Freshwater Monitoring Action Plan

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Version	1	**Date**	25/04/2013

1.0 INTRODUCTION

CAMERAS has approved an environmental monitoring strategy for Scotland. This sets out the vision for monitoring in Scotland;

"*Scotland's coordinated programme of environmental monitoring will provide the evidence needed for decision-makers to protect and improve the environment, thereby enhancing people's wellbeing and supporting sustainable economic growth*."

It is important to value the key role monitoring plays in helping us understand the environment and to assess and predict future challenges under different climate and environmental change scenarios. Appropriate monitoring allows us to protect the environment from harmful activities, as well as ensuring our limited funds are targeted to deliver the greatest benefit and protect people and property from the harmful effects of environmental extremes.

The key aims of this MAP are to:

- identify monitoring requirements for understanding the biggest challenges facing Scotland's freshwaters;
- develop a process to co-ordinate and streamline monitoring; and
- maximise efficiencies, so rationalising the overall cost of monitoring to Scotland.

The MAP will identify both gaps in our monitoring and opportunities to improve how we work. The MAP proposes which organisations should work together to implement changes to freshwater monitoring, and recommends a timetable for action.

National Ecosystem Assessment

Rivers, lakes, ponds . . . and wetlands provide major services, but their benefits are inadequately identified and valued. . . When managed appropriately, freshwaters provide: consumptive and non-consumptive uses of water; organisms for food, recreation and conservation; and energy. They can regulate flooding, erosion, sedimentation, local climates and water quality, while facilitating the dilution and disposal of pollutants. They support dispersal through, and resilience in, adjacent ecosystems (for example, though water or nutrient supply), and act as a medium for key biogeochemical cycles. They have large cultural value for recreation, tourism, education, heritage and as inspiration for arts and religion.

Improving the monitoring network in Scotland will provide the evidence to enhance our understanding of the links between freshwater and the services it provides.

Robust and defensible monitoring programmes are often expensive, and as such require regular review and examination to ensure money is spent appropriately. Monitoring provides the evidence to inform policy makers, scientists and managers on the state of the environment, and provides the basis for sound and informed decision making.

The freshwater MAP will identify where savings and efficiency gains may be made. Co-ordinating monitoring allows all the organisations involved to make better use of data, and assess the state of the environment, the pressures on it and what is being done to protect and improve it.

The Scottish Government has set five strategic objectives, to create a more successful country.

- Wealthier and fairer
- Healthier
- Greener
- Safer and stronger
- Smarter

A well designed freshwater monitoring network contributes to the delivery of all of these objectives, and in particular is vital to help us in:

- managing the environment;
- increasing Scotland's economic competitiveness and
- providing the evidence base to understand and manage the environment

2.0 THE FRAMEWORK FOR MONITORING

2.1 Scope

For this MAP, freshwater monitoring is defined as all regular observations that are intended to assess the state, or track change, and which are scheduled to be carried out over a period in excess of three years. This includes any modelling which is undertaken as part of the process of assessing the environment, although modelling itself can require significant amounts of monitoring data to design and verify.

Monitoring covered by the MAP should deliver a pan-Scotland understanding; although individual sampling programmes may only cover a small spatial scale, they are addressing issues which are significant in a Scotland-wide context.

The freshwater MAP covers all surface freshwaters (including canals) and wetlands, including groundwater dependent wetlands, but excludes groundwater, soil waters and all monitoring carried out below the tidal limit. These will be addressed through other monitoring action plans.

