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ASSESSING RIVER STABILITY: USE OF THE PFANKUCH METHOD

by

Kevin Collier

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ABSTRACT

Several studies in New Zealand and overseas have shown that physical stability assessed by the method of D.J. Pfankuch is correlated with the taxonomic richness and abundance of benthic invertebrate communities, the biomass of periphyton and trout, and the density of blue duck on rivers. This report describes the application of the Pfankuch reach inventory and channel stability evaluation method as it has been used in New Zealand. Changes have been made to the content and format of the original document in order to clarify interpretation and make the method easier to use. Blank evaluation forms are provided in the back of this report.

1. INTRODUCTION

Several studies in New Zealand and overseas have shown that physical stability is correlated with the taxonomic richness and abundance of benthic invertebrate communities (Collier et *al.* 1993, Rounick & Winterbourn 1982, Winterbourn & Collier 1987), the biomass of periphyton (Death 1991), trout standing crop (Eifert & Wesche 1982), and the density of blue duck on rivers (Collier *et al.* 1993). In all these studies, assessments of physical stability were carried out using the stream reach inventory and channel stability evaluation method described by Pfankuch (1975). This provides a combined assessment of upper bank, lower bank, and channel stability by scoring several physical variables (weighted according to their perceived importance) and summing all values to generate an overall stability rating. The lower the rating the more stable (or less unstable) the site. The final score is an indication of the capacity of a reach to resist the detachment of bed and bank materials, and to recover from potential changes in flow and/or increases in sediment production.

This report is essentially a summary of the document published by Pfankuch (1975). Some modifications in content and format have been made based on the experiences of people who have used the index in New Zealand in order to make the method easier to use. The report presents details on interpretation of the stability evaluation forms, particularly in terms of how these could relate to the suitability of habitat for aquatic life in New In addition to assessing habitat for aquatic biota, stability evaluations have utility for monitoring changes to the river environment, and for assisting land and water managers to make decisions on management practices and development options.

2. GOLDEN RULES OF EVALUATION

1. The evaluation form (see pages 4 and 5) is tailored to best fit second, third and fourth order streams and should ideally be used for streams of these sizes. Blue duck mostly inhabit such streams. A first order stream is the smallest tributary of a river system with permanently flowing water. A second order stream is by two first order streams merging, and a third order stream is formed when two second order streams coalesce, and so on (Fig. 1). However, when a second order stream flows into a third order stream, the stream remains third order.

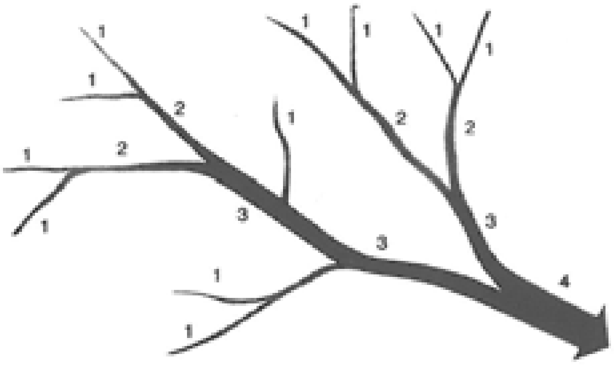


Fig. 1 Orders (numerals) of streams and rivers formed by coalescing tributaries.

2. Where possible, the reach evaluated should he of sufficient length (greater than about 100 m) to provide the observer with enough information to make a sound selection from the available alternatives presented on the evaluation form.

3. The channel should be assessed only during periods of low flow so that the can see the substrate clearly.

4. Do not key in on a single variable or group of variables when scoring the river section. Work through the form methodically.

5. If conditions fall between those described, cross out the proposed score and write an intermediate value which better expresses the situation as

6. Do not attempt an evaluation without reading the explanatory notes in the following sections.

3. WHAT AREAS ARE BEING ASSESSED? (Fig. 2)

Upper banks: That portion of river cross-section from the break in general slope of the surrounding land to the normal high water line. Terrestrial plants and animals normally inhabit this area. In deeply incised channels or where a bank is very steep this would be the area above the normal high water line where perennial vegetation starts even though there is no discernible change in slope. Where the channel is braided, upper banks usually occur at the extreme edges, although some large islands may also qualify.

Lower banks: That portion of river cross-section from the normal high water line to the water's edge during summer low flow which is intermittently submerged. This section is usually sparsely colonised by perennial plants although rapidly growing species may become abundant during extended periods of low flow, especially on braided channels.

Bottom: That portion of river cross-section which is almost always submerged and can be considered a totally aquatic environment.

