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RAPID HABITAT PRESSURES ASSESSMENT PROTOCOL FOR RIVERS AND STREAMS

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EXECUTIVE SUMMARY

This report details the finalised Rapid Habitat Pressures Assessment (RHPA) protocol for rivers and streams. The protocol is a relatively quick (< 20 minute) assessment applied at the reach-scale to determine the degree of anthropogenic pressures facing physical instream and riparian habitat. It is based solely on bank-side visual observations and is intended to be used in situations where detailed and more accurate physical habitat assessments are impractical or too resource intensive to apply.

The RHPA complements the existing Rapid Habitat Assessment (RHA) protocol, which assesses the current state of general habitat condition in a river or stream reach. Both protocols are designed to be applied in tandem at State of Environment monitoring (SoE) sites. More generally, the protocols can be applied as part of habitat assessment and monitoring associated with stream restoration and protection initiatives.

We anticipate that the RHPA protocol will:

1. Allow regional and unitary authorities and other river managers (e.g., Iwi, DOC) to undertake a nationally standardised visual assessment of biophysical pressures affecting stream habitat to complement regional SoE monitoring.
2. Identify sites at-risk of degradation. This information will be useful in catchment or regional planning for allocation of stream remediation resources (e.g., riparian planting or erosion protection measures)
3. Enable assessment of trends in ecosystem health pressures at regional and national scales. Ultimately, when paired with habitat state / condition data (such as produced by the RHA), a river habitat assessment database will allow cause and effect relationships between potential pressures and ecosystem states to be better defined.

Below we provide the finalised RHPA assessment template that can be printed for use in the field. The protocol has been amended based on feedback and analysis of data provided as part of a trial application of a draft RHPA protocol by regional council staff—the results of this trial are described in this report. A photographic guide to aid application in the field is provided in the appendices.

Defining an assessment reach

For an RHPA assessment site, the reach length is defined as 20 times the average (baseflow) wetted width, to a minimum length of 50 m or a maximum length of 150 m. Ensure you record the GPS position at the downstream end of the reach. The procedure for defining reach area is the same as the companion assessment protocol—the Rapid Habitat Assessment (RHA). A video guide for the RHA protocol can be found here: https://www.cawthron.org.nz/research/our-projects/rapid-habitat-assessment-protocol/. We recommend viewing this before attempting to apply either the RHA or RHPA protocols.

Apply in the RHPA protocol

When applying the RHPA, carefully read each attribute narrative. Walk the reach multiple times and circle the appropriate score (out of 10) for each attribute. Write the attribute scores in the left-hand column of the field sheet and sum all scores to give a pressure score (out of 120). A high score indicates a river subject to a high amount of anthropogenic pressure. Interim score interpretation bands are provided in the report (Section 1.5).

Habitat parameter	Condition category										SCORE
A1: Nuisance benthic algae: Estimate the percentage cover (plan view) of thick algal mats (> 3 mm) and / or filamentous algae within the wetted area of the entire assessment reach. If filamentous green algae and / or thick cyanobacteria matts (black algae >3mm think) are present in any amount, then score the site higher.	*The cover of algal mats and filamentous algae is less than 10% of the streambed wetted area.*		*The cover of algal mats and filamentous algae is 11-20 % of the streambed.*		*The cover of algal mats and / or filamentous green algae is 21-30 % of the streambed.*		*Cover of algal mats and / or filamentous green algae is 31-50% of the streambed.*		*Cover of algal mats and / or filamentous green algae is more than 50% of the streambed.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
A2: Nuisance aquatic macrophytes: Estimate the percentage cover (plan view) of macrophytes (native and introduced aquatic plants) within the streambed wetted area of the entire assessment reach and match with the appropriate score range below. If the passage of water through the reach is impeded by macrophytes, then score the site higher.	*The cover of macrophytes is less than 10% of the streambed. Aquatic plant growths are causing no noticeable impediment to flow. If introduced macrophytes are present, then score the site higher.*		*The cover of macrophytes is between 11–20% of the streambed, if aquatic plant growths are causing a minor impediment to flow then score the site higher.*		*The cover of macrophytes is between 21–30% of the streambed, score higher if aquatic growths are causing some impediment to flow, with cross-sectional area or volume comprising macrophyte beds up to 10% in places.*		*The cover of macrophytes is 31–50% of the stream bed, score higher if aquatic growths are causing some impediment to flow, with cross-sectional area or volume comprising macrophyte beds between 10–50% in places.*		*Cover of macrophytes is more than 50% of the stream bed. Score higher if there is flow impoundment or channel 'clogging', with cross-sectional area or volume comprising macrophyte beds more than 50% in places.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	

A3: Instream structures (structures below the waterline): Count the number of structures that occur within the wetted channel during baseflows. Structures could include (but are not limited to) weirs, vehicle fords and bank protection infrastructure that extends below the baseflow wetted channel edge (note that stream bank structures are assessed as a separate attribute). Large structures that could impede upstream fish passage and / or modify and constrict flow, e.g. by causing ponding / impoundment, should be scored higher.	*None or one small instream structure is present within the assessment reach. If one structure is present that causes minimal changes to habitat, such as short sections of rock rip rap (< 10 m long or < 10% of reach length) or a bridge abutment that extends below the baseflow water line, then score the site higher.*		*No structures are present that traverse the entire wetted width of the channel. One to three structures are present that extend into the baseflow channel, e.g. rock groynes or short sections of rock rip rap or bridge abutments (< 10 m long or < 10% of reach length).*		*A structure such as a weir is present across the entire baseflow channel. Any increased water velocity created by the structure is equivalent to natural riffles in the wider reach. There is no 'perching' (vertical falls of water) or vertical sections present that could impede upstream fish passage. Score higher if the structure causes substantial impoundment relative to natural pools, e.g. the pool upstream of structure is more than twice the size of natural pools in the reach*		*A large instream structure, between 0.2 to 4 m high, is present that increases velocity or causes impoundment to a greater degree than is present naturally in the stream, i.e. upstream pooling more than twice as large as natural pools. Score the reach higher if near-vertical sections or vertical drops are present on the structure that would impede fish passage, or if there are additional lesser structures present that do not traverse the entire wetted width.*		*One very large (> 4 m high), or more than 2 large (0.2-m to 4-m high), instream structures are present that either have a perched downstream outlet or have a near vertical face. If the structure(s) is likely to impede upstream fish passage, e.g. either have a perched downstream outlet or have a near vertical face, or the transport of bedload sediment downstream, then score the site higher.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
A4: Instream disturbance: Assess the degree and regularity of livestock or human disturbance in the wetted channel, look for evidence of stock and vehicle crossings or for evidence of instream disturbance with heavy machinery.	*None or minor historical instream disturbance is evident. If some historical disturbance is evident but appears unlikely to occur again then score the site higher.*		*Reach shows evidence of an infrequently used vehicle or stock crossing, e.g. a few times a year. If it is a stock crossing, then score the site higher.*		*Two vehicle ford or stock crossings, or a single stream crossing is present and appears to receive regular use, e.g. weekly to monthly use. If a stock crossing is present, then score the site higher.*		*There is evidence of regular/high degree of disturbance to the channel. For example, at least part of the reach may be subjected to a) mechanical clearing of silt, macrophytes or woody debris or b) frequent vehicle or stock disturbance, e.g. weekly. Record which type of disturbance that resulted in your score decision (A, B or A+B).*		*Heavily disturbed streambed in part of the reach, may a) be subjected to instream disturbance from heavy machinery though instream gravel extraction or regular silt and macrophyte clearing, e.g. annually, or b) have a stock or vehicle crossing that is used daily, e.g. by a dairy herd. Record which type of disturbance that resulted in your score decision (A, B or A+B).*		**Circle: A B A+B**
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	

A5: Discharges and drains: Count the number of open drains and piped inflows, noting the diameter of any piped inflows. Consider the potential for pollution from the drain's source based on the land use in the drainage area.	*No artificial drains or piped inflows present. If a modified tributary or open farm drain is present but has low potential to deliver pollutants, e.g. drains low intensity farmland, then score the site higher.*		*No piped inflows are present. One open drain or channelised tributary may be present. If drains have a high potential for delivering pollution, e.g. drain intensive agricultural or semi-urban land use, then score the reach higher.*		*One or two piped inflows (< 20 cm in diameter), or two or more channelised tributaries or open drains, are present. If drains have a high potential for delivering pollution, e.g. drain intensive agricultural or semi-urban land use, then score the reach higher.*		*Three to five piped inflows (< 20 cm in diameter are present), or a large piped inflow (> 20 cm in diameter) is present. If drains have a high potential for delivering pollution (e.g. drain intensive agricultural or semi-urban land use then score the reach higher.*		*Five or more small piped inflows are present, or more than two large piped inflows (> 20 cm in diameter) are present. If drains have a high potential to deliver pollutants form urban land use or industrial sources, then score the site higher.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
A6: Introduced riparian plants occurring at nuisance levels: Assess the degree to which introduced and invasive plants occur in the near stream and riparian environment. Assess the extent of introduced species as a percentage of the riparian area (within 30m of the wetted edge).	*No or little evidence of introduced plants in the riparian area (banks and channel) or stream. If some introduced plants are present in the riparian areas but are minimal in extent e.g. fewer than 3 willows or <5% of the riparian area, then score higher.*		*Some introduced plants present in the riparian area but they are not extensive and do not form monocultures along the stream banks, e.g. individual willows, gorse or broom are present but surrounded by predominantly native vegetation. If 6-15% of riparian vegetation is exotic vegetation, then score higher.*		*Riparian areas (banks and channel) comprise mixed exotic species, some native vegetation may be present. Willows or exotic grasses may be present but are not the dominant form of bank vegetation and are not obstructing flow during baseflow conditions. If 16-50% of riparian vegetation is exotic, then score higher.*		*Riparian areas (banks and channel) comprise mostly exotic species, e.g. exotic grasses (51-75%). If exotic invasive weed species are present, such as, gorse and blackberry, or old* man's beard, or *willow or other riparian plants and introduced macrophytes are encroaching upon the low-flow channel and impeding flow, then score higher.*		*Very little native vegetation, large areas (> 75%) of the riparian zone have exotic monocultures. If notifiable pest plants are present, or willows and other introduced plants and emergent macrophytes are ubiquitous throughout the instream and riparian areas, then score higher.*		**Note introduced plant and animals species here**
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	

