greater WELLINGTON
REGIONAL COUNCIL
Te Pane Matua Taiao

Environmental Monitoring Plan

For river management activities

For more information, contact Greater Wellington:

Wellington
PO Box 11646

T 04 384 5708
F 04 385 6960
E info@gw.govt.nz

www.gw.govt.nz

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Environmental Monitoring Plan

1 Introduction

This Environmental Monitoring Plan (EMP) sits alongside and supports GWRC's Code of Practice for River Management Activities (Code). It proposes a programme of environmental monitoring, involving collection of a range of physical parameters that reflect aspects of river natural character and processes, and which can be used as indicators of the effects of river management activities on selected environmental values. This information forms a valuable database against which the appropriateness of river management activities, in terms of their environmental effects, may be evaluated. This knowledge can be used to inform changes to river management practice (as outlined in the Code), to allow it to evolve and improve in terms of environmental outcomes over time.

This EMP includes:

- Definition of the components that should be included in a regular baseline environmental monitoring, to build a general understanding of ecological resources and the condition of river reaches managed by GWRC, and to allow assessment of the cumulative effects of river management activities over time.

- Description of the methodologies to be used in the collection of baseline data

- Identification of a methodology for determining the activities that should be targeted for periodic site specific event monitoring, and when this should occur, to provide a sharper focus when such activities are conducted on a larger scale or in sensitive environments.

The analysis of monitoring information and consideration of findings that arise from it, will be conducted according to defined review, reporting and feedback processes that are outlined in the Code. Guidelines on:

- specific questions to be asked as part of monitoring analysis,
- actions that must be taken in response to monitoring outcomes, and
- management responses when prescribed 'trigger levels' in specific values are reached are also included in the Code.

Like the Code, the EMP is intended to be a living document that is adapted over time to ensure it remains useful and relevant. Hence it is important that monitoring effort concentrates on areas or issues of importance, and that methodologies are robust and well-designed so that they deliver good quality information. The regular analysis of monitoring information noted above must also consider the overall effectiveness of the monitoring programme and make recommendations for improvements as appropriate.

The EMP will be supported by development of a GIS mapping tool[1] that includes an **Activity** layer which records the location, extent, timing and duration of all 'high disturbance' river management activities. It would also include an **Ecological Values** layer that would record information on the

[1] Currently under development by GWRC

location of sensitive habitats and species, and would identify management reaches with high, moderate and low sensitivity to disturbance by river management activities. These layers could be overlayed to produce a map of river reaches with a low to high risk of adverse effects which would be used to guide overall work planning. That assessment would also be used to identify activities that need both a site specific environment management plan (SEMP) to manage effects (as described in the Code), and a site specific monitoring plan (Section 3 below).

As described in the Code, each of the rivers managed by GWRC will be divided into a series of management reaches with similar morphological characteristics for the purpose of allowing a more detailed approach to selection of appropriate management techniques and methods, taking into account the specific characteristics and values of each reach (as opposed to a broad-brush ‘whole of river’ approach). The management reach framework will also inform the establishment of baseline monitoring sites and will facilitate targeting of environmental monitoring to deliver the most effective outcomes in terms of the need for knowledge on the effects of specific activities on key values. Management reaches have been defined for the Hutt, Waikanae and Otaki Rivers and will also be defined for GWRC managed rivers in the Wairarapa valley.

2 Baseline Monitoring

2.1 Overview of programme development

Development of an effective baseline monitoring programme includes the following steps:

a) Standardisation of record keeping for high disturbance river management activities (bed recontouring, gravel extraction, ripping in the active channel, channel diversion cut, mechanical clearance of drains/minor watercourses) to include the date, location, extent and type of works undertaken. [This is currently under development by GWRC].

b) Incorporation of this activity information into a regularly updated GIS map (showing the location, timing, extent, type and frequency of high disturbance works) and a summary table. [This is currently under development by GWRC].

c) Development of this information into a tool to predict where large scale or frequent riverbed disturbance activities are undertaken, and where cumulative effects are most likely to occur. [This is currently under development by GWRC].

d) Identification of river management reaches for each of the major river systems. Management reaches and baseline monitoring sites for the Hutt, Waikanae and Otaki Rivers have been defined and are shown in Table 2-1. Management reaches for rivers in the Wairarapa Valley have yet to be developed.

e) Use of the activity tool to inform the establishment of baseline monitoring sites, targeting reaches where bed disturbance activities occur frequently, and cumulative effects are most likely to occur. [This will follow once (c) above has been achieved].

f) Undertake monitoring of the specific parameters of the baseline programme outlined in Section 2.2. [This is already underway].

g) Review and evaluation of monitoring information over time according to the review processes defined in the Code, and feedback of any changes in monitoring needs into the monitoring programme. [This work will follow once the review process in the Code commences, following grant of resource consents].

