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Shannon International River Basin District Project

Freshwater Morphology POMS Study

Final Report

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SHANNON INTERNATIONAL RIVER BASIN DISTRICT

PROJECT

Freshwater Morphology POMS Study
Final Report

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1.0 Introduction

This is the Final Report of the Freshwater Morphology Programmes of Measures and Standards (POMS) Study, completed through the Shannon International River Basin District (IRBD) Project.

Through a series of literature reviews, benchmarking with other Member States, data collection and analysis, fieldwork and consultation with river management experts; recommendations have been made on the key elements that contribute towards an overall management framework for Freshwater Morphology, and inform River Basin Management Plans. The key elements are as follows:

- Classification and Monitoring
- Risk Assessment
- Programmes of Measures for Morphology

The POMS Study Reports are listed as follows:

- Literature Review 1, 2006
- Literature Review 2, 2007
- Comparative Study of Morphological Assessment Techniques for Rivers, 2007;
- Comparative Studies of Morphological Assessment Techniques, Outcome Report, April 2007;
- Risk Assessment, Classification and Management, Outcome Report, March 2008
- Aerial Survey, Feature extraction, typology generation and development of a GIS tool to assist in Irish river and lake morphological assessment, 2008.
- Assessment of the Risk of Barriers to Fish Migration in the Nore Catchment, 2008
- Existing Policy and Legislation Review, 2008;
- Cost Effectiveness and Feasibility of River Enhancement Schemes, 2008;
- Irish Fisheries Recovery Dataset Provision, 2007;
- Channelisation Recovery Assessment, 2007;
- Best Practice Measures Toolkit;
- Recommendations on Programmes of Measures Report; 2008

A technical steering committee was commissioned at the outset of the POMS Study to review all work and provide technical input. The Steering Committee comprised the following members:

- Dr Colin Byrne (Chair), Department of Environment, Heritage and Local Government
- Enda Thompson, Shannon IRBD Project Coordinator
- John Lucey, Environmental Protection Agency
- Mary Toland, Northern Ireland Environmental Agency
- Nathy Gilligan, Office of Public Works
- Dr Martin O'Grady, Central Fisheries Board
- Jim Ryan, National Parks and Wildlife Service
- Dr Aine O'Connor, National Parks and Wildlife Service

- Dr Phil Mc Ginnity, Marine Institute
- John O'Keeffe, Department of Agriculture, Fisheries and Food
- Dr Paddy Boylan, Loughs Agency
- Mark Diamond, UK Technical Advisory Group and Environment Agency

All POMS Study reports are currently available on the WFD POMS Tracker www.nsshare.com and will be publicly available following the publication of the draft River Basin Management Plans in December 2008.

This report outlines the key recommendations for each element in freshwater morphology management for the Water Framework Directive (WFD); classification and monitoring, risk assessment, and Programmes of Measures.

2.0 Classification and Monitoring

Morphological Assessment for WFD is undertaken with the objective of classifying waterbodies as high, good, moderate, poor, or bad morphological status. The morphological status of a surface waterbody should support ecological status. In accordance with WFD, a waterbody cannot be classified as high ecological status, if the morphology status is not high. Therefore morphological assessment is an important part of the overall classification process.

Prior to the introduction of the WFD, classification and monitoring of morphological condition was not systematically undertaken in Ireland. Therefore a methodology had to be established to provide a field survey and associated scoring system to allow classification of morphology in terms of WFD status. The main output of this is determining if morphology status supports overall High Ecological Status. It is also important in confirming impact of morphology pressures acting on waterbodies.

Trials of field techniques developed in the UK were undertaken at sample sites across Ireland and Northern Ireland. The methods trialled were:

1. *Morphological Impact Assessment System (MImAS),* used by the Scottish Environmental Protection Agency (SEPA);

2. *Rapid Assessment Technique (R.A.T.),* developed through the North South Shared Aquatic Resource Project for assessment of Irish rivers;

3. *River Habitat Survey (RHS)*, used by Environment Agency (England and Wales) and Northern Ireland Environment Agency.

Scores obtained in the field were compared with assessments made by UK and Ireland based river management experts in hydromorphology, biology and fisheries. A national workshop was held to discuss the trial and to gain feedback from main stakeholders[1].

The recommendations made are as follows:

- R.A.T is to be used as the classification tool for river morphology. Amendments to the technique were made by EPA and NIEA. The tool is now adopted and in use for WFD Surveillance Monitoring by both Agencies. [1]

- Remote sensing is to be used where possible to supplement and augment the classification process. A morphological database has been compiled to drive a decision support tool. Data collection and tool development is to continue, to increase the applicability of the remote sensing function and increase efficiency of morphological assessment over time. [2]

Further recommendations in relation to classification and monitoring are [3]:

- Sampling strategies for Surveillance Monitoring should be developed in the context of the overall waterbody. This may involve R.A.T surveying several sites within a waterbody to ensure a representative score.

- Research into methodologies on developing representative sampling strategies is recommended.

- The CBAS survey (technique for recording and scoring sites based on macrophyte presence, diversity and abundance) may be considered as a useful supplement to R.A.T surveys in morphology monitoring, particularly the Substrate Impact Metric, since it is a useful indicator of negative impact caused by siltation.