A7: Bank modification: Assess stream banks to determine if they have a modified shape and if there are structures present that are managed for bank protection, such as willows, groynes, rock rip-rap and / or concrete walls. The stream banks are defined as the wetted edge of the baseflow channel to bank full (top of the high flow channel). Estimate the percentage length of the reach (either bank) that is affected by the various forms of bank modification.	*No or very little bank modification and the stream appears natural in form. May be some minor historical bank modification along < 5% of the assessment reach.*		*Some bank modification in the form of bank protection through managed willows / vegetation or rock groynes along part of the assessment reach. Less than 10% of the length of either bank is affected by hard bank protection infrastructure, e.g. rock armouring of the bank, score the site higher if a hard bank protection structure is present.*		*Some channel modification present. Bank battering, i.e. contouring of the streambank to a uniform slope, channel straightening or rock groynes occur along 11–50% of either bank. If there is evidence that streambed lowering has occurred score the reach higher.*		*The channel is confined with embankments, rock rip-rap or other bank armouring, on either bank for half to 80% of the reach length. If the stream has been lowered and / or straightened and banks are uniform in shape, e.g. trapezoid managed channel, then score higher.*		*Channel confined by high banks that appear artificial in nature and / or the streambed has been lowered for more than 80% of the reach length. The channel appears to be a uniform shape, e.g. trapezoid managed channel, and / or straightened for > 80% of the reach. Bank armouring in place and appears uniform in construction. If the channel is concrete lined in places, then score higher.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
A8: Livestock riparian disturbance: Assess the type, amount and apparent regularity of livestock access to the streambanks and riparian area. The riparian area is defined as 30 m from the wetted channel. Urban areas will likely score highly in this attribute, human floodplain disturbance is assessed in Attribute 9.	*No means for livestock to access the defined riparian area, either because there is no farming within the surrounding land, or the entire riparian area is protected by stock exclusion fencing that appears to be effective. If there is potential for very infrequent livestock access, e.g. less than once per year, then score higher.*		*Occasional or infrequent stock access, low densities of stock only during certain months of the year, such as occurs in a high-country farming setting, or effective stock exclusion fencing is in place and is set back from the stream edge by at least 10 m (average width through reach). If the reach shows evidence of occasional / historical stock access within 10 m of the wetted edge of the stream, then score higher.*		*Stock exclusion fencing set 3 -10m from the stream edge (average width throughout the assessment reach). Score higher if fencing widths are at the lower end of this range, or there is evidence of occasional / historical stock access within the fenced area.*		*Stock exclusion fencing is in place but is set back by less than 3 m from the stream edge (on average). Evidence of stock access to the stream edge should score higher. Evidence would include recent or previous stock plugging along banks adjacent to the stream and / or trampled and eroded stock tracks.*		*Ineffective or lack of stock exclusion fencing in place. Stock has regular access to the stream edge. If there is evidence of recent and previous stock plugging along banks adjacent to the stream and / or trampled and eroded stock tracks, then score higher.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	

A9: Human riparian disturbance: Assess the amount and apparent regularity of human caused disturbance in the floodplain. Here the floodplain area is defined as 30 m from the baseflow wetted edge, or 10 times the wetted width, whichever area is larger. The occurrence of infrastructure in the floodplain such as sealed roads is assessed in Attribute 11.	*No or limited evidence of human activity in the floodplain. If foot or cycle access tracks are present but are well defined and small in extent or set well back from the stream, e.g. one track, then score higher.*		*Vehicle tracks are present in the floodplain, although tracks are well defined, and use appears to be infrequent, e.g. likely only used during weekends by a few people. Score higher if track cross any stream tributaries.*		*Evidence of regular vehicle / human activity in the floodplain that is likely to cause disturbance to riparian flora and fauna, e.g. stream or wetland birds. If use by vehicles appears likely to occur most days of the week or by multiple groups of people on weekends, then score higher.*		*Substantial and regular disturbance of the floodplain. If the reach includes an infrequently used, e.g. once or twice per year, gravel extraction site then score higher*		*Substantial and regular disturbance of the riparian areas and floodplain. Reach may be subjected to regular gravel extraction within the active channel, e.g. gravel bars. Four-wheel drive tracks may be extensive through the riparian areas or heavy machinery activity appears to occur regularly, e.g. monthly. Score higher if both gravel extraction and vehicle use occurs.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
A10: Occurrence of rubbish in the stream and riparian area: Assess the level of rubbish in the riparian areas of the assessment reach (30m from the wetted channel). If a high proportion of the rubbish items are likely to be environmentally persistent and / or harmful to aquatic life or human health, then the stream reach should score higher. Examples of persistent and / or harmful items include chemical containers, plastic bags, bottles, batteries, dead animals and toilet paper. Check the high-water level areas and note if rubbish has accumulated there from sources further upstream during floods. If rubbish appears to be coming from upstream, then score the reach higher.	*Little or no rubbish to be found (< 5 items) after a reach-wide search. If rubbish is environmentally persistent or potentially harmful then score higher.*		*Rubbish is evident on the stream bank and / or on the streambed (6–10 items). If rubbish is environmentally persistent or potentially harmful then score higher.*		*Rubbish is evident at a low to medium level (11–25 items). If rubbish is environmentally persistent or potentially harmful then score higher.*		*Rubbish is evident at a medium level (26–50 items). If rubbish is accumulating from upstream or rubbish is environmentally persistent / potentially harmful then score higher.*		*Rubbish distracts the eye (over 50 items), rubbish present throughout the stream and the riparian area. If rubbish is accumulating from upstream or rubbish is environmentally persistent / potentially harmful then score higher.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	

A11: Surrounding land use and floodplain modification: Determine the type and percent cover of landuse in the floodplain of the assessment reach on both banks. Here the floodplain area is defined as 30 m from the baseflow wetted edge, or 10 times the wetted width, whichever area is larger. Estimate the percentage cover in this area that has an impervious surface, including surfaces such as tar-sealed roads, building roofs and concreate areas.	*Native vegetation dominates the floodplain with no or limited evidence of modification, If minor modification, e.g. small amounts of parklands or low intensity landuse (<10 % of area) are present then score higher.*		*Area comprises exotic forestry and / or low intensity farming (e.g. sheep and beef) and / or urban parklands with less than 10% impervious surfaces (e.g. concreated or tar sealed areas). If some native vegetation landuse or extensive vegetated riparian corridors (e.g. 20 m wide on average) are present then score higher.*		*Area comprises exotic forestry and / or low intensity farming, e.g. sheep and beef, and / or urban parklands with less than 10% impervious surfaces, e.g. concreated or tar sealed areas. If some native vegetation land use or extensive vegetated riparian corridors, e.g. 20-m wide on average, are present then score higher.*		*Area is mostly intensive landuse, semi-urban or a mix of urban and other land uses. Sites with high impervious surface cover (11-50%) should score higher.*		*Area is mostly intensive landuse, semi-urban or a mix of urban and other land uses. Sites with high impervious surface cover (11-50%) should score higher.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
A12: Flood plain constraints: Determine if there are stop-banks present that are designed to constrain the stream during high flows. If present, estimate how close they are to the stream with respect to the following narrative descriptions.	*No or limited stop-banks are present. If they are present, they occur on only one bank and are set back from the stream edge by at least 10 times the active channel width, i.e. the channel that appears to be regularly inundated during high flows.*		*Stop-banks are present on both banks but are set well back from the stream by more than 10 times the active channel width. If some floodplain habitats, such as backwaters or side channels, are present within the stop banked area then score lower.*		*Stop-banks are present within 5 to 10 times the active channel width on at least one bank of the stream. If some floodplain habitats, such as backwaters or side channels, are present within the stop banked area then score lower.*		*Stop-banks present within 5 times the active channel width on at least part of one side of the stream. Water may flow against parts of the stop-banks which may have embankment reinforcing, e.g. rock reinforcing. If the stream has some room to move between stop-banks with some riparian areas occurring on inside bend areas, and / or gravel beaches exist on inside bends, then score lower.*		*The stream is constrained by high stop-banks on both sides within 5 times the active channel width. Water flows between the stop-banks in a confined manner. If there is evidence of embankment armouring, e.g. though rock riprap or concrete, on some of the stop-banks that suggests a high degree of channel confinement, then score higher.*		
SCORE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
TOTAL										(Sum of parameters 1-12)	

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1. INTRODUCTION

This report details the finalised Rapid Habitat Pressures Assessment (RHPA) protocol for rivers and streams (hereafter 'streams'). This is the second stage of the protocol development—building on the previous Envirolink grant (2061-HBRC255) that resulted in a draft protocol for field testing (Holmes et al. 2020). Four regional councils applied the draft protocol during summer 2020/21 at State of Environment (SoE) monitoring sites. Two regional councils also provided written feedback. I have incorporated their feedback into the finalised RHPA protocol presented.

1.1. Background

The RHPA is the second of two rapid habitat assessment protocols designed to assess physical habitat in streams. The companion Rapid Habitat Assessment (RHA) protocol was developed (previously) to evaluate the state of general physical stream and riparian habitat condition (Clapcott 2015). The RHA provides a single 'habitat quality score' for a stream reach and is now used routinely by (almost) all regional councils as part of SoE monitoring. Video and photographic guides to aid applying the RHA protocol can be found here: https://www.cawthron.org.nz/research/our-projects/rapid-habitat-assessment-protocol/.

The RHA is largely a measure of *current state,* whereas the RHPA is designed to assess the degree of modification or anthropogenic *pressure* acting on physical stream habitat (i.e., physical habitat attributes that can affect the state of stream habitat condition or quality). The RHPA is intended to take no more than 20 minutes to complete at a site and can be used to complement an RHA assessment by providing a single habitat 'pressures score' that is calculated by summing the component attribute scores. As well as providing an overall pressure score, the individual component attribute scores enable diagnosis and reporting of the specific (reach-scale) stream pressures.

Both the RHA and RHPA enable nationally standardised routine monitoring. The protocols are designed for situations where more accurate stream habitat assessments, such as those provided in Harding et al. (2009), are impractical or too resource intensive to apply. For example, the rapid assessment protocols are ideal for long-term and / or extensive (catchment or region-wide) monitoring applications.

It is anticipated that the RHPA protocol will:

1. Allow regional and unitary authorities and other stream managers (e.g. Iwi, DOC) to undertake a nationally standardised visual assessment of biophysical pressures affecting stream habitat to complement regional SoE monitoring.

2. Identify sites at risk of degradation. This information will be useful in catchment or regional planning for allocation of stream remediation resources (e.g., riparian planting or erosion protection measures)
3. Enable assessment of trends in ecosystem health pressures at regional and national scales. Ultimately, when paired with habitat state / condition data (such as produced by the RHA), a stream habitat assessment database will allow cause and effect relationships between potential pressures and ecosystem states to be better defined.