Table 2-1: Location of management reaches* and proposed baseline monitoring sites (shaded) for the Hutt, Waikanae and Otaki rivers

River	Management reach		cross sections (XS)		Baseline monitoring site ('Reference' or 'Disturbed')
	Code	Name	Start	Finish	
Hutt	H1	Te Marua	2830	2780	-
	H2	Akatarawa	2780	2550	-
	H3	Birchville	2400	2270	Reference
	H4	Totara park	2260	1920	Reference
	H5	Whakatiki	1920	1630	-
	H6	Heretaunga	1630	1350	-
	H7	Silverstream	1340	1090	Disturbed
	H8	Pomare	1090	850	
	H9	Avalon	840	510	Disturbed
	H10	Melling	510	360	Disturbed
	H11	Ava	360	210	-
	H12	Estuary	210	100	-
Waikanae	W1	WTP	550	430	Reference
	W2	Edgewater	430	350	-
	W3	Jim Cooke	345	310	Disturbed
	W4	Jim Cooke lower	300	240	Disturbed
	W5	Pukekawa	240	175	-
	W6	Otaihanga	175	80	-
	W7	Estuary	80	20	-
Otaki	O1	Lower Gorge	1180	1020	-
	O2	Rahui Rd	1020	860	Reference
	O3		860	720	-
	O4		720	600	
	O5	Crystalls	600	490	Disturbed
	O6		490	370	-
	O7	Batching	290	220	Disturbed
	O8		220	120	-
	O9	Estuary	120	20	-

*Note: Management reaches are the same as those defined in Operational Plans

2.2 Baseline monitoring parameters

The specific parameters chosen for baseline monitoring and included in the EMP at any one time, depend on which values are considered to be the most appropriate for particular attention at that time.

The individual parameters to be monitored as part of the programme of baseline monitoring are described in Table 2-2, along with the proposed monitoring frequency, the reason for their inclusion in the programme, the information they will deliver to the review process and relevant triggers and management responses that apply to each.

Table 2-2 Baseline monitoring – key details

Parameter	Monitoring frequency	What will be monitored & data output	Who will undertake monitoring	Reasons for monitoring
Hydrological information	Continuous	Flow regime, flood and low flow summary data for each river	GWRC	Essential to provide context for analysis of other monitoring data. This information is collected routinely as part of GWRC's river monitoring network; no specific additional monitoring is required.
Deposited sediment	Annually at baseline monitoring sites	Monitoring sites established for the Otaki, Waikanae and Hutt Rivers (see Table 2-1). It is proposed that FP management reaches and baseline monitoring sites will also be established for the Ruamahanga, Waiohine, Waipoua, and Waingawa Rivers. The results of the deposited sediment monitoring will be summarised in an annual report produced by the survey authors.	Aquatic ecologist	The amount of deposited sediment on the river bed can be used as an indicator of aquatic habitat quality; changes can be used to indicate changes in habitat quality over time.
Riverbank undercutting & overhanging vegetation	Annually at baseline monitoring sites	Length of riverbank undercutting and overhanging vegetation will be assessed annually at the baseline monitoring sites listed in Table 1-1. The measurements would be undertaken at 3x 200m long survey reaches (on both banks) to be established at each monitoring site. It is anticipated that FP management reaches and baseline monitoring sites would also be established in the Ruamahanga,	Aquatic ecologist	River bank undercutting and overhanging vegetation provide opportunities for aquatic habitat diversity, which in turn may contribute to overall aquatic ecological health

Parameter	Monitoring frequency	What will be monitored & data output	Who will undertake monitoring	Reasons for monitoring
		Waiohine, Waipoua, and Waingawa Rivers. Results will be summarised in an annual report produced by survey authors.		
Trout abundance	Annual surveys until 2018	Drift dives in reaches of the Hutt and Waikanae Rivers as listed in Table 2-3. Annual report on survey, and 20 year summary report.	Fish & Game NZ & Aquatic ecologist	To identify trends in population numbers and distribution, in order to investigate the effects of river management activities in both the short and longer term.
Native fish communities	Each site will be surveyed at three-yearly intervals	Backpack electric fishing, trapping and spotlighting, as appropriate. Surveys will be undertaken in: • each of the watercourses listed in Table 2-4, at locations frequently disturbed by flood protection activities and at relatively undisturbed reference sites. • all perennial streams affected by mechanical clearance of aquatic weeds, before and after the clearance operation.	GWRC Aquatic ecologist or alternative suitably qualified fish specialist	Information will: • provide quantitative data on populations and distribution of individual native species and trends over time; this could be incorporated into the Ecological Values GIS layer, which will be taken account of in Operational Plans, • assist identification and assessment of specific and cumulative effects of river management activities on fish communities over time.
Riparian vegetation	Hutt, Waikanae, Otaki & Wainuiomata Rivers: within 3 years of consent granting, and 10-yearly thereafter Upper Ruamahanga River system (where already mapped): 10 yearly cycle Other Wairarapa rivers: within 3 years of consent granting, and 10-yearly thereafter	Vegetation types on the riparian margins; mapped using high resolution aerial photography, compiled in GIS, and ground-truthed at accessible, randomly chosen locations to confirm interpretation.	GIS mapping specialist with assistance from Botanist/Ecologist	Information obtained would be analysed to identify valuable areas of riparian vegetation to be incorporated into the Ecological Values GIS layer, This could be used to show: - high value areas that may require protection from river management activities and which will be taken account of in Operational Plans. - changes over time that may indicate adverse effects from river management - potential areas for inclusion in the environmental enhancement programme
River birds	Ongoing annual surveys on a ‘three year on three year off’ cycle, alternating between the	Three shorebird species: - banded dotterel, - pied stilt and	GWRC ornithologist or alternative suitably qualified bird specialist	Information will: • provide quantitative data on populations and distribution of targeted