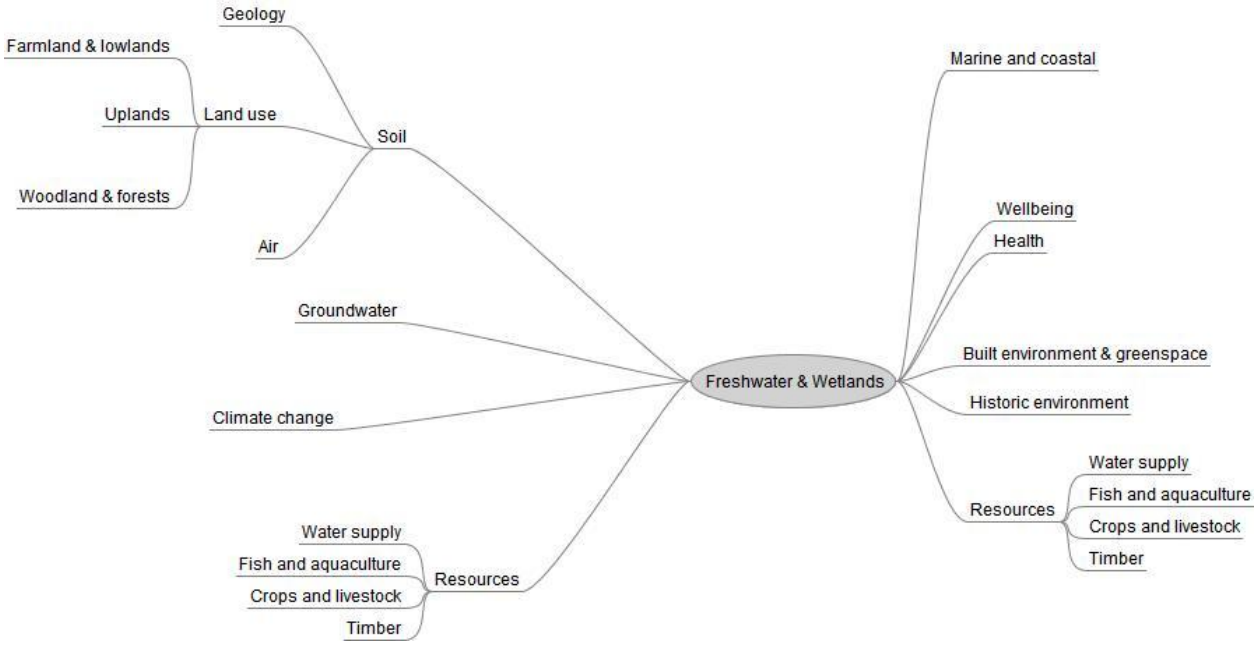
It encompasses monitoring of plants, animals, physical (e.g. hydrology, habitat structure) and chemical parameters in the freshwater environment (water, sediments and biota), where that monitoring is used primarily to understand the state of the environment.

Freshwater often behaves as a receptor of pressures, and "transports" those pressures to act on other aspects of the environment. It is important to recognise these differing roles and the interdependency between different environmental "compartments".

The freshwater MAP aims to identify what monitoring is necessary to further our understanding of the links between these compartments of the environment, as well

as ensuring we can provide the evidence to understand the environment, the pressures and inform management decisions.

(Figure.1) Links between CAMERAS monitoring action plans and the freshwater MAP



The CAMERAS environmental monitoring strategy suggested a series of environmental "components" for which MAPS should be developed. Some of these interact with the freshwater environment, Figure 1 shows the links between the various relevant monitoring action plans suggested.

MAPs for soil, air and freshwater will be delivered in phase I of the CAMERAS initiative; remaining MAPs will be delivered subsequently.

The MAPs on the left hand side of the Figure can have an impact on freshwaters; those on the right hand side are generally impacted by changes in the state of freshwaters and wetlands.

As identified in Figure 1, freshwater interacts with a variety of other environmental components. These relationships should be considered when revising freshwater monitoring, to ensure that monitoring provides the evidence needed by other MAPs to understand their component of the environment. Likewise, other MAPS should consider how their monitoring can help fill gaps in the knowledge of the freshwater environment.

2.2 Objectives

The Freshwater MAP aims to develop a process for streamlining monitoring effort in Scotland. In the first instance, effort on reviewing monitoring should be targeted at the largest existing networks. Further iterations of the freshwater MAP should aim to expand this process, to cover monitoring carried out by other organisations. Improving the co-ordination and cohesiveness of freshwater monitoring networks will deliver a number of benefits; the main objectives of the freshwater MAP are listed below:

- Improve the coverage of our monitoring by identifying and filling gaps in monitoring.
- Increase the efficiency by identifying inefficiencies in monitoring and sharing effort and resources between organisations, thereby reducing our financial and carbon costs
- Identify and protect valuable long-term monitoring networks, highlighting the importance of monitoring for providing the evidence to understand and manage the environment.
- Provide a potential mechanism for future revisions of freshwater monitoring.
- Increase awareness of one another's monitoring activities and knowledge of what information is available.
- Contribute to improved monitoring technologies and techniques.