4. INTERPRETATION OF THE VARIABLES

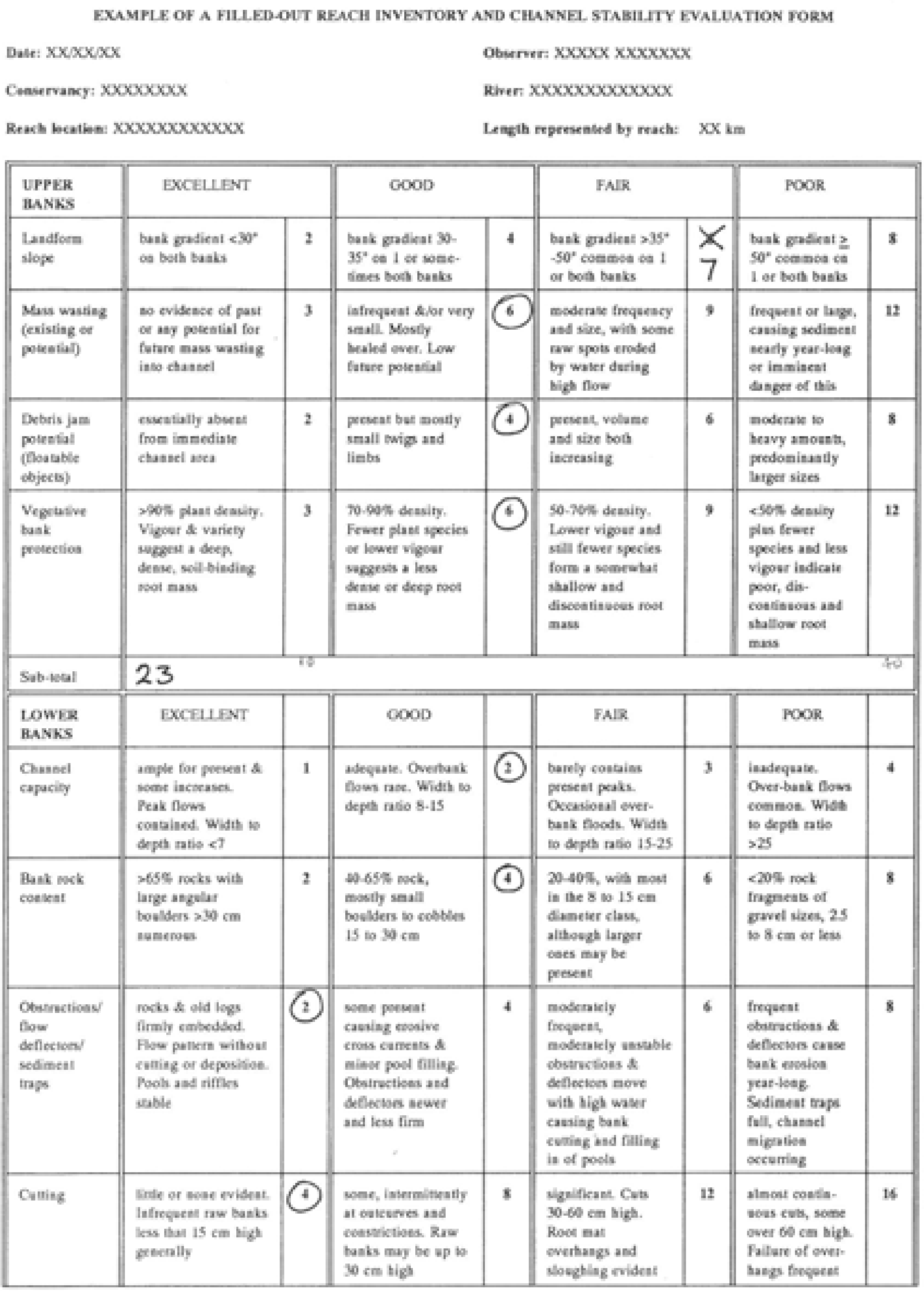
The descriptors for each variable are phrased in fairly general terms to maximise their applicability. The notes below are intended to assist you in interpreting the evaluation forms and should be used in association with those forms. Overlap between the forms and the explanatory notes below has been minimised to avoid repetition. You may wish to add notes to describe particular conditions encountered in your conservancy. Space is provided for this. You could even include photos as visual aids if you wish. Blank evaluation forms are given in the back of this report.

4.1 Upper Banks

4.1.1 Landform slope (Fig. 3)

The steepness of the land adjacent to the channel determines the extent to which banks can be eroded and the potential volume of material that can enter the water. Look at both banks and score them according to the descriptions on the form.

Notes:



EXAMPLE OF A FILLED-OUT REACH INVENTORY AND CHANNEL STABILITY EVALUATION FORM

Date: XX/XX/XX

Observer: XXXXX XXXXXXX

Conservancy: XXXXXXXX

River: XXXXXXXXXXXXX

Reach location: XXXXXXXXXXXX

Length represented by reach: XX km

UPPER BANKS	EXCELLENT		GOOD		FAIR		POOR	
Landform slope	bank gradient <30° on both banks	2	bank gradient 30-35° on 1 or sometimes both banks	4	bank gradient >35° -50° common on 1 or both banks	✗ 7	bank gradient ≥ 50° common on 1 or both banks	8
Mass wasting (existing or potential)	no evidence of past or any potential for future mass wasting into channel	3	infrequent &/or very small. Mostly healed over. Low future potential	[✓ 6]	moderate frequency and size, with some raw spots eroded by water during high flow	9	frequent or large, causing sediment nearly year-long or imminent danger of this	12
Debris jam potential (floatable objects)	essentially absent from immediate channel area	2	present but mostly small twigs and limbs	[✓ 4]	present, volume and size both increasing	6	moderate to heavy amounts, predominantly larger sizes	8
Vegetative bank protection	>90% plant density. Vigour & variety suggest a deep, dense, soil-binding root mass	3	70-90% density. Fewer plant species or lower vigour suggests a less dense or deep root mass	[✓ 6]	50-70% density. Lower vigour and still fewer species form a somewhat shallow and discontinuous root mass	9	<50% density plus fewer species and less vigour indicate poor, discontinuous and shallow root mass	12
Sub-total	23	10						40

LOWER BANKS	EXCELLENT		GOOD		FAIR		POOR	
Channel capacity	ample for present & some increases. Peak flows contained. Width to depth ratio <7	1	adequate. Overbank flows rare. Width to depth ratio 8-15	[✓ 2]	barely contains present peaks. Occasional overbank floods. Width to depth ratio 15-25	3	inadequate. Over-bank flows common. Width to depth ratio >25	4
Bank rock content	>65% rocks with large angular boulders >30 cm numerous	2	40-65% rock, mostly small boulders to cobbles 15 to 30 cm	[✓ 4]	20-40%, with most in the 8 to 15 cm diameter class, although larger ones may be present	6	<20% rock fragments of gravel sizes, 2.5 to 8 cm or less	8
Obstructions/ flow deflectors/ sediment traps	rocks & old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable	[✓ 2]	some present causing erosive cross currents & minor pool filling. Obstructions and deflectors newer and less firm	4	moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling in of pools	6	frequent obstructions & deflectors cause bank erosion year-long. Sediment traps full, channel migration occurring	8
Cutting	little or none evident. Infrequent raw banks less that 15 cm high generally	[✓ 4]	some, intermittently at outcurves and constrictions. Raw banks may be up to 30 cm high	8	significant. Cuts 30-60 cm high. Root mat overhangs and sloughing evident	12	almost continuous cuts, some over 60 cm high. Failure of overhangs frequent	16

