
Exotic trees	plantations	grazed	3	472	1.7	0.2	139	29.4	4.1
	plantations	fenced	7	971	3.6	0.2	170	17.5	2.4
	woodlots	grazed	2	207	0.8	0.1	5	2.4	2.1
	woodlots	fenced	5	732	2.7	0.2	100	13.7	2.5
	bank plantings	grazed	9	916	3.4	0.2	415	45.3	3.2
	bank plantings	fenced	14	1712	6.3	0.3	371	21.7	2.0
Totals:			211	27261	100.0		8201	30.1	0.5

Photo 7: Modified wetland

Photo 8: Disturbed wetland

Photo 9: Degraded wetland

Photo 10: Grazed pasture

Grass

Exotic grasses sown as pasture are widespread, occupying 32% of stream banks in the Mahurangi. Its composition is diverse. Grazed pasture devoid of other vegetation (Photo 10) is present on just 8% of sample banks. Another 2% is grazed pasture with scattered woody vegetation, either scrub or remnant bush trees. 8% has grazed pasture with extensive woody vegetation forming an open canopy.

8% of sample banks have a mix of grazed pasture on one bank and rank grass (fenced) on the other. Rank grass on both banks (Photo 11), retired from grazing by bank fences or in young forestry blocks, is present on 6%. This figure includes banks where weeds, exotic scrub or native scrub are emerging through rank grass.

Within pasture, sediment sources occupy :

- 54% of sample reach length in grazed open pasture,
- variable figures between 19 and 47% in grazed pasture where woody vegetation is scattered,
- variable figures between 29 and 47% in grazed pasture where woody vegetation is open,
- 27% where one bank is grazed and the other is rank grass,
- 24% where both banks are rank grass.

Photo 11: Rank grass

Photo 12: Exotic scrub

Exotic scrub

Exotic scrub species such as gorse (Photo 12), blackberry, pampas grass, giant reed, wild ginger, are surprisingly rare along streams in the Mahurangi. They have been recorded only as secondary vegetation on sample banks; generally where the principal bank vegetation is grass or wetland that has been fenced and retired from grazing or planted in trees. Patches have also been recorded where bank vegetation is native bush or scrub that has been disturbed, creating opportunity for weeds to colonise.

Indigenous scrub

Indigenous scrub is a common secondary bank vegetation in grass and wetland. As a primary bank vegetation it is present but not widespread, variable in its species composition and structure. Intact successional scrub (Photo 13), dominated by tall kanuka with an understorey of forest floor species such as hangehange and punga, has been recorded on 3% of reach length. Regenerating scrub (Photo 14), dominated by kanuka but with an open canopy, few forest floor species, and a ground cover of rank grass, occupies just 1%. Scattered scrub (Photo 15) - mostly isolated kanuka or tree fern on banks that are otherwise pasture - is widespread but is included in the grass total.

Within scrub, sediment sources occupy :

- 41% of reach length where regenerating scrub is fenced,
- 54% where successional scrub is grazed (just one reach),
- 20% where successional scrub is intact.

Photo 13: Successional scrub

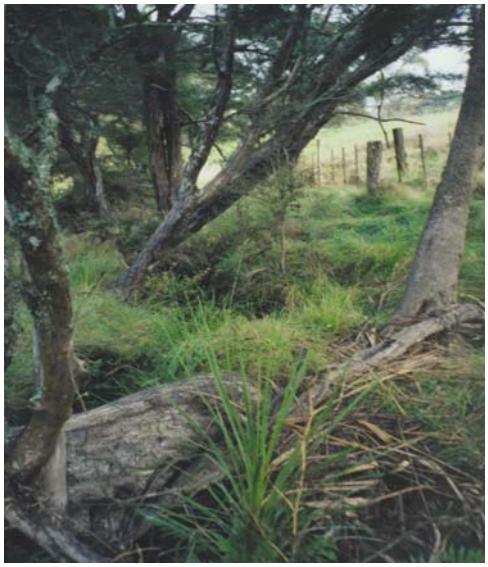


Photo 14: Regenerating scrub

Photo 15: Scattered scrub

Photo 16: Conifer plantation

Exotic trees

Planted exotic trees are common, accounting for 18% of bank vegetation. Stands are diverse. Conifers - pines and cypresses established as commercial plantations - were recorded on 5% of stream banks (Photo 16). Hardwoods - willows, poplars, gums, wattles, planes, alders - were recorded on 3% of stream banks as farm woodlots (Photo 17); and on 10% as spaced plantings for bank stability (Photo 18). Scattered exotic trees (Photo 19) - remnants from old shelterbelts or recent amenity plantings – are included in the grass total.