2.3 Who requires monitoring and why

Freshwater monitoring is required to meet the needs of a variety of different drivers. These can be grouped into five main categories:

Table.1 Key drivers of freshwater monitoring

Driver	Description	Example
EU Legislation	Monitoring undertaken to meet requirements of EU Directives, and to track progress against their objectives	Water Framework Directive Habitats Directive
International treaties	Monitoring to meet obligations under international treaties	OSPAR, NASCO
Government/Public Body policy	Monitoring to support government policy	Cryptosporidium Direction
Monitoring commitment	Commitments to support UK monitoring initiatives	Environmental Change Network National River Flow Archive UK Acid Waters Monitoring Network (Upland Water Monitoring Network)

Management and investigation	Monitoring change in the environment (to identify where action is required, and effectiveness of interventions)	Catchment-scale monitoring to trace source of pesticide pollution Assessment of response from habitat restoration or improvement measures
Research	Intensive monitoring to investigate a hypothesis, often long-term	Fish population assessment Forest-water interactions Climate change impacts

Improving data sharing and bringing data together will allow a more complete story to be told on the state of the freshwater environment.

The users of freshwater monitoring data can be grouped into twelve main categories, and the intention of this MAP is to progressively improve the relevance of the data provided for these users.

Table.2 Examples of users of freshwater monitoring data

User	**Example of organisation**
International bodies	ICES, OSPAR, NASCO
Scottish & UK Government	DEFRA, Scottish Government, JNCC, Marine Scotland (MS)
European institutions	EEA, Eurostat, JRC, Research councils
Public bodies & partners	SNH, SEPA, FCS/Forest Research, Scottish Water
Local authorities	Scottish Local Authorities, National Park Authorities
Academics and scientific community	CEH, Higher Education Institutes, Marine Scotland Science (MSS)
Main Research Providers	JHI, SAC
Water managers and landowners	Agricultural sector, fishery owners, Fisheries Trusts, district salmon fishery boards
Water users	Anglers, Kayakers
Industry	Scottish Water, Scottish and Southern Electric

Non-Governmental organisations	Scottish Environment Link, RSPB
General public	

Further work on prioritising monitoring effort and identifying opportunities for efficiencies should also consider the opportunities to "harvest" data from other sources, such as academic studies and well-planned, appropriately targeted citizen observations/science.

2.4 Identify and prioritise the monitoring requirements

2.4.1 What's changing

In order to understand what's changing in the environment, the baseline condition (state of the environment) has to be known.

The quantity and quality of freshwater, together with dependent species and habitats are monitored to answer questions on:

- physical and chemical processes
- status and trends
- population dynamics
- population health

Robust data are required to protect the health of the environment and drive appropriate management and improvement measures. As the effects of climate change become more apparent, monitoring will also be needed to help inform mitigation and adaptation strategies; for instance, monitoring flows to understand any increased flood risk.

2.4.2 Why is it changing

As part of the development of a CAMERAS monitoring strategy, a workshop was held to determine the key pressures on the environment. The freshwater group have taken the resulting scoring system and revised the freshwater pressure assessments.

Each pressure was scored from 1-3 (corresponding to a high, medium or low level of impact). This was normalised to a scale of 1-5 and combined with assessments of the scale of the pressure (what area of Scotland is affected, scored 1-5), how easy it is to reverse the problem (scored 1-3) and the whether the trend is improving or worsening (scored from -3 to 3).