Deposition	little or no enlargement of channel or point bars	[✓ 4]	some new increase in bar formation, mostly from coarse gravels	8	moderate deposition of new gravel & coarse sand on old and some new bars	12	extensive deposits of predominantly fine particles. Accelerated bar development	16
Sub-total	16	13						52
BOTTOM	EXCELLENT		GOOD		FAIR		POOR	
Rock angularity	sharp edges & corners, plane surfaces roughened	1	rounded corners & edges, surfaces smooth & flat	2	corners & edges well rounded in 2 dimensions	[✓ 3]	well rounded in all dimensions, surfaces smooth	4
Brightness	surface dull, darkened or stained by algae or minerals. Bright surfaces <5% of area	[✓ 1]	mostly dull, but may have up to 35% bright surfaces, some on larger rocks	2	mixture, 50-50% dull & bright, ±15% (i.e. 35-65%)	3	predominantly bright, >65% exposed or scoured surfaces	4
Consolidation or particle packing of substrate	assorted sizes tightly packed &/or overlapping	2	moderately packed with some overlapping	5	mostly a loose assortment with no apparent overlap	6	no packing evident, loose assortment, easily moved	8
% stable materials	Stable materials 80-100%	4	Stable materials 50-80%	[✓ 8]	Stable materials 20-50%	12	Stable materials 0-20%	16
Scouring & deposition	<5% of the channel length affected by scouring & deposition	[✓ 6]	5-30% affected. Scour at constrictions & where grade steepens. Some deposition in pools & backwaters	12	30-50% affected. Deposits & scour at obstructions, constrictions & bends. Some filling of pools	18	>50% of the bottom in a state of flux or change nearly year-long	24
Clinging aquatic vegetation (mosses & algae)	abundant. Growth largely moss-like, dark green, year-round. In swift water too	1	common. Algal forms in low velocity and pool areas. Moss here too and swifter waters	[✓ 2]	present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick	3	perennial types scarce or absent. Yellow-green, short term bloom may be present	4
Sub-total	25	15						60

38 152

TOTAL STABILITY SCORE = 23 + 16 + 25 = 64
(sum of sub-totals)

% Substrate Composition:

Bedrock	= 0		Boulders (>26 cm diameter)	= 60
Large cobbles (13-26 cm)	= 30		Small cobbles (6-12 cm)	= 5
Gravel (0.2-6 cm)	= 3		Sand (<0.2 cm)	= 2
Silt	= trace			

% Riparian Vegetation Composition:	True left bank	True right bank	Average
Native forest	80	40	60
Exotic woodland	20	5	13
Scrub	0	35	18
Crop/pasture	0	20	10
Tussock	0	0	0

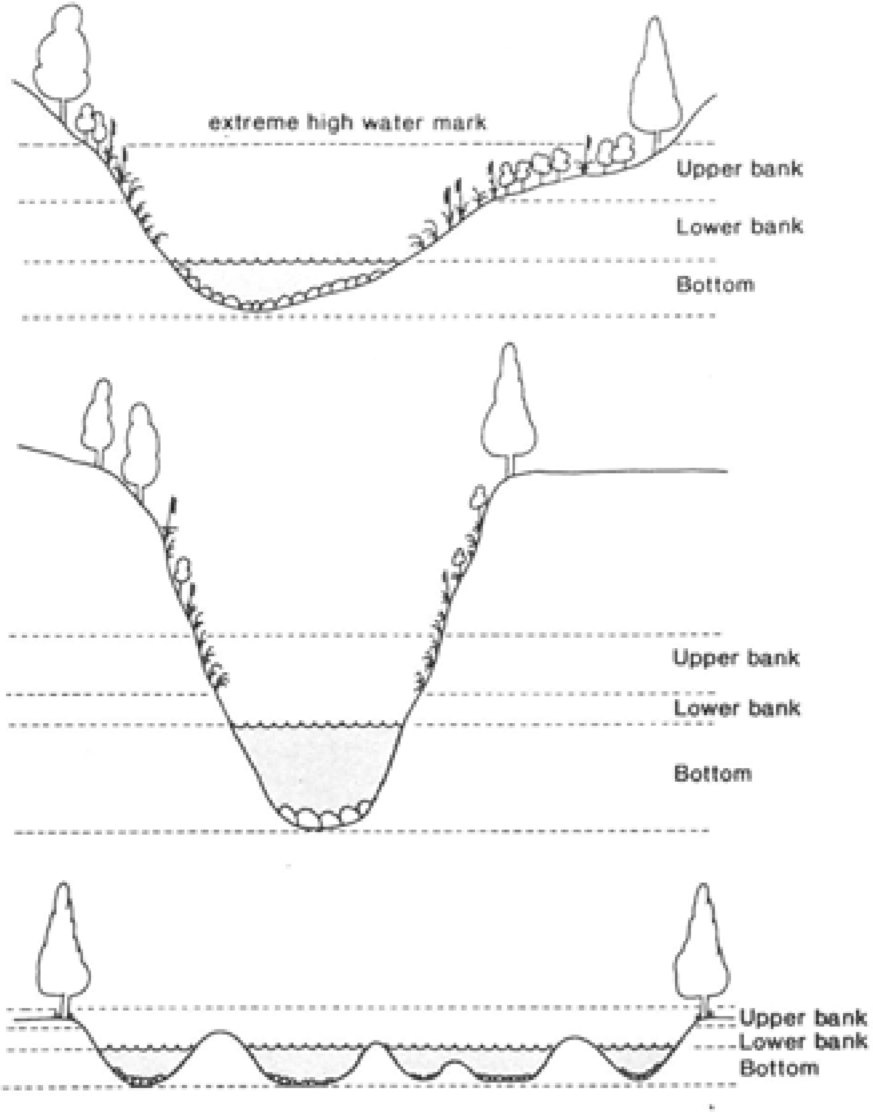


Fig. 2 Boundaries of upper banks, lower banks, and bottoms as assessed by the evaluation method in three hypothetical river cross-sections.

4.1.2 Mass-wasting

This describes the extent of existing or potential detachment of large pieces of ground and their movement into waterways below. Mass movement of banks by slumping or sliding introduces large volumes of soil into rivers causing constrictions that can increase flow velocities, cutting power and sedimentation rates. Sediment can fill the interstices between riverbed substrates and coat their surfaces making conditions unfavourable for many aquatic invertebrates. Slumping of banks could also reduce nesting potential for blue duck.