While the RHA is being used by most regional councils, increasingly, it is also being used as part of farm environmental planning and by community stream-care groups to plan and monitor the outcomes of stream improvement actions. We anticipate that the RHPA will also be useful in similar contexts, in particular, when planning what actions are needed (and where).

2. DRAFT RAPID HABITAT PRESSURES ASSESSMENT PROTOCOL DEVELOPMENT

The development of the draft RHPA is detailed in Holmes et al. (2020). In short, an initial strawman protocol was created based on a review of similar habitat pressure assessments in New Zealand and overseas. The strawman protocol was then provided to a panel of experts and practitioners to critique during a video conference workshop (See Appendix 1 for a list of workshop attendees). As part of the workshop, a list of 61 potential stream pressure attributes was created and considered to include in the protocol. From this initial list, 12 attributes were selected based on a range of considerations, including:

1. the relative importance of the attribute in terms of its ability to affect stream habitat state / quality
2. the inclusion of the attribute within similar overseas assessments methods
3. whether the attribute is a measure of a pressure or state (or both)
4. how practical it would be to visually assess the attribute at the reach-scale
5. if the attribute overlaps with or complements attributes included as part of the (previously developed) RHA companion protocol.

The short list of attributes included in the RHPA were: 1. Nuisance benthic algae, 2. Nuisance aquatic macrophytes, 3. Instream structures, 4. Instream disturbance, 5. Discharges and drains, 6. Introduced riparian plants, 7. Bank modification, 8. Livestock riparian disturbance, 9. Human riparian disturbance, 10. Rubbish, 11. Land use, and 12. Floodplain modification.

Potential narratives for assessing and scoring the 12 attributes on a 1–10 scale, where 10 equated to a relatively unmodified habitat condition, or a low level of anthropogenic pressure, were circulated among the workshop attendees for feedback. The feedback that was included into a draft RHPA protocol. The draft protocol was then field-tested by four regional councils at SoE monitoring sites during summer 2020/21. The regional councils involved in the trial included: Hawke's Bay Regional Council (HBRC), Environment Southland (ES), Horizons Regional Council (Horizons) and Waikato Regional Council (WRC). Greater Wellington Regional Council (GWRC) provided written feedback on the draft protocol but did not supply field trial data.

In the next report section, using data from the draft protocol field trials, we provide an analysis of the distribution of attribute scores, inter-user variability and a comparison between RHA and RHPA assessments undertaken at the same sites. Within the version tested by the regional council's a *high* score indicated a *low* level of stream habitat pressure for each individual attribute. We present the results of the trial using this scoring arrangement. However, to align the protocol with the European Union River Habitat Modification Assessment Methodology (Raven et al. 2000), and to enable the calculation of a total pressures score (where a *high* score indicates a *high* level of anthropogenic pressure), the narrative scores were reversed in the finalised version presented in this report (see the Executive Summary table and Appendix 2).

3. DRAFT RHPA FIELD TRIAL DATA ANALYSIS: RESULTS AND DISCUSSION

3.1. Attribute and total pressure score distributions

The distribution of the assessment scores for the individual RHPA attributes, observed at 251 test sites, are shown in Figure 1. For most attributes, the score distributions are skewed towards higher scores (i.e., low levels of anthropogenic pressure). The exception was Attribute 6 (Introduced plants), which was reasonably normally distributed nearer the middle of the score range (Figure 1, A6). Most streams within the SoE monitoring network are in areas of native or agricultural land use, as opposed to urban settings where streams would be under a high level of anthropogenic pressure. Nationally, less than 2% of stream length occurs within urban areas (NZCA 2011). Relatively few SoE sites within urban areas likely explains the general tendency for attribute score distributions to be skewed towards a low level of pressure. Despite the skewed nature of the score distributions, scores were observed across the entire range (1–10) for all attributes. This indicates sufficient discrimination of pressure levels within the test dataset, which did contain some assessment sites within urbanised areas.

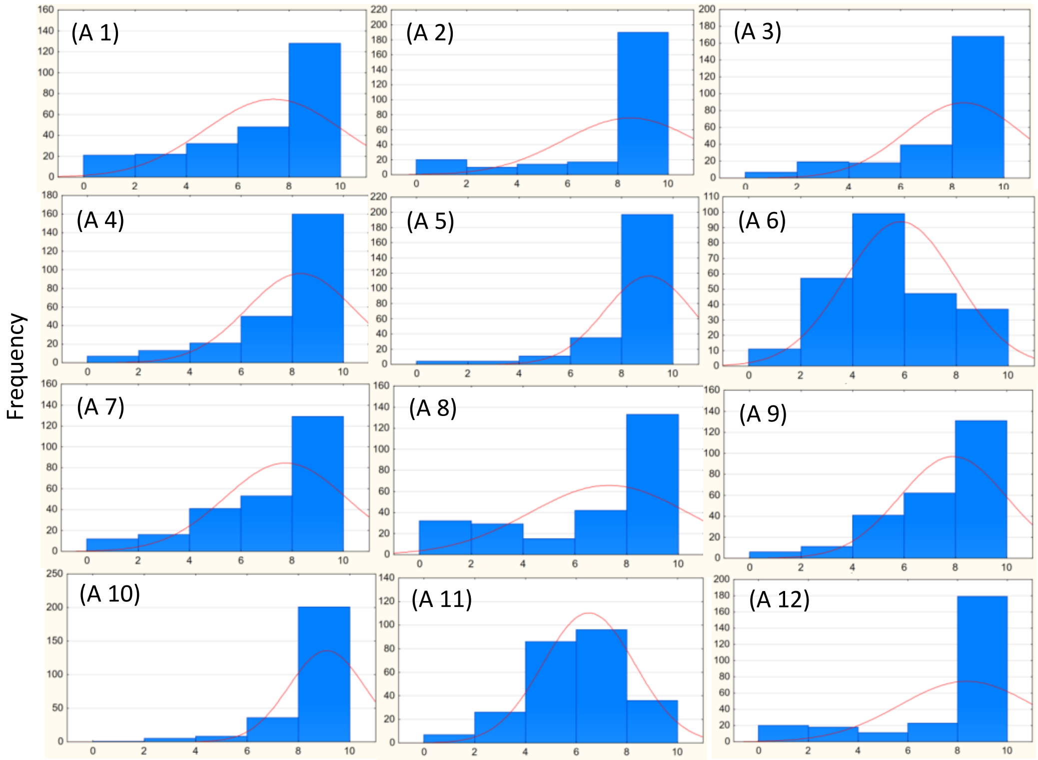

Figure 1. Frequency distributions of scores for the 12 different Rapid Habitat Pressures Assessment attributes determined from applying the draft version of the protocol at SoE sites (*n* = 251). The red lines show the expected normal distribution. Attributes are labelled as follows: (A1) Nuisance benthic algae, (A2) Nuisance aquatic macrophytes, (A3) Instream structures, (A4) Instream disturbance, (A5) Discharges and drains, (A6) Introduced riparian plants, (A7) Bank modification, (A8) Livestock riparian disturbance, (A9) Human riparian disturbance, (A10) Rubbish, (A11) Land use and floodplain modification, (A12) Floodplain constraints.

The RHPA total pressure score is determined by summing the individual attribute scores at an assessment reach. The distribution and descriptive statistics of the pressure scores calculated from the trial sites are shown in Figure 2 and Table 1, respectively. The pressure scores were normally distributed near the upper quartile of the score range (10–120), with an average score of 94. No site scored less than 40 (Figure 2, Table 1).

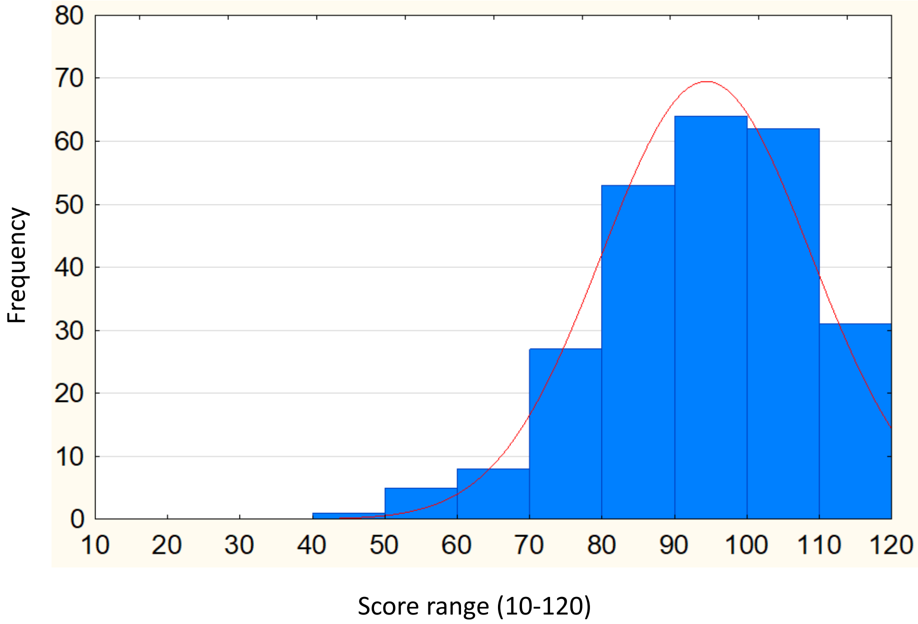

Figure 2. Distribution of the (draft) Rapid Habitat Pressures Assessment total pressure scores determined from regional council SoE monitoring sites (n = 251). Red line shows expected normal distribution.

Table 1. Descriptive statistics for the (draft) Rapid Habitat Pressures Assessment total pressure scores determined from regional council SoE monitoring sites (n = 251).

Descriptive statistic	Pressure score
Average	94
Minimum	50
Maximum	120
Standard Deviation	14
Median	95
Lower quartile	84
Upper quartile	105

3.2. Attribute score relationships

A correlation matrix of the relationships and their R^2 values between RHPA component attributes (Figure 3 and Table 2) shows that most attributes were significantly positively correlated with each other. The strongest positive correlation among attributes and pressure scores was between the Total Pressure score and the Land use and floodplain modification attribute score (Attribute 11) (R^2 = 0.53). The Land use and floodplain modification attribute was weakly (significantly) positively correlated with Discharges and drains (Attribute 5; R^2 = 0.20, P = < 0.01), Introduced riparian plants (Attribute 6; 0.23, P = < 0.01), Bank modification (Attribute 7; R^2 0.26, P = < 0.01) and Floodplain constraints (Attribute 12, R^2 = 0.27, P = < 0.01) (Figure 3, Table 2).