Table.3 List of prioritised pressures on the freshwater environment

Abstractions
Agriculture (e.g. compaction, erosion, drainage)
Development (e.g. sealing, flood defence)
Greenhouse gas emissions
Nutrients
Acidic substances
Disease
Aquaculture
Forestry (e.g. drainage, erosion)
Hazardous Substances
Impoundments
Invasive non-native species
Particulates (suspended solids)
Fishing (exploitation)
Game land management (burn, grazing, access)
Hydrological impacts of discharges
Litter
Noise and vibrations
Recreation (compaction, erosion)

The pressures were ranked into three levels of risk, with no ranking within the groups (i.e. the group made no judgment on whether abstractions were a greater pressure than nutrients). No ranking within the three broad colour categories should be inferred.

2.4.3 What are the consequences of change

Changes in the freshwater environment that impact on other environmental components as shown in Figure 1. These changes can be detected in the environmental components affected, and also in socio-economic responses. For instance, acidification from overseas power generation impacts on the number of fish in rivers, which supports angling, which itself provides inputs to the local economy, both directly in lower beat-rents and indirectly through a reduction in local spend on hotels/shops etc.. Failure to meet the monitoring requirements of Directives can have indirect costs (the loss of ecosystem services, or of inappropriate regulation), as well as the direct financial costs of infraction proceedings.

Monitoring of these socio-economic changes could be carried out to clearly demonstrate the links between the environment and society. However, this edition of the freshwater MAP will concentrate on the monitoring of the environment. Future versions could consider the monitoring of consequences on society directly.

2.5 Identify existing monitoring

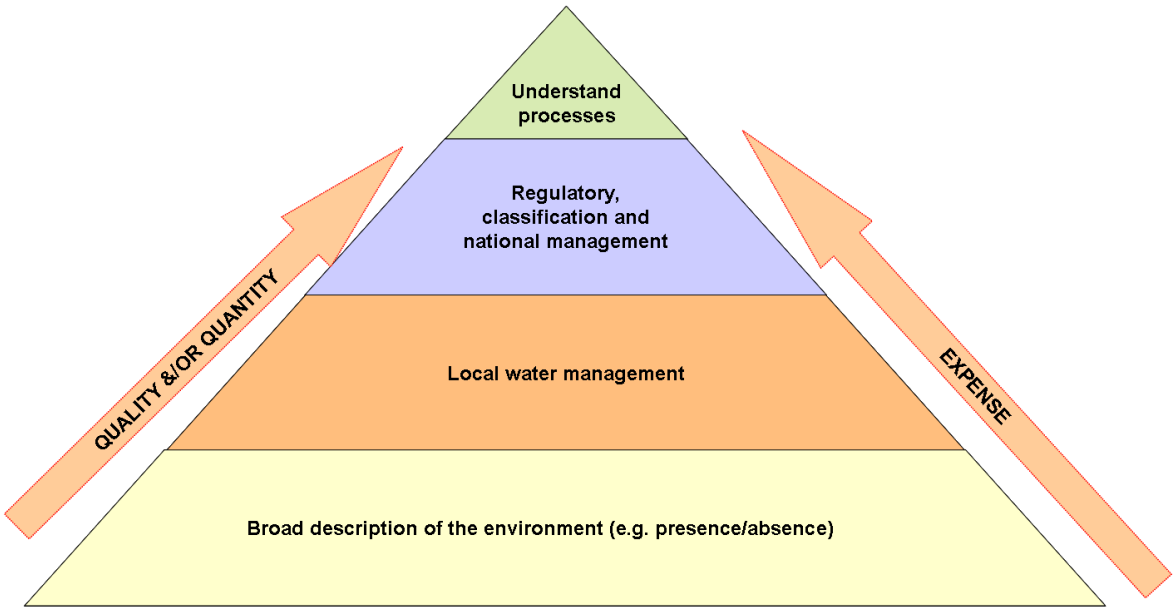
2.5.1 What's done where

The majority of freshwater monitoring in Scotland is carried out by SEPA, Scottish Water, Fishery Trusts and District Salmon Fishery Boards, SNH and Marine Scotland Science. Summarising current monitoring effort is difficult, and instead the MAP has identified the need to map all existing monitoring as a key early deliverable of the implementation plan.

2.5.2 Strengths, weaknesses and accessibility of monitoring data

There are four broad types of monitoring data:

Figure.2 Types of monitoring data



Generally, the cost of monitoring increases with increased accuracy and precision, as well as with the quantity of monitoring data gathered.