Parameter	Monitoring frequency	What will be monitored & data output	Who will undertake monitoring	Reasons for monitoring
	western rivers and the Wairarapa rivers. Baseline river bird monitoring has been completed over three consecutive summers on the Ruamahanga, Waingawa, Tauherenikau, Hutt, Waikanae and Otaki rivers (McArthur et al, 2013; McArthur et al 2015). The next three year set of surveys are scheduled to start in late 2016 for the Wairarapa rivers.	- black-fronted dotterel A summary report would be produced at Years 1 and 2, at Year 3 the report would include a detailed analysis of population status		species and trends over time; this could be incorporated into the Ecological Values GIS layer which will be taken account of in Operational Plans, • allow assessment and quantification of the impacts of river management activities on river nesting bird populations
Aerial photography	Aerial photography mosaics will be produced at least once every three years	Managed reaches of the Hutt, Otaki, Waikanae, Wainuiomata Ruamahanga, Waiohine, Waipoua, and Waingawa Rivers.	Aerial survey specialist	Aerial photography mosaics will be produced at least once every three years
Pool and riffle counts	At least once every three years	Each river management reach in the Otaki, Waikanae, Hutt, Ruamahanga, Waiohine, Waipoua, and Waingawa Rivers. The results of the pool and riffle monitoring will be summarised in a report produced by the survey authors.	Fish and Game NZ and GWRC.	The number of pools and riffles is a measure of the diversity of aquatic habitat and morphological complexity of a river, which in turn can be used as an indicator of the overall ecological health of the river (particularly when considered in conjunction with other aquatic survey data).
River bed levels	At least once every five years	Hutt, Waikanae, Otaki, Ruamahanga, Waiohine, Waipoua, and Waingawa Rivers; the Wainuiomata River. Minor watercourses are excluded from these surveys. An analysis of riverbed levels against design envelopes will be undertaken after each riverbed survey and the results summarised in a report by FP river engineering staff.	Surveyor & GWRC river engineer	Monitoring of riverbed levels is important due to their impact on flood capacity and channel stability. Survey data are used to analyse trends in gravel movement and to determine river management policies for the next five year period.
Inanga spawning habitat	At least once every 15 years in tidal parts of identified waterways	On-ground mapping in Hutt River, Opahu Stream, Korokoro Stream, Porirua Stream, Kenepuru Stream, Taupo Stream, Waikanae River, Waimeha Stream, Otaki River, Rangiuru/Ngatoko Stream, Pahiko/Katihiku Drains, Waitohu Stream,	GWRC aquatic ecologist or alternative suitably qualified aquatic specialist	Information obtained would be analysed to identify changes to known areas of inanga spawning habitat to be incorporated into the Ecological Values GIS layer, This could be used to show: - high value areas that may require protection from river management

Parameter	Monitoring frequency	What will be monitored & data output	Who will undertake monitoring	Reasons for monitoring
		Ruamahanga River, Pounui Stream and Lake Onoke.		activities which will be taken account of in Operational Plans, . - changes over time that may indicate adverse effects from river management - potential areas for inclusion in the environmental enhancement programme.
Natural Character Index	Once every three years	A combination of reach scale geomorphological characteristics (including sinuosity, braiding, percent pools, active channel width, bank-full channel width and floodplain channel width) to provide an index for each management reach.	Geomorphologist/Aquatic ecologist	The NCI is under development as a potential tool to indicate morphological (and by extension, ecological) health of the river. In time it may be able to be used also as a trigger for mitigation action.

2.3 Survey methodologies

Further details on individual survey methodologies are given below.