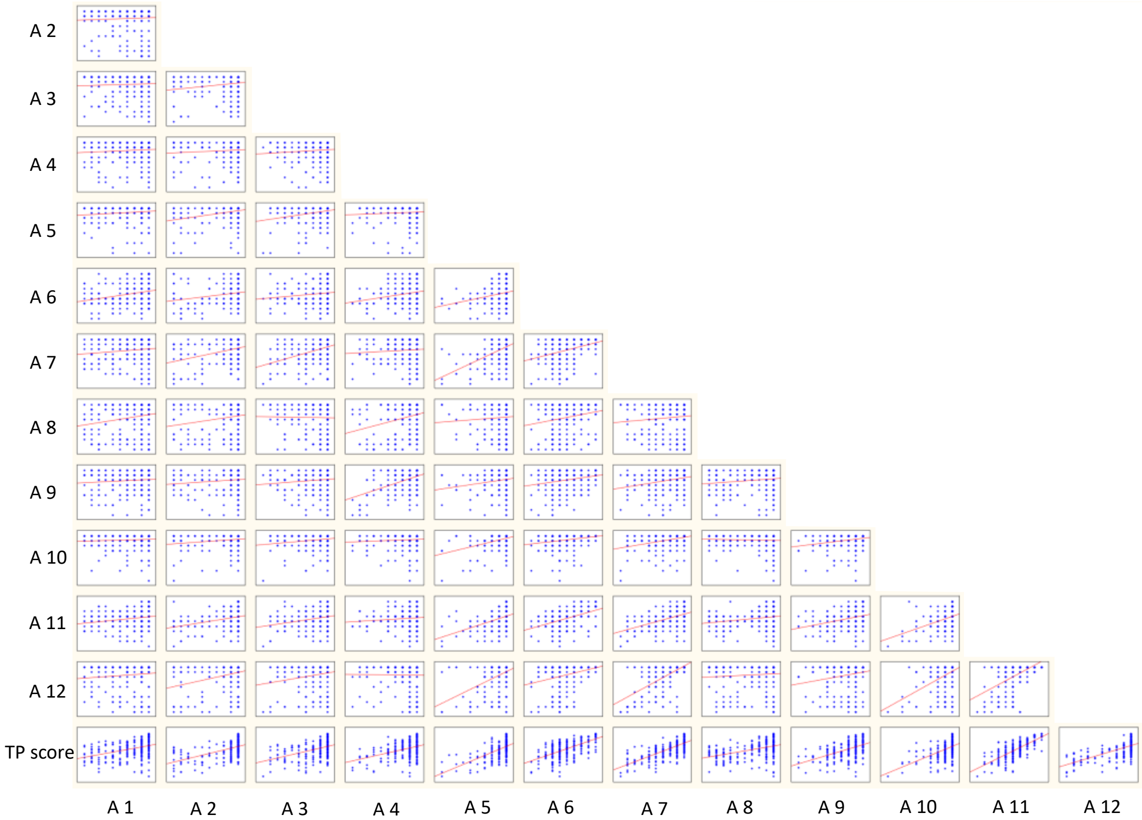

Figure 3. Correlation matrix between all of the (draft) individual Rapid Habitat Pressures Assessment attributes and the total pressure scores. Red line shows best fit. Notation key: (A1) Nuisance benthic algae, (A2) Nuisance aquatic macrophytes, (A3) Instream structures, (A4) Instream disturbance, (A5) Discharges and drains, (A6) Introduced riparian plants, (A7) Bank modification, (A8) Livestock riparian disturbance, (A9) Human riparian disturbance, (A10) Rubbish, (A11) Land use and floodplain modification, (A12) Floodplain constraints, (TP score) Total Pressure score (n = 251).

Table 2. Matrix of R^2 values for the correlations between all of the (draft) individual Rapid Habitat Pressures Assessment attributes and the total pressure scores. Shaded cells denote a significant correlation (P = <0.05). Notation key: (A1) Nuisance benthic algae, (A2) Nuisance aquatic macrophytes, (A3) Instream structures, (A4) Instream disturbance, (A5) Discharges and drains, (A6) Introduced riparian plants, (A7) Bank modification, (A8) Livestock riparian disturbance, (A9) Human riparian disturbance, (A10) Rubbish, (A11) Land use and floodplain modification, (A12) Floodplain constraints. (*n* = 251).

	A 1	A 2	A 3	A 4	A 5	A 6	A 7	A 8	A 9	A 10	A 11	A 12
A 2 Macro.	0.00											
A 3 Inst.struct.	0.00	0.03										
A 4 Inst. disturb.	0.01	0.01	0.01									
A 5 Drains	0.01	0.10	0.08	0.01								
A 6 Rip. plants	0.07	0.05	0.02	0.05	0.06							
A 7 Bank mod.	0.02	0.12	0.15	0.00	0.24	0.11						
A 8 Stock disturb.	0.04	0.04	0.00	0.07	0.00	0.04	0.01					
A 9 Human disturb.	0.01	0.02	0.01	0.24	0.03	0.04	0.07	0.02				
A10 Rubbish	0.00	0.03	0.03	0.01	0.16	0.05	0.15	0.00	0.06			
A 11 Landuse	0.04	0.11	0.07	0.01	0.20	0.23	0.26	0.05	0.10	0.17		
A 12 Floodplain const.	0.01	0.10	0.04	0.00	0.21	0.07	0.47	0.01	0.04	0.19	0.27	
TP score	0.16	0.28	0.18	0.15	0.35	0.35	0.52	0.18	0.25	0.25	0.53	0.43

A high degree of correlation between attributes was expected because anthropogenic pressures occur in clusters, generally related to land-use change. For example, as river flats are converted from native vegetation to farmland, drainage may be required, introduced plants can spread more easily and the channel may be modified to prevent flooding or erosion of property (Allan 2004). Despite correlation between attributes, it is important to keep the different assessment components so the RHPA can retain its function as a diagnostic tool for stream pressures. Before analysing any data generated by the RHPA, likely correlations between attributes should be considered. To ensure this can be accounted for, individual attribute scores must be recorded alongside the overall pressure score within any database.

3.3. Inter-observer variability

Two different assessor teams from Environment Southland (each comprising two staff) undertook draft RHPA assessments at the same 55 sites. This enabled a limited assessment of inter-observer variability. Below Figure 4 shows that total pressure scores were highly comparable between the two assessor teams (R^2 = 0.9). While this comparison is limited to just two assessor teams, it suggests that the degree of inter-observer variability may be acceptable. Further trials will be necessary to assess inter-observer variability in a statistically rigorous manner.

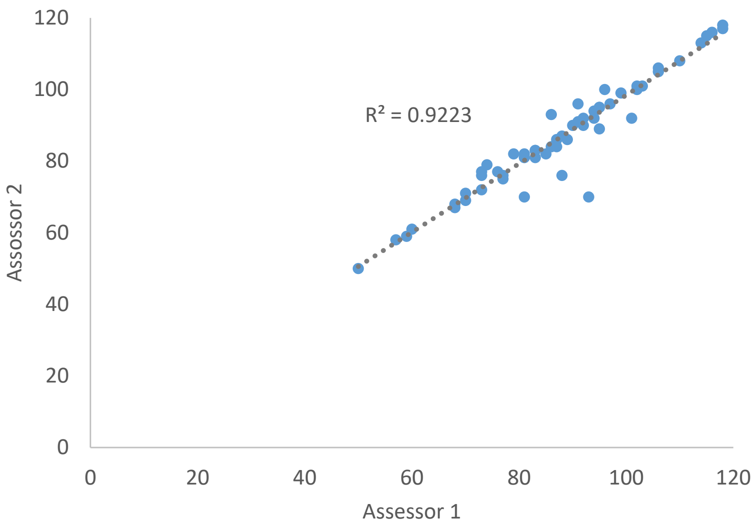

Figure 4. Comparison of total pressure scores calculated from (draft) RHPA assessments undertaken by two separate assessor teams at the same assessment sites in Southland (*n* = 55).

The three potential outliers in the lower centre of the relationship shown in Figure 4 were primarily the result of Assessor 1 scoring Bank modification (A7) higher than Assessor 2., Assessor 1 also recorded moderately higher scores for Instream structures (A3), Livestock riparian disturbance (A8), Land use and floodplain modification (A11), and Floodplain constraints(A12). When developing instructional resources for applying the protocol, particular regard to these attributes will help to reduce inter-assessor variability.

3.4. Comparison of RHA and draft RHPA scores

Two councils undertook both RHA and draft RHPA assessments at the same sites. There was a weak positive correlation between the (RHA) habitat quality score and the (RHPA) total pressures score. This indicates that general habitat quality (as assessed by the RHA) increases with a decreasing degree of reach-scale habitat pressure (Figure 5).

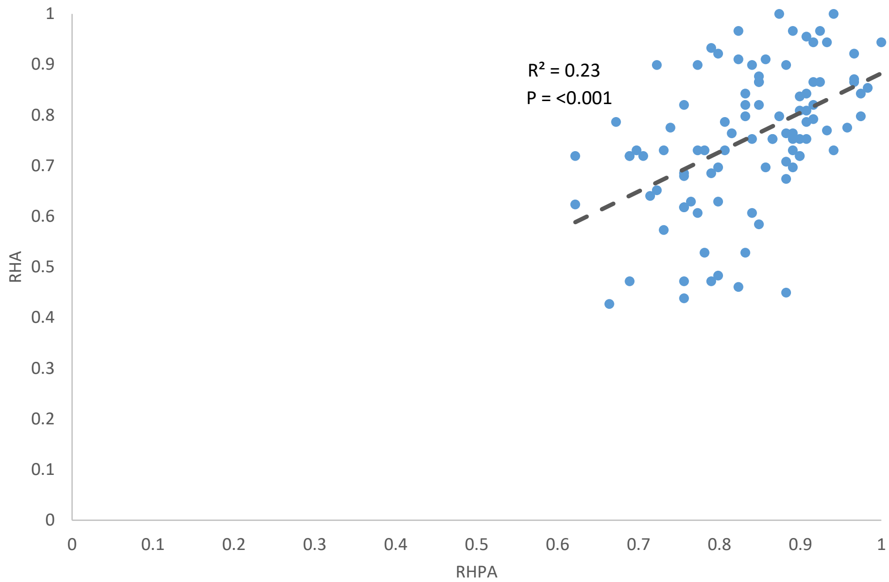

Figure 5. Correlation between (draft) Rapid Habitat Assessment total pressure scores and Rapid Habitat Assessment habitat quality scores determined from the same assessment sites in the Hawke's Bay and Horizons regions (*n* = 97). Data normalised to a 0-1 scale.