There are fewer sites at which the most accurate and precise monitoring is undertaken, compared to those where data on presence/absence of species are collected. The grade of monitoring carried out should be determined by the question(s) it is being collected to address; monitoring should be fit for purpose.

Generally, data collected with the greatest degree of precision and accuracy can be used for all other purposes while data collected at "coarser" resolutions cannot.

The great strength of freshwater monitoring in Scotland is its spatial and temporal coverage. Unlike some other monitoring regimes (for example groundwater or soil monitoring), there is a long history of monitoring many aspects of the freshwater environment in Scotland. For some aspects of the freshwater environment, there is also good existing co-ordination. For example, monitoring of cyano-bacteria blooms is co-ordinated between local authorities, Scottish Water and SEPA.

These data may not all be accessible through one organisation's monitoring networks; there are often gaps in both spatial and temporal coverage for individual organisations, but taken collectively there is a strong body of data across Scotland.

A prominent challenge for the future will involve assessment of the monitoring scope of different organisations, and devising mechanisms for data sharing. This, along with other weaknesses, is explored further in section 2.6.

2.6 Gaps and overlaps

2.6.1 Gaps in knowledge

Areas where there is insufficient monitoring of pressures and indicators of the environment are shown in Table 5.

These gaps are not mere scientific curiosity; the group believes that the lack of knowledge in these areas has serious potential risks.

Lack of knowledge can lead to:

- Inappropriate management, either;
    - Unnecessary/inappropriate intervention or inappropriate development (resulting in costs to industry or the public purse etc.)
    - Loss of resource (not making an intervention where necessary)
- Lost opportunity (not exploiting resources to their full, sustainable potential)
- Irreversible damage to ecosystem services

The most prominent gaps have been identified by the group.

Table.4 Gaps in monitoring of freshwaters

Gap – changes in state	Gap in evidence base	Gap in understanding of extent	Links to other MAPs
Morphological changes and impacts (especially interactions with ecology)	X		Landscape
Abstractions (especially interactions with ecology)	X		Water supply; energy use
Invasive non-native species	X	X	
Population and distribution of non-salmonid fish (e.g. eels and lamprey)	X	X	
Predators of key fish species	X	X	
Population dynamics of key fish stocks (especially salmonids)	X	X	Marine and coastal; energy
Loch fish populations	X	X	
Marine survival of migratory fish (understanding the impacts on freshwater populations)	X	X	
Nutrient cycling (soil to water)	X	X	Farmland and lowlands;
Suitable site network (e.g. diatoms) to support appropriate growth and investment		X	soils; marine and coastal
Effectiveness of diffuse pollution measures, source apportionment	X		
Hazardous substances			Health; Water supply
Sources and pathways to freshwaters		X	
Prevalence in environment (including biota, sediments and accumulation)	X	X	
Mixtures of hazardous substances	X		
Biological measures of hazardous substances	X	X	
Endocrine disruptors	X	X	
Nanotechnology impacts	X	X	
Biodiversity and state of habitats outside Protected Areas			Uplands; Farmlands and
Wetlands	X	X	lowlands
Species		X	
Habitats		X	
Disease and non-native parasites		X	Fish and aquaculture
Climate change detection			Climate change; Soils
Sediment monitoring in peat-dominated catchments		X	
Biological indicators of climate change	X		
Review appropriateness of hydrographic network for monitoring climate change	X		
Stream temperature change	X	X	

Climate change mitigation (efficacy of) Riparian woodlands Wetland management Natural flood management	 X X X		Climate change; Environment and economy

Gap – consequence of changes in state	**Gap in evidence base**	**Gap in understanding of extent**	**Links to other MAPs**
Benefits from ecosystem services	X	X	Environment and economy
Quality of private drinking water supplies	X	X	Water supply

Not all of the pressures identified in section 3.4.2 are identified as gaps, as for some of the pressures there is already good management of the activity; for instance fishing in freshwaters is generally well controlled, and poses little threat to the environment. Controlling fishing requires adequate data and evidence.