2.3.1 Deposited Sediment

Deposited sediment measurements will include assessment of fine sediment cover and substrate grain size by Wolman pebble count (SAM3), and measurement of re-suspendible sediment using the shuffle index (SAM5) in accordance with the Clappcott et al (2011). Monitoring will be conducted in run habitat, which is intermediary between riffle and pools and therefore provides an average measure for the stream reach, replicated across three runs in each baseline monitoring site.

The Wolman pebble count is based on at least 100 particle measurements (B-axis) using a gravelometer or ruled rod. Results are recorded in particle size classes on a modified Wentworth scale (refer Clappcott, 2011).

The shuffle index is a rapid qualitative assessment of the amount of total suspendible solids deposited on the streambed (refer Clapcott, 2011). A white tile (10 x 10cm) is placed on the streambed in a run at a water depth of 20 to 50cm, where the flow is between 0.2 and 0.6 m/sec. The assessor, standing 3m upstream of the tile, disturbs the bed by moving feet vigorously for 5 seconds. A score from 1 – 5 is assigned where:

Score 1: No or small plume

Score 2: Plume briefly reduces visibility of tile

Score 3: Plume partially obscures tile but quickly clears

Score 4: Plume partially - fully obscures tile but slowly clears

Score 5: Plume fully obscures tile and persists even when tile clears

2.3.2 Riverbank Undercutting & Overhanging Vegetation

Length of riverbank undercutting and overhanging vegetation are assessed on both banks over a river length of 200m at three separate locations within a 1000m river length at each baseline monitoring site. The GPS coordinates at the beginning and end of each 200m reach are recorded to allow repeat surveys at the same locations.

Lineal lengths of bank undercutting and overhanging vegetation are recorded both in metres and as a percentage of the total bank length surveyed at each site.

2.3.3 Trout Abundance

Annual monitoring of trout abundance (brown trout >200mm) has been undertaken in the Hutt and Waikanae Rivers since 1999 using a standard method for counting trout in rivers (Jowett, 1990; Teirney and Jowett, 1990). These surveys have been conducted in accordance with a Memorandum of Understanding between Fish and Game NZ and GWRC[2] at the reaches shown in Table 2-3. The

[2] This MoU expired in December 2013. GWRC intends to renew this.

primary objective of this monitoring has been to provide information to allow exploration of the relationship between trout abundance and variables such as the timing and magnitude of flood events, and the timing and location of FP activities. A preliminary analysis shows considerable year by year variation in trout abundance and indicates that the severity of floods between August and November is a primary cause (Pilkington, 2014).

It is proposed that annual monitoring of trout abundance, according to the methodology described in the Fish and Game NZ reports will continue by agreement between Fish & Game NZ and GWRC at least until 2018 so as to provide a 20 year monitoring record.

Table 2-3: Location of Fish & Game NZ drift dive reaches

River	FP Management Reach		FP cross sections (XS)		F&G Drift Dive Reaches	
	Code	Name	Start	Finish	Start	Finish
Hutt	-	Kaitoke	Upstream of FP scheme		-	-
	-	Te Marua	Upstream of FP scheme		-	-
	H3	Birchville	2400	2270	2550	2440
	H5	Whakatiki	1920	1630	1920	1810
	H6	Heretaunga	1630	1350	1730	1560
	H7	Silverstream	1340	1090	1350	1240
	H9	Avalon	850	510	980	740
	H10	Melling	510	360	540	410
Waikanae	-	Upstream WTP	Upstream of FP scheme		-	-
	W1	WTP	550	430	550	420
	W3	Jim Cooke	345	310	340	260

2.3.4 Native Fish Communities

The New Zealand Freshwater Fish Database (NZFFD) contains a significant amount of information about freshwater fish communities in the Wellington Region, which can be supplemented by predictions of fish species occurrence from the FENZ database (Leathwick, et al, 2010) based on geographical locations and physical attributes of the watercourse. Further survey work is necessary to characterise fish populations in managed river reaches to a level sufficient to allow for comprehensive understanding of the effects (or lack of effects) of river management on those populations. This particularly includes fish in deeper waters which are difficult to survey by electric fishing methods and so are not well represented in the NZFFD.

The aim of this programme of baseline monitoring is to ensure that the fish fauna is adequately characterised in habitats potentially affected by river management activities. Baseline monitoring is not designed to assess the effects of individual river management activities on fish populations, but over time will contribute to understanding the cumulative effect of multiple activities. A more rigorous site specific B-A-C-I design is required for the assessment of individual river management activities, as discussed in Section 3.

It is proposed that fish surveys will be undertaken on a regular basis at the monitoring reaches listed in Table 2-4 at locations frequently disturbed by flood protection activities as well as relatively undisturbed reference sites. The surveys will be conducted by backpack electric fishing, trapping and spotlighting, as appropriate. For wadeable rivers (where at least 90% of the site is ≤0.6 m deep and mean wetted width is ≤12m) the surveys will be conducted in general accordance with the New Zealand Freshwater Fish Sampling protocols (Joy, David & Lake, 2013). In larger or deeper watercourses a modified methodology will need to be developed on a case by case basis.

