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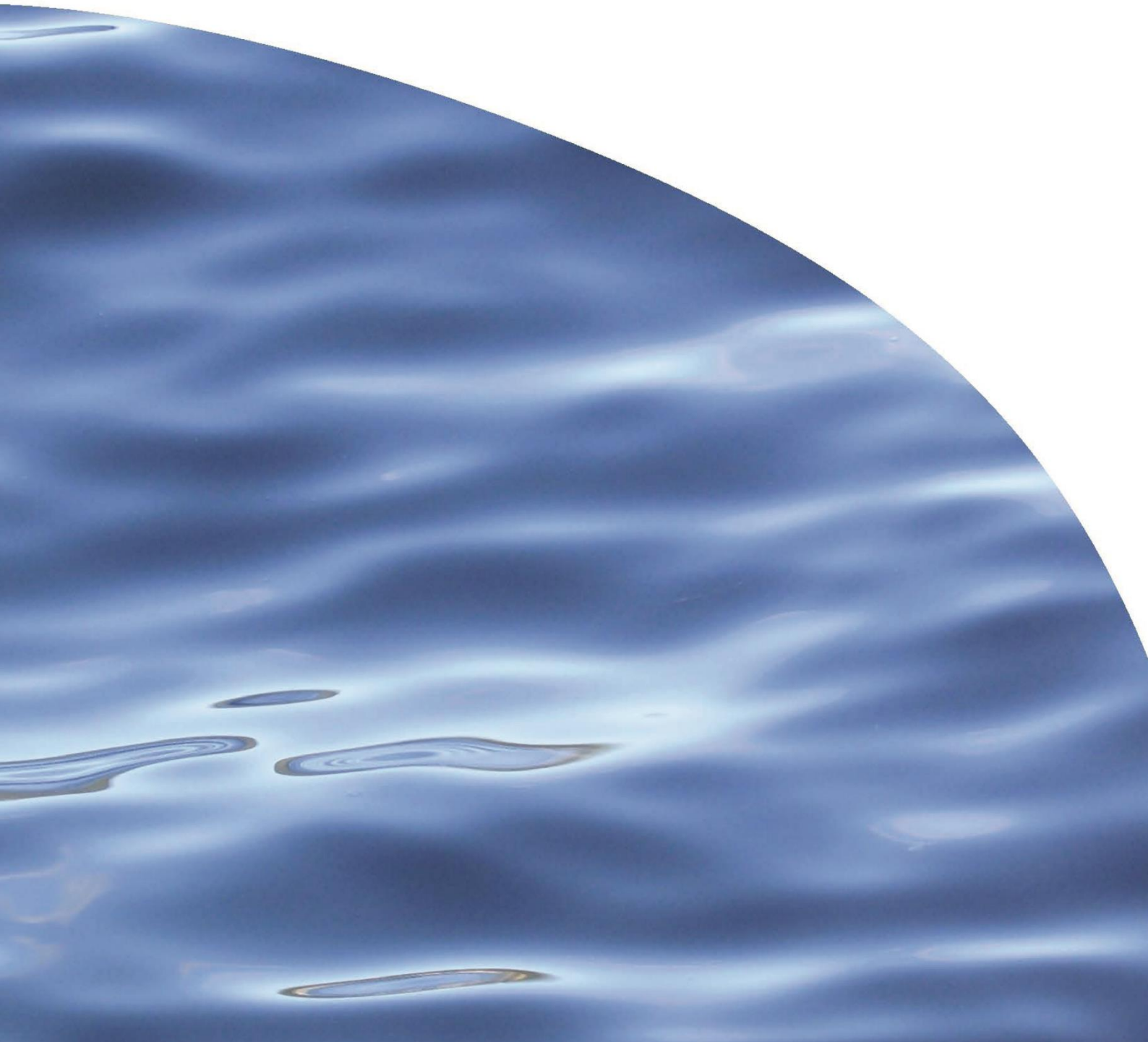
DRAFT NATIONAL RAPID HABITAT PRESSURE ASSESSMENT PROTOCOL FOR STREAMS AND RIVERS



DRAFT NATIONAL RAPID HABITAT PRESSURE ASSESSMENT PROTOCOL FOR STREAMS AND RIVERS

ROBIN HOLMES[1], JOANNE CLAPCOTT[1], SANDY HAIDEKKER[2], ANDY HICKS[2], MICHAEL PINGRAM[3], ROGER HODSON[4], AMANDA DEATH[5], IAN FULLER[6], JON HARDING[7], MARTIN NEALE[8], AMANDA VALOIS[9], PAUL FRANKLIN[9].

[1]CAWTHRON INSTITUTE, [2]HAWKE'S BAY REGIONAL COUNCIL [3]WAIKATO REGIONAL COUNCIL [4]SOUTHLAND REGIONAL COUNCIL, [5]GREATER WELLINGTON REGIONAL COUNCIL, [6]MASSEY UNIVERSITY, [7]UNIVERSITY OF CANTERBURY, [8]PUHOI STOUR LIMITED, [9]NATIONAL INSTITUTE OF WATER AND ATMOSPHERIC RESEARCH.

Prepared for Hawke's Bay Regional Council
Envirolink 2061-HBRC255

CAWTHRON INSTITUTE
98 Halifax Street East, Nelson 7010 | Private Bag 2, Nelson 7042 | New Zealand
Ph. +64 3 548 2319 | Fax. +64 3 546 9464
www.cawthron.org.nz

REVIEWED BY:
John Hayes

APPROVED FOR RELEASE BY:
Roger Young

ISSUE DATE: 30 October 2020

RECOMMENDED CITATION: Holmes R, Clapcott J, Haidekker S, Hicks A, Pingram M, Hodson R, Death A, Fuller I, Harding J, Neale M, Valois A, Franklin P 2020. National rapid river pressures assessment protocol for streams and rivers. Prepared for Hawke's Bay Regional Council/Envirolink. Cawthron Report No. 3543. 36 p. plus appendices.

EXECUTIVE SUMMARY

Here we detail the development of a draft Rapid Habitat Pressures Assessment (RHPA) protocol for rivers and streams that it is suitable for field testing by river managers. A habitat pressure in this context is any human-induced modification to a river or its flood plain which is likely to reduce ecosystem health. The RHPA is being developed to complement the existing Rapid Habitat Assessment protocol that is already widely used by regional councils to assess the state of stream habitat quality. When finalised and implemented the RHPA will bring New Zealand's national river assessment methods in line with equivalent monitoring programs in the European Union and United States.

To develop the draft RHPA protocol an initial strawman protocol was created based on a review of similar habitat assessments in New Zealand and overseas. The strawman protocol was provided to a panel of experts (see report author list for panel members) and critiqued during a video conference workshop. The protocol was then amended according to feedback from workshop attendees.

In total, 12 river pressure attributes were chosen for inclusion in the draft protocol:

1. Nuisance benthic algae
2. Nuisance aquatic macrophytes
3. Instream structures (structures below the base flow waterline)
4. Instream disturbance
5. Discharges and drains
6. Introduced riparian plants occurring at nuisance levels
7. Bank modification
8. Livestock riparian disturbance
9. Human riparian disturbance
10. Occurrence of rubbish in the stream and riparian area
11. Surrounding landuse and flood plain modification
12. Flood plain constraints.

The draft protocol field sheets with instructional narratives are provided below:

Habitat parameter	Condition category										SCORE
1. 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.	*The cover of algal mats and filamentous algae is less than 10% of the stream bed wetted area. If filamentous green algae are present in any amount, then score the site lower.*		*The cover of algal mats and filamentous algae is 11–20% of the stream bed. If filamentous green algae are present in any amount, then score the site lower.*		*The cover of algal mats, filamentous green algae is between 21–30% of the stream bed.*		*Cover of algal mats and filamentous green algae is 31–50% of the stream bed.*		*Cover of algal mats and filamentous green algae is more than 50% of the stream bed.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
2. Nuisance aquatic macrophytes: Estimate the percentage cover (plan view) of aquatic weed (macrophytes) within the wetted area of the entire assessment reach and match with the appropriate score range below. In addition, assess if, and by how much, the passage of water through the reach is impeded by macrophytes.	*The cover of macrophytes is less than 10% of the stream bed wetted area. Aquatic weed growths are causing no noticeable impediment to flow.*		*The cover of macrophytes is between 11–20% of the stream bed, aquatic weed growths are causing no substantial impediment to flow.*		*The cover of macrophytes is between 21–30% of the stream bed, aquatic growths may be 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, aquatic growths may be 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. There may be substantial flow impoundment or channel 'clogging', with cross-sectional area or volume comprising macrophyte beds more than 50% in places.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
3. Instream structures (structures below the waterline): Count the number of structures that occur within the wetted area of stream bed during base flows. Structures could include (but are not limited to) weirs, vehicle fords and bank protection infrastructure that extends below the base-flow wetted channel edge (note that stream bank structures are assessed as a separate attribute). Determine the height and the degree to which the structures modify and constrict flow and cause ponding upstream (impoundment). Also consider how the structure affects upstream fish passage.	*No instream structures present within the entire stream assessment reach, or one small structure may be present that causes minimal changes to habitat, such as short sections of rock rip rap or a bridge abutment (< 10 m long or < 10% of reach length) that extends below the base-flow water line.*		*No instream structures are present that traverse the entire wetted width of the reach. One to three structures are present that extend into the base-flow 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 or vehicle ford is present across the entire low-flow channel. The structure does not cause substantial impoundment relative to natural pools (e.g. the pool upstream of structure is less than twice the size of natural pools in the reach). Any increased water velocity created by the structure is equivalent to natural riffles in the reach and surrounding stream segment. There is no 'perching' (vertical falls of water) or vertical sections present that could impede upstream fish passage.*		*A large (e.g. 0.2-m to 4-m high) instream structure 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 lower if near-vertical sections or vertical drops are present . If there are additional lesser structures present that do not traverse the entire wetted width, then score the site lower.*		*One (> 4-m high) or more large instream structures (0.2-m to 4-m high) are present that either have a perched downstream outlet or have a near vertical face. The structure is likely to impede the transport of bedload sediment downstream and / or cause substantial upstream impoundment. If there are other additional (lesser) instream structures present as described above, then score the site lower.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	