Within exotic trees, sediment sources occupy :

- 2% of sample reach length where woodlots are grazed,
- 14% of reach length where woodlots are fenced,
- 29% where plantations are grazed,
- 18% where plantations are fenced.

Photo 17: Hardwood woodlot

Photo 18: Spaced exotic trees

Photo 19: Scattered exotic trees

Photo 20: Mature forest

Indigenous trees

These are also 15% of bank vegetation in the Mahurangi. Like indigenous scrub, the stands are variable in composition and structure. Mature forest (Photo 20) dominated by kauri, tanekaha, puriri or taraire, was recorded on 9% of bank length. Remnant forest dominated by these species, and regenerating forest (Photo 21) dominated by totara, kahikatea or rimu, occupy 6% of bank length. The canopy is best described as closed rather than open, with an understorey of forest species like hangehange and punga where fenced, and a ground cover of sparse grass but little else where not. Scattered forest trees (Photo 22) are also common on stream banks which are otherwise grazed pasture, and are included in the grass total.

Within bush, sediment sources occupy :

- 26% of sample reach length where remnant or regenerating forest is fenced,
- 54% where mature forest is grazed (just one reach),
- 26% where mature forest is relatively undisturbed.

Photo 21: Remnant and regenerating forest

Photo 22: Scattered forest trees

Grain, greenfeed or vegetable crops

The random sample did not pick up any reaches with cropped banks. A very few are known to exist where streams flow through terraces and flats in the vicinity of Warkworth. Their scarcity reflects firstly, that cropping of any kind is now rare in the Mahurangi. Secondly, cultivation of banks is not a practice favoured amongst crop growers; current practice being to leave an uncultivated strip of rank grass or weeds between the crop and the stream.