2.6.2 Overlaps (efficiency savings and collaboration)

Table.5 Areas for further collaboration

Area for collaboration	Organisations involved (order of organisations does not infer lead or relative contribution)
Identify monitoring networks, especially of "research-quality" sites (e.g. Upland Waters Monitoring Network (UWMN), previous known as the UK Acid Waters Monitoring Network), SEPA priority catchments, MSS research catchments (e.g. Girnock,. Baddoch, N. Esk, Loch Ard), SNH Remedies database etc.). Longer-term aim to co-locate monitoring effort, where appropriate, to get additional value from monitoring	All, SEWeb to deliver functionality to support this
Upland Waters Monitoring Network - Improve visibility of network and encourage use of data - Explore wider sharing of the cost of monitoring at the existing network - Embed new monitoring, where appropriate, in existing monitoring networks	SNH, MSS, SEPA
Share and develop monitoring resources to best meet requirements of SNH site condition monitoring and Scottish Biodiversity Surveillance Strategy (incorporating monitoring for the Habitats Directive and Water Framework Directive). E.g. review how hydromorphological changes are recorded	SNH, SEPA, MSS, RAFTS
Co-ordinated network of river temperature monitoring sensors to avoid duplication (including data management and sharing protocols)	SEPA, MSS
Review and develop fish monitoring (e.g. improve knowledge of monitoring currently undertaken, ensure all publicly-funded data freely available)	SG, MS, SNH, SEPA, Fishery interests (SFCC, RAFTS, ASFB)
Optimise water chemistry sampling and analysis effort by sharing services where possible. Sample methods and analysis used will have to be considered.	SEPA, SWtr, MSS

Data sharing and transfer of data between organisations	All – to take forward through SEWeb
Improve access to database(s) of fish data (where appropriate and technically feasible)	MS, RAFTS, SFCC, SEPA, SNH
Agree common methodologies for sampling and analysis, where appropriate. Consider cross-training of staff Review comparability of methodologies	MSS, SEPA, SNH, RAFTS, SWtr Concentrate initial phases on monitoring of fish and macrophytes in standing waters
Review existing network of private water supply monitoring. - identify current private water supply network - explore possibility of using data from Private Water Supply monitoring to inform wider environmental issues - review appropriateness of private water supply network	SEPA, SWtr, DWQR

2.6.3 Innovation opportunities and use of citizen observations

The following potential opportunities for innovation, or the use of citizen science, have been identified.

Table.6 Innovation opportunities

Innovation opportunity
Rapid assessment techniques Risk assessments, using citizen observations More rapid techniques
Passive samplers (identify and expand role of passive samplers in monitoring of freshwaters)
Remote sensing (e.g. vegetation change of wetlands)
OMICS (genomics etc.) Monitoring Microbial source tracking
Citizen observations Use to “keep an eye” on stable species, e.g. otter Collecting data on fish barriers Collecting data on invasive non-native species Mapping wetlands (e.g. BASC involvement in wetland mapping project) Snow monitoring: depth, extent, water equivalent
Getting more value from existing data Obtaining fish catch effort data at comparable spatial and temporal scales Reviewing data in NBN and use in assessing state of the environment Analysing flow records for changes to catchment response

Citizen science has an important role to play in helping us understand, protect and improve the environment. Is it particularly useful in helping in a general risk-assessment, or as part of a campaign to raise awareness of, or engagement with, an issue.

3.0 IMPLEMENTING THE MAP

3.1 Prioritised actions to improve and co-ordinate monitoring

From the lists of identified gaps, overlaps and innovation opportunities, the FWMAP group has prioritised tasks for implementation. These were thought to be the either of high priority, or achievable within a three-year timescale. A process of reviewing and re-prioritising the tasks should be put in place, with additional tasks being identified when there is resource to deliver them.

The actions detailed below are reliant on the lead organisation(s) taking the work forward. Any delays in particular workstreams may impact on other workstreams in the implementation plan.

The indicative timetable shows the proposed start time of each task.