Notes:

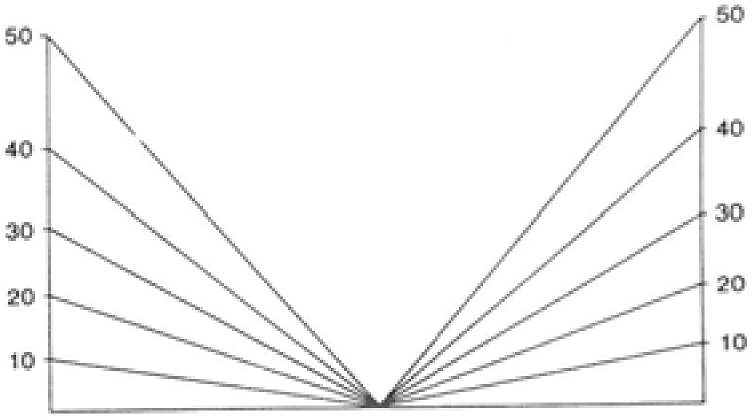


Fig. 3 Some possible slopes (degrees) of upper banks.

4.1.3 Debris jam potential

Tree trunks, limbs, twigs and leaves are deposited on river banks and form the source of the bulk of the obstructions, flow deflectors and sediment traps rated for the lower banks. Debris jam potential indicates the likelihood of increasing these impediments to the uninterrupted direction and force of flow **where they now tie or could lie under certain flow conditions**. Blue duck can use large debris jams as nesting sites and the long-term stability of these would be advantageous for birds.

Excellent -debris may be present on the banks but is of such a size or location that the stream is not able to push or float it into the channel. The potential for debris jam formation is therefore essentially absent.
Good -The debris present offers some bank protection for a while but is small enough to be floated away in time. Only small jams could be formed with this material alone.
Fair - There is a noticeable accumulation of all sizes and the stream is large enough to float it away at certain times thus decreasing bank protection and adding to the debris jam potential downstream.
Poor -High flow will float some debris away and the remainder will probably cause channel changes.

Notes:

4.1.4 Vegetative bank protection (Fig. 4)

The soil on banks is held in place by plant roots. Trees and scrub generally have deeper root systems and therefore offer more bank protection than grasses, although tussock can have good soil binding properties. In addition to the root mat stabilising the bank,

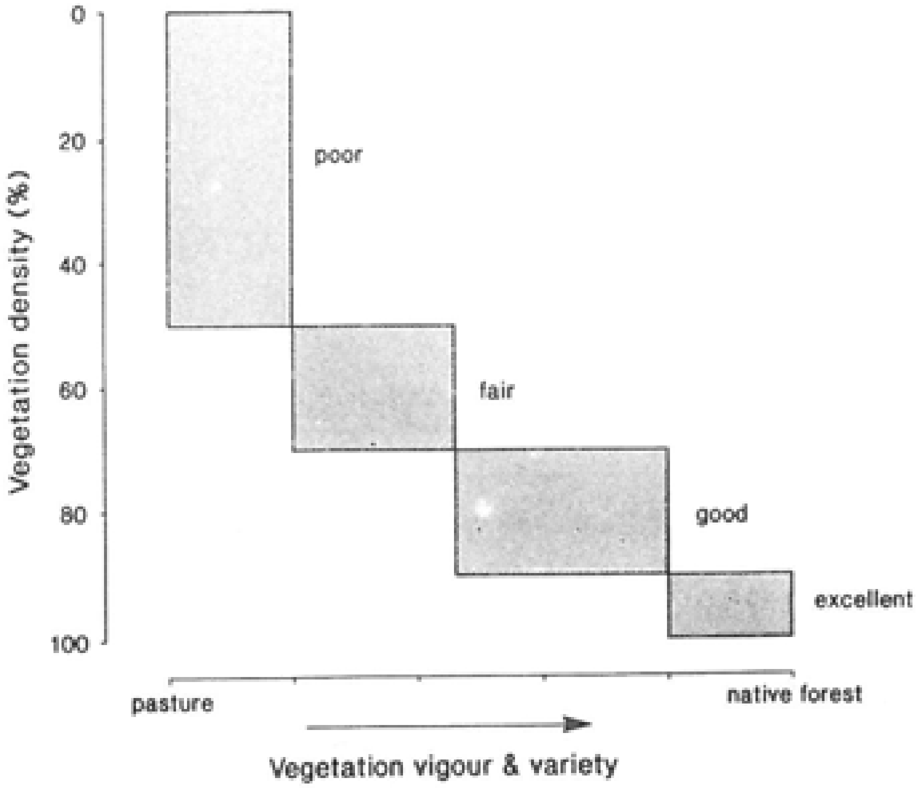


Fig. 4 Range of conditions that could be encountered when assessing vegetative bank protection.

stems help reduce the velocity of flood flows by taking some of the energy out of the water. The larger the stems and the greater their density, the more energy is dissipated. The more diverse the plant community on the banks the better; this could infer a diversity of nesting sites for blue duck as well as increased bank protection. Young plants which grow and reproduce rapidly are better than old plants. Where there is a mix of vegetation types along a reach, select a score that best describes the average situation.

Excellent -Openings in the >90% vegetative cover are small and evenly dispersed. A variety of plant species of different ages is present. Growth is vigorous and reproduction of under-and over-storey plants appears to be proceeding at a rate that ensures continued ground cover. A deep, dense root mat is inferred.

Good -Scrub more prevalent than forest. Openings in the tree canopy are larger than the space resulting from the loss of mature single trees. Vigour of growth is good for all species, but the likelihood of continued long-term reproduction may be small or absent. This could infer a deep root mat that is not continuous and potential for the expansion of current openings.

Fair -Lack of vigour is evident in some individuals and/or species. No seedling reproduction.

Poor -Trees essentially absent. Shrubs largely exist in scattered clumps, or are absent.

Notes:

4.2 Lower Banks

4.2.1 Channel capacity (Fig. 5)

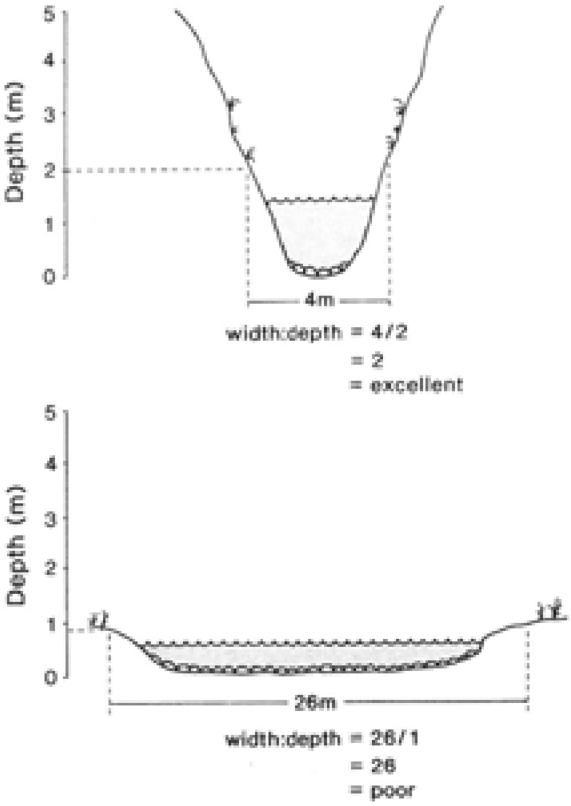


Fig. 5 The capacities of two hypothetical channel shapes to accommodate changes in flow (widths and depths are not to scale).