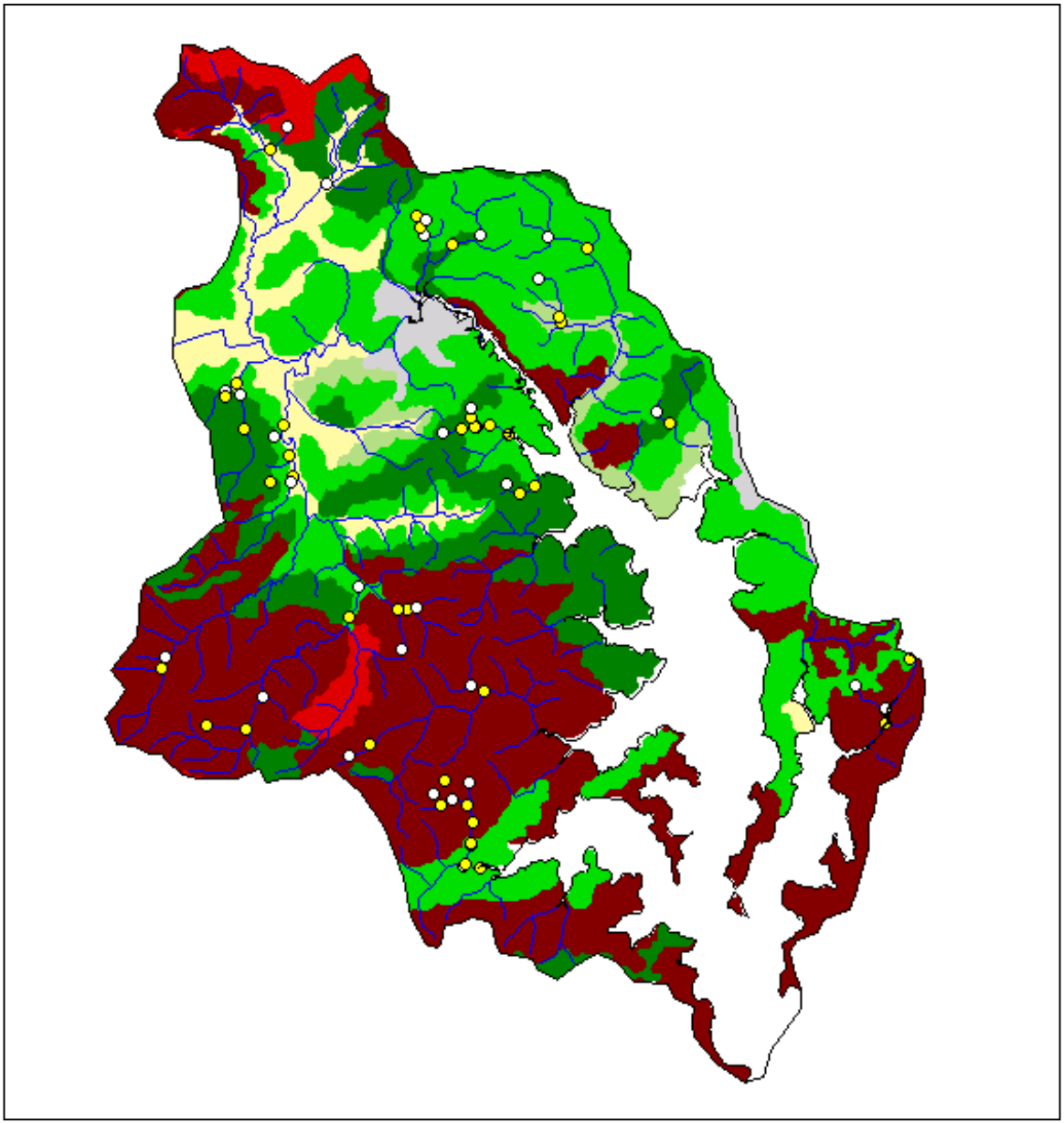
Fruit trees or vines

The random sample did not pick up any reaches with fruit trees or vines planted on banks. Three reaches were adjacent to orchards but had other bank vegetation. Orchards are scattered throughout the Mahurangi; but most are now small-scale plantings on lifestyle blocks, not commercial ventures. Vineyards, now common in the Matakana catchment, are starting to locate on easy-contour land in the Mahurangi. As with cropland, growers favour leaving a strip of unplanted rank grass between the bank and the vines.

Unvegetated surfaces

The random sample did not pick up any banks with extensive unvegetated surfaces e.g. road pavements, unsealed roads, clay tracks, farm yards, industrial yards, quarries. Two reaches were adjacent to roads but separated from them by indigenous forest on banks. Three reaches were adjacent to a quarry but separated from it by rank grass banks with an open canopy of planted and indigenous trees. Another reach was adjacent to a concrete yard but separated from it by a strip of indigenous forest. The Mahurangi's main channel, from the junction of East and West Branches to tidewater, flows past the outskirts of Warkworth. Here urban uses (houses, commercial premises, schools) abut the water at a few points, but most of its length is separated by thin strips of remnant or regenerating forest which has been preserved on banks.

Slope Classes within the Mahurangi Catchment and Location of Stream Reaches



Map 4

Discussion

Map 4 shows the Mahurangi's stream network relative to published vegetation maps. The sample indicates a considerably more detailed pattern of bank vegetation.

- Mature or regenerating forest is a common bank vegetation, occupying 15% of sample reach length. The split is 9% mature and 6% regenerating.

- Successional or regenerating scrub is uncommon, occupying 4% of sample reach length. The split is 3% successional and 1% regenerating.

- Exotic trees, planted for commercial harvest, as farm woodlots or for bank stability, also occupy 18% of sample reach length. The split is 5% plantations, 3% woodlots, and 10% plantings for bank stability.