At the individual attribute level, RHA scores for ‘bank vegetation’ were positively correlated with the RHPA attributes: ‘Introduced riparian plants’ (R^2 = 0.37, P = < 0.001) and Livestock riparian disturbance (R^2 = 0.19, P = < 0.001). As expected, this indicates that the quality of riparian habitat (i.e., “the maturity, diversity and naturalness of bank vegetation”, as stated in the RHA attribute narrative) is higher in areas with low amounts of introduced plants and livestock disturbance. The RHA attribute ‘riparian width’ was also positively correlated with Livestock riparian disturbance (r^2 = 0.45, P = < 0.001), indicating that wider riparian areas have lower levels of stock access.

There were no other notable relationships between individual RHA and RHPA attributes (results not shown). In general, these results suggest potential pressure-state relationships within the riparian area are easier to determine than pressure-state relationships within the instream environment. There are a variety of factors affecting physical instream habitat condition that manifest across multiple spatial and temporal scales. For instance, unstable banks or livestock access can cause increased deposited streambed fine sediment in downstream reaches, but not necessary in the same reach where this pressure occurs. This is because fine sediment drifts downstream from its source before settling. In addition, there may be substantial lag periods between when stream bank damage or erosion becomes visible and when this pressure results in observable increases in deposited streambed fine sediment. Overall, the presence of a weak significant positive correlation between the draft RHPA and the RHA total scores suggests that RHPA will be useful for determining and reporting on stream pressures when data are aggregated at regional and national scales.

3.5. Comparison of draft RHPA and Macroinvertebrate Community Index scores

There was no relationship between the RHPA pressure scores and Macroinvertebrate Community Index (MCI) scores in the Horizons region—where both stream health indices were determined from the same sites (n = 90, results not shown).

Many of the attributes in the RHPA would not be expected to have a strong influence on macroinvertebrate communities (e.g., the degree of rubbish in the riparian areas or presence of riparian weeds). In addition, any effect of reach-scale habitat modifications on macroinvertebrates is likely to be overwhelmed by overriding catchment scale variables—such as nutrient and fine sediment loads that accumulate at the catchment scale. Therefore, while some of the assessment attributes may be indirectly linked to macroinvertebrate habitat quality, the absence of a correlation at the reach-scale is to be expected.

3.6. Draft RHPA trial feedback

Below I have summarised the key comments and critiques provided within written feedback from regional council staff who took part in the draft RHPA protocol trial. I have noted if this resulted in an amendment to the protocol in the comment response.

Comment
It was noted that determining scores for most attributes requires consideration of more than one stream feature. It was suggested that narratives were consistently structured using a two-stage process to ensure that an assessor can work systematically through the assessment process. More consistent terminology around when to score a site higher or lower was also requested.
Response
Where the narratives conflated two stream features, the features were separated into a two-step assessment process using the following general structure: 'assess the percent occurrence of feature X, if feature Y is present then score higher'.

Comment
It was suggested that algae cover be assessed as a percentage of 'available habitat' to account for areas that do not provide suitable habitat for algae (e.g. fine sediment areas).

Response

No changes to the narratives were made because it would be difficult to ask assessors to determine what habitat is suitable for algae and what is not.

Comment

It was suggested that the narrative for Attribute 6 (Introduced riparian plants) needed clarifying. Specific guidance was requested on scoring sites that are mostly 'rank introduced grasses' because these are common at agricultural sites.

Response

The narrative now provides guidance on how to score different percent coverages of exotic grasses. Minor changes have been made to the narrative wording so that it is consistent with the two-step process for assessing scores.

Comment

A query was raised regarding why there were different scores for filamentous green algae and algal mats within the algal assessment attribute.

Response

The scoring distinction between algal mats and filamentous green algae has been removed in the final protocol.

Comment

One assessor noted that referring to macrophytes (Attribute 2) as 'aquatic weeds' rather than aquatic plants made some assessors focus only on invasive species.

Response

The narrative for this attribute has been changed to refer to both native and exotic macrophytes.

Comment

It was noted that the scoring instructions for Attribute 3 (Instream structures) was confusing and did not adequately distinguish between 'large' structures and structures with perched or vertical faces (that could impede fish passage).

Response

The narrative for Attribute 3 has been changed to a two-step process with assessors asked first to determine the amount and height of structures, before then deciding to score higher within a score band for structures with perched or vertical faces.

Comment

It was suggested that the narrative wording for Attribute 5 was confusing because it was difficult to determine how to score 'open drains' in intensive landscapes.

Response

The narrative has been amended to clarify this issue and has been changed to a two-step process to determine first the amount and size of drain(s), with the score being higher or lower depending on the potential for the drain to deliver pollutants.

Comment

It was noted that some additional wording may be required to describe some technical terms used like ‘active channel’, ‘bank full’ and ‘segment scale’.

Response

No changes were made because there is limited space within an assessment sheet to use longer narratives to explain these concepts. If training resources are developed (e.g., instructional videos or pamphlets) then these resources should include explanations of these concepts / terms, ideally with visual schematics or graphics.

3.6.1. Summary of RHPA protocol changes

The most profound change from the draft RHPA to the final version was rearranging the scoring system such that a *high score* now indicates a *high* level of anthropogenic pressure (i.e., a score of 10 indicates a high level of pressure and a score of 1 indicates low pressure or a near pristine level of anthropogenic influence). This change does not alter the analysis of draft RHPA trial data presented in Section 1.3, however, it should make future RHPA results more intuitive to interpret.

Another modification to the draft protocol included changing the description that defined the ‘riparian area’ of an assessment reach. The riparian area is now defined as 30 m either side of the baseflow wetted channel, no matter how wide the stream is. Previously, the riparian areas definition was similar to the definition of a floodplain within the protocol. A floodplain is defined as '30 m either side of the baseflow wetted channel, or 10 times the wetted with, whichever area is larger'. The previous riparian area definition would have meant huge assessment areas for large rivers.

Some minor changes were made to various individual attribute narratives to ensure a consistent two-step process for assigning an attribute score. Now, a primary stream feature determines the score band (i.e., 1–2, 2–3, 3–4, 4–5, 5–6, 7–8 and 9–10), then a secondary feature determines if the attribute should be scored higher or lower within that band. For example, for Rubbish (Attribute 10), if 11–25 rubbish items are found in the reach then this places the site in the 5–6 score band; if the items are deemed environmentally persistent or harmful then this means the reach is scored higher (i.e., 6). Numerous other minor changes were made to the assessment narratives to improve clarity and consistency.

3.7. Interim RHPA total pressure score interpretation bands

The quartiles and median values of the range of possible pressure scores from the draft RHPA trial can be used to determine overall habitat pressure score interpretation bands. This assumes that the narratives for each of the attributes provided by the expert panel are appropriate to assess pressure level. Based on this logic, *interim* score bands for interpreting RHPA pressure scores are provided in Table 3. The score bands can be used to communicate how much pressure a stream reach is being subjected to. Note that the score bands are the reverse of scores determined from the draft protocol trial to reflect the change in the scoring system. Now, in the revised protocol, a high score indicates a reach subject to a high amount of anthropogenic pressure. Applying these bands to the 251 SoE test sites would place 40% of stream reaches in the 'Low' pressure band, 56% in the 'Moderate' band and 4% in the 'High' band. None of the stream reaches occurred in the 'Very high' pressure band.

Table 3. *Interim* Rapid Habitat Pressures Assessment (RHPA) bands for communicating the amount of anthropogenic habitat pressure / stress a stream reach is being subjected to. Score bands are based on the median and quartiles from assessments undertaken at State of Environment monitoring sites in the Hawke's Bay, Manawatu-Wanganui and Southland regions (n = 251). Band cut-off points have been rounded to the nearest 5.

RHPA pressure score *interim* interpretation bands			
< 30 **Low**	**31–60** **Moderate**	**61–90** **High**	**> 90** **Very High**

4. SUMMARY

The finalised protocol is presented as a table in the Executive Summary and a photographic guide for applying the protocol is provided in Appendix 3.

Overall, the draft RHPA performed adequately during the field trials by regional council staff. The RHPA pressure scores showed a significant (weak) correlation with RHA scores. This indicates that the assessment method is likely to have some predictive power to determine reach-scale instream habitat quality—despite instream habitat quality being determined largely by the cumulative effects of pressures occurring at wider scales (i.e., segment to catchment scales). Within the draft trial, most individual component attribute scores had distributions that were skewed towards scores that indicate relatively low levels of stream pressure. Most New Zealand streams within the SoE monitoring network are likely subject to a moderate to low amount of anthropogenic pressure—relative to the amount of degradation that is possible in streams. This is because most streams in New Zealand are situated within native or agricultural settings, with only a small percentage within urbanised areas. Nevertheless, across the trial dataset, scores were observed across the 1-10 score range for all attributes. Accordingly, I chose not to substantially alter the attribute narratives. A limited assessment of inter-observer variability (between just two assessor teams) suggests that similar scores for the same reach can be achieved by different assessors.

Written feedback was provided by council staff who trialled the draft version of the RHPA protocol. Numerous minor changes have been made to clarify instructions within the finalised protocol scoring narratives. The most substantial change from the draft version was reversing the scoring system so that a high score now indicates a site subject to a high amount of anthropogenic pressure. This change was made so the calculation of total pressure scores is intuitive and in line with similar overseas pressure assessments.

Interim score bands, based on the quartiles and median of the pressure scores from the draft RHPA trial, are put forward to help interpret and communicate results from applying the protocol (Table 3). It is envisioned that these score bands may need amending based on analysis of data gathered from streams spanning a wider geographical range and using the finalised version of the protocol.

5. REFERENCES

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6. APPENDICES

Appendix 1. List of workshop attendees who provided input into the development of the Rapid Habitat Pressures Assessment (RHPA) for streams and streams.

Joanne Clapcott (Cawthron Institute)
Amanda Death (Greater Wellington Regional Council)
Paul Franklin (NIWA)
Ian Fuller (Massey University)
Sandy Haidekker (Hawke's Bay Regional Council)
Jon Harding (University of Canterbury)
Andy Hicks (Hawke's Bay Regional Council)
Roger Hodson (Environment Southland)
Martin Neale (Puhoi Stour Limited)
Michael Pingram (Waikato Regional Council)
Amanda Valois (NIWA)

Appendix 2. Narratives from the Rapid Habitat Pressures Assessment amended according to data and user feedback from the draft trial.

A2.1. Attribute 1: Nuisance benthic algae

A2.1.1. Narrative

Estimate the percentage cover (plan view) of thick algal mats (> 3 mm) and / or filamentous algae within the wetted area of the entire assessment reach.

Score range 1-2
The cover of algal mats and filamentous algae is less than 10% of the streambed wetted area. If filamentous green algae and / or thick cyanobacteria matts (black algae > 3 mm thick) are present in any amount, then score the site higher.