This variable reflects the ability of the lower banks to contain changes in discharge. The width, depth, gradient and roughness of the river channel adjust to changes in riparian vegetation, run-off and prevailing climate. Where adjustments are in progress widening and/or deepening of the channel may be occurring and this can affect the ratio of width to depth. Low width to depth ratios indicate a deep channel which can accommodate increases in flow whereas high ratios indicate a wide and shallow channel whose lower banks commonly overflow. When the capacity of the channel is exceeded, deposits of sediment are found on the lower banks and organic debris may be trapped in bank vegetation. These are indications of a recent flood event. Longer term indicators will be more difficult to find. You may need to use your knowledge of the river to estimate normal peak flows and whether the present cross-section is adequate to handle the load without bank deterioration. Bear in mind that spring-fed streams may have high width to depth ratios but rarely overflow their banks because flows are so stable. Banks that frequently overflow may provide few places of refuge for blue duck during floods, and may also have reduced stability.

Notes:

4.2.2 Bank rock content (Fig. 6)

The composition of bank materials indicates the capacity of the bank to resist erosion by flow. Since vegetation is generally lacking from the lower banks, the volume, size and shape of the rock component primarily determine the resistance of banks to flow

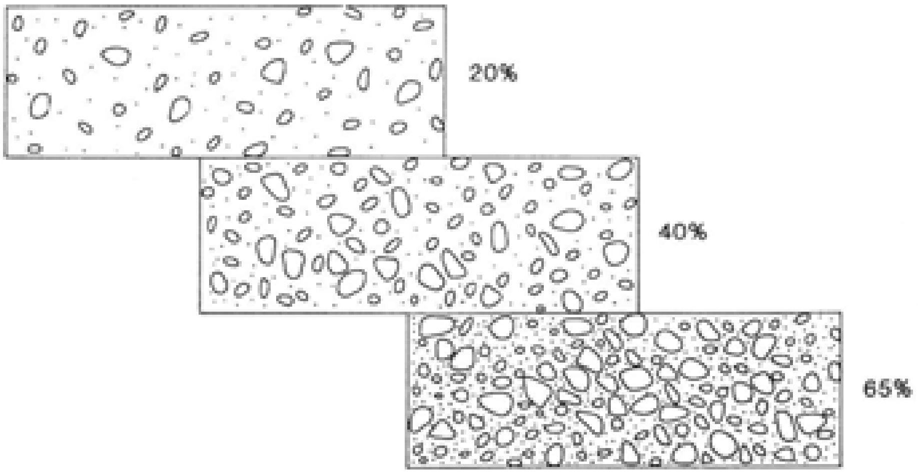


Fig. 6 Examples of different rock contents that could be encountered. Percent bank rock compositions shown represent critical values in the evaluation form.

forces. Bank rock content (i.e. the proportion of bank materials that are rock) can be determined by examining areas where banks are already exposed.

Notes:

4.2.3 Obstructions/flow deflectors/sediment traps

Objects like large rocks, embedded logs and bridge pylons will change the direction and sometimes the velocity of flow. These may cause problems where the flow is deflected against unstable banks and bottom materials. Where velocity falls, coarse sediments drop out of the water. Firmly embedded obstructions such as logs and emergent boulders can provide long-term roosting sites for blue duck and cover for fish.
Excellent - Obstructions to flow are firmly embedded and produce a pattern of flow which does not erode the banks or cause sediment build up.
Good -Obstructions cause some minor bank and bottom erosion. Some obstructions are newer, not firmly embedded and move to new locations during high flows. Some sediment is trapped in pools decreasing their capacity.
Fair - The frequent and often unstable obstructions cause noticeable erosion of the channel. Considerable sediment accumulates behind obstructions.
Poor - Obstructions and traps cause continual shift of sediments. As sediment traps are filled soon after they are formed, the channel migrates and widens.

Notes:

4.2.4 Cutting

Erosion of banks by flow can cause near vertical walls with overhanging sods of roots that eventually topple into the water. Sometimes, under-cutting can occur in the absence of vegetation where different soil layers are compacted to different degrees. In other situations where banks are loosely consolidated, the flow constantly nibbles away, yet little overhang develops. Vertical banks mean that it is difficult for blue duck to obtain access to upper banks for nesting.

Excellent -Raw, eroding banks are infrequent, cuts are short and predominantly less that 15 cm high.

Good -Eroded areas equivalent in length to one channel width or less and vertical cuts are less than 30 cm high.

Fair -Significant bank cuts occur frequently in the reach.

Poor -Undercutting, sod-root overhangs and vertical side failures may be frequent.

Notes:

4.2.5 Deposition

Deposition on the less steep lower banks and on the downstream sides of flow deflectors can be quite large. The appearance of sand and gravel bars where they did not previously exist can be one of the first signs of upstream erosion. If disturbances continue, these bars tend to widen in a shoreward direction. Deposition may also occur on the inside of bends, particularly if cutting is taking place on the opposite bank. Deposits of sediment are also found below constrictions where there is a sudden flattening of stream gradient. Deposits of sediment that move from lower banks on to the bed following floods can be detrimental to aquatic invertebrates.

Excellent -Very little or no deposition of fresh silt, sand or gravel in channel bars in straight reaches or point bars on the inside banks of curved reaches.

Good -Some fresh deposits behind obstructions.

Fair -Bars are enlarging and pools are filling so riffle areas predominate.

Poor -Extensive deposits of fresh fine sands, some silts and small gravels. Storage areas full of sediments and fine particles may move during periods of low flow.