Table.7 Actions to take forward

Action	Type of work	Organisations involved	Lead	Timetable
Broad reviews of monitoring networks for:				
• Monitoring of fish populations	Gap/ Overlap	SNH, SG, MSS, SEPA, RAFTS	SG	Oct, 2013
• Optimising monitoring and analysis between SEPA and SWtr (both hydrology gauging and chemistry)		SEPA, SWtr	SEPA	Aug, 2013
• Co-ordinated network of riverine temperature monitoring sensors		MSS, SEPA	MSS, SEPA	Aug, 2013
• Sharing and developing monitoring resources to best meet requirements of SNH site condition monitoring and Scottish Biodiversity Surveillance Strategy (incorporating monitoring for the Habitats Directive and Water Framework Directive)		SNH, SEPA, MSS, RAFTS	SNH	Sept, 2013
• Invasive non-native species		SNH, SEPA, MSS, RAFTS	SEPA/SNH	July, 2013
Understand our monitoring landscape:				
• Identify monitoring networks, especially of "research-quality" sites (SEPA priority catchments, MSS research catchments, UWMN, SNH Remedies database etc.).	Gap/ Overlap	All	SEWeb	Mapped: July, 2013
• Longer-term aim to co-locate monitoring effort, where appropriate, to get additional value from monitoring				Reviewed: March, 2014
Improve our methods and data sharing:				
• Undertake a review of contracting, to ensure any data from fish monitoring contracts let by SEPA and SNH are available freely to all	Gap/ Overlap	MSS, RAFTS, SNH, SEPA	SEPA/SNH	Aug, 2013
• Review methods used to survey macrophytes in standing waters		SNH, SEPA	SNH	Aug, 2013
• Passive samplers (identify and expand role of passive samplers in monitoring of freshwaters)	Innovate	SEPA, SWtr	SEPA	Oct, 2013

Upland Waters Monitoring Network: • Improve visibility of network and encourage use of data • Explore wider sharing of the cost of monitoring at the existing network • Embed new monitoring, where appropriate, in existing monitoring networks	Overlap	MSS, SNH, SEPA	MSS	June, 2013
Review existing network of private water supply monitoring • Identify current private water supply network • Explore possibility of using data from Private Water Supply monitoring to inform wider environmental issues • Review appropriateness of private water supply network	Gap/ overlap	SEPA, SWtr, DWQR, LAs	DWQR	July, 2013 Oct, 2013 Jan, 2014
Citizen science • Collecting data on fish barriers • Improve the collection and recording of data on invasive non-native species	Innovate	SEPA, SNH, MSS, RAFTS SEPA, SNH, MSS, RAFTS	SNH, SEPA	Sept, 2013 Dec, 2013
Hazardous substances • Review evidence on sources and pathways to freshwaters • Identify and quantify prevalence in environment (including biota, sediments and accumulation up the food chain) • Review effects and monitoring of mixtures of hazardous substances • Develop indicators to provide biological measures of hazardous substances • Monitoring to detect nanotechnology impacts	Gap/ overlap	SEPA, SWtr, MSS	SEPA	Ongoing
Climate change detection • Review sediment monitoring in peat-dominated catchments • Review and identify appropriate biological indicators of climate change	Gap	SEPA, MSS, SNH, ClimateXchange, CREW	SEPA CREW	Oct, 2013 Oct, 2013
Climate change mitigation (efficacy of) • Riparian woodlands • Wetland management/Natural flood management	Gap	SEPA, MSS, SNH, FCS/FRS	MSS,FRS SEPA	Oct, 2013 Oct, 2013

3.2 Reviewing monitoring reviewing

It is anticipated that all the reviews will follow a similar pattern, and will have to consider:

- Why monitoring is required – what question(s) does it need to answer?
- What should be monitored, how and where – which parameters or techniques are appropriate?
- What monitoring methods will be used
    - Where should this monitoring be carried out – what is the spatial distribution of monitoring required?
    - What is the existing distribution of monitoring?
    - What methods should be employed for monitoring – what are the optimum techniques? How does this compare to existing monitoring?
    - What level of discrimination is needed – what accuracy, precision and monitoring frequency are required?
- Who is best-placed to carry out the monitoring – which organisation or organisations are best placed to deliver and / or co-ordinate network?
- How will the data be made accessible – who needs the data? How will it be shared? What infrastructure is necessary to support this?
- Timetable for delivery
- Opportunities for innovation and citizen science

3.3 Next steps

Once leads and indicative timescales are agreed, the lead organisation(s) will be responsible for delivering a more detailed implementation plan (as shown in annex 1).