Habitat parameter	Condition category										SCORE
4. Instream disturbance: Assess the degree and regularity of human or stock disturbance in the wetted channel, look for evidence of vehicle and stock crossings or for evidence of instream disturbance with heavy machinery.	*No instream disturbance is evident, some use for swimming maybe evident.*		*Reach shows evidence of a single vehicle or stock crossing. However, it appears to receive infrequent use e.g. less than once per month.*		*Two vehicle ford or stock crossings, or a single river crossing is present and appears to receive regular use (e.g. weekly to monthly use).*		*There is evidence of regular 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 annually (or less often) or b) frequent vehicle or stock disturbance (e.g. weekly). Record which type of disturbances that resulted in your score decision (a, b or a+b).*		*Heavily disturbed stream bed in part of the reach, may be a) subjected to instream disturbance from heavy machinery though gravel extraction or regular silt and macrophyte clearing (e.g. more than annually), or b) reach may have a stock or vehicle crossing that is used daily (e.g. by a dairy herd). Record which type of disturbances that resulted in your score decision (a, b or a+b).*		**Circle: A B A+B**
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
5. Discharges and drains: Count the number of drains in the entire reach (both banks), note their type and size.	*No artificial drains or piped inflows present, a modified tributary or open farm drain may be present but has low potential to deliver pollutants, e.g. drains low intensity farmland.*		*No piped inflows are present and 1 or 2 open drains may be present but drain low intensity farmland. If drains have a high potential for delivering pollution, e.g. drain-intensive agricultural or semi-urban land use, then score the reach lower.*		*Two or more channelised tributaries or open drains are present, or one or two piped inflows, less than 20 cm in diameter, 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 lower.*		*Two to more 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 lower.*		*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 lower.*		
.	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
6. Introduced riparian plants occurring at nuisance levels: Assess the degree to which introduced and invasive plants occur in the near stream and riparian environment. Note the presence of large areas of introduced species that form smothering monocultures. Make a note if there is evidence in the stream and riparian environment of introduced animals such as carp, goldfish, rabbits, hares, goats and pigs. However, observations of introduced animals do not contribute to the overall score.	*No or little evidence of introduced plants in the riparian area (banks and channel) or river. Some introduced plants may be present in the riparian areas but are minimal in extent (e.g. < 2 willows).*		*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.*		*Riparian areas (banks and channel) comprise mixed exotic species, some native vegetation may be present. Willows may be present and may be the dominant form of bank edge vegetation but are not obstructing flow during base flow conditions.*		*Riparian areas (banks and channel) comprise mostly exotic invasive weed species such as gorse and blackberry, notifiable pest species such as old man's beard may be present. Willows or other riparian plants and introduced macrophytes may be encroaching upon the low-flow channel and impeding flow.*		*Large areas (> 20%) of the riparian zone have pest species monocultures, notifiable pest plants are present. Willows and other introduced plants and macrophytes may be ubiquitous thoughout the instream and riparian areas.*		**Note introduced plant and animals species here**
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	

Habitat parameter	Condition category										SCORE
7. Bank modification: Bank modification should be visible and assessed at the reach-scale, although some active channel modification may occur at the segment scale. Some additional wording in the assessment instructions may be needed to describe concepts like the 'active channel' and 'bank full' to enable more consistent assessments by less experienced assessors. For example, specific guidance may be needed so that assessors can distinguish the 'active channel' from the floodplain.	*No bank modification and the stream appears natural in form. May be some minor historical bank modification in < 5% of the reach length.*		*Some bank modification in the form of bank protection provided by managed willows / vegetation or rock groynes along part of the reach. Less than 10% of the length of either bank is affected by hard bank protection infrastructure (e.g. rock armouring of the bank).*		*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 length of either bank. There may be some evidence that streambed lowering has occurred. If so, score the reach lower.*		*A confined channel with embankments on either bank for more than half of the reach. Stream may have been lowered and / straightened and banks may be a uniform shape (e.g. trapezoid managed channel) for 20 to 80% of the reach length. Rock rip-rap or other bank armouring may be in place at most outside bends. Most high flow events (e.g. annual floods) would be contained within the top of the channel embankments.*		*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 lower.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
8. Livestock riparian disturbance: Assess the type, amount and apparent regularity of livestock access to the riverbanks and the near-bank riparian area.	*No means for livestock to access the riparian area, either because there is no farming within the surrounding land area or the entire riparian area is protected by stock exclusion fencing that appears to be effective. The entire riparian area can be defined as 30 m from each of the base flow wetted edges, or, 10 times the wetted width whichever area is larger.*		*Very occasional or infrequent stock access (e.g. only certain months of the year, such as occurs in a high-country farming setting). Stock access is by sheep or low densities of beef cattle (e.g. as might occur in a high-country 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).*		*Stock exclusion fencing of 10m or more may be in place but the area between the fence and river edge appears to be grazed infrequently by sheep. Or effective stock exclusion fencing is in place and is set back from the stream edge by between 5 and 10 m (average width throughout the assessment reach).*		*Stock exclusion fencing is in place but is set back by between 3 to 5 m from the stream edge. Or, may be some evidence of frequent or regular stock having to the stream edge. Evidence would include recent and previous stock plugging along banks adjacent to the stream or trampled and eroded stock tracks. Stock access by cattle score lower.*		*No stock exclusion fencing is in place and stock have free and regular to the stream edge. Stock access for cattle scores lower.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
9. Human riparian disturbance: Assess the amount and apparent regularity of human mediated disturbance in the riparian area and flood plain. Here the riparian area and flood plain are defined as 30 m from the base flow wetted edge, or 10 times the wetted width, whichever area is larger.	*No evidence of activity in the riparian area or flood plain. Foot or cycle access tracks may be present but are well defined and are modest in extent (e.g. one track).*		*Vehicle tracks are present in the floodplain and riparian areas, although tracks are well defined, and use appears to be infrequent (e.g. likely used during weekends by < 3 groups of people).*		*Evidence of regular vehicle activity in the surrounding land and some use of the riparian area. Use by vehicles likely occurs most days of the week or by multiple vehicles on weekends. Activity likely to cause significant disturbance to riparian fauna (e.g. river birds). Gravel extraction may be occurring outside of the mainstem channel but not directly on gravel beaches.*		*Substantial and regular disturbance of the riparian areas and floodplain. Reach may include a gravel extraction site or undergo beach raking activities, however, gravel extraction appears to occur infrequently (e.g. once or twice per year).*		*Substantial and regular disturbance of the riparian areas and floodplain. Reach may include a gravel extraction site or undergo beach raking activities. Four-wheel drive tracks may be extensive through the riparian areas or heavy machinery activity appears to occur regularly (e.g. monthly).*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	

Habitat parameter	Condition category										SCORE
10. Occurrence of rubbish in the stream and riparian area: Assess the level of rubbish in and around the stream for the entire reach. 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 lower. Examples of persistent and / or harmful items include chemical containers, plastic bags, bottles, batteries, dead animals and toilet paper. Note if rubbish appears to have accumulated in the reach from sources further upstream during floods, check for evidence of accumulations of rubbish along high-water levels. If rubbish appears to be coming from upstream, then score the reach lower.	*Little or no rubbish to be found (< 5 items) after a reach-wide search.*		*Rubbish is evident on the stream bank and on the stream bed (6–10 items).*		*Rubbish is evident at a low to medium level (11–25 items). Most items are not environmentally persistent or harmful (e.g. paper food wrappers as opposed to plastic items).*		*Rubbish is evident at a medium level (26–50 items). May be evidence that rubbish is accumulating from upstream (e.g. accumulating because of deposition during floods). Some types of rubbish may be environmentally persistent or potentially harmful.*		*Rubbish distracts the eye, rubbish present throughout the stream and the riparian area. Rubbish of many different kinds are present, including persistent and / or potentially harmful items (>50 items).*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
11. Surrounding land use and floodplain modification: Determine the type and percent cover of land use adjacent to the assessment reach on both banks within an area of at least 30 m from the wetted channel or 10 x the average wetted width of the stream reach (whichever is larger). Estimate the percentage cover in this area that has an impervious surface, including surfaces such as tar-sealed roads, building roofs and concrete areas.	*Entire area is undisturbed native vegetation, may have some minor modification, e.g. walking or cycle access tracks.*		*Area comprises exotic forestry and / or low intensity farming (e.g. sheep and beef). May have some native vegetation land use or extensive vegetated riparian corridors (e.g. 20 m wide on average).*		*Area mostly comprises moderate or high intensity land use. For example, dairy farming or urban parklands. May have some infrastructure or dwellings in place creating impervious surface cover of less than 10% of the assessment area.*		*Area is all intensive land use, semi-urban or a mix of urban and other land uses. Sites with high impervious surface cover (11-50%) should score lower.*		*Semi-urban or urban land use, impervious surface cover more than 51% of the adjacent land and potential flood plain.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
12. Flood plain constraints: Walk the length of the reach and determine if there are stop banks in place 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 to determine the reach score. Also search for floodgates, tide gates and pump stations on the flood plain, note if these are present but do not include them in the assessment score.	*No stop banks or other artificial structures in place, or if 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 may be present but are set well back from the stream by between 5 and 10 times the active channel width. In addition, side channels and off channel wetted habitats are present that would be inundated during an annual flood.*		*Stop banks present within 5 to 10 times the active channel width on at least part of one bank of the stream. If some flood plain habitats, such as backwaters or side channels, are present within the stop banked area then score reach higher.*		*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). The stream still 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.*		*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. 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.*		**Note the type and number of floodgate, tidegates and/or pumpstations in the flood plain**
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
TOTAL										(Sum of parameters 1-12)	

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1. INTRODUCTION

Physical habitat is the template upon which hydraulic and physicochemical regimes define aquatic biological communities in rivers; yet in New Zealand it is often the last aspect of a river ecosystem to be routinely measured as part of river health assessments. To address this, the Rapid Habitat Assessment (RHA) (Clapcott 2015) was developed to evaluate 'general' river habitat condition in wadable streams. The RHA provides a single 'habitat condition score' for a river reach and is now used routinely by (almost all) regional councils as part of State of Environment (SoE) monitoring. However, the RHA is largely a measure of *current state* and was not designed to assess the degree of modification or potential pressures such as instream or bank engineering. This means that the RHA is of limited use for predicting future states or identifying areas that may be vulnerable to degradation as a result of habitat modification. During the design of the RHA protocol a separate assessment methodology was intended to be developed, focussing on river pressures and / or river habitat modification (Clapcott 2015). This report presents the first step towards developing a standard national (rapid) river habitat pressure / modification field assessment method.

1.1. Benefits and vision

A nationally standardised Rapid Habitat Pressures Assessment (RHPA) protocol will bring New Zealand's national river assessment methods in line with equivalent monitoring programmes in the European Union and United States, where monitoring habitat modification is commonplace. It is anticipated that the RHPA will have the following benefits:

- Councils and other river practitioners (e.g. DOC) will be able to undertake more holistic reach-scale assessments of river health (i.e. collect habitat data together with water quality, invertebrate and fish data), while ensuring that regional assessments are comparable nationally.
- Over time, the RHPA protocol will enable sites at risk of degradation to be identified, and this information will be useful in catchment or regional-scale planning (e.g. for spatial allocation of riparian planting initiatives).
- Eventually, a national river pressures database will enable an assessment of trends in ecosystem health at regional and national scales. When paired with habitat state / condition data (e.g. such as collated with the RHA), a reach-scale river pressures database will allow cause-and-effect relationships between potential pressures and river habitat states to be investigated. This will enable improved targeting of ecosystem health protection and enhancement measures though adaptive management.

1.2. Scope, methods and constraints

In the present report we outline a prototype Rapid Habitat Pressures Assessment (RHPA) protocol for rivers and streams. We anticipate that the protocol will require further refinement after field testing and user feedback.

The draft RHPA was developed using a two-stage process. First, an initial strawman protocol was developed based on a review of similar habitat assessment methods in New Zealand and overseas (see Section 2) and consideration of the practical constraints within New Zealand's water management setting (see below). The strawman protocol was discussed and critiqued during a video conference workshop with an expert panel held on 12 August 2020 (see report authors for the list of attendees). Following the workshop, the lead author amended the protocol and workshop attendees were provided further opportunity to make suggestions. These suggestions were then incorporated into the final draft RHPA, again by the lead author (draft presented in Section 3).