Notes:

4.3 Bottom

4.3.1 Rock angularity

Angular fragments of rock are more resistant to tumbling than rounded rocks which pack poorly and, depending on size, may be easily moved downstream. Rock surfaces generally become smoother with time, although the degree of smoothness depends on the type of rock.

Notes:

4.3.2 Brightness

Stones in motion gather no moss or substantial growths of algae and become polished (i.e. brighter) by frequent tumbling. Constantly moving stones are not conducive to the establishment of abundant and diverse invertebrate faunas. The degree of perceived staining by vegetation can also depend on water temperature, season, nutrient levels, light conditions and other factors which can affect the utility of this variable. Staining can also be caused by minerals or organic matter dissolved in the water. Rocks that feel slippery can be assumed to be stained by algae. Do your best - this variable is given a low weighting. Look first for changes in the sand and gravels and then compare their brightness with that of larger substrates if they are composed of the same rock type.

Notes:

43.3 Consolidation or particle packing (Fig. 7)

Under stable conditions in streams fed by runoff, rock particles pack together and larger rocks tend to overlap providing stable interstitial spaces for invertebrates and small fish. This packing makes the bed very resistant to movement by flow forces. Keep in mind the type of flow regime (fed by run-off or spring water) when assessing this as spring-fed streams can have relatively poor particle packing but still have stable substrates because flows rarely increase enough to move the stones. Try kicking the substrate with your boot to assess particle packing.

Excellent - Difficult to dislodge by kicking.

Good -Rocks may be overlapping in fast water parts of the channel. Some rocks might be dislodged by higher than average flow conditions.

Fair -Most elements moved by average high flow conditions.

Poor -Loose array easily moved by less than high flow conditions and move underfoot while walking on the bottom. These rocks tend to be round and of a similar size.

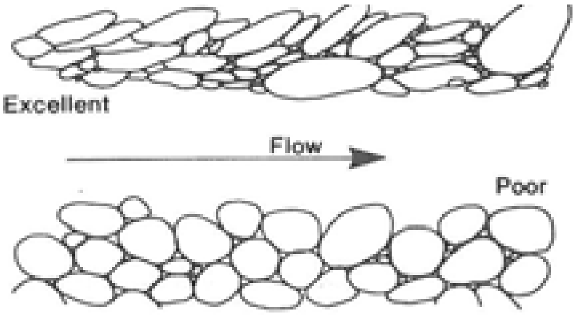


Fig. 7 Cross-section through substrates showing different consolidation or particle packing scenarios.

Notes:

4.3.4 Percentage stable materials

Rocks remaining on a stream bottom partly reflect geological conditions and preceding flow regime. Normally, there is an array of sizes that you would expect to see in a given location and some experience will enable you to sense abnormal conditions. Bedrock and boulders (>26 cm diameter) can generally be considered stable elements. Smaller rocks in smaller channels may also be classified as stable. If you are revisiting sites regularly, you may wish to monitor the movement of stones coloured with enamel paint to get an indication of substrate stability.

Notes:

4.3.5 Scouring and/or deposition

Earlier assessments of size, angularity and brightness should assist you in coming to some conclusions about the amount of scouring and/or deposition that is occurring on the channel bottom (i.e. the percent of channel undergoing change). Invertebrate populations have difficulty becoming established in areas where these processes are widespread and occurring frequently.

Excellent -Neither scouring nor deposition are much in evidence. Up to 5% of either process or both processes in combination may be present along the reach (i.e. up to 5 m in a 100 m reach).

Good -Sediment in pools tends to move on through so pools change only slightly in depth.

Fair - Moderate changes occurring. 30-50% of the bottom in a state of flux. Pools filling in with sediment and decreasing in size.

Poor -Cutting and deposition common. More than half the bottom is moving, not necessarily just during periods of high flow.

Notes:

4.3.6 Aquatic vegetation

Changes in volume of flow and/or sedimentation rates may cause temporary losses of clinging aquatic vegetation. Algae (mats covering upper rock surfaces and filamentous growths) and mosses do not have roots and can be washed away during high flows. To some extent the distribution and abundance of aquatic vegetation in a river will be influenced by season, light conditions, nutrient levels and the time elapsed since preceding flood events. Make the best assessment you can, taking into account your knowledge of the river; this variable is given a low weighting. For algae, concentrate more on the extent of mats rather than on filamentous growths which can appear quickly and be transient.

Excellent - Clinging plants abundant throughout the reach from bank to bank. A continuous mat of vegetation is not required but moss and/or algae are readily seen in all directions across the stream.

Good - Plants common in slower portions of the reach but thin out markedly in swift flowing portions.
Fair -Plants almost totally absent from swifter portions of the reach and may also be absent in some of the slow and still water areas.
Poor -Clinging plants rarely found anywhere in the reach.

Notes:

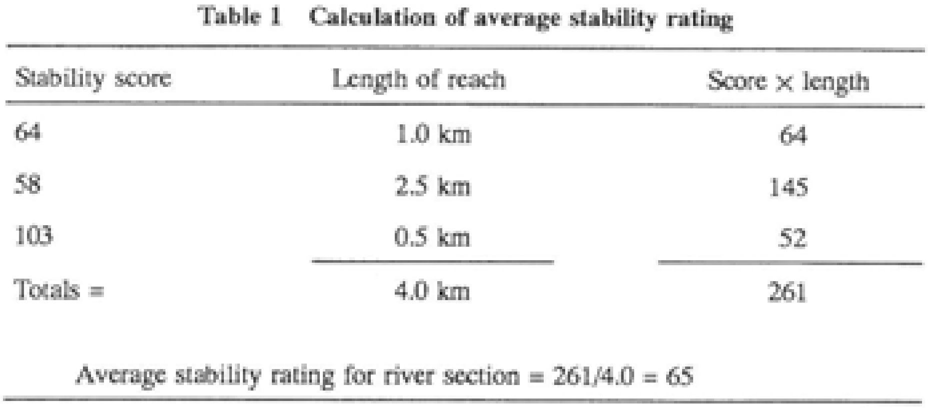
5. EVALUATION PROTOCOL

I have avoided recommending critical limits for suitable habitat as interpretation of the forms can vary between observers (although over-and under-ratings of variables tend to balance out), and there may be geographical variations in the conditions encountered. For assessing habitat suitability, do some trial evaluations to get the hang of it and then try the evaluations on a few rivers that support good populations of the target species, like blue duck. You can then compare those with ratings obtained from other rivers which you may be considering for introductions of blue duck. Do all your assessments in the same season; summer is best as the chances of flooding are usually lower.