3.0 Risk Assessment

GIS based risk assessments were undertaken in 2005 under Article 5 of the WFD, Characterisation. The aim of this work was to quantify the key pressures acting on waterbodies that could place them at risk of failing to meet Good Ecological Status by 2015. The morphology risk assessment for freshwaters consisted of:

- Channelisation – using OPW Drainage Scheme and Drainage District GIS layers
- Embankments – using OPW Embankments Layers
- Water regulation – using datasets depicting the location of locks and weirs
- Intensive Land Use- using Corine 2000 land use GIS layer for forestry, urban fabric, exploited peatlands, and arable land.

Since morphological impact had not been historically monitored, there was uncertainty as to the pressure thresholds that should be applied, above which a waterbody would be considered at risk. Expert judgement based guidance from the UK Technical Advisory Group was used to establish tentative thresholds, resulting in four risk based categories:

1a – at risk
1b – probably at risk
2a – probably not at risk
2b – not at risk

The greatest uncertainty with thresholds applied was associated with channelisation. It was considered that rivers can recover post channelisation, although evidence was not available to support this. As a consequence, the risk assessment threshold for channelisation was capped at 1b – "probably at risk" using a figure of 15% *.

The results of the morphology risk assessment in 2005 indicated that channelisation and intensive land use were the most significant pressures placing waterbodies at risk. Given the degree of uncertainty with the thresholds applied, a key objective of this POMS Study was to test the thresholds by comparing field based impact data with pressure extent and subsequently refine the risk assessment.

A pilot study was undertaken whereby morphology scores (R.A.T.); biology scores (macroinvertebrates and macrophytes) were obtained at sample sites with known channelisation and intensive land use pressures. Sample sites also included sites with no pressures acting, so that a range of results could be analysed. Fieldwork was undertaken over two summer/autumn periods. A second national workshop was held for key stakeholder groups to discuss the pilot study, and to address issues raised. [1,3]

The recommendations in relation to the channelisation and intensive land use risk assessments are as follows:

* 15% denotes percentage of total river length drained. Given the uncertainty with the risk assessment in 2004, rivers with greater than 15% of river length drained was called "probably at risk" as opposed to "at risk"

3.1 Channelisation Risk Assessment [3]

- It is recommended that the pressure threshold between 'at risk' and 'not at risk' is increased 'from 15% to 50%.

- Lowland meandering and pool riffle rivers are more sensitive to channelisation pressures. Whilst it could be argued that a higher threshold (less stringent) between good status and less than good status could be applied to upland rivers it is recommended that 50% is applied throughout since the majority of rivers subjected to drainage are lowland meandering and pool riffle.

- A GIS based tool for depicting channel typology at frequent intervals may be used to differentiate between channel types for inclusion in the risk assessment.

- Whether a channel is maintained or not should be accounted for in the risk assessment. A higher (less stringent) threshold should be applied to rivers that are not maintained. However maintenance records on a national or RBD level are not readily available at present. Improvements on this dataset should be made and stored within a morphological alterations database with a view to refining the risk assessment further in the second RBMP cycle.

- The lowest gradient rivers (<0.2%) generally score a WFD class (R.A.T score of 0.2) behind lowland rivers within the 0.2-0.5% slope category. Since R.A.T is the chosen surveillance monitoring method for EPA and NIEA it was recommended that it is modified to account for this in the survey i.e. very low gradient rivers should be scored accordingly, by noting that the reference condition for these rivers is different to higher slope rivers.

- Research into the reference condition of low gradient rivers should be undertaken with a view to further refining the R.A.T scoring system and risk assessment methodology.

Note:
It should be noted that these recommendations were made to NIEA and EPA who have advised that the issue of channel slope is being accounted for in the modified version of R.A.T that has been used for surveillance monitoring purposes in 2008.

3.2 Intensive Land Use Risk (ILU) Assessment Recommendations[3]

- The current ILU risk assessment methodology is too crude to provide any meaningful identification of waterbodies that may be at risk and as such, is not effective in serving this purpose.

- The comparison of percentage ILU within a waterbody with R.A.T scores on the ground revealed no meaningful relationship.

- It is recommended that the ILU element of the morphology risk assessment is omitted.

- However, the fact remains that several river waterbodies will require improvement measures to address ILU pressures such as forestry, peat exploitation, urbanisation and agriculture. These must be identified for the inclusion of appropriate measures in RBMPs.

- These measures, and the waterbodies requiring them, are all identified in other national PoMS Studies and will be included in RBMPs as measures to address problems such as siltation, substrate damage, loss of riparian zones and cattle poaching.

- Measures to address areas of known impact, such as overgrazing should be included in the RBMPs by utilising expert judgement from the PoMS Study technical steering committee.

- Research into the development of a more detailed, but practical GIS based risk assessment method is recommended.

3.3 GIS Based Risk Assessment Results

The refined threshold for channelisation (50%), and the omission of the ILU assessment, was applied in the new 2008 morphology risk assessment. In addition, GIS based updates to the OPW datasets used were undertaken to improve the accuracy of the pressure extent calculations and further refine the results.

Figure 1 indicates the 2005 channelisation risk assessment in comparison with the 2008 risk assessment.