- Grass is the most widespread bank vegetation in the Mahurangi, occupying 32% of sample reach length. Just 8% is grazed pasture without other vegetation; 8% is a mix of grazed and rank pasture on opposite banks; and 6% is rank pasture on both banks. Grazed pasture with scattered woody vegetation accounts for 2% of reach length; while grazed pasture with an open canopy of trees or shrubs accounts for 8%.

- Wetland is almost as widespread, occupying 31% of sample reach length. Of this 11% is disturbed but fenced or lightly grazed. 17% is heavily grazed and degraded. Just 3% is relatively undisturbed.

- Intensive land uses (crops, orchards, vineyards) rarely occur as bank vegetation.

- Urban/industrial uses (roads, yards, quarries, factories, houses) are separated from banks, usually by belts of indigenous vegetation.

Standard errors (Table 4a) indicate a high degree of confidence that sample percentages for bank vegetation represent the catchment as a whole. Sediment sources, expressed as a percentage of reach length for each bank vegetation, are representative for the main categories and also for sub-types that are widespread. Standard errors are somewhat high for uncommon sub-types; percentages for the latter should be used with caution.

Table 4b gives frequency distributions for sediment sources, amongst reaches with different bank vegetations in the Mahurangi. Their role can be seen by comparing the range under natural vegetation, with the ranges under modified or planted vegetation (Table 4c).

TABLE 4b: FREQUENCY DISTRIBUTIONS FOR SEDIMENT SOURCES AMONGST BANK VEGETATIONS

% of reach affected	Mature bush & scrub	Regenerating bush & scrub (fenced)	Remnant bush & scrub (grazed)	Exotic trees (fenced)	Exotic trees (grazed)	Grass (rank)	Grass (grazed)	Wetland (rank)	Wetland (grazed)
0-	0.07	0.13	0.04	0.31	0.00	0.13	0.00	0.45	0.02
1-10	0.29	0.27	0.19	0.19	0.14	0.07	0.13	0.27	0.29
11-20	0.25	0.00	0.08	0.08	0.07	0.20	0.21	0.05	0.15
21-30	0.00	0.13	0.27	0.19	0.14	0.27	0.13	0.18	0.12
31-40	0.14	0.20	0.19	0.04	0.07	0.27	0.13	0.05	0.12
41-50	0.07	0.07	0.08	0.12	0.29	0.00	0.08	0.00	0.02
51-60	0.18	0.13	0.00	0.04	0.14	0.00	0.08	0.00	0.10
61-70	0.00	0.07	0.04	0.00	0.07	0.00	0.08	0.00	0.07
71-80	0.00	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.05
81-90	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
91-100	0.00	0.00	0.08	0.04	0.00	0.00	0.17	0.00	0.05
Totals:	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 4c: RANGE OF SEDIMENT SOURCES BY BANK VEGETATION

Bank vegetation	Natural % of length	Regenerating % of length	Remnant (grazed) % of length	Open (grazed) % of length	Open & rank (lightly grazed) % of length	Rank % of length
Bush	0-56	0-65	2-100	-	-	-
Scrub	2-58-	36-52	1-65-	-	-	-
Exotic trees			-	-	2-49-	0-45
Grass	-	-	-	3-100	6-100	0-78
Wetland	0-25	0-38	0-100	-	-	-

The range of sediment sources is high for most bank vegetations in the sample. Nonetheless some differences can be discerned.

Sediment sources range from zero up to more than half reach length, for natural bush and scrub, and remain similar where regenerating bush and scrub are fenced.

Overall range is similar for commercial plantations and farm woodlots, including those where understorey is lightly grazed. Where exotic trees have been planted on banks for stability, sediment sources range up to 100% of reach length. Some such reaches remain very unstable; others now have zero sediment sources (see Table 4b).

Sediment sources range up to entire reach length, for grazed pasture with remnant woody vegetation. The overall range is similar for grazed open pasture; also for banks that are a mix of grazed pasture and rank grass; but drops to between zero and four fifths of reach length where both banks are fenced rank grass. Most such reaches now have zero or few sediment sources, but some do not (Table 4b).