The first round of surveys is programmed to be completed within the first three years of the resource consent, and each site will be re-surveyed at three-yearly intervals thereafter (or until modified through the review of this EMP).

Table 2-4: Location of fish monitoring reaches

River	FP Management Reach		FP cross sections (XS)		Monitoring Site Type	Initial survey
	Code	Name	Start	Finish		
Hutt	H3	Birchville	2400	2270	Reference	Summer 2016/17
Hutt	H4	Totara park	2260	1920	Reference	Summer 2016/17
Hutt	H7	Silverstream	1340	1090	Disturbed	Summer 2016/17
Hutt	H9	Avalon	840	510	Disturbed	Completed 2012, 15 & 16
Hutt	H10	Melling	510	360	Disturbed	Summer 2016/17
Waikanae	W1	WTP	550	430	Reference	Summer 2016/17
Waikanae	W3	Jim Cooke	345	310	Disturbed	Summer 2016/17
Waikanae	W4	Jim Cooke lower	300	240	Disturbed	Summer 2016/17
Otaki	O2	Rahui Rd	1020	860	Reference	Summer 2017/18
Otaki	O5	Crystalls	600	490	Disturbed	Summer 2017/18
Otaki	O7	Batching	290	220	Disturbed	Summer 2017/18
Wairarapa Valley	-	-	-	-	-	To be determined

In addition, clearance of aquatic weeds from some low gradient watercourses is undertaken in order to maintain channel capacity and to reduce the risk of flooding. Some of these watercourses, such as the Waimeha Stream in Waikanae, are known to support diverse native fish populations and are highly valued, while in other instances the native fish values are not known.

During the first three year period under the new consents, fish surveys will be undertaken on all perennial streams that routinely affected by mechanical clearance of aquatic weeds, as listed in Table 2-5. Fish surveys will be undertaken by backpack electric fishing, and where appropriate by trapping and/or spotlighting. The need for further monitoring of fish populations in these watercourses will be determined during the annual review.

Table 2-5: Location of fish monitoring reaches in mechanically cleared soft bottom streams

Watercourse	Hand-cleared length (m)	Mechanically cleared length (m)	Initial survey
Mangapouri Stream	3,345	50	Not required
Ngatotara Drain	0	4,132	2016/17 summer
Te Awahohonu Drain	3,174	0	Not required
Rangiuru Stream	0	3,940 (weed boat)	2016/17 summer
Ngatoko Stream	0	1,702 (weed boat)	2016/17 summer
Katihuku Drain	0	2,293	2017/2018 summer
Pahiko Drain	0	3,887	2017/2018 summer
Powles Drain	0	1,413	2017/2018 summer
Walkers Drain	0	1,038	2017/2018 summer

Mangaone Stream	0	3,897 (weed boat)	2017/2018 summer
Sages Drain	0	0	Not required
Waimeha	1254	2104	2016/17 summer

2.3.1 **Riparian Vegetation**

Vegetation types have recently been mapped on the riparian margins of the Ruamahanga River system as part of the development of the Floodplain Management Plan for the Upper Wairarapa Valley. Vegetation was broadly mapped using high resolution aerial photography, compiled in GIS, and ground-truthed at accessible, randomly chosen locations to confirm interpretation. The survey boundary was the 50 year ARI flood extent or 50m from the river centreline, whichever was the greater.

It is intended that similar surveys would be conducted within the riparian margins of the Hutt, Wainuiomata, Waikanae and Otaki rivers.

2.3.2 **River Birds**

The methodology to be used is described in McArthur, Small and Govella (2015).

A three-year on, three year off cycle of surveys is considered to be an appropriate survey frequency, given the focus on the three shorebird species (banded dotterel, pied stilt and black-fronted dotterel), because each of these species is relatively long-lived (with an average lifespan of 10-15 years; Heather & Robertson, 2015) and census counts generated from the 2012-2015 surveys suggests that local population sizes are relatively stable from one year to the next (McArthur et al, 2015). A small number of consecutive annual counts are necessary to estimate a mean population size for each species (smoothing out any inter-annual variation in numbers caused double-counting, or the non-detection of birds during the each survey), however ongoing annual counts will be unlikely to provide additional useful information given the apparently stable populations from one year to the next. A gap of three years in between each series of three consecutive annual counts will allow an assessment of trends in local shorebird population sizes 3-4 times per generation, providing the Flood Protection department with the ability to detect any decline in local shorebird numbers relatively quickly in relation to the average life-span of these shorebirds.