This will provide more detail on what the aim of the work is, and will address the questions set-out in section 3.2.

It should be noted that many of the identified tasks (e.g. monitoring of hazardous substances) cut across media, and the implementation plans should make the links between environmental media, and not be constricted to freshwater.

The implementation plan will then be discussed with the FWMAP group, who will provide advice and guidance to the lead. The FWMAP will report progress and any issues to the CAMERAS co-ordination group.

ANNEX 1; EXAMPLE TEMPLATE FOR IMPLEMENTATION PLAN

Below is an example of how an implementation plan should be written. Note that this is for illustration only.

1.0 Aim – why monitoring is required

To provide data to model current and future river temperatures across Scotland and assess temporal trends.

In detail, this monitoring will:

- Provide the data to allow the modelling and prediction of temperatures and temperature change across Scotland
- Provide evidence to direct effective mitigation for temperature extremes under climate change, for fishery and other interests
- Contribute to the understanding of the links between changing riverine temperature, hydro-chemical processes and biological responses
- Identify the impacts of changing water temperature on ecological communities,
- Provide evidence to direct work to revise regulatory standards.

This should be a representative monitoring network for the deployment of temperature sensors. Deploying sensors throughout the identified network is likely to be phased, depending on the resources available.

1.1 What should be monitored, how and where

River water temperature should be monitored at a representative network of sites. The choice of sites should be established through research that considers landscape controls on stream temperature and scales of temperature variability. The accuracy and precision of the data should allow overall changes in water temperature across Scotland to be detected. The majority of the data will be collected using temperature data loggers, allowing multiple assessments to be made per day.

Monitoring effort (installing and calibrating/maintaining sensors, and downloading data) will be shared between MSS and SEPA, with potential outsourcing to local fisheries boards or trusts.

1.2 What monitoring methods will be used?

The intention is to use relatively cheap but accurate and precise temperature sensors across most of the network. These will be cross-calibrated, and their performance assessed against more expensive sensors (both in terms of accuracy and reliability, ease of use etc.). Consideration will also be given to new, inexpensive methods being deployed in North America.

1.3 Who are the main contributors

The initial requirement for a monitoring network will be developed by Marine Scotland (science) in collaboration with SEPA . The development of the network will draw on expertise from academic collaborators that MSS has worked with on extensive previous stream temperature work and will ideally be delivered through a PhD programme. Once developed, other partners can be incorporated, as appropriate.

Given the geographic breadth of the work and the importance of stream temperature for fish and fisheries, opportunities will be explored to work with local fisheries boards and trusts on the deployment and download of dataloggers deployed by MSS.

1.4 Data management and data availability

All data gathered will be shared between MSS and SEPA, and will be made publicly available. Ideally, this would be done through a Scottish Water Temperature querying tool or database, although other options, including opportunities to work with N. American collaborators who have already delivered similar technologies should be explored. The partner organisations would have the opportunity to publish from the data prior to other scientific users.

1.5 Timetable for delivery

An indicative timetable is given below – this is likely to change as the project progresses.

Action	**Deadline**
Define appropriate monitoring network (identify areas to be monitored)	October, 2013
Identify existing sites which could be used	July, 2013
Workshop to discuss cross-calibration of sensors	June, 2013
Agree method for cross-calibration	August, 2013
Agree data sharing protocol	Sept, 2013
Sensors start to be deployed (phased)	June, 2013

1.6 Opportunities for innovation and citizen science

It is hoped that some of the sensors can be deployed / downloaded by fisheries boards or trusts; their involvement in the project would reduce the burden of deploying and maintaining the sensors, and ensure local fisheries management staff were provided with accurate data on the thermal regimes of rivers in which they are interested.

The project also provides an opportunity to review the performance of relatively low-cost sensors against the more expensive sensors currently deployed by SEPA. This may lead to a change in purchasing policy.