Up to entire reach length is affected by sediment sources where bank vegetation is degraded or disturbed wetland that is grazed; but drops to between zero and two fifths where such reaches are fenced. Up to a quarter of reach length is affected on the few reaches where bank vegetation is modified wetland.

These ranges will be a surprise to some people, as they contradict the "accepted wisdom" that there are few sediment sources on banks with natural vegetation cover.

They also show that planted trees on banks can hold sediment sources to much the same range as natural vegetation cover, provided livestock are excluded. Where livestock graze banks in pasture beneath planted trees (or retained trees), the range remains similar to open pasture.

Upper ranges for banks in open pasture seemingly confirm another "accepted wisdom", that sediment sources are numerous where stock graze grassed banks unprotected by any kind of tree or scrub cover. However lower ranges do not confirm this view. There are many instances where sediment sources can be few on grazed banks (Table 4b). Either grazing management, or reach characteristics, come into play.

The ranges for wetland vegetation indicate that where present (on infilled channels), it holds sediment sources to a lower range than natural tree or scrub cover, providing stock are excluded. Low percentages on a proportion of channels where wetland is grazed by stock (Table 4b) suggest, again, that grazing management or reach characteristics can hold sediment sources low.

Conclusions specific to this survey are that :

- There are fewer sediment sources amongst bank vegetations where there is stock exclusion (bush and scrub, tree plantations and woodlots, disturbed and degraded wetlands).

- There are more amongst bank vegetations where stock have access (pasture with remnant bush or scrub, pasture with planted trees, open pasture, disturbed and degraded wetlands).

- There is great reach-to-reach variability in extent of sediment sources, for any one bank vegetation.