2.3.3 **Aerial Photography**

Colour Aerial Photography is flown with 80% forward & 60% side overlap & provided digitally. Fly height suitable to provide 0.15m - 0.2m GSD imagery (1:250 scale).

Aerials are best flown mid-day, mid-summer with low wind, no cloud & low-flow river levels so minimal shadow or water reflection is visible in the imagery.

Georeferencing of the new imagery is carried out using 'Agisoft Photoscan Professional'. The ground control used in this georeferencing process is captured using GIS & high resolution Ortho imagery & Lidar, where a minimum of 5 control points per image is recommended (4 corners & centre of image). Ground control comprises road markings, hydrants, manholes & other distinguishable 'ground level' features.

2.3.4 **Pool and Riffle Counts**

The counts will be undertaken by representatives of Wellington Fish and Game and GWRC according to an agreed methodology[3], using high resolution aerial photography mosaics (or similar) flown no more than 12 months prior to the count. Emerging technologies such as water penetrating LiDAR and aerial drones have the potential to improve existing methods and should be considered.

2.3.5 **River Bed Levels**

A number of rivers and streams throughout the Wellington region contain standard cross-sections with maintained benchmarks and cut lines. These cross-sections are located at various spacing along the length of managed floodways. GWRC maintains an ongoing historical database of this important past bed-level data, which is currently housed within an in-house GIS environment.

GWRC will continue to contract suitably qualified surveyors to produce topographical surveys of standard cross-sections. These surveys will be carried out on a scheduled basis, with each river's survey repeating on an average 5 yearly basis.

Profile data for each survey will be processed using the Hilltop Hydro software package, which results in mean bed levels (MBLs) at each cross-section. These mean bed levels are reported and used to inform recommendations for gravel management through a regular gravel analysis program.

The technology for capturing topographical data, such as cross section points, is quickly evolving – with methods such as LiDAR becoming a valued data collection technique. New technologies and collection methods will be managed in parallel with traditional survey methods until such time that older data collection methods become obsolete.

2.3.6 **Inanga Spawning Habitat**

GWRC commissioned a comprehensive survey of inanga spawning habitat in tidal reaches of 33 rivers in the Wellington Region during 2000, 2001 & 2002 (Taylor and Kelly 2001; 2003) and repeated the survey in 2016 (Taylor and Marshall, 2016 Draft report). Inanga spawning habitat that may potentially be affected by flood protection activities has been identified on the Hutt River, Opahu Stream, Korokoro Stream, Porirua Stream, Kenepuru Stream, Taupo Stream, Waikanae River, Waimeha Stream, Otaki River, Rangiuru/Ngatoko Stream, Pahiko/Katihiku Drains, Waitohu Stream, Ruamahanga River, Pounui Stream and Lake Onoke. It is proposed that an inanga habitat survey be conducted on these watercourses at least once every 15 years.

Inanga spawning habitat surveys of these watercourses should follow a methodology that is generally consistent with the earlier surveys referenced above, and:

- At a minimum collect the necessary information at each site to meet the data and information requirements for NZ's National Inanga Spawning Habitat Database;

[3] To be defined. Will be included as part of the MoU renewal.

- Include appropriate documentation of methodology and the extent of the surveys/sites assessments so that surveys can be repeated at a later date;
- Evaluate the extent and quality of spawning habitat at each site and any limitations of the survey at each site;
- For sites that have been assessed previously consider the results of those previous surveys while in the field to ensure that, as far as is possible, adequate information is collected to allow an assessment of changes (in habitat extent or quality, etc) between the two surveys.
- Identify generic and site specific management issues and restoration opportunities and provide recommendations where appropriate (especially in relation current river management practices)
- Identify further monitoring requirements to better inform management of habitat, and future monitoring surveys.

2.3.7 **Natural Character Index**

As part of its assessment into the environmental effects of its river management work, GWRC is investigating the use of a natural character index (NCI), developed by Massey University researchers. The index is made up of a combination of parameters that reflect river morphology and process, with scores reflecting the ability of a managed river to express a form approximating that which might be expected in a 'natural' or unmanaged river. There is an increasing body of research evidence that suggests that healthy and diverse river morphology is necessary for healthy and diverse aquatic ecology. So NCI scores have the potential to be used also as a proxy indicator of potential aquatic ecological health as well.

Measurement of changes in the NCI over time reflect trends in river form and it is hoped that this might be also be able to provide a measure of the cumulative effects of river management activities on river morphology for specified river reaches.

Two potential applications of the NCI are under development. Death et al (in prep) refers to these as the overall Natural Character Index (*o*NCI) and the NCI to assess individual engineering activities (*e*NCI).