The draft protocol was developed according to the following considerations and practical constraints:

1. Its attributes must align with, and complement, habitat data that are generated by the (original) RHA protocol
2. It must provide information on common habitat pressures that have scientifically defensible (cause-and-effect) links to aspects of stream habitat that affect river health, and more specifically, to the ability of a river to sustain instream values such as native biodiversity, mahinga kai and fisheries.
3. It must be applied at the reach-scale (i.e. reaches of streams or rivers in the order of 150 m).
4. It must produce a single 'river habitat pressure score' that can be calculated in the field.
5. It should be able to be applied without specialist expertise or equipment and have minimal training requirements (e.g. less than a day's training required).
6. It should take less than 25 minutes to complete—and so will be necessarily based largely on visual assessments.

It is important to note that the RHPA is a *rapid* assessment and cannot measure all potentially important aspects of river habitat pressures and / or modification. In addition, where resourcing allows it should not supersede more in-depth assessments of river habitat—for example, those found in the Stream Habitat Assessment Protocols (SHAP) or the Stream Ecological Valuation (SEV) methods (Harding et al. 2009; Storey et al. 2011).

1.3. The pressure-state-impact assessment framework

In common with the European Union, New Zealand's environmental reporting is based on a pressure-state-impact framework (MfE 2014). On the MfE website (https://www.mfe.govt.nz/publications/environmental-reporting/environment-aotearoa-2015-our-new-reporting-approach/reporting) the pressure-state-impact framework is defined as follows:

- Pressure: the natural or human pressures that influence the state of the environment. Pressures explain why the domains (ecosystems) are in the condition they are in.
- State: the physical, chemical, and biological characteristics of each aspect of the environment, and how these aspects are changing over time.
- Impact: the ecological, economic, social, and cultural consequences of changes in the state of the environment. Environmental impacts that have significance for Māori are covered under te ao Māori (Māori world view).

The focus of the current protocol is to identify potential river habitat *pressures* rather than ecosystem states or impacts. River habitat state is intended to be assessed by the (original) RHA protocol. However, the issue of where a physical river habitat attribute sits within the pressure-state-impact framework is not always straightforward. It depends on the scale of the assessment (e.g. if a river's flood plain is considered part of the river) and how degradation is defined. For example, depending on the circumstances, macrophytes can fit into all three pressure-state-impact categories. Macrophytes can be considered an impact or a modification of the river environment if they are an introduced species, a state of the instream habitat, or a pressure on instream ecology if they reach nuisance growth levels.

For the purposes of this assessment, as long as the potential pressure in question is a direct result of human influence then it ought to be suitable for inclusion in the protocol. In addition, if the habitat attribute in question is a measure of a pressure *or* a state then it will potentially be suitable. This is because a state measure can be considered a pressure indicator if it is defined by the degree of deviation from near-pristine reference conditions (i.e. using an observed vs. expected reference condition approach).

2. BRIEF REVIEW OF PHYSICAL HABITAT PRESSURE ASSESSMENTS

Below we briefly review the different rapid (or semi-rapid) habitat assessment methodologies and initiatives in New Zealand and overseas. The focus of this review is on what habitat pressure / modification attributes are measured, rather than how they are measured or why. This review helped inform which potential measurement attributes ought to be included within the RHPA protocol.

2.1. New Zealand stream habitat assessment protocols

2.1.1. The Rapid Habitat Assessment (RHA) method

As discussed earlier, the RHA is now the reach-scale rapid habitat assessment method of choice for most regional councils for SoE monitoring. The methodology is detailed in Clapcott (2015). In short, the RHA involves scoring the following 10 parameters (listed below) on a 1–10 scale using a standardised field assessment sheet (Appendix 1):

1. deposited sediment
2. invertebrate habitat diversity
3. invertebrate habitat abundance
4. fish cover diversity
5. fish cover abundance
6. hydraulic heterogeneity
7. bank erosion
8. bank vegetation
9. riparian width
10. riparian shade.

Parameter scores are assigned based on numerical and narrative guidelines that were developed by a panel of river ecologists and regional council staff. The total score (out of a 100) can be interpreted as an indication of general habitat quality for hard bottomed streams, or it can be scaled to an expected reference condition score to provide a percent habitat condition score for reporting on atypical stream types (e.g. soft-bottomed streams).

2.1.2. River habitat modification indicators

In 2018 the Ministry for Environment (MfE) commissioned a report to investigate developing physical River Habitat Modification Indicators (RHMI) that are suitable for national monitoring and reporting (Holmes et al. 2018). A workshop was convened on

2 March 2018 with water managers and relevant experts to determine a candidate list of habitat modification attributes that would be suitable for monitoring in New Zealand. The outcome of that process prioritised five indicators for initiating a national monitoring and reporting programme:

1. riparian vegetation type
2. presence of channel engineering
3. presence of stopbanks for flood protection
4. river planform measurements
5. presence of potential fish passage barriers.

The full list of potential habitat modification attributes that were identified and considered at the workshop is given in Appendix 2. The preferred shortlists of attributes by individual workshop attendees are shown in Appendix 3. Holmes et al. (2018) outline the process of obtaining information on these attributes. In most instances information gathering is best done as a desktop exercise, for example, by interrogating spatial databases and regional council records. Nevertheless, some of the attributes, or at least aspects of them, could be assessed as part of onsite field work. In particular, it was noted that effective assessments of the degree of channel engineering, bank modification and fish passage would best be done using field-derived assessment data.

Two other New Zealand stream habitat assessment protocols are in regular use: the Stream Habitat Assessment Protocols (SHAP) (Harding et al. 2009) and the Stream Ecological Valuation (SEV) (Storey et al. 2011). These are explained below. Both methods contain protocols that are relatively comprehensive but are also labour intensive and have moderate to high training requirements (relative to the RHA).

2.1.3. Stream Habitat Assessment Protocols

The SHAP protocols were developed in 2009 and contain three habitat assessment protocols with varying levels of precision and effort (Harding et al. 2009). The P1 protocol represents the most rapid habitat assessment and is most applicable to developing the RHPA. Most of the attributes are aspects of stream habitat state / condition and do not focus directly on potential river pressures or modification. The various habitat attributes in the P1 method are listed below, those of relevance to the development of the RHPA are in italics:

1. Bank characteristics (width, hight, bank stability, etc.)
2. Macrophytes
3. Periphyton
4. Wood (instream)
5. Moss and leaves (instream)
6. Shading

7. Riparian width
8. *Stock access / stock damage*
9. *Pest plants*
10. *Adjacent land use.*

2.1.4. Stream Ecological Valuation

The SEV was developed to assess physical habitat quality in Auckland's urban streams (Storey et al. 2011). The protocol combines measurements and visual assessment of various attribute states and potential pressures, as well as measuring indicators of ecological processes (such as oxygen reducing process). The attributes measured as part of the protocol are listed below, those relevant to the RHPA are shown in italics:

1. Cross sectional measurements of inorganic and organic material
2. Channel characteristics (depth, macrophytes, velocity, shade and vegetation)
3. *Channel modification (presence of artificial structures in the stream)*
4. *Size and number of piped inflows*
5. *Fish migration barriers*
6. *Flood plain features (degree of connectivity)*
7. *Type of channel lining (e.g. rock lined channel)*
8. Indicators of oxygen reduction process
9. Riparian vegetation
10. Galaxiid spawning habitat
11. Riparian zone description
12. Intactness of riparian zone
13. Physical habitat quality.

The full list of habitat pressure / modification attributes from the SEV are shown within Appendix 4. Within the SEV, the method for gathering information on the attributes generally rely on using a subjective scoring system guided by narrative descriptions. Some of the assessments involve the identification of ecological processes which requires a reasonably high level of expertise.

2.1.5. The Riparian Management Classification

While not in regular use, the Riparian Management Classification (RMC) system (Quinn 2009) is relevant because it was developed to assess riparian condition and the degree of riparian modification or potential for improvement. This methodology also requires a reasonable level of ecological expertise on the part of the assessor. When applying the RMC protocol, a field worker assesses a section of stream by rating the ability of the riparian zone (on a 0–5 Likert scale) to perform the twelve

functions listed below, attributes that are relevant to the development of the RHPA are italicised:

1. Control of livestock excreta and damage
2. *Bank stabilisation*
3. Overland flow filtering
4. Nutrient uptake by plants
5. Denitrification
6. Shading
7. Leaf litter input
8. Wood input
9. Enhancing in-stream fish habitat
10. *Control of downstream flooding*
11. Human recreation
12. Aesthetics

2.2. International habitat assessment protocols

Below we briefly summarise three examples of national-scale monitoring programmes for river habitat modification overseas.

2.2.1. United Kingdom - River Habitat Quality survey protocol

As part of the European Union Water Framework Directive, monitoring of river habitat modification occurred across the United Kingdom (Raven et al. 2000). Habitat modification reporting is based on data gathered using a standardised 500-m stream reach and River Habitat Quality survey protocol. The information collected on habitat modification includes a mix of measurements and subjective assessments on the degree of channel and bank modification, bank profile and riparian vegetation. In addition, the presence of artificial features such as weirs and culverts is also recorded. Survey information is combined into a Habitat Modification Score; these scores are categorised into five habitat modification classes from 1 (near pristine) to 5 (severely modified). The attributes listed below are all included in the Habitat Modification Score (Raven et al. 2000), all are relevant to consider when developing a New Zealand-specific river habitat pressures / modification assessment method:

1. *Reinforcement to banks*
2. *Reinforcement to bed*
3. *Resectioned (enlarged channel) bank or bed*
4. *Two-stage bank modification*
5. *Embankment*
6. *Culvert*

7. *Dam, weir, ford*
8. *Bank poached by livestock*
9. *Footbridge*
10. *Road bridge*
11. *Enhancements such as groynes*
12. *Site partially affected by flow control*
13. *Partially realigned channel*
14. *Extensively or wholly realigned channel.*

2.2.2. United States of America – National Rivers and Streams Assessment

In the United States, the National Rivers and Streams Assessment programme is administered by the Environmental Protection Agency (US EPA). Their standardised river habitat assessment protocol has a focus on river habitat state rather than habitat modification and is applied throughout the country (US EPA 2016). There are four components of the assessment protocol that measure aspects of river habitat modification. These include excess fine sediments in the streambed, in-stream fish habitat, riparian vegetation and riparian disturbance. The first three indicators are interpreted with respect to an observed vs. expected reference condition approach. The riparian disturbance component of the protocol includes an assessment of habitat modification. For this parameter, riparian areas are scored based on the presence (or absence) of 11 types of anthropogenic influence (within 50 m of each river edge). Determining the level of anthropogenic influence includes noting the presence of the following features:

1. *Walls, dikes, revetments, riprap, and dams*
2. *Buildings*
3. *Cleared lot, pavement (e.g., paved, gravelled, dirt parking lot, foundation)*
4. *Roads or railroads*
5. *Inlet or outlet pipes*
6. *Landfills or trash (e.g., cans, bottles, trash heaps)*
7. *Parks or maintained lawns*
8. *Row crops*
9. *Pastures, rangeland, or hay fields*
10. *Logging*
11. *Mining (include gravel mining).*

River reaches are given a ‘riparian condition score’ contingent on a set of rules about the frequency and extent of the above human activities recorded along a survey reach.