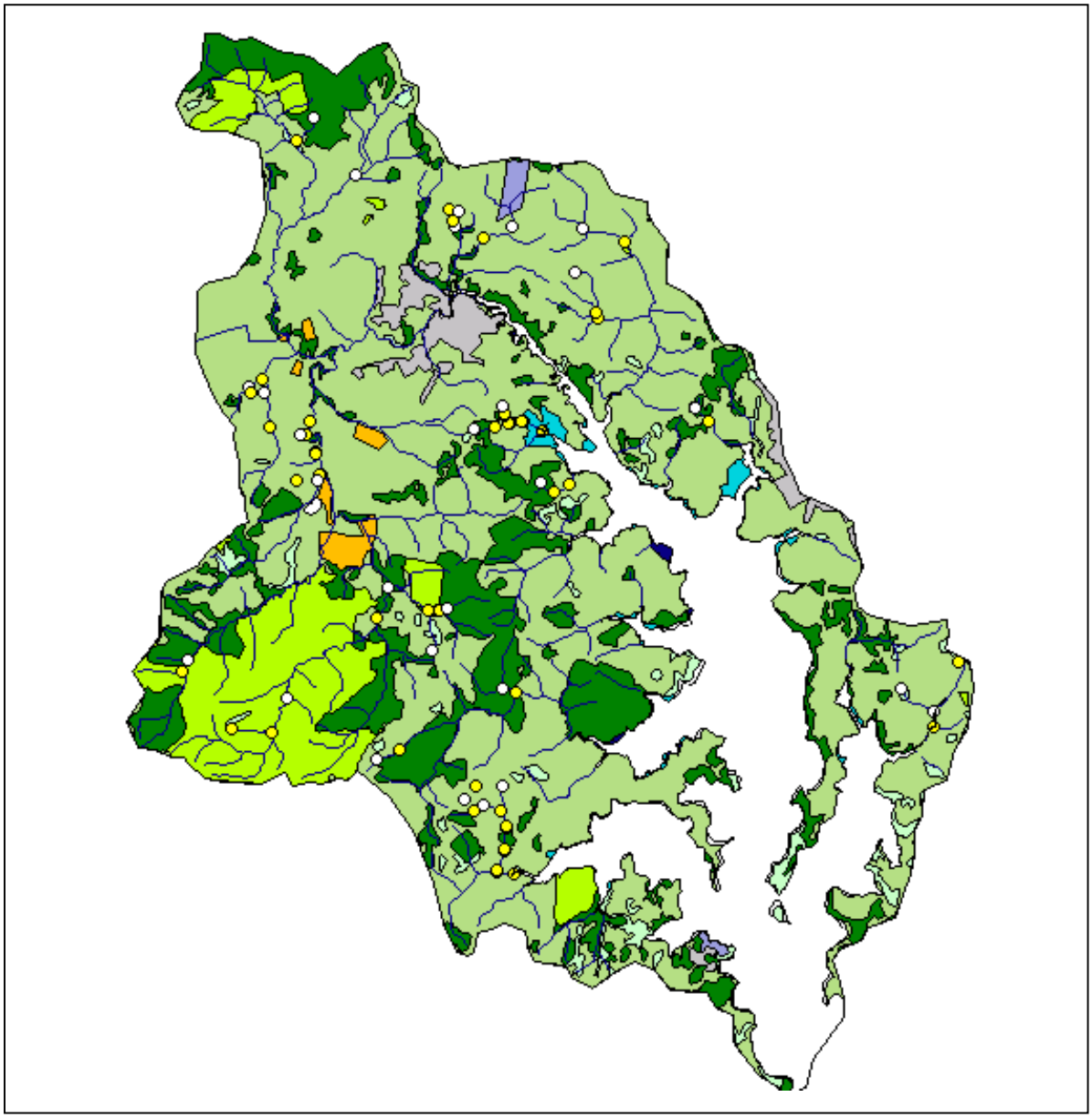
5 LAND USES IN THE MAHURANGI CATCHMENT

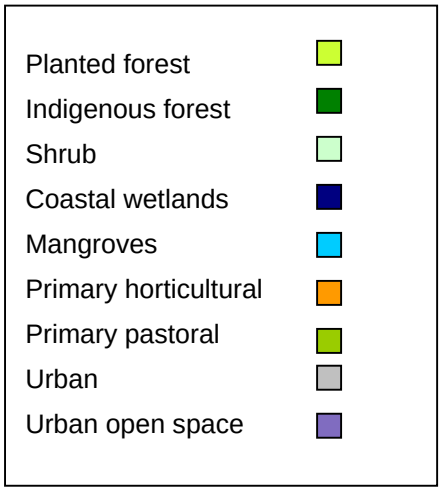
Introductory comments

Map 5 shows the Mahurangi's stream network relative to published land use maps held in ARC's geographic information system. It indicates that most of the Mahurangi is occupied by four uses - drystock pasture, bush and scrub conservation areas, plantation forests, and dairy pasture. Intensive uses - cropland, orchards, vineyards, market gardens - occupy just 3% of land. Non-rural uses - urban areas, industrial sites and quarries - occupy just 4%.

The streambank sample is broadly in line with these proportions, but shows a more intricate pattern of use along banks. It is rare for a stream segment to have the same use along its entire length. Uses commonly differ on opposite banks, and along the same bank, they change every few hundred metres. This intricacy has been taken into account by breaking the segments up into reaches, not just where channel forms change, but also where there are changes in bank vegetation and adjacent land use. Table 5a summarises sample data relative to land use.

Land Uses and within the Mahurangi Catchment and Location of Stream Reaches





Map 5

TABLE 5a: SUMMARY OF SAMPLE DATA RELATIVE TO LAND USE

Use	Type	Reaches (number)	Length (paces)	% of sample	sample error (+-2 s.e.)	Sediment sources (paces)	% of sub-sample	sub-sample error (+-2s.e.)
conservation	reserve	10	1287	4.7	0.3	256	19.9	2.2
	farm	11	1439	5.3	0.3	413	28.7	2.3
	lifestyle	10	1238	4.5	0.2	369	29.8	2.5
forestry	plantation	13	1852	6.8	0.3	393	21.2	1.9
	woodlot	7	948	3.5	0.2	105	11.1	2.0
farm	dairy	22	3313	12.2	0.4	1866	56.3	1.7
	drystock	68	9883	36.3	0.6	3007	30.4	0.9
	lifestyle	55	5512	20.2	0.5	1513	27.4	1.2
intensive	crop	0		0.0	0.0			
	orchard	4	379	1.4	0.1	94	24.8	4.3
	vineyard	0		0.0	0.0			
non-rural	quarry	6	719	2.6	0.2	17	2.4	1.1
	industrial	0		0.0	0.0			
	urban	5	691	2.5	0.2	168	24.3	3.2
Totals:		211	27261	100.0	0.0	8201	30.1	0.5