Look also at the proportion of cover by different vegetation types along the river banks and at the percentage cover by different sizes of substrate on the beds in runs and riffles, factors that are also thought to influence the presence of blue duck pairs (Collier *et al.* 1993) . Space for these assessments is provided at the end of the form. Channel gradient can also affect blue duck distribution and sections with gradient less than 10 $m.km^{-1}$ generally support few pairs of birds. Be conscious that other factors such as water quality or intensity of recreational use can also influence habitat suitability for different species - don't base your final decision just on the stability evaluation.

Ideally, you would do an evaluation for each reach in the section of river you are assessing. However, this may not always be feasible where there are many bends in the river, and it may not even be necessary where the physical state of the river changes little in a number of reaches. In this instance, you could simply make evaluations of representative reaches and note the river length represented by each assessment. New evaluations can be made where the river changes noticeably. Maps and aerial photographs can be used to help you determine the length of reach represented by different assessments. Where the river shows no obvious physical change over a long distance, carry out at least three assessments at different points and take the average. You can then multiply the overall ratings by the length of river that they represent. The sum of these totals divided by the total length of river assessed will provided an average rating for that section (see example in Table 1).

Table 1 Calculation of average stability rating



Stability score	Length of reach	Score × length
64	1.0 km	64
58	2.5 km	145
103	0.5 km	52
Totals =	4.0 km	261

Average stability rating for river section = 261/4.0 = 65

Obviously, land and water management should not be based on averages. Sections with high scores (i.e. lower stability) may represent "weak links" in the system (e.g., the 0.5 km section in the example above). Take note of these. They could indicate areas where some form of management upstream is desirable (e.g. riparian enhancement). You can also compare the ratings for river sections in different seasons or years to understand what changes are occurring over time. You should do your assessments in the same reaches each year to determine this.

6. ACKNOWLEDGEMENTS

The reach inventory and channel stability evaluation method was devised by D.J. Pfankuch of the U.S.D.A. Forest Service, Montana, U.S.A. I thank Russell Death (Massey University), Mike Winterbourn (University of Canterbury), and Mike Wakelin, Murray Williams, Richard Sadleir, Ian Millar, Cam Speedy, Mary Creswell and Ian Mackenzie for comments on drafts of this report.

7. REFERENCES

Collier, K.J., Moralee, S.J. and Wakelin, M.D. 1993 Factors affecting the distribution on blue duck on New Zealand rivers. *Biological Conservation* 63.

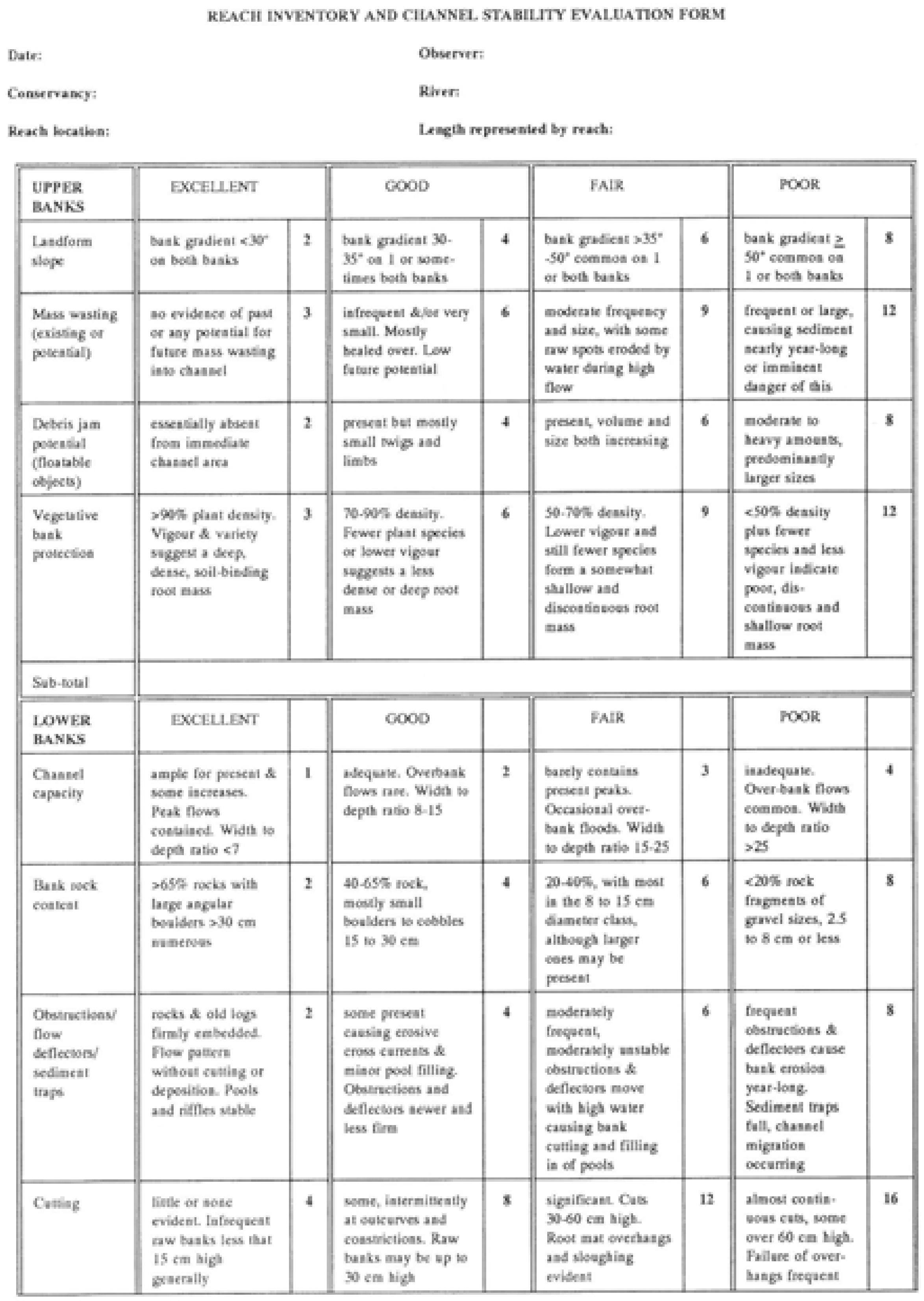
Death, R.G. 1991. Environmental stability: its effects on stream benthic communities. Unpublished thesis, University of Canterbury, New Zealand.