2.2.3. Australia

The AUSRIVAS program includes both water quality and physical river habitat assessment components. The physical habitat component is based on data collected using a nationally standardised protocol that was closely modelled on the US EPA stream habitat assessment method. The program uses an observed vs expected reference condition approach to assess the degree of physical habitat alteration (Parsons et al. 2004). In addition to the AUSRIVAS programme, the Sustainable Rivers Audit is an ecosystem health assessment that is applied to the entire Murray-Darling river system—which drains about a seventh of Australia's land mass. Within this programme there is a strong focus on floodplain habitats and vegetation. In the most recent application of the Sustainable Rivers Audit, extensive LiDAR surveys were used to determine the quality of riparian vegetation and extent of floodplain wetland areas. These types of assessment are of less relevance to developing field-based rapid river pressures assessment because they rely on spatial mapping. The area of land adjacent to rivers that is inundated during a rain event with a 100-year return period is used to delineate floodplain area for assessment (MDBA 2012).

3. DRAFT RAPID HABITAT PRESSURES ASSESSMENT PROTOCOL

The draft RHPA protocol with descriptive narratives is presented below in Table 1. Rational and justification for the inclusion (or exclusion) of the various habitat pressure attributes is provided in Section 4 below.

Table 1. Draft river habitat pressures / modification protocol for field testing by water managers (assessment components 1-3 shown).

Habitat parameter	Condition category										SCORE
1. 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.	*The cover of algal mats and filamentous algae is less than 10% of the stream bed wetted area. If filamentous green algae are present in any amount, then score the site lower.*		*The cover of algal mats and filamentous algae is 11–20% of the stream bed. If filamentous green algae are present in any amount, then score the site lower.*		*The cover of algal mats, filamentous green algae is between 21–30% of the stream bed.*		*Cover of algal mats and filamentous green algae is 31–50% of the stream bed.*		*Cover of algal mats and filamentous green algae is more than 50% of the stream bed.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
2. Nuisance aquatic macrophytes: Estimate the percentage cover (plan view) of aquatic weed (macrophytes) within the wetted area of the entire assessment reach and match with the appropriate score range below. In addition, assess if, and by how much, the passage of water through the reach is impeded by macrophytes.	*The cover of macrophytes is less than 10% of the stream bed wetted area. Aquatic weed growths are causing no noticeable impediment to flow.*		*The cover of macrophytes is between 11–20% of the stream bed, aquatic weed growths are causing no substantial impediment to flow.*		*The cover of macrophytes is between 21–30% of the stream bed, aquatic growths may be 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, aquatic growths may be 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. There may be substantial flow impoundment or channel 'clogging', with cross-sectional area or volume comprising macrophyte beds more than 50% in places.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
3. Instream structures (structures below the waterline): Count the number of structures that occur within the wetted area of stream bed during base flows. Structures could include (but are not limited to) weirs, vehicle fords and bank protection infrastructure that extends below the base-flow wetted channel edge (note that stream bank structures are assessed as a separate attribute). Determine the height and the degree to which the structures modify and constrict flow and cause ponding upstream (impoundment). Also consider how the structure affects upstream fish passage.	*No instream structures present within the entire stream assessment reach, or one small structure may be present that causes minimal changes to habitat, such as short sections of rock rip rap or a bridge abutment (< 10 m long or < 10% of reach length) that extends below the base-flow water line.*		*No instream structures are present that traverse the entire wetted width of the reach. One to three structures are present that extend into the base-flow 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 or vehicle ford is present across the entire low-flow channel. The structure does not cause substantial impoundment relative to natural pools (e.g. the pool upstream of structure is less than twice the size of natural pools in the reach). Any increased water velocity created by the structure is equivalent to natural riffles in the reach and surrounding stream segment. There is no 'perching' (vertical falls of water) or vertical sections present that could impede upstream fish passage.*		*A large (e.g. 0.2-m to 4-m high) instream structure 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 lower if near-vertical sections or vertical drops are present . If there are additional lesser structures present that do not traverse the entire wetted width, then score the site lower.*		*One (> 4-m high) or more large instream structures (0.2-m to 4-m high) are present that either have a perched downstream outlet or have a near vertical face. The structure is likely to impede the transport of bedload sediment downstream and / or cause substantial upstream impoundment. If there are other additional (lesser) instream structures present as described above, then score the site lower.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	

Table 1. (*continued*). Draft river habitat pressures / modification protocol for field testing by water managers (assessment components 4-6 shown).

Habitat parameter	Condition category										SCORE
4. Instream disturbance: Assess the degree and regularity of human or stock disturbance in the wetted channel, look for evidence of vehicle and stock crossings or for evidence of instream disturbance with heavy machinery.	*No instream disturbance is evident, some use for swimming maybe evident.*		*Reach shows evidence of a single vehicle or stock crossing. However, it appears to receive infrequent use e.g. less than once per month.*		*Two vehicle ford or stock crossings, or a single river crossing is present and appears to receive regular use (e.g. weekly to monthly use).*		*There is evidence of regular 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 annually (or less often) or b) frequent vehicle or stock disturbance (e.g. weekly). Record which type of disturbances that resulted in your score decision (a, b or a+b).*		*Heavily disturbed stream bed in part of the reach, may be a) subjected to instream disturbance from heavy machinery though gravel extraction or regular silt and macrophyte clearing (e.g. more than annually), or b) reach may have a stock or vehicle crossing that is used daily (e.g. by a dairy herd). Record which type of disturbances that resulted in your score decision (a, b or a+b).*		**Circle: A B A+B**
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
5. Discharges and drains: Count the number of drains in the entire reach (both banks), note their type and size.	*No artificial drains or piped inflows present, a modified tributary or open farm drain may be present but has low potential to deliver pollutants, e.g. drains low intensity farmland.*		*No piped inflows are present and 1 or 2 open drains may be present but drain low intensity farmland. If drains have a high potential for delivering pollution, e.g. drain-intensive agricultural or semi-urban land use, then score the reach lower.*		*Two or more channelised tributaries or open drains are present, or one or two piped inflows, less than 20 cm in diameter, 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 lower.*		*Two to more 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 lower.*		*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 lower.*		
.	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
6. Introduced riparian plants occurring at nuisance levels: Assess the degree to which introduced and invasive plants occur in the near stream and riparian environment. Note the presence of large areas of introduced species that form smothering monocultures. Make a note if there is evidence in the stream and riparian environment of introduced animals such as carp, goldfish, rabbits, hares, goats and pigs. However, observations of introduced animals do not contribute to the overall score.	*No or little evidence of introduced plants in the riparian area (banks and channel) or river. Some introduced plants may be present in the riparian areas but are minimal in extent (e.g. < 2 willows).*		*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.*		*Riparian areas (banks and channel) comprise mixed exotic species, some native vegetation may be present. Willows may be present and may be the dominant form of bank edge vegetation but are not obstructing flow during base flow conditions.*		*Riparian areas (banks and channel) comprise mostly exotic invasive weed species such as gorse and blackberry, notifiable pest species such as old man's beard may be present. Willows or other riparian plants and introduced macrophytes may be encroaching upon the low-flow channel and impeding flow.*		*Large areas (> 20%) of the riparian zone have pest species monocultures, notifiable pest plants are present. Willows and other introduced plants and macrophytes may be ubiquitous thoughout the instream and riparian areas.*		**Note introduced plant and animals species here**
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	

Table 1. (*continued*). Draft river habitat pressures / modification protocol for field testing by water managers (assessment components 7-9 shown).

Habitat parameter	Condition category										SCORE
7. Bank modification: Bank modification should be visible and assessed at the reach-scale, although some active channel modification may occur at the segment scale. Some additional wording in the assessment instructions may be needed to describe concepts like the 'active channel' and 'bank full' to enable more consistent assessments by less experienced assessors. For example, specific guidance may be needed so that assessors can distinguish the 'active channel' from the floodplain.	*No bank modification and the stream appears natural in form. May be some minor historical bank modification in < 5% of the reach length.*		*Some bank modification in the form of bank protection provided by managed willows / vegetation or rock groynes along part of the reach. Less than 10% of the length of either bank is affected by hard bank protection infrastructure (e.g. rock armouring of the bank).*		*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 length of either bank. There may be some evidence that streambed lowering has occurred. If so, score the reach lower.*		*A confined channel with embankments on either bank for more than half of the reach. Stream may have been lowered and / straightened and banks may be a uniform shape (e.g. trapezoid managed channel) for 20 to 80% of the reach length. Rock rip-rap or other bank armouring may be in place at most outside bends. Most high flow events (e.g. annual floods) would be contained within the top of the channel embankments.*		*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 lower.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
8. Livestock riparian disturbance: Assess the type, amount and apparent regularity of livestock access to the riverbanks and the near-bank riparian area.	*No means for livestock to access the riparian area, either because there is no farming within the surrounding land area or the entire riparian area is protected by stock exclusion fencing that appears to be effective. The entire riparian area can be defined as 30 m from each of the base flow wetted edges, or, 10 times the wetted width whichever area is larger.*		*Very occasional or infrequent stock access (e.g. only certain months of the year, such as occurs in a high-country farming setting). Stock access is by sheep or low densities of beef cattle (e.g. as might occur in a high-country 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).*		*Stock exclusion fencing of 10m or more may be in place but the area between the fence and river edge appears to be grazed infrequently by sheep. Or effective stock exclusion fencing is in place and is set back from the stream edge by between 5 and 10 m (average width throughout the assessment reach).*		*Stock exclusion fencing is in place but is set back by between 3 to 5 m from the stream edge. Or, may be some evidence of frequent or regular stock having to the stream edge. Evidence would include recent and previous stock plugging along banks adjacent to the stream or trampled and eroded stock tracks. Stock access by cattle score lower.*		*No stock exclusion fencing is in place and stock have free and regular to the stream edge. Stock access for cattle scores lower.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
9. Human riparian disturbance: Assess the amount and apparent regularity of human mediated disturbance in the riparian area and flood plain. Here the riparian area and flood plain are defined as 30 m from the base flow wetted edge, or 10 times the wetted width, whichever area is larger.	*No evidence of activity in the riparian area or flood plain. Foot or cycle access tracks may be present but are well defined and are modest in extent (e.g. one track).*		*Vehicle tracks are present in the floodplain and riparian areas, although tracks are well defined, and use appears to be infrequent (e.g. likely used during weekends by < 3 groups of people).*		*Evidence of regular vehicle activity in the surrounding land and some use of the riparian area. Use by vehicles likely occurs most days of the week or by multiple vehicles on weekends. Activity likely to cause significant disturbance to riparian fauna (e.g. river birds). Gravel extraction may be occurring outside of the mainstem channel but not directly on gravel beaches.*		*Substantial and regular disturbance of the riparian areas and floodplain. Reach may include a gravel extraction site or undergo beach raking activities, however, gravel extraction appears to occur infrequently (e.g. once or twice per year).*		*Substantial and regular disturbance of the riparian areas and floodplain. Reach may include a gravel extraction site or undergo beach raking activities. Four-wheel drive tracks may be extensive through the riparian areas or heavy machinery activity appears to occur regularly (e.g. monthly).*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	

Table 1. (*continued*). Draft river habitat pressures / modification protocol for field testing by water managers (assessment components 10-12 shown).

Habitat parameter	Condition category										SCORE
10. Occurrence of rubbish in the stream and riparian area: Assess the level of rubbish in and around the stream for the entire reach. 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 lower. Examples of persistent and / or harmful items include chemical containers, plastic bags, bottles, batteries, dead animals and toilet paper. Note if rubbish appears to have accumulated in the reach from sources further upstream during floods, check for evidence of accumulations of rubbish along high-water levels. If rubbish appears to be coming from upstream, then score the reach lower.	*Little or no rubbish to be found (< 5 items) after a reach-wide search.*		*Rubbish is evident on the stream bank and on the stream bed (6–10 items).*		*Rubbish is evident at a low to medium level (11–25 items). Most items are not environmentally persistent or harmful (e.g. paper food wrappers as opposed to plastic items).*		*Rubbish is evident at a medium level (26–50 items). May be evidence that rubbish is accumulating from upstream (e.g. accumulating because of deposition during floods). Some types of rubbish may be environmentally persistent or potentially harmful.*		*Rubbish distracts the eye, rubbish present throughout the stream and the riparian area. Rubbish of many different kinds are present, including persistent and / or potentially harmful items (>50 items).*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
11. Surrounding land use and floodplain modification: Determine the type and percent cover of land use adjacent to the assessment reach on both banks within an area of at least 30 m from the wetted channel or 10 x the average wetted width of the stream reach (whichever is larger). Estimate the percentage cover in this area that has an impervious surface, including surfaces such as tar-sealed roads, building roofs and concrete areas.	*Entire area is undisturbed native vegetation, may have some minor modification, e.g. walking or cycle access tracks.*		*Area comprises exotic forestry and / or low intensity farming (e.g. sheep and beef). May have some native vegetation land use or extensive vegetated riparian corridors (e.g. 20 m wide on average).*		*Area mostly comprises moderate or high intensity land use. For example, dairy farming or urban parklands. May have some infrastructure or dwellings in place creating impervious surface cover of less than 10% of the assessment area.*		*Area is all intensive land use, semi-urban or a mix of urban and other land uses. Sites with high impervious surface cover (11-50%) should score lower.*		*Semi-urban or urban land use, impervious surface cover more than 51% of the adjacent land and potential flood plain.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
12. Flood plain constraints: Walk the length of the reach and determine if there are stop banks in place 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 to determine the reach score. Also search for floodgates, tide gates and pump stations on the flood plain, note if these are present but do not include them in the assessment score.	*No stop banks or other artificial structures in place, or if 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 may be present but are set well back from the stream by between 5 and 10 times the active channel width. In addition, side channels and off channel wetted habitats are present that would be inundated during an annual flood.*		*Stop banks present within 5 to 10 times the active channel width on at least part of one bank of the stream. If some flood plain habitats, such as backwaters or side channels, are present within the stop banked area then score reach higher.*		*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). The stream still 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.*		*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. 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.*		**Note the type and number of floodgate, tidegates and/or pumpstations in the flood plain**
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
TOTAL	(Sum of parameters 1-12)										

4. RATIONALE FOR INDIVIDUAL PROTOCOL ATTRIBUTES

Below we have provided the rationale for the inclusion of each river pressure assessment attribute into the draft RHPA. Also provided are highlights from workshop discussion about some of the problems that arise when undertaking rapid-style field assessments (e.g. assessing river pressures at the reach scale, when the pressure may occur at segment to catchment scales. The expert panel strongly recommended that to effectively assess some habitat pressure attributes a desktop assessment component additional to the RHPA be developed. The panel also suggested that assessing fish passage, floodplain constraints and landuse modification ought to be assessed as a desktop exercise, as well as in the field. Some suggestions for how this might be achieved, for example though analysing aerial imagery, are provided in Holmes et al. (2018).

As with the (original) RHA, the length of an 'assessment reach' for the RHPA is defined by an area 20 times the average (base flow) wetted width, to a minimum length of 50 m or a maximum length of 150 m. To define the survey reach width, a cut-off point for the 'riparian assessment area' was set at 30 m out from the wetted edge of each bank. This was based on Sweeney and Newbold's (2014) suggestion that 30-m wide (continuous) mature vegetation riparian buffer zones are the minimum required for stream ecological possesses and structure to be minimally affected by surrounding land use. To accommodate the potential for assessments being undertaken in larger rivers, an arbitrary cut-off point of 10 times the wetted width was chosen to constrain the riparian assessment area. If this area extends beyond 30 m (e.g. the stream or river has an average wetted width of more than 3 m) then this latter rule has precedence and defines the area being assessed (for certain attributes).

The assessment attributes (1–12) are ordered within the protocol from instream pressures to pressures occurring along the banks and out into the wider floodplain. It should be noted that some further instructional material may need to accompany a field assessment sheet for users to apply the protocol effectively. This material could include longer-form narratives describing attributes and how to assess them, photographic guides and / or instructional videos such as those developed for the RHA (See: https://vimeo.com/396859560, https://vimeo.com/396860576).

4.1. Attribute 1: Nuisance benthic algae

There was consensus among workshop attendees to include an attribute that assesses the occurrence of nuisance benthic algal mats and macrophyte growths.

4.1.1. How the attribute relates to river scale

Algal (and macrophyte) growths are affected by numerous anthropogenic factors at the catchment and segment scales. These include non-point source nutrient pollutants, flow modification and the presence of invasive species (e.g. didymo). Algal growths are also affected by reach-scale riparian vegetation clearance and bank modification which can lead to increased stream-bed light levels.

This attribute will be suitable for a reach-scale bank side assessment because benthic algae is easily visible during base flows (provided the river is clear and shallow enough to see most of the stream bed). In the initial draft this attribute was combined with an assessment of aquatic macrophytes as a 'nuisance aquatic growths assessment'. However, following the second-stage review of the draft protocol by workshop attendees, this attribute was split into two separate attributes: one attribute that focuses on benthic algal growths and the other on macrophytes.

4.1.2. Suggested measurement type

Assess the cover of algal mats (plan view) on the stream bed. Scoring should be based on percent cover, with scores and definitions of 'nuisance level' growths and mat thickness defined by previous assessment methodologies (e.g. Biggs & Kilroy 2000), as well as the National Objective Framework (NOF) attribute guidelines provided in Matheson et al. (2012). During the workshop it was discussed (and agreed) that there is no need to distinguish between native and introduced algal species—because excessive cover of native algal species can also occur due to habitat modification.

4.1.3. 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 9-10
The cover of algal mats and filamentous algae is less than 10% of the stream bed wetted area. If filamentous green algae are present in any amount, then score the site lower.
Score range 7-8
The cover of algal mats and filamentous algae is 11-20 % of the stream bed. If filamentous green algae are present in any amount, then score the site lower.
Score range 5-6
The cover of algal mats and filamentous green algae is 21-30 % of the stream bed.
Score range 3-4
Cover of algal mats and filamentous green algae is 31-50% of the stream bed.
Score range 1-2
Cover of algal mats and filamentous green algae is more than 50% of the stream bed.

4.2. Attribute 2: Nuisance aquatic macrophytes

4.2.1. How the attribute relates to river scale

As with benthic algae, macrophyte growths are affected by numerous anthropogenic factors operating at the reach to catchment scales. These include non-point source nutrient pollutants, flow modification and the presence of invasive species (e.g. *Potamogeton crispus*). Macrophyte growths are also affected by reach-scale riparian vegetation clearance and bank modification leading to increased light levels. This attribute will be suitable for a reach-scale bank side assessment because macrophytes are easily visible during base flows.

4.2.2. Suggested measurement type

Assess the percent cover (plan view) of macrophytes on the stream bed and the wetted channel volume of macrophytes. Scoring is based on percent cover, with scores defined by previous assessment methodologies including Collier et al. (2006) and the NOF attribute guidelines in Matheson et al. (2012). It was agreed in the workshop that there is no need to distinguish between native and introduced species because most nuisance macrophyte growths are the result of introduced species.

4.2.3. Narrative

Estimate the percentage cover (plan view) of aquatic weed (macrophytes) within the wetted area of the entire assessment reach and match with the appropriate score range below. In addition, assess if, and by how much, the passage of water through the reach is impeded by macrophytes.

Score range 9-10
The cover of macrophytes is less than 10% of the stream bed wetted area. Aquatic weed growths are causing no noticeable impediment to flow.

Score range 7-8
The cover of macrophytes is between 11–20% of the stream bed, aquatic weed growths are causing no substantial impediment to flow.

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

Score range 3-4
The cover of macrophytes is 31–50% of the stream bed, aquatic growths may be causing some impediment to flow, with cross-sectional area or volume comprising macrophyte beds between 10–50% in places.

Score range 1-2
Cover of macrophytes is more than 50% of the stream bed. There may be substantial flow impoundment or channel ‘clogging’, with cross-sectional area or volume comprising macrophyte beds more than 50% in places.

4.3. Attribute 3: Instream structures (structures below the base flow waterline)

There was consensus at the workshop that *instream* structures are an important river modification and that they should be included as a separate attribute (e.g. as separate from bank modification). This attribute should include bank modification structures that extend below the base-flow water line e.g. bridge abutments and bank protection infrastructure such as rock riprap. Fish passage as a component of instream structures was discussed. However, fish passage is not a pressure or a state but rather an impact of instream structures. Therefore, the severity of instream structures should be assessed (and scored) as they relate to their effect on fish passage (e.g. through height and angle) but the attribute should not assess fish passage explicitly.

4.3.1. How the attribute relates to river scale

Instream structures should be easily visible, and assessed, at the reach scale. It was suggested that the number and severity of structures should be determined, with the severity of modification assessed by parameters such as extent, height and steepness. Scoring should be determined by how much the structures affect the impoundment of water, transport of streambed sediments and fish passage.

The issue of downstream fish passage barriers was discussed, these are impossible to include in a reach-scale field assessment and would require a catchment scale approach, or at least consideration of all structures downstream of a particular point in a river. Recent and ongoing work on assessing fish passage in New Zealand can be found here: https://niwa.co.nz/freshwater/management-tools/fish-passage-assessment-tool.

4.3.2. Narrative

Count the number of structures that occur within the wetted area of stream bed during base flows. Structures could include (but are not limited to) weirs, vehicle fords and bank protection infrastructure that extends *below* the base-flow wetted channel edge (note that stream bank structures are assessed as a separate attribute). Determine the height and the degree to which the structures modify and constrict flow and cause ponding upstream (impoundment). Also consider how the structure affects upstream fish passage.

Score range 9-10

No instream structures present within the entire stream assessment reach, or one small structure may be present that causes minimal changes to habitat, such as short sections of rock rip rap or a bridge abutment (< 10 m long or < 10% of reach length) that extends below the base-flow water line.

Score range 7-8

No instream structures are present that traverse the entire wetted width of the reach. One to three structures are present that extend into the base-flow 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 or vehicle ford is present across the entire low-flow channel. The structure does not cause substantial impoundment relative to natural pools (e.g. the pool upstream of structure is less than twice the size of natural pools in the reach). Any increased water velocity created by the structure is equivalent to natural riffles in the reach and surrounding stream segment. There is no 'perching' (vertical falls of water) or vertical sections present that could impede upstream fish passage.