Conservation

15% of land adjacent to stream banks is in conservation use. For the purpose of this survey "conservation use" is defined as the formal or informal retention of land in natural cover. Most such land is indigenous forest, though areas of successional scrub and fragments of wetland are included. A feature of land in conservation use is that natural vegetation extends back across most - though not necessarily all - the slopes between channel and watershed.

Adjacent to stream banks, 5% of land in conservation use is formally reserved as DOC scenic reserves, QEII covenants, or similar. Another 5% is land on commercial farms preserved from clearance by private landowners; afforded a degree of management by stock exclusion fences, pest control, and weed control. 5% is similar land on lifestyle blocks.

Within conservation land, sediment sources occupy :

- 20% of reach length adjacent to land that is formally reserved,
- 29% of reach length adjacent to land that is informally preserved on commercial farms,
- 30% of reach length adjacent to land that is informally preserved on lifestyle blocks.

Forestry

10% of land adjacent to stream banks is used for forestry. 7% is land occupied by pine plantations, many pine blocks on farms in addition to commercial stands. 3% is land occupied by hardwood woodlots, entirely on farms. Out of 20 reaches, the sample includes two freshly logged, as well as two recently logged which have been re-planted.

A feature of the pine reaches is that few actually have pines on the banks. Most are separated by strips of rank grass, wetland, or regenerating scrub - either native or exotic. Hardwood woodlots are poplars, alders, gums, or wattles - often mixed - and on many reaches planted right to the banks; though interspersed with an understorey of rank grass and scrub.

Within plantation forests, sediment sources occupy :

- 21% of reach length next to pine plantations,
- 11% of reach length next to hardwood woodlots.

Livestock farms

68% of land adjacent to stream banks is used for livestock farming. The most extensive land use in the Mahurangi, livestock farms adjoin 68% of the sample's reach length. 12% is next to dairy farms, until recent years a widespread land use; most have now been sub-divided into lifestyle blocks or vineyards. 36% is next to drystock farms that graze cattle, sheep or deer. 20% is next to lifestyle blocks, most of which are lightly grazed by diverse stock types.

Where land is used for livestock grazing, sediment sources occupy :

- 56% of reach length next to dairy farms,
- 30% of reach length next to drystock farms,
- 27% of reach length next to lifestyle blocks.

Intensive land uses

The sample includes four reaches adjacent to an orchard (1.4% of sample reach length), but none adjacent to land that is currently cropped or planted in vineyards. Failure to sample the latter two uses is a deficiency, but would have been hard to remedy without departing from a random sampling strategy.

On all the orchard reaches sampled, fruit trees are separated from the stream by a wide belt of mown grass, with bush or shelterbelt trees on the actual banks. This separation appears typical of intensive uses elsewhere, though there are exceptions - for instance fields cropped for maize right to the top of the bank, on a property next to the Right Branch.

On the reaches sampled adjacent to intensive use, sediment sources occupy :

- 25% of reach length.

Non-rural uses

The sample includes six reaches adjacent to a quarry, five reaches adjacent to urban open space (school grounds and buildings), but none adjacent to urban housing or industrial areas. Again, it would have been difficult to cover the spectrum other than by sampling in a non-random fashion.

All the non-rural reaches were separated from adjacent uses by mown grass or rank grass, with remnant bush or planted trees on banks. Again, this separation appears typical of non-rural land uses in the catchment, though there are instances where houses are built close to a bank or industrial yards extend to its top.

On the non-rural reaches sampled, sediment sources occupy :

- 13% of reach length.