The oNCI utilises measurable parameters to characterise geomorphological condition at river reach scale e.g. sinuosity, extent of braiding, percent of pools, active channel width, bank-full channel width and floodplain channel width. These can be evaluated using aerial photographs, LiDAR, and GIS. They can be used to determine changes at the reach scale compared to a reference condition. Death et al (in prep) used *o*NCI to assess changes in geomorphology for the Otaki, Hutt and Waikanae rivers between 1939 (Otaki), 1951 (Hutt), 1952 (Waikanae) and the present condition, as of 2010.

GWRC is considering the application of a refinement of this method on management reaches (see Figure 2-1) at regular three yearly intervals to track any changes in geomorphological condition over time, as part of it baseline monitoring programme, and as a means of assessing the cumulative effects of river management activities on each management reach.

GWRC is also investigating the use of *e*NCI as one component of its Event Monitoring programme which would apply when river management activities are conducted on a large scale or in sensitive environment (refer Section 3). An eNCI assessment would be conducted at the works site and on an upstream reach of similar length. Both sites would be assessed before and after the works. The parameters measured for this type of assessment are yet to be finalised but are likely to be selected from the following:

- *Substrate*
    - Grain size (D50) of surface gravel in river channel
    - Bed compaction of river bed
    - Substrate diversity
    - Deposited sediment (fines)
- *Channel*
    - Pools: number & area
    - Active channel width & area
    - Wetted channel width & area
    - Thalweg length
    - Area of bars
    - Riparian vegetation

The ratio of these variables (expressed as a combined index of before to after) would be calculated for the works and upstream reaches (i.e. to produce a 'works reach' *e*NCI and an 'upstream reach' *e*NCI).

3 Event Monitoring

If a proposed event involving an activity or set of activities is likely to generate significant adverse effects in the river environment it may be necessary to be conducted in accordance with a more detailed, site specific environmental management plan (SSEMP), in addition to following general good practice methods.

A method to determine when a SSEMP is required is described in Section 3.3 of the Code. The Code also prescribes matters to be covered in a SSEMP, and who is involved in its preparation.

A SSEMP will generally require site specific monitoring. This will need to be designed specifically for the event or events in question, taking into account the specific values and issues of relevance to the affected site or reach.

Where appropriate, site monitoring associated with a SSEMP would be based on a before/after/control/impact design and will include some or all of the following (depending on the ecological values known, or likely to be present, at the site):

- Water quality monitoring (suspended solids, turbidity, Total-Nitrogen, Total-Phosphorus)
- Deposited sediment monitoring (sediment cover and substrate size)
- Habitat mapping at impact and reference sites
- Macroinvertebrate re-colonisation
- Survey of fish populations
- Fine scale monitoring of physical, chemical and biological indicators in estuarine environments (where applicable)
- NCI calculated for the works and upstream reaches (i.e. to produce a ‘works reach’ NCI and an ‘upstream reach’ NCI).

4 Auditing

Include Nick Bibby's check sheet.

An App is being developed that will enable the habitat assessment forms to be done on a handheld device. All medium and high risks will have a habitat assessment form completed so that each piece of work can be assigned a number. A number of pieces of work will be selected on a random basis to audit, to ensure that the processes in the EMP and Code have been applied.

Appendix A: Before/after habitat assessment template

<table>
<tr><td colspan="6">Habitat Assessment Template for Consented River Maintenance Work requiring between three and six days work in the wetted river channel</td></tr>
<tr><td colspan="6">Applicable consent</td></tr>
<tr><td colspan="3">□ WGNxxx – Wainuiomata River</td><td colspan="3">□ WGNxxx – Hutt River</td></tr>
<tr><td colspan="3">□ WGNxxx – Waikanae River</td><td colspan="3">□ WGNxxx – Otaki River</td></tr>
<tr><td colspan="3">□ WGNxxx – Upper Ruamahanga</td><td colspan="3"></td></tr>
<tr><td colspan="6">Type of Work Proposed</td></tr>
<tr><td colspan="3">□ Bed re-contouring; lineal metres______(m)</td><td colspan="3">□ Groyne construction; lineal metres____(m)</td></tr>
<tr><td colspan="6">□ Other: lineal metres_____(m)</td></tr>
<tr><td>Date of pre-works assessment:</td><td></td><td colspan="2">Assessors name:</td><td colspan="2"></td></tr>
<tr><td>Date of work:</td><td></td><td colspan="2">Landowners Name:</td><td colspan="2"></td></tr>
<tr><td colspan="6">Location of assessment:</td></tr>
<tr><td colspan="6">River cross section: XS______; +______(m) to XS______; +_______(m)</td></tr>
<tr><td colspan="2">□Right Bank</td><td colspan="2">□Left Bank</td><td colspan="2">□Mid Channel</td></tr>
<tr><td colspan="6">Pre-works Habitat Assessment</td></tr>
<tr><td>Site length (definition)</td><td colspan="4">Approximate length of assessment site:__________(m)</td><td>Photographic record</td></tr>
<tr><td>Wetted vs. dry channel width</td><td colspan="4">Average wetted width over assessment site:______(m)