Score range 3-4
The cover of algal mats and filamentous algae is 11–20% of the streambed.

Score range 5-6
The cover of algal mats and / or filamentous green algae is 21–30% of the streambed.

Score range 7-8
Cover of algal mats and / or filamentous green algae is 31–50% of the streambed.

Score range 9-10
Cover of algal mats and / or filamentous green algae is more than 50% of the streambed.

A2.2. Attribute 2: Nuisance aquatic macrophytes

A2.2.1. Narrative

Estimate the percentage cover (plan view) of macrophytes (native and introduced aquatic plants) within the streambed wetted area of the entire assessment reach and match with the appropriate score range below. If the passage of water through the reach is impeded by macrophytes, then score the site higher.

Score range 1-2
The cover of macrophytes is less than 10% of the streambed. Aquatic plant growths are causing no noticeable impediment to flow. If introduced macrophytes are present, then score the site higher.

Score range 3-4
The cover of macrophytes is between 11–20% of the streambed, if aquatic plant growths are causing a minor impediment to flow then score the site higher.

Score range 5-6
The cover of macrophytes is between 21–30% of the streambed, score higher if aquatic growths are causing some impediment to flow, with cross-sectional area or volume comprising macrophyte beds up to 10% in places.

Score range 7-8
The cover of macrophytes is 31–50% of the stream bed, score higher if aquatic growths are causing some impediment to flow, with cross-sectional area or volume comprising macrophyte beds between 10–50% in places.

Score range 9-10
Cover of macrophytes is more than 50% of the stream bed. Score higher if there is flow impoundment or channel 'clogging', with cross-sectional area or volume comprising macrophyte beds more than 50% in places.

A2.3. Attribute 3: Instream structures (structures below the waterline)

A2.3.1. Narrative

Count the number of structures that occur within the wetted channel during baseflows. Structures could include (but are not limited to) weirs, vehicle fords and bank protection infrastructure that extends *below* the baseflow wetted channel edge (note that stream bank structures are assessed as a separate attribute). Large structures that could impede upstream fish passage and / or modify and constrict flow, e.g. by causing ponding / impoundment, should be scored higher.

Score range 1-2
None or one small instream structure is present within the assessment reach. If one structure is present that causes minimal changes to habitat, such as short sections of rock rip rap (< 10 m long or < 10% of reach length) or a bridge abutment that extends below the baseflow water line, then score the site higher.

Score range 3-4
No structures are present that traverse the entire wetted width of the channel. One to three structures are present that extend into the baseflow channel, e.g. rock groynes or short sections of rock rip rap or bridge abutments (< 10 m long or < 10% of reach length).

Score range 5-6
A structure such as a weir is present across the entire baseflow channel. Any increased water velocity created by the structure is equivalent to natural riffles in the wider reach. There is no 'perching' (vertical falls of water) or vertical sections present that could impede upstream fish passage. Score higher if the structure causes

substantial impoundment relative to natural pools, e.g. the pool upstream of structure is more than twice the size of natural pools in the reach.

Score range 7-8
A large instream structure, between 0.2 to 4 m high, is present that increases velocity or causes impoundment to a greater degree than is present naturally in the stream, i.e. upstream pooling more than twice as large as natural pools. Score the reach higher if near-vertical sections or vertical drops are present on the structure that would impede fish passage, or if there are additional lesser structures present that do not traverse the entire wetted width.

Score range 9-10
One very large (> 4 m high), or more than 2 large (0.2 m to 4 m high), instream structures are present that either have a perched downstream outlet or have a near vertical face. If the structure(s) is likely to impede upstream fish passage, e.g. either have a perched downstream outlet or have a near vertical face, or the transport of bedload sediment downstream, then score the site higher.

A2.4. Attribute 4: Instream disturbance

A2.4.1. Narrative

Assess the degree and regularity of livestock or human disturbance in the wetted channel, look for evidence of stock and vehicle crossings or for evidence of instream disturbance with heavy machinery.

Score range 1-2
None or minor historical instream disturbance is evident. If some historical disturbance is evident but appears unlikely to occur again then score the site higher.

Score range 3-4
Reach shows evidence of an infrequently used vehicle or stock crossing, e.g. a few times a year. If it is a stock crossing, then score the site higher.

Score range 5-6
Two vehicle ford or stock crossings, or a single stream crossing is present and appears to receive regular use, e.g. weekly to monthly use. If a stock crossing is present, then score the site higher.

Score range 7-8
There is evidence of regular/high degree of disturbance to the channel. For example, at least part of the reach may be subjected to **a**) mechanical clearing of silt, macrophytes or woody debris or **b**) frequent vehicle or stock disturbance, e.g. weekly. Record which type of disturbance that resulted in your score decision (A, B or A+B).

Score range 9-10
Heavily disturbed streambed in part of the reach, may **a**) be subjected to instream disturbance from heavy machinery though instream gravel extraction or regular silt and macrophyte clearing, e.g. annually, or **b**) have a stock or vehicle crossing that is used daily, e.g. by a dairy herd. Record which type of disturbance that resulted in your score decision (A, B or A+B).

A2.5. Attribute 5: Discharges and drains

A2.5.1. Narrative

Count the number of open drains and piped inflows, noting the diameter of any piped inflows. Consider the potential for pollution from the drain's source based on the land use in the drainage area.

Score range 1-2
No artificial drains or piped inflows present. If a modified tributary or open farm drain is present but has low potential to deliver pollutants, e.g. drains low intensity farmland, then score the site higher.

Score range 3-4
No piped inflows are present. One open drain or channelised tributary may be present. If drains have a high potential for delivering pollution, e.g. drain intensive agricultural or semi-urban land use, then score the reach higher.

Score range 5-6
One or two piped inflows (< 20 cm in diameter), or two or more channelised tributaries or open drains, are present. If drains have a high potential for delivering pollution, e.g. drain intensive agricultural or semi-urban land use, then score the reach higher.

Score range 7-8
Three to five piped inflows (< 20 cm in diameter are present), or a large piped inflow (> 20 cm in diameter) is present. If drains have a high potential for delivering pollution (e.g. drain intensive agricultural or semi-urban land use then score the reach higher.

Score range 9-10
Five or more small piped inflows are present, or more than two large piped inflows (> 20 cm in diameter) are present. If drains have a high potential to deliver pollutants form urban land use or industrial sources, then score the site higher.

A2.6. Attribute 6: Introduced riparian plants

A2.6.1. Narrative

Assess the degree to which introduced and invasive plants occur in the near stream and riparian environment. Assess the extent of introduced species as a percentage of the riparian area (within 30 m of the wetted edge).

Score range 1-2
No or little evidence of introduced plants in the riparian area (banks and channel) or stream. If some introduced plants are present in the riparian areas but are minimal in extent e.g. fewer than 3 willows or < 5% of the riparian area, then score higher.

Score range 3-4
Some introduced plants present in the riparian area but they are not extensive and do not form monocultures along the stream banks, e.g. individual willows, gorse or broom are present but surrounded by predominantly native vegetation. If 6–15% of riparian vegetation is exotic vegetation, then score higher.

Score range 5-6
Riparian areas (banks and channel) comprise mixed exotic species, some native vegetation may be present. Willows or exotic grasses may be present but are not the dominant form of bank vegetation and are not obstructing flow during baseflow conditions. If 16–50% of riparian vegetation is exotic, then score higher.

Score range 7-8
Riparian areas (banks and channel) comprise mostly exotic species, e.g. exotic grasses (51–75%). If exotic invasive weed species are present, such as, gorse and blackberry, or old man's beard, or willow or other riparian plants and introduced macrophytes are encroaching upon the low-flow channel and impeding flow, then score higher.

Score range 9-10
Very little native vegetation, large areas (> 75%) of the riparian zone have exotic monocultures. If notifiable pest plants are present, or willows and other introduced plants and emergent macrophytes are ubiquitous throughout the instream and riparian areas, then score higher.

A2.7. Attribute 7: Bank modification

A2.7.1. Narrative

Assess stream banks to determine if they have a modified shape and if there are structures present that are managed for bank protection, such as willows, groynes, rock rip-rap and / or concrete walls. The stream banks are defined as the wetted edge of the baseflow channel to bank full (top of the high flow channel). Estimate the percentage length of the reach (either bank) that is affected by the various forms of bank modification.

Score range 1-2
No or very little bank modification and the stream appears natural in form. May be some minor historical bank modification along < 5% of the assessment reach.

Score range 3-4
Some bank modification in the form of bank protection provided by managed willows / vegetation or rock groynes along part of the assessment reach. Less than 10% of the length of either bank is affected by hard bank protection infrastructure, e.g. rock armouring of the bank, score the site higher if hard bank protection infrastructure is present.

Score range 5-6
Some channel modification present. Bank battering, i.e. contouring of the streambank to a uniform slope, channel straightening or rock groynes occur along 11–50% of either bank. If there is evidence that streambed lowering has occurred score the reach higher.

Score range 7-8
The channel is confined with embankments, rock rip-rap or other bank armouring, on either bank for half to 80% of the reach length. If the stream has been lowered and / or straightened and banks are uniform in shape, e.g. trapezoid managed channel, then score higher.

Score range 9-10
Channel is confined by high banks that appear artificial in nature and / or the streambed has been lowered for more than 80% of the reach length. The channel appears to be a uniform shape, e.g. trapezoid managed channel, and / or straightened for more than 80% of the reach. Bank armouring in place and appears uniform in construction. If the channel is concrete lined in places, then score higher.

A2.8. Attribute 8: Livestock disturbance in the riparian area

A2.8.1. Narrative

Assess the type, amount and apparent regularity of livestock access to the streambanks and riparian area. The riparian area is defined as 30 m from the wetted channel. Urban areas will likely score highly in this attribute, human floodplain disturbance is assessed in Attribute 9.

Score range 1-2
No means for livestock to access the defined riparian area, either because there is no farming within the surrounding land, or the entire riparian area is protected by stock exclusion fencing that appears to be effective. If there is potential for very infrequent livestock access, e.g. less than once per year, then score higher.

Score range 3-4
Occasional or infrequent stock access, e.g. accessed by low densities of stock only during certain months of the year, such as occurs in a high-country farming setting, or, effective stock exclusion fencing is in place and is set back from the stream edge by at least 10 m (average width throughout the assessment reach). If the reach shows evidence of occasional / historical stock access within 10 m of the wetted edge of the stream, then score higher.

Score range 5-6
Stock exclusion fencing set 3–10 m from the stream edge (average width throughout the assessment reach). Score higher if fencing widths are at the lower end of this range, or there is evidence of occasional / historical stock access within the fenced area.