Score range 3-4

A large (e.g. 0.2 to 4 m high) instream structure 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 lower if near-vertical sections or vertical drops are present on the structure that would impede fish passage. If there are additional lesser structures present that do not traverse the entire wetted width, then score the site lower.

Score range 1-2

One (> 4 m high) or more large instream structures (0.2-m to 4-m high) are present that either have a perched downstream outlet or have a near vertical face. The structure is likely to impede the transport of bedload sediment downstream and / or cause substantial upstream impoundment. If there are other additional (lesser) instream structures present as described above, then score the site lower.

4.4. Attribute 4: Instream disturbance

Most of the expert panel agreed that an instream disturbance attribute was important to include. This attribute would assess the amount of instream disturbance from activities such as vehicles or livestock crossing the river. Instream gravel extraction and / or cross-blading and silt, macrophyte or woody debris removal were also suggested as important types of instream disturbance to assess.

4.4.1. How the attribute relates to river scale

Instream disturbance should be visible, and assessed, at the reach-scale, although determining the degree of regularity will be problematic, e.g. there may be a vehicle ford or stock crossing in place, but it may be difficult to determine how frequently it is used. This same issue applies to instream mechanical works such as macrophyte clearing using diggers. The panel suggested that it may be necessary to undertake an additional desktop assessment for this component (e.g. assessing council records to determine the frequency of macrophyte clearing).

4.4.2. Suggested measurement type

Determine the number and severity of instream disturbance features, look for evidence of disturbance frequency (e.g. by how clean, or silted, disturbed patches of stream bed look relative to the surrounding bed).

4.4.3. Narrative

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

Score range 9-10
No instream disturbance is evident, some use for swimming maybe evident.
Score range 7-8
Reach shows evidence of a single vehicle or stock crossing. However, it appears to receive infrequent use e.g. less than once per month.
Score range 5-6
Two vehicle ford or stock crossings, or a single river crossing is present and appears to receive regular use (e.g. weekly to monthly use).
Score range 3-4
There is evidence of regular 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 annually (or less often) or **b**) frequent vehicle or stock disturbance (e.g. weekly). Record which type of disturbances that resulted in your score decision (A, B or A+B).
Score range 1-2
Heavily disturbed stream bed in part of the reach, may be **a**) subjected to instream disturbance from heavy machinery though gravel extraction or regular silt and macrophyte clearing (e.g. more than annually), or **b**) reach may have a stock or vehicle crossing that is used daily (e.g. by a dairy herd). Record which type of disturbances that resulted in your score decision (A, B or A+B).

4.5. Attribute 5: Discharges and drains

Assessing drains and other visible sources of pollution was considered important by most of the expert panel. However, consensus was not reached that this should be included as an attribute. Some panel members considered that a drain / discharge assessment would be more important for urban streams than streams in agricultural landscapes. Agricultural drains may be difficult to score because it is hard to define if an open farm drain is in fact a ‘modified tributary’. Also, under-field (tile) drains may be hard to see.

4.5.1. How the attribute relates to river scale

Drains and other point source discharges occur at the reach-scale but potentially have far reaching downstream effects. Effects of drains can be cumulative, so there is a problem with scoring a drain within an individual reach because its impacts will depend on the landuse / activities occurring in the drainage area and how many other drains are present upstream (i.e. one drain is not a problem but 100 drains are). The assessment below is modelled closely on the discharge assessment component of the SEV (Storey et al. 2011).

4.5.2. Suggested measurement type

Count the number of drains in the entire reach (both banks), note their type and size.

4.5.3. Narrative

Walk the reach and count the number of open drains and piped outlets, note the diameter of any piped inflows. Consider the potential for pollution from the drain's source, based on the landuse in the drainage area.

Score range 9-10
No artificial drains or piped inflows present, a modified tributary or open farm drain may be present but has low potential to deliver pollutants, e.g. drains low intensity farmland.

Score range 7-8
No piped inflows are present and 1 or 2 open drains may be present but drain low intensity farmland. If drains have a high potential for delivering pollution, e.g. drain intensive agricultural or semi-urban land use, then score the reach lower.

Score range 5-6
Two or more channelised tributaries or open drains are present, or one or two piped inflows, less than 20 cm in diameter, 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 lower.

Score range 3-4
Two to more 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 lower.

Score range 1-2
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 lower.

4.6. Attribute 6: Introduced riparian plants occurring at nuisance levels

During the workshop an attribute that assesses the presence of introduced plants and animals in the riparian and aquatic environments was discussed. Some of the panel considered that the presence of notifiable pest plants, as well as evidence of introduced pest species such as rabbits and pigs, should be noted (and scored). It was also suggested that the presence of introduced pest fish like carp or goldfish should be noted and should potentially contribute to the score.

4.6.1. How the attribute relates to river scale and other potential problems

Introduced riparian plants and macrophytes should be assessed at the reach-scale although some potential introduced species may be hard to identify, and not all introduced species are 'pests' all the time. For example, willows may be present but not occur at nuisance levels.

Introduced animals may be transient, nocturnal, or hard to find. Assessment quality may vary between observers based on experience with introduced plant identification and pre-existing knowledge, e.g. an observer may know there are introduced fish present but not see them during the assessment. There is also some potential conflict with scoring introduced species as a 'negative' river pressure. This is because they may have functional benefits for stream health, e.g. riparian willows can provide shade and instream habitat. Following circulation of the draft among panel members it was decided that this assessment component should focus on nuisance introduced plant and macrophyte species.

4.6.2. Suggested measurement type

Assess the occurrence of introduced species and the degree to which invasive plant monocultures occur instream and in the near-river riparian area.

4.6.3. Narrative

Assess the degree to which introduced and invasive plants occur in the near stream and riparian environment. Note the presence of large areas of introduced species that form smothering monocultures. Make a note if there is evidence in the stream and riparian environment of introduced animals such as carp, goldfish, rabbits, hares, goats and pigs. However, observations of introduced animals do not contribute to the overall score.

Score range 9-10

No or little evidence of introduced plants in the riparian area (banks and channel) or river. Some introduced plants may be present in the riparian areas but are minimal in extent (e.g. fewer than 2 willows).

Score range 7-8

Some introduced plants present in the riparian area but they are not extensive and do not forming monocultures along the stream banks, e.g. individual willows, gorse or broom are present but surrounded by predominantly native vegetation.

Score range 5-6

Riparian areas (banks and channel) comprise mixed exotic species, some native vegetation may be present. Willows may be present and may be the dominant form of bank edge vegetation but are not obstructing flow during base flow conditions.

Score range 3-4

Riparian areas (banks and channel) comprise mostly exotic invasive weed species such as, gorse and blackberry, notifiable pest species such as old man's beard may be present. Willows or other riparian plants and introduced macrophytes may be encroaching upon the low-flow channel and impeding flow.

Score range 1-2

Large areas (> 20%) of the riparian zone have pest species monocultures, notifiable pest plants are present. Willows and other introduced plants and macrophytes may be ubiquitous throughout the instream and riparian areas.

4.7. Attribute 7: Bank modification

There was agreement among all panel members to include an active channel (bank) modification attribute. The difficulty of assessing channel modifications that extend from the bank to below the low-flow channel was discussed (e.g. bank protection infrastructure such as rock rip rap that extend below the base flow waterline). This was resolved by assessing *instream* modification (during base flow) by structures separately (as in Attribute 3). This attribute focusses on assessing bank modification from the water edge (at base-flow) to bank full. The panel discussed the need for an additional 'desktop' assessment to the protocol to assess channel straightening at greater spatial scales.

4.7.1. How the attribute relates to river scale

Bank modification should be visible and assessed at the reach-scale, although some active channel modification may occur at the segment scale. Some additional wording in the assessment instructions may be needed to describe concepts like the 'active channel' and 'bank full' to enable more consistent assessments by less experienced assessors. For example, specific guidance may be needed so that assessors can distinguish the 'active channel' from the floodplain.

4.7.2. Suggested measurement type

Scoring defined by degree and extent. Assessor should determine what type of channel modification is present (e.g. managed willows, rock rip rap or concrete walls) and how much of the reach is affected (% length).

4.7.3. Narrative

Walk the length of the reach and determine if the stream banks have a modified shape and if there are structures that are managed for bank protection, such as willows, groynes, rock rip-rap and / or concrete walls. The stream bank is defined as the wetted edge of the base flow 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 9-10
No bank modification and the stream appears natural in form. May be some minor historical bank modification in < 5% of the reach length.
Score range 7-8
Some bank modification in the form of bank protection provided by managed willows / vegetation or rock groynes along part of the 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 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 length of either bank. There may be some evidence that streambed lowering has occurred. If so, score the reach lower.
Score range 3-4
A confined channel with embankments on either bank for more than half of the reach. Stream may have been lowered and / straightened and banks may be a uniform shape (e.g. trapezoid managed channel) for 20 to 80% of the reach length. Rock rip-rap or other bank armouring may be in place at most outside bends. Most high flow events (e.g. annual floods) would be contained within the top of the channel embankments.
Score range 1-2
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 lower.

4.8. Attribute 8: Livestock riparian disturbance

While not discussed during the workshop, riparian disturbance and bank edge damage caused by livestock is a widespread modification to stream environments in New Zealand. In addition, it is widely recognised as a key stream pressure because it is linked with elevated nutrient and fine sediment inputs.

4.8.1. How the attribute relates to river scale

Stock damage should be visible and assessed at the reach-scale. However, it will be difficult to determine how frequent stock can access a reach during a single reach assessment (if there is no stock exclusion fencing in place).

4.8.2. Suggested measurement type

Determine the frequency and severity of livestock access to the riparian area and stream edge.

4.8.3. Narrative

Assess the type, amount and apparent regularity of livestock access to the streambanks and the near-bank riparian area. The riparian area is defined as 30 m from each of the base flow wetted edges, or 10 times the wetted width, whichever area is larger.

Score range 9-10

No means for livestock to access the 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.

Score range 7-8

Very occasional or infrequent stock access (e.g. only certain months of the year, such as occurs in a high-country farming setting). Stock access is by sheep or low densities of beef cattle (e.g. as might occur in a high-country 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).

Score range 5-6

Stock exclusion fencing set 5 m or more from the stream edge may be in place but the area between the fence and stream edge appears to be grazed infrequently by sheep, or, effective stock exclusion fencing is in place and is set back from the stream edge by between 3 and 5 m (average width throughout the assessment reach). A reach with evidence of occasional stock access should score lower.

Score range 3-4

May be some evidence of frequent or regular stock access to the stream edge. Evidence would include recent and previous stock plugging along banks adjacent to the stream and / or trampled and eroded stock tracks. Alternatively, effective stock exclusion fencing is in place but is set back by less than 3 m from the stream edge (on average).

Score range 1-2

No stock exclusion fencing is in place and stock have free and regular access to the stream edge. Sites with stock access for cattle score lower.

4.9. Attribute 9: Human riparian disturbance

Riparian disturbance, through activities such as gravel extraction, four-wheel driving or berm mowing was thought to be an important pressure attribute and one that will resonate with community groups. The panel recommended that riparian disturbance should be separated from instream disturbance because they are different in their effects and severity.

4.9.1. How the attribute relates to river scale

Human riparian disturbance should be visible and assessed at the reach scale. The number of roads and tracks can be noted as well as evidence of dry channel or floodplain gravel abstraction and beach raking activities etc., although it will be problematic to determine frequency of disturbance and / or current from historical use.

4.9.2. Suggested measurement type

Degree and severity of human activities in the riparian environment and floodplain.

4.9.3. Narrative

Assess the amount and apparent regularity of human mediated disturbance in the riparian area and flood plain. Here the riparian area and flood plain are defined as 30 m from the base flow wetted edge, or 10 times the wetted width, whichever area is larger.

Score range 9-10
No evidence of activity in the riparian area or flood plain. Foot or cycle access tracks may be present but are well defined and are modest in extent (e.g. one track).
Score range 7-8
Vehicle tracks are present in the floodplain and riparian areas, although tracks are well defined, and use appears to be infrequent (e.g. likely used during weekends by < 3 groups of people).
Score range 5-6
Evidence of regular vehicle activity in the surrounding land and some use of the riparian area. Use by vehicles likely occurs most days of the week or by multiple vehicles on weekends. Activity likely to cause significant disturbance to riparian fauna (e.g. river birds). Gravel extraction may be occurring outside of the mainstem channel but not directly on gravel beaches.
Score range 3-4
Substantial and regular disturbance of the riparian areas and floodplain. Reach may include a gravel extraction site or undergo beach raking activities; however, gravel extraction appears to occur infrequently (e.g. once or twice per year).
Score range 1-2
Substantial and regular disturbance of the riparian areas and floodplain. Reach may include a gravel extraction site or undergo beach raking activities. Four-wheel drive

tracks may be extensive through the riparian areas or heavy machinery activity appears to occur regularly (e.g. monthly).

4.10. Attribute 10: Occurrence of rubbish in the stream and riparian area

Most workshop attendees considered that an attribute that records the amount and type of rubbish in a reach was important. However, consensus was not attained. One or two attendees suggesting that rubbish was not an important stream and river pressure. This is because, although it has aesthetic impacts, they considered rubbish to have only minor ecological effects relative to other pressures.

4.10.1. How the attribute relates to river scale

Rubbish accumulation in streams is affected by the upstream catchment area in urban and agricultural land uses. It is also affected by reach-scale factors such as public access. This attribute should be easy to assess because rubbish can be easily spotted and identified.

4.10.2. Suggested measurement type

Assess the amount and type of rubbish in the reach. The score weighting below is based on wording from an assessment methodology developed in San Francisco Bay (Moore et al. 2007). However, score weighting was shifted down from the original San Francisco assessment to reflect the lower population levels in New Zealand and more aspirational standards for lower amounts of rubbish here.

4.10.3. Narrative

Assess the level of rubbish in and around the stream for the entire reach. 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 lower. Examples of persistent and / or harmful items include chemical containers, plastic bags, bottles, batteries, dead animals and toilet paper. Note if rubbish appears to have accumulated in the reach from sources further upstream during floods, check for evidence of accumulations of rubbish along high-water levels. If rubbish appears to be coming from upstream, then score the reach lower.

Score range 9-10
Little or no rubbish to be found (< 5 items) after a reach-wide search.
Score range 7-8
Rubbish is evident on the stream bank and on the stream bed (6–10 items).

Score range 5-6

Rubbish is evident at a low to medium level (11–25 items). Most items are not environmentally persistent or harmful (e.g. paper food wrappers as opposed to plastic items).

Score range 3-4

Rubbish is evident at a medium level (26–50 items). May be evidence that rubbish is accumulating from upstream (e.g. accumulating because of deposition during floods). Some types of rubbish may be environmentally persistent or potentially harmful.

Score range 1-2

Rubbish distracts the eye, rubbish present throughout the stream and the riparian area. Rubbish of many different kinds are present, including persistent and / or potentially harmful items (over 50 items).

4.11. Attribute 11: Surrounding land use and floodplain modification

There was wide agreement during the meeting about the need for a floodplain modification assessment component to the protocol. However, there was little time available for discussion on what this attribute would measure in the field. It was suggested that land use type(s) and the expanse of impervious surfaces adjacent to the reach would be good candidate indicators for this attribute.

4.11.1. How the attribute relates to river scale

Floodplain and land-use modification is a result of changes that occur at the reach to catchment scales. However, determining the appropriate size of the assessment area adjacent to a reach is problematic because it will be related to the stream's flow regime and topography. Assessing floodplain modification is further complicated by the fact that the floodplain itself may have been reduced in size through modification. Despite this, surrounding land use should be easily observable and a rough estimate of impervious surfaces should also be achievable by a bank side observer. It was widely agreed that a desktop assessment method should be developed and undertaken alongside a field-based assessment for this attribute.

4.11.2. Suggested measurement type

Assess the land use in broad categories and amount of impervious surface as a percentage cover of the land surrounding the reach. The assessment area adjacent to the reach should be scaled according to stream size, e.g. by a multiple of the average wetted width at base flow. Scoring defined by the degree of land use intensification and percent cover of impervious surfaces.

4.11.3. Narrative

Determine the type and percent cover of land use adjacent to the assessment reach on both banks within an area of at least 30 m from the wetted channel or 10 x the average wetted width of the stream reach (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 10-9
Entire area is undisturbed native vegetation, may have some minor modification, e.g. walking or cycle access tracks.
Score range 7-8
Area comprises exotic forestry and / or low intensity farming (e.g. sheep and beef). May have some native vegetation land use or extensive vegetated riparian corridors (e.g. 20 m wide on average).
Score range 5-6
Area mostly comprises moderate or high intensity land use. For example, dairy farming or urban parklands. May have some infrastructure or dwellings in place creating impervious surface cover of less than 10% of the assessment area.
Score range 3-4
Area is all intensive land use, semi-urban or a mix of urban and other land uses. Sites with high impervious surface cover (11-50%) should score lower.
Score range 1-2
Semi-urban or urban land use, impervious surface cover more than 51% of the adjacent land and potential flood plain.

4.12. Attribute 12: Flood plain constraints

Floodplain connectivity was not discussed in the meeting because there was too little time. However, it was agreed that it was important to assess flood plain constraints such as the stop banks. It was suggested that the severity of flood plain constraints needs to be assessed, rather than just the presence or absence of various types of constraints.

4.12.1. How the attribute relates to river-scale

It is problematic to incorporate flood plain constraints in a reach scale assessment because they may not be visible at the reach scale in large rivers. In addition, it is hard to assess the severity of pressure or modification that existing flood protection infrastructure places on a river. This is because flood plain constraints interact with other factors, primarily the flow regime. For example, stop banks surrounding a spring fed stream (with stable flows) will have less effect on physical habitat structure and ecology than stop banks surrounding a rainfed stream which would otherwise inundate its flood plain more frequently. It was agreed that stream bed lowering

should be separated out from this assessment attribute because it is more relevant to the 'instream channel modification' attribute.

It was widely agreed that it will be better / easier to assess flood plain modification using aerial photography. However, it ought to still be useful to have an on-the-ground assessment that is specific to a reach. There may need to be some direction for protocol users to identify stop banks from the desktop and whilst assessors are accessing the sites—rather than just from the river's edge. This is especially true for large rivers.

4.12.2. Suggested measurement type

Scoring defined by degree and extent, i.e. how close are the stop banks to the base flow channel. Stop bank height is not an appropriate measure because this needs to be understood relative to the flow regime. The proximity of stop bank to the base flow channel will be suitable to indicate scoring ranges because this will indicate how constrained the stream is.

4.12.3. Narrative

Walk the length of the reach and determine if there are stop banks in place 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 to determine the reach score. Also search for floodgates, tide gates and pump stations on the flood plain, note if these are present but do not include them in the assessment score.

Score range 9-10
No stop banks or other artificial structures in place, or if 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 7-8
Stop banks may be present but are set well back from the stream by between 5 and 10 times the active channel width. In addition, side channels and off channel wetted habitats are present that would be inundated during an annual flood).
Score range 5-6
Stop banks present within 5 to 10 times the active channel width on at least part of one bank of the stream. If some flood plain habitats, such as backwaters or side channels, are present within the stop banked area then score reach higher.
Score range 3-4
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). The stream still 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.

Score range 1-2

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. 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.

5. POTENTIAL ATTRIBUTES

The following are attributes that were considered but not selected. Discussion around each of these is given here for the reader's information.

5.1. Potential Attribute: Fine sediment (as a pressure)

There was discussion about including a fine sediment attribute in the assessment protocol. However, it should be noted that percentage cover of fine sediment and the occurrence of bank erosion are already state measurements in the pre-existing RHA. It was suggested that a fine sediment embeddedness measure could be incorporated into the RHPA.

5.1.1. How the attribute relates to river scale and other potential problems

Fine sediment is a product of diffuse pollution at the sub-catchment and catchment scale. Fine sediment loads are also influenced by reach-scale sources such as drains and bank erosion. It is difficult to determine if fine sediment is a *pressure* without some knowledge of natural fine sediment levels.

A visual assessment of sedimentation issues such as embeddedness could be undertaken, although bankside observers without substantial experience would find this difficult to do. For example, often algal and detrital material can be mistaken for fine sediment. Also, even quantitative instream sediment embeddedness measurements are difficult to undertake in a consistent manner. A shuffle test could be appropriate (e.g. SAM 5, in Clapcott et al. 2011) but would require getting into the stream which is outside the scope of a bankside rapid habitat assessment.

On this basis an assessment of fine sediment was omitted from the draft RHPA. However, one potential approach to include a fine sediment (as a pressure) attribute is to post-process the percentage fine-sediment cover assessment data from the original RHA assessment using an observed vs. expected approach. This would require estimating the expected reference condition of reach-scale fine sediment cover in a stream This could be done using the deposited sediment state classification predictions in the River Environment Classification system, sediment cover in nearby reference streams or exert opinion. Then, the observed % fine sediment cover could be divided by the estimated natural level of fine sediment percent cover. The quotient indicates the degree of impact of human-derived fine sediment inputs. The National Objective Framework attribute thresholds in Franklin et al. (2019) could be used to guide scoring, although these are based on sediment cover assessments in run habitat only. For example:

- < 5% increase in absolute cover = a score of 10
- 6–10% increase = score of 8 to 9
- 11–15% = 6 to 7

- 16–20% = 4 to 5
- 21–25% = 2 to 3
- > 25% = score of 1).

5.2. Potential Attribute: Instream woody material (dead wood and branches in the river)

There was discussion during the workshop of the need to include an assessment of the woody / vegetative material in a stream (or the lack thereof) as a potential river and stream pressure. However, consensus was not reached on its inclusion.

5.2.1. How the attribute relates to river scale and other problems

The supply of wood and other vegetative material is related to catchment-scale land use and segment- to reach-scale riparian modification. The supply of vegetative material to a stream can be reduced by land clearance or potentially increased by plantation forestry. This attribute is appropriate to assess at the reach scale, although it will be difficult to determine the levels of vegetative debris that would be expected under natural conditions, or amounts that are appropriate to support instream health. For example, very little vegetative debris would be expected in tussock streams *versus* forest streams. The type of riparian forest will also have a large effect on expected amounts of wood in the stream. Furthermore, this attribute will interact with flow and reach-scale channel form in complex ways. Generally, wider or more sinuous channels will be more likely to be natural sinks for woody material. This attribute may be more suited to a 'state' measurement as part of the RHA. Suggestions for the narratives for this attribute are provided below, however, we did not include it in the draft RHPA protocol supplied for field testing.

5.2.2. Suggested measurement type

A visual assessment of the type and amount of vegetative material, perhaps assessed against an expected amount of vegetative material.

5.2.3. Narrative

Assess the type and amount of vegetative material in the wetted area of the reach. Note the presence (or absence) of any accumulations of large logs and branches and determine if there is vegetative debris in various stages of decay in the stream, indicating that there is a continuous supply of vegetative material from upstream. Note if there appears to be excessive amounts of vegetative material in the stream because of exotic forestry activities (e.g. forestry slash) or willow encroachment of the channel.

Score range 9-10

Large woody debris and other vegetative material in various sizes from large trunks to small branches are present. Vegetative material is present in various stages of decay,

indicating a continuous supply. Vegetative material visible in most corner pools, appears to be derived from surrounding or upstream native forest. Large accumulations of logs appear to be (in part) forming the mesohabitat structure of the river (i.e. the sequence of runs, riffles, and pools).

Score range 7-8

Some woody debris present not necessarily originating from native trees, present in a range of sizes. Log accumulations present but not to the extent that they are influencing the mesohabitat structure of river reach.

Score range 5-6

Vegetative material present but spread sporadically throughout the reach, no large accumulations of logs present.

Score range 3-4

Very few pieces of vegetative material present, large areas of the reach (e.g. more than 90% are devoid of any vegetative debris.

Score range 1-2

No vegetative debris present, or large accumulations of forestry slash or large amounts of fallen willow wood are present and are clogging the river and causing ponding / impoundment.

5.3. Potential Attribute: Flow modification

Some members of the panel expressed a desire to include a flow modification attribute. However, there was not enough time to discuss how this could be achieved in a rapid (reach-scale) habitat assessment during the workshop.

5.3.1. How the attribute relates to river scale

Flow is affected by land use, diversion, abstraction, and impoundment. It is not possible to effectively assess at the reach-scale without additional knowledge of flow regimes in the catchment and the degree of potential flow modification through abstraction or impoundment. In addition, it is very difficult to determine natural flow variation from flow modification at the reach scale, without complicated hydrological modelling and scenario testing.

5.3.2. Suggested measurement type

A high-level assessment would need to consider modification to various aspects of the flow regime (e.g. channel forming flood flows, channel flushing freshes, as well as annual base flows and midrange flows during flow recessions).

Any flow assessment would be best undertaken by a desk-top exercise and so is not suitable to be part of a rapid field assessment. We suggest that the potential for a rapid desktop flow modification assessment, that could be undertaken in parallel with the RHPA, is investigated.

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7. APPENDICES

Appendix 1. Habitat assessment field sheet from the Rapid Habitat Assessment (RHA) protocol from Clapcott et al. (2015).

Habitat parameter	Condition category										SCORE
1. Deposited sediment	*The percentage of the stream bed covered by fine sediment.*										
	0	*5*	*10*	*15*	*20*	*30*	*40*	*50*	*60*	*≥ 75*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
2. Invertebrate habitat diversity	*The number of different substrate types such as boulders, cobbles, gravel, sand, wood, leaves, root mats, macrophytes, periphyton. Presence of interstitial space score higher.*										
	≥ 5	*5*	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*1*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
3. Invertebrate habitat abundance	*The percentage of substrate favourable for EPT colonisation, for example flowing water over gravel-cobbles clear of filamentous algae/macrophytes.*										
	95	*75*	*70*	*60*	*50*	*40*	*30*	*25*	*15*	*5*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
4. Fish cover diversity	*The number of different substrate types such as woody debris, root mats, undercut banks, overhanging/encroaching vegetation, macrophytes, boulders, cobbles. Presence of substrates providing spatial complexity score higher.*										
	≥ 5	*5*	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*1*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
5. Fish cover abundance	*The percentage of fish cover available.*										
	95	*75*	*60*	*50*	*40*	*30*	*20*	*10*	*5*	*0*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
6. Hydraulic heterogeneity	*The number of of hydraulic components such as pool, riffle, fast run, slow run, rapid, cascade/waterfall, turbulance, backwater. Presence of deep pools score higher.*										
	≥ 5	*5*	*4*	*4*	*3*	*3*	*2*	*2*	*2*	*1*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
7. Bank erosion	*The percentage of the stream bank recently/actively eroding due to scouring at the water line, slumping of the bank or stock pugging.*										
Left bank	*0*	*≤ 5*	*5*	*15*	*25*	*35*	*50*	*65*	*75*	*> 75*	
Right bank	*0*	*≤ 5*	*5*	*15*	*25*	*35*	*50*	*65*	*75*	*> 75*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
8. Bank vegetation	*The maturity, diversity and naturalness of bank vegetation.*										
Left bank AND Right bank	*Mature native trees with diverse and intact understorey*		*Regenerating native or flaxes/sedges/tussock > dense exotic*			*Mature shrubs, sparse tree cover > young exotic, long grass*			*Heavily grazed or mown grass > bare/impervious ground.*		
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
9. Riparian width	*The width (m) of the riparian buffer constrained by vegetation, fence or other structure(s).*										
Left bank	*≥ 30*	*15*	*10*	*7*	*5*	*4*	*3*	*2*	*1*	*0*	
Right bank	*≥ 30*	*15*	*10*	*7*	*5*	*4*	*3*	*2*	*1*	*0*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
10. Riparian shade	*The percentage of shading of the stream bed throughout the day due to vegetation, banks or other structure(s).*										
	≥ 90	*80*	*70*	*60*	*50*	*40*	*25*	*15*	*10*	*≤ 5*	
SCORE	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**	
TOTAL	(Sum of parameters 1-10)										

Appendix 2. The 'long list' of potential river habitat modification indicators determined at the Ministry for Environment river habitat modification indicators workshop. Indicators are presented in no particular order.

1. Riparian vegetation type (composition within a buffer)
2. Channelisation
3. Stop banks and / or permitted flood plain
4. Meandering / sinuosity
5. Riprap / bank protection structures
6. Fish passes
7. Residual pool depth
8. Unaltered wild rivers
9. Fish passage barriers: presence / absence of instream structures
10. Fish passage barriers >3m
11. Dams
12. Degree of fish passage barrier effect
13. % Fine sediment cover
14. Substrate compaction
15. Substrate size composition
16. Bank composition
17. Riparian vegetation cover
18. Functional riparian width
19. Riparian pest species
20. Degree of riparian vegetation shading
21. Draping vegetation hanging over the water
22. Macrophytes (as habitat structure)
23. Macrophyte clearing
24. Bridging (including human use)
25. Degree of fencing
26. Stock access (heavy vs light vs avian)
27. Stock crossings
28. Stock damage to bank (pugging)
29. Presence of feed lots
30. Adjacent land use
31. Adjacent land cover
32. Catchment land use
33. Catchment land cover
34. Effective imperviousness

35. Large wood
36. Rubbish
37. Contaminants - heavy metals, PAHs, etc
38. Flood plain connectivity
39. Connected wetland area
40. Channel straightening
41. Channel widening
42. Channel narrowing
43. Channel depth change (bed level change)
44. Channel incision/entrenchment
45. Water abstraction take
46. Bank re-battering/contouring
47. Bank undercutting
48. Bank stability
49. Degree of channel braiding (braiding index)
50. Bar area
51. Bar type
52. Channel rationalisation (island bisection etc)
53. Gravel extraction
54. Flood gates, tide gates, flow control structures, flood pumps
55. Piping / undergrounding
56. Water abstraction structures
57. Catchment hydrology modification
58. Storm water point source discharge
59. Human activity access (e.g. 4 wheel drive, swimming, tracks, trails, tow paths, horse trekking)
60. Human resource access (e.g. mahinga kai)
61. Human fishing structures (e.g. eel fishing, whitebaiting)

Appendix 3. The five (or six) most important habitat modification indicators listed by selected individual attendees at the Ministry for Environment river habitat modification indicators workshop (Holmes and Fuller 2018).

Michael Lake, Waikato Regional Council:

1. Unaltered wild rivers
2. Meandering / sinuosity
3. Channelisation
4. Riparian vegetation type
5. Fish passage barriers: presence/absence
6. Stop banks

Andy Hicks, Hawke's Bay Regional Council:

1. Riparian vegetation type (composition within a buffer)
2. Channelisation
3. Stop banks and / or permitted flood plain
4. Meandering / sinuosity
5. Unaltered wild rivers
6. Catchment hydrology modification

Natasha Petrove, Department of Conservation (National Office):

1. Riparian vegetation type (composition within a buffer)
2. Channelisation
3. Stop banks and / or permitted flood plain
4. Meandering / sinuosity
5. Channel engineering
6. Catchment hydrology modification

Kevin Collier, Waikato University:

1. Riparian vegetation index - type, width, extent
2. Channel modification index – sinuosity / channelisation, bank structure
3. Dysconnectivity index (area / length disconnected) - stop banks, floodgates / tide gates (there should be council layers for these), fish barriers Meandering / sinuosity
4. Drainage modification index - impervious area, tile drains, drainage ditches (roughly discernible on REC), catchment hydrology modification
5. Flow modification index - abstraction, dams for hydropeaking, water transfers.

Ian Fuller and Russell Death, Massey University:

1. Riparian vegetation type (composition within a buffer)
2. Channelisation including narrowing, widening, straightening
3. Stop banks and / or permitted flood plain
4. Meandering / sinuosity
5. Rip rap / bank protection structures

Appendix 4. Tables from Stream Ecological Valuation (SEV) with habitat assessment attributes that are relevant to the Rapid River Pressure Assessment.

Channel type	Weighting (W)	Proportion of channel (P)	Score (W x P)
Natural channel with no modification	1		
Natural channel, but flow patterns affected by a reduction in roughness elements (e.g. woody debris, or boulders)	0.8		
Channel not straightened or deepened, but upper banks widened to increase flood flow capacity	0.5		
Natural channel, but evidence of channel incision from flood flows	0.5		
Natural channel, but flow patterns affected by increase in roughness elements (e.g. excessive macrophyte growth)	0.4		
Flow patterns affected by artificial in-stream structure (e.g. ponding due to culvert, weir or unnatural debris)	0.1		
Channel straightened and/or deepened	0.1		
	Sum W x P		

Type of channel lining	Weighting (W)	Proportion of channel (P)	Score (W x P)
Natural channel with no modification	1		
Bed with unnatural loading of fine sediment	0.8		
Bank OR bed lined with permeable artificial lining (e.g. gabion baskets)	0.6		
Bank OR bed lined with impermeable artificial lining (e.g. concrete)	0.4		
Bank AND bed lined with permeable artificial lining	0.2		
Bank AND bed lined with impermeable artificial lining	0		
	Sum W x P		

Floodplain description	Weighting (W)	Proportion of channel (P)	Score (W x P)
Movement of flood flows onto and across the floodplain is not restricted by any artificial structures or modifications	1		
Floodplain present, connectivity to floodplain is restricted by artificial modification (for example stop banks or urban development)	0.4		
Floodplain present, but connectivity to floodplain reduced by channel incision or bank widening so that most flood flows are unlikely to reach the floodplain	0.2		
No hydrological connectivity with floodplain as all flows are likely to be artificially contained within the channel	0		
	Sum W x P		