Average dry width over assessment site:_______(m)</td><td>Pre-works photo date:</td></tr>
<tr><td>Flow conditions</td><td colspan="2">□ Low flow</td><td colspan="2">□ Base flow</td><td>□ High flow</td></tr>
<tr><td>Flow types present In linear metres (definition)</td><td>Rapid:______(m)</td><td>Deep run:_______(m)

Shallow run: (m)</td><td colspan="2">Riffle:_______(m)</td><td>Pools: _______(m)

Pools (number):</td></tr>
<tr><td>Maximum depth found within assessment site</td><td colspan="2">Maximum depth:_______(m)</td><td colspan="3">Approximate lineal distance of max depth length: ______(m)</td></tr>
<tr><td>Wetted bank habitat (definition)</td><td colspan="5">Total length of wetted habitat against bank:__________(m)</td></tr>
<tr><td>Overhanging vegetation</td><td colspan="5">Total length of overhanging vegetation:___________(m)</td></tr>
<tr><td>Bank undercut</td><td colspan="5">Total length of undercut:____________(m)</td></tr>
<tr><td>Channel shape</td><td>☐ Artificially channelised</td><td>☐ Straight</td><td colspan="2">☐ Weakly sinuous</td><td>☐Strongly sinuous</td></tr>
<tr><td>Braided channel?</td><td>☐ Single thread channel</td><td>☐ Split channel</td><td colspan="3">☐ Braided channel</td></tr>
</table>

<table>
<tr><td colspan="6">Post-works Habitat Assessment</td></tr>
<tr><td colspan="2">Date of post-works assessment:</td><td colspan="2"></td><td>Assessors name:</td><td></td></tr>
<tr><td>Site length (definition)</td><td colspan="4">Approximate length of assessment site:__________(m)</td><td>Photographic record</td></tr>
<tr><td>Wetted vs. dry channel width</td><td colspan="4">Average wetted width over assessment site:_______(m)
Average dry width over assessment site:________(m)</td><td>Pre-works photo date:</td></tr>
<tr><td>Flow conditions</td><td colspan="2">□ Low flow</td><td colspan="2">□ Base flow</td><td>□ High flow</td></tr>
<tr><td>Flow types present In linear metres (definition)</td><td>Rapid:______(m)</td><td>Deep run:________(m)
Shallow run______(m)</td><td colspan="2">Riffle:_______(m)</td><td>Pools: _______(m)
Pools (number):</td></tr>
<tr><td>Maximum depth found within assessment site</td><td colspan="2">Maximum depth:_________(m)</td><td colspan="3">Approximate lineal distance of run length_______(m)</td></tr>
<tr><td>Wetted bank habitat (definition)</td><td colspan="5">Total length of wetted habitat against bank:__________(m)</td></tr>
<tr><td>Overhanging vegetation</td><td colspan="5">Total length of overhanging vegetation:__________(m)</td></tr>
<tr><td>Bank undercut</td><td colspan="5">Total length of undercut:___________(m)</td></tr>
<tr><td>Channel shape</td><td>☐ Artificially channelised</td><td colspan="2">☐ Straight</td><td>☐ Weakly sinuous</td><td>☐Strongly sinuous</td></tr>
<tr><td>Braided channel?</td><td>☐ Single thread channel</td><td colspan="2">☐ Split channel</td><td colspan="2">☐ Braided channel</td></tr>
<tr><td colspan="6">Aerial perspective of work site</td></tr>
<tr><td colspan="2">Before work</td><td colspan="4">After work</td></tr>
<tr><td colspan="6">Flow path</td></tr>
<tr><td colspan="6">Has the flow trajectory been changed in such a way that it will affect downstream habitat: □yes □no. If yes what are the effects:</td></tr>
<tr><td colspan="6">Backwater habitat</td></tr>
<tr><td colspan="6">Has existing backwater habitat at this work site been affected by the works: □yes □no. If yes, provide details:
Has new backwater habitat been created at the works site: □yes □no. If yes provide details:</td></tr>
<tr><td colspan="6">What other ‘good practice’ methods have been implemented at the site:</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6"></td></tr>
</table>

Definitions:

Site length is the length of the area being assessed. The area affected by works may be less.	**Rapid habitat** is an area of fast moving broken white water
Flow conditions are generalized as low, base or high. For accurate measurement refer to GWRC record on the date of	**Riffle habitat** is an area of fast moving turbulent water

assessment	
Deep run is deeper than 0.6m (thigh high)	**Wetted bank habitat** is the total length of wetted channel against a bank edge. This may be greater than the assessment site length (e.g. if wetted bank is on both sides of the site or on an island