Score range 7-8
Stock exclusion fencing is in place but is set back by less than 3 m from the stream edge (on average). Evidence of stock access to the stream edge should score higher. Evidence would include recent or previous stock plugging along banks adjacent to the stream and / or trampled and eroded stock tracks.

Score range 9-10
Ineffective or lack of stock exclusion fencing in place. Stock has regular access to the stream edge. If there is evidence of recent and previous stock plugging along banks adjacent to the stream and / or trampled and eroded stock tracks, then score higher.

A2.9. Attribute 9: Human floodplain disturbance

A2.9.1. Narrative

Assess the amount and apparent regularity of human caused disturbance in the floodplain. Here the floodplain area is defined as 30 m from the baseflow wetted edge, or 10 times the wetted width, whichever area is larger. The occurrence of infrastructure in the floodplain such as sealed roads is assessed in Attribute 11.

Score range 1-2
No or limited evidence of human activity in the floodplain. If foot or cycle access tracks are present but are well defined and small in extent or set well back from the stream, e.g. one track, then score higher.

Score range 3-4
Vehicle tracks are present in the floodplain, although tracks are well defined, and use appears to be infrequent, e.g. likely only used during weekends by a few people. Score higher if track cross any stream tributaries.

Score range 5-6
Evidence of regular vehicle / human activity in the floodplain that is likely to cause disturbance to riparian flora and fauna, e.g. stream or wetland birds. If use by vehicles appears likely to occur most days of the week or by multiple groups of people on weekends, then score higher.

Score range 7-8
Substantial and regular disturbance of the floodplain. If the reach includes an infrequently used, e.g. once or twice per year, gravel extraction site then score higher.

Score range 9-10
Substantial and regular disturbance of the riparian areas and floodplain. Reach may be subjected to regular gravel extraction within the active channel, e.g. gravel bars. Four-wheel drive tracks may be extensive through the riparian areas or heavy machinery activity appears to occur regularly, e.g. monthly. Score higher if both gravel extraction and vehicle use occurs.

A2.10. Attribute 10: Rubbish: occurrence of rubbish in the stream and riparian area

A2.10.1. Narrative

Assess the level of rubbish in the riparian areas of the assessment reach (30 m from the wetted channel). If a high proportion of the rubbish items are likely to be environmentally persistent and / or harmful to aquatic life or human health, then the stream reach should score higher. Examples of persistent and / or harmful items include chemical containers, plastic bags, bottles, batteries, dead animals and toilet paper. Check the high-water level areas and note if rubbish has accumulated there from sources further upstream during floods. If rubbish appears to be coming from upstream, then score the reach higher.

Score range 1-2
Little or no rubbish to be found (< 5 items) after a reach-wide search. If rubbish is environmentally persistent or potentially harmful then score higher.

Score range 3-4
Rubbish is evident on the stream bank and / or on the streambed (6–10 items). If rubbish is environmentally persistent or potentially harmful then score higher.

Score range 5-6
Rubbish is evident at a low to medium level (11–25 items). If rubbish is environmentally persistent or potentially harmful then score higher.

Score range 7-8
Rubbish is evident at a medium level (26–50 items). If rubbish is accumulating from upstream or rubbish is environmentally persistent / potentially harmful then score higher.

Score range 9-10
Rubbish distracts the eye (over 50 items), rubbish present throughout the stream and the riparian area. If rubbish is accumulating from upstream or rubbish is environmentally persistent / potentially harmful then score higher.

A2.11. Attribute 11: Surrounding land use and floodplain modification

A2.11.1. Narrative

Determine the type and percent cover of land use in the floodplain of the assessment reach on both banks. Here the floodplain area is defined as 30 m from the baseflow wetted edge, or 10 times the wetted width, whichever area is larger. Estimate the percentage cover in this area that has an impervious surface, including surfaces such as tar-sealed roads, building roofs and concreate areas.

Score range 1-2
Native vegetation dominates the floodplain with no or limited evidence of modification, If minor modification, e.g. small amounts of parklands or low intensity land use (< 10% of area) are present then score higher.

Score range 3-4
Area comprises exotic forestry and / or low intensity farming, e.g. sheep and beef, and / or urban parklands with less than 10% impervious surfaces, e.g. concreated or tar sealed areas. If some native vegetation land use or extensive vegetated riparian corridors, e.g. 20-m wide on average, are present then score higher.

Score range 5-6
Area mostly comprises moderate or high intensity land use. For example, dairy farming or market gardens. May have some infrastructure or dwellings in place creating impervious surface cover of less than 10% of the assessment area.

Score range 7-8
Area is mostly intensive land use, semi-urban or a mix of urban and other land uses. Sites with high impervious surface cover (11–50%) should score higher.

Score range 9-10
Semi-urban or urban land use, impervious surface cover more than 50% of the adjacent floodplain.

A2.12. Attribute 12: Floodplain constraints

A2.12.1. Narrative

Determine if there are stopbanks present that are designed to constrain the stream during high flows. If present, estimate how close they are to the stream with respect to the following narrative descriptions.

Score range 1-2
No or limited stopbanks are present. If they are present, they occur on only one bank and are set back from the stream edge by at least 10 times the active channel width, i.e. the channel that appears to be regularly inundated during high flows.

Score range 3-4
Stopbanks are present on both banks but are set well back from the stream by more than 10 times the active channel width. If some floodplain habitats, such as backwaters or side channels, are present within the stop banked area then score lower.

Score range 5-6
Stopbanks are present within 5 to 10 times the active channel width on at least one bank of the stream. If some floodplain habitats, such as backwaters or side channels, are present within the stopbanked area then score lower.

Score range 7-8
Stopbanks present within 5 times the active channel width on at least part of one side of the stream. Water may flow against parts of the stopbanks which may have embankment reinforcing, e.g. rock reinforcing. If the stream has some room to move between stopbanks with some riparian areas occurring on inside bend areas, and / or gravel beaches exist on inside bends, then score lower.

Score range 9-10
The stream is constrained by high stopbanks on both sides within 5 times the active channel width. Water flows between the stopbanks in a confined manner. If there is evidence of embankment armouring, e.g. though rock riprap or concrete, on some of the stopbanks that suggests a high degree of channel confinement, then score higher.

Appendix 3. Photographic field guide for attributes 1-10.

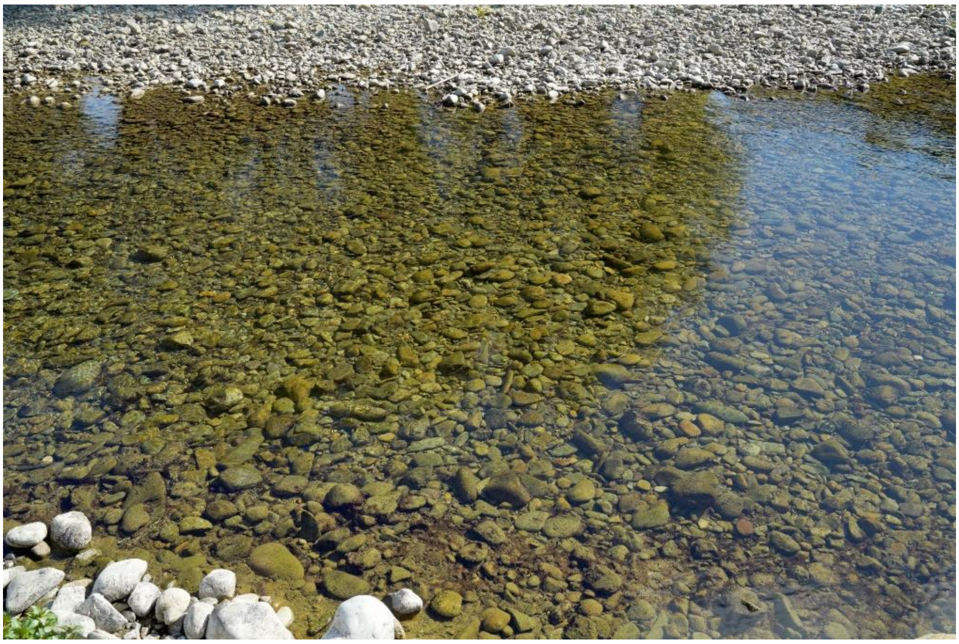
For each attribute there are three example photos of features that would result in a lower, mid and upper range score (out of 10). The photos have accompanying descriptions and notes describing why the feature results in a particular score. Photos are necessarily shown at the 'within-reach' scale but should be interpreted to be applied to the entire assessment reach (i.e., the entire 50–150 m length of stream or river assessed).

These pages can be printed and laminated for reference in the field. Not all features described in the attribute narratives are depicted in the photographic guide, so remember to carefully familiarise yourself with the narratives. Photographic guides for Land use and floodplain modification (Attribute 11)) and Floodplain constraints (Attribute 12) are not shown because these require consideration of landscape-scale features that are difficult to represent in site-scale photographs.

Attribute 1: Nuisance streambed algae

Score range 1-2: The cover of algal mats and filamentous algae is less than 10% of the streambed wetted area. If filamentous green algae and / or thick cyanobacteria matts (black algae > 3 mm thick) are present in any amount, then score the site higher.

Notes: Stream bed with no filamentous algae, small amounts of algal mat present at bottom right of picture so site scored higher. **Score: 2**



Score range 5-6: The cover of algal mats and / or filamentous green algae is 21–30 % of the streambed.

Notes: About 21–25% cover of brown/black algal mats (cyanobacteria). **Score: 5**

Score range 7-8: Cover of algal mats and / or filamentous green algae is 31–50% of the streambed.

Notes: About 45–50% Long filamentous green algae cover. **Score: 8**

Attribute 2: Nuisance aquatic macrophytes

Score range 1-2: The cover of macrophytes is less than 10% of the streambed. Aquatic plant growths are causing no noticeable impediment to flow. If introduced macrophytes are present, then score the site higher.

Notes: Introduced macrophytes are present (water cress) but cover less than 10% of the stream bed and are not obstructing flow. **Score: 2**

Score range 7-8: The cover of macrophytes is 31–50% of the stream bed, score higher if aquatic growths are causing some impediment to flow, with cross-sectional area or volume comprising macrophyte beds between 10–50% in places.

Notes: About 45% macrophyte cover (Glyceria / sweetgrass). About half the cross-sectional volume of the channel taken up by macrophytes. **Score: 8**

Score range 9-10: Cover of macrophytes is more than 50% of the stream bed. Score higher if there is flow impoundment or channel 'clogging', with cross-sectional area or volume comprising macrophyte beds more than 50% in places.

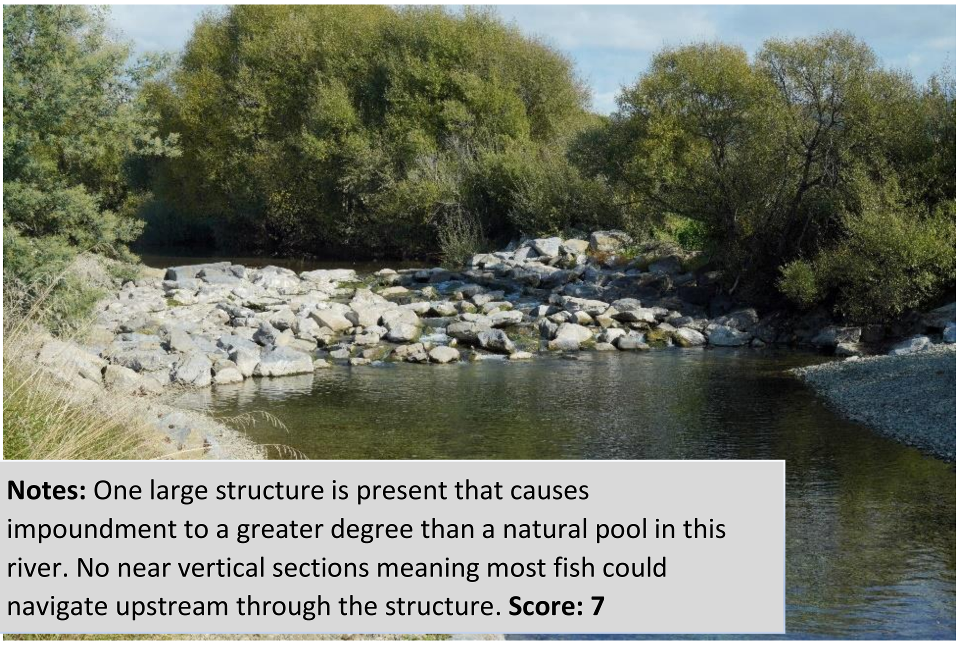
Notes: 100% cover of the streambed. More than 50% of the channel volume comprising macrophytes. **Score: 10**

Attribute 3: Instream structures

Score range 1-2: None or one small instream structure is present within the assessment reach. If one structure is present that causes minimal changes to habitat, such as short sections of rock rip rap (< 10 m long or < 10% of reach length) or a bridge abutment that extends below the baseflow water line, then score the site higher.

Notes: One structure present (bridge pylon) that extends below the low flow water line, otherwise the reach is unmodified. **Score: 2**

Score range 7-8: A large instream structure, between 0.2 to 4 m high, is present that increases velocity or causes impoundment to a greater degree than is present naturally in the stream, i.e. upstream pooling more than twice as large as natural pools. Score the reach higher if near-vertical sections or vertical drops are present on the structure that would impede fish passage, or if there are additional lesser structures present that do not traverse the entire wetted width.



Notes: One large structure is present that causes impoundment to a greater degree than a natural pool in this river. No near vertical sections meaning most fish could navigate upstream through the structure. **Score: 7**

Score range 9-10: One very large (> 4 m high), or more than 2 large (0.2-m to 4-m high), instream structures are present that either have a perched downstream outlet or have a near vertical face. If the structure(s) is likely to impede upstream fish passage, e.g. either have a perched downstream outlet or have a near vertical face, or the transport of bedload sediment downstream, then score the site higher.

Notes: Two large structures across the entire channel, near vertical faces present in upper structure that could impede fish passage. **Score: 10**

Attribute 4: Instream disturbance

Score range 1-2: None or minor historical instream disturbance is evident. If some historical disturbance is evident but appears unlikely to occur again then score the site higher.

Notes: Historical evidence of vehicle use present but appears no longer in use, no evidence of livestock access to stream. **Score: 2**

Score range 5-6: Two vehicle fords or stock crossings, or a single stream crossing is present and appears to receive regular use, e.g. weekly to monthly use. If a stock crossing is present, then score the site higher.

Notes: A single vehicle ford / crossing area that appears to receive regular use (estimated to be weekly). **Score: 6**

Score range 9-10: Heavily disturbed streambed in part of the reach, may a) be subjected to instream disturbance from heavy machinery though instream gravel extraction or regular silt and macrophyte clearing, e.g. annually, or b) have a stock or vehicle crossing that is used daily, e.g. by a dairy herd. Record which type of disturbance that resulted in your score decision (A, B or A+B).

Notes: Stream is subjected to regular macrophyte and silt clearing with heavy machinery. **Score: 10 (A)**

Attribute 5: Discharges and drains

Score range 1-2: Count the number of open drains and piped inflows, noting the diameter of any piped inflows. Consider the potential for pollution from the drain's source based on the land use in the drainage area.

Notes: Riparian area has no drains. **Score: 1**

Score range 5-6: One or two piped inflows (< 20 cm in diameter), or two or more channelised tributaries or open drains, are present. If drains have a high potential for delivering pollution, e.g. drain-intensive agricultural or semi-urban land use, then score the reach higher.

Notes: A single small (< 200 mm) piped inflow. Drain has high potential to deliver contaminants. **Score: 6**

Score range 7-8: Three to five piped inflows (< 20 cm in diameter are present), or a large, piped inflow (> 20 cm in diameter) is present. If drains have a high potential for delivering pollution (e.g. drain intensive agricultural or semi-urban land use then score the reach higher.

Notes: A single large (> 200 mm) piped stormwater inflow. **Score: 8**

Attribute 6: Introduced riparian plants

Score range 1-2: No or little evidence of introduced plants in the riparian area (banks and channel) or stream. If some introduced plants are present in the riparian areas but are minimal in extent e.g. fewer than 3 willows or < 5% of the riparian area, then score higher.

Notes: Little evidence of introduced plants, a few individual gorse and other introduced plants present throughout the reach. **Score: 2**

Score range 5-6: Riparian areas (banks and channel) comprise mixed exotic species, some native vegetation may be present. Willows or exotic grasses may be present but are not the dominant form of bank vegetation and are not obstructing flow during baseflow conditions. If 16–50% of riparian vegetation is exotic, then score higher.

Notes: Near 50% cover of exotic plants in the riparian area (exotic herb cover on right of photo). Native flaxes and trees present. **Score: 6**

Score range 9-10: Very little native vegetation, large areas (> 75%) of the riparian zone have exotic monocultures. If notifiable pest plants are present, or willows and other introduced plants and emergent macrophytes are ubiquitous throughout the instream and riparian areas, then score higher.

Notes: More than 75% exotic plants in riparian area, emergent (stream edge) macrophytes and invasive weeds present in much of the reach. **Score: 10**

Attribute 7: Bank modification

Score range 1-2: No or very little bank modification and the stream appears natural in form. May be some minor historical bank modification along < 5% of the assessment reach.

Notes: Minor bank modification, large boulders for bank stabilisation, present for less than 5% of the reach length. **Score: 2**

Score range 5-6: Some channel modification present. Bank battering, i.e. contouring of the streambank to a uniform slope, channel straightening or rock groynes occur along 11–50% of either bank. If there is evidence that streambed lowering has occurred score the reach higher.

Notes: Rock riprap present on one bank for about 20% of the reach. **Score: 5**

Score range 9-10: Channel is confined by high banks that appear artificial in nature and / or the streambed has been lowered for more than 80% of the reach length. The channel appears to be a uniform shape, e.g. trapezoid managed channel, and / or straightened for more than 80% of the reach. Bank armouring in place and appears uniform in construction. If the channel is concrete lined in places, then score higher.

Notes: Streambed appears lowered for entire reach, channel uniform trapezoid shape and straightened. No concrete lining in place. **Score: 9**

Attribute 8: Livestock disturbance in the riparian area

Score range 1-2: No means for livestock to access the defined riparian area, either because there is no farming within the surrounding land, or the entire riparian area is protected by stock exclusion fencing that appears to be effective. If there is potential for very infrequent livestock access, e.g. less than once per year, then score higher.

Notes: Very little livestock access because of position of stream within headwaters of a high-country farm, there is some potential for very low levels of livestock access. **Score: 2**

Score range 5-6: Stock exclusion fencing set 3–10 m from the stream edge (average width throughout the assessment reach). Score higher if fencing widths are at the lower end of this range, or there is evidence of occasional / historical stock access within the fenced area.

Notes: Well established and effective stock exclusion fencing located 5 m from the low flow wetted edge (on average). **Score: 5**

Score range 7-8: Stock exclusion fencing is in place but is set back by less than 3 m from the stream edge (on average). Evidence of stock access to the stream edge should score higher. Evidence would include recent or previous stock pugging along banks adjacent to the stream and / or trampled and eroded stock tracks.

Notes: Stock exclusion fencing is in place but set back less than 3m from the stream edge, evidence of stock pugging within the fenced area. **Score: 8**

Attribute 9: Human riparian disturbance

Score range 1-2: No or limited evidence of human activity in the floodplain. If foot or cycle access tracks are present but are well defined and small in extent or set well back from the stream, e.g. one track, then score higher.

Notes: Very little evidence of human riparian disturbance. Some infrequently used walking tracks through the bush. **Score: 2**

Score range 5-6: Evidence of regular vehicle / human activity in the floodplain that is likely to cause disturbance to riparian flora and fauna, e.g. stream or wetland birds. If use by vehicles appears likely to occur most days of the week or by multiple groups of people on weekends, then score higher.

Notes: Regular vehicle activity as evidenced by tracks through the floodplain, use appears likely to occur regularly. **Score: 6**

Score range 7-8: Substantial and regular disturbance of the floodplain. If the reach includes an infrequently used, e.g. once or twice per year, gravel extraction site then score higher.

Notes: Reach includes a gravel extraction site that appears to be used infrequently. **Score: 8**

Attribute 10: Occurrence of rubbish in the riparian area

Score range 5-6: Rubbish is evident at a low to medium level (11–25 items). If rubbish is environmentally persistent or potentially harmful then score higher.

Notes: Rubbish is evident at a low level (< 25 items). Some items are environmentally persistent **Score: 6**

Score range 7-8: Rubbish is evident at a medium level (26–50 items). If rubbish is accumulating from upstream or rubbish is environmentally persistent / potentially harmful then score higher.

Notes: Rubbish present at a medium level (e.g. > 30 items), evidence that rubbish is accumulating from upstream during high flows. **Score: 8**

Score range 9-10: Rubbish distracts the eye (over 50 items), rubbish present throughout the stream and the riparian area. If rubbish is accumulating from upstream or rubbish is environmentally persistent / potentially harmful then score higher.

Notes: Rubbish distracts the eye, multiple kinds of rubbish present including environmentally persistent items. **Score: 10**