Eifert, W.H. & Wesche, T.A. 1982. Evaluation of the stream reach inventory and stability index for habitat analysis. *Water Resources Series No.82.* Water Resources Institute, University of Wyoming, Wyoming.

Pfankuch, D.J. 1975. Stream reach inventory and channel stability evaluation. U.S.D.A. Forest Service, Region 1, Missoula, Montana, U.S.A.

Rounick, J.S. & Winterbourn, M.J. 1982. Benthic faunas of forested streams and suggestions for their management. *New Zealand Journal of Ecology 5:* 140-150.

Winterbourn, M.J. & Collier, K.J. 1987. Distribution of benthic invertebrates in acid, brown water streams in the South Island of New Zealand. *Hydrobiologia* 153: 277-289.



REACH INVENTORY AND CHANNEL STABILITY EVALUATION FORM

Date: **Observer:**

Conservancy: **River:**

Reach location: **Length represented by reach:**

UPPER BANKS	EXCELLENT		GOOD		FAIR		POOR	
Landform slope	bank gradient <30° on both banks	2	bank gradient 30-35° on 1 or some-times both banks	4	bank gradient >35° -50° common on 1 or both banks	6	bank gradient ≥ 50° common on 1 or both banks	8
Mass wasting (existing or potential)	no evidence of past or any potential for future mass wasting into channel	3	infrequent &/or very small. Mostly healed over. Low future potential	6	moderate frequency and size, with some raw spots eroded by water during high flow	9	frequent or large, causing sediment nearly year-long or imminent danger of this	12
Debris jam potential (floatable objects)	essentially absent from immediate channel area	2	present but mostly small twigs and limbs	4	present, volume and size both increasing	6	moderate to heavy amounts, predominantly larger sizes	8
Vegetative bank protection	>90% plant density. Vigour & variety suggest a deep, dense, soil-binding root mass	3	70-90% density. Fewer plant species or lower vigour suggests a less dense or deep root mass	6	50-70% density. Lower vigour and still fewer species form a somewhat shallow and discontinuous root mass	9	<50% density plus fewer species and less vigour indicate poor, dis-continuous and shallow root mass	12
Sub-total								
LOWER BANKS	EXCELLENT		GOOD		FAIR		POOR	
Channel capacity	ample for present & some increases. Peak flows contained. Width to depth ratio <7	1	adequate. Overbank flows rare. Width to depth ratio 8-15	2	barely contains present peaks. Occasional over-bank floods. Width to depth ratio 15-25	3	inadequate. Over-bank flows common. Width to depth ratio >25	4
Bank rock content	>65% rocks with large angular boulders >30 cm numerous	2	40-65% rock, mostly small boulders to cobbles 15 to 30 cm	4	20-40%, with most in the 8 to 15 cm diameter class, although larger ones may be present	6	<20% rock fragments of gravel sizes, 2.5 to 8 cm or less	8
Obstructions/ flow deflectors/ sediment traps	rocks & old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable	2	some present causing erosive cross currents & minor pool filling. Obstructions and deflectors newer and less firm	4	moderately frequent, moderately unstable obstructions & deflectors move with high water causing bank cutting and filling in of pools	6	frequent obstructions & deflectors cause bank erosion year-long. Sediment traps full, channel migration occurring	8
Cutting	little or none evident. Infrequent raw banks less that 15 cm high generally	4	some, intermittently at outcurves and constrictions. Raw banks may be up to 30 cm high	8	significant. Cuts 30-60 cm high. Root mat overhangs and sloughing evident	12	almost contin-uous cuts, some over 60 cm high. Failure of over-hangs frequent	16

Deposition	little or no enlargement of channel or point bars	4	some new increase in bar formation, mostly from coarse gravels	8	moderate deposition of new gravel & coarse sand on old and some new bars	12	extensive deposits of predominantly fine particles. Accelerated bar development	16
Sub-total								
BOTTOM	EXCELLENT		GOOD		FAIR		POOR	
Rock angularity	sharp edges & corners, plane surfaces roughened	1	rounded corners & edges, surfaces smooth & flat	2	corners & edges well rounded in 2 dimensions	3	well rounded in all dimensions, surfaces smooth	4
Brightness	surface dull, darkened or stained by algae or minerals. Bright surfaces <5% of area	1	mostly dull, but may have up to 35% bright surfaces, some on larger rocks	2	mixture, 50-50% dull & bright, ±15% (i.e. 35-65%)	3	predominantly bright, >65% exposed or scoured surfaces	4
Consolidation or particle packing of substrate	assorted sizes tightly packed &/or overlapping	2	moderately packed with some overlapping	4	mostly a loose assortment with no apparent overlap	6	no packing evident, loose assortment, easily moved	8
% stable materials	Stable materials 80-100%	4	Stable materials 50-80%	8	Stable materials 20-50%	12	Stable materials 0-20%	16
Scouring & deposition	<5% of the channel length affected by scouring & deposition	6	5-30% affected. Scour at constrictions & where grade steepens. Some deposition in pools & backwaters	12	30-50% affected. Deposits & scour at obstructions, constrictions & bends. Some filling of pools	18	>50% of the bottom in a state of flux or change nearly year-long	24
Clinging aquatic vegetation (mosses & algae)	abundant. Growth largely moss-like, dark green, year-round. In swift water too	1	common. Algal forms in low velocity and pool areas. Moss here too and swifter waters	2	present but spotty, mostly in backwater areas. Seasonal blooms make rocks slick	3	perennial types scarce or absent. Yellow-green, short term bloom may be present	4
Sub-total								

TOTAL STABILITY SCORE = _____ + _____ + _____ = _____
(sum of sub-totals)

% Substrate Composition:

Bedrock = _____

Large cobbles (13-26 cm) = _____

Gravel (0.2-6 cm) = _____

Silt = _____

Boulders (>26 cm diameter) = _____

Small cobbles (6-12 cm) = _____

Sand (<0.2 cm) = _____

% Riparian Vegetation Composition:	True left bank	True right bank	Average
Native forest	_____	_____	_____
Exotic woodland	_____	_____	_____
Scrub	_____	_____	_____
Crop/pasture	_____	_____	_____
Tussock	_____	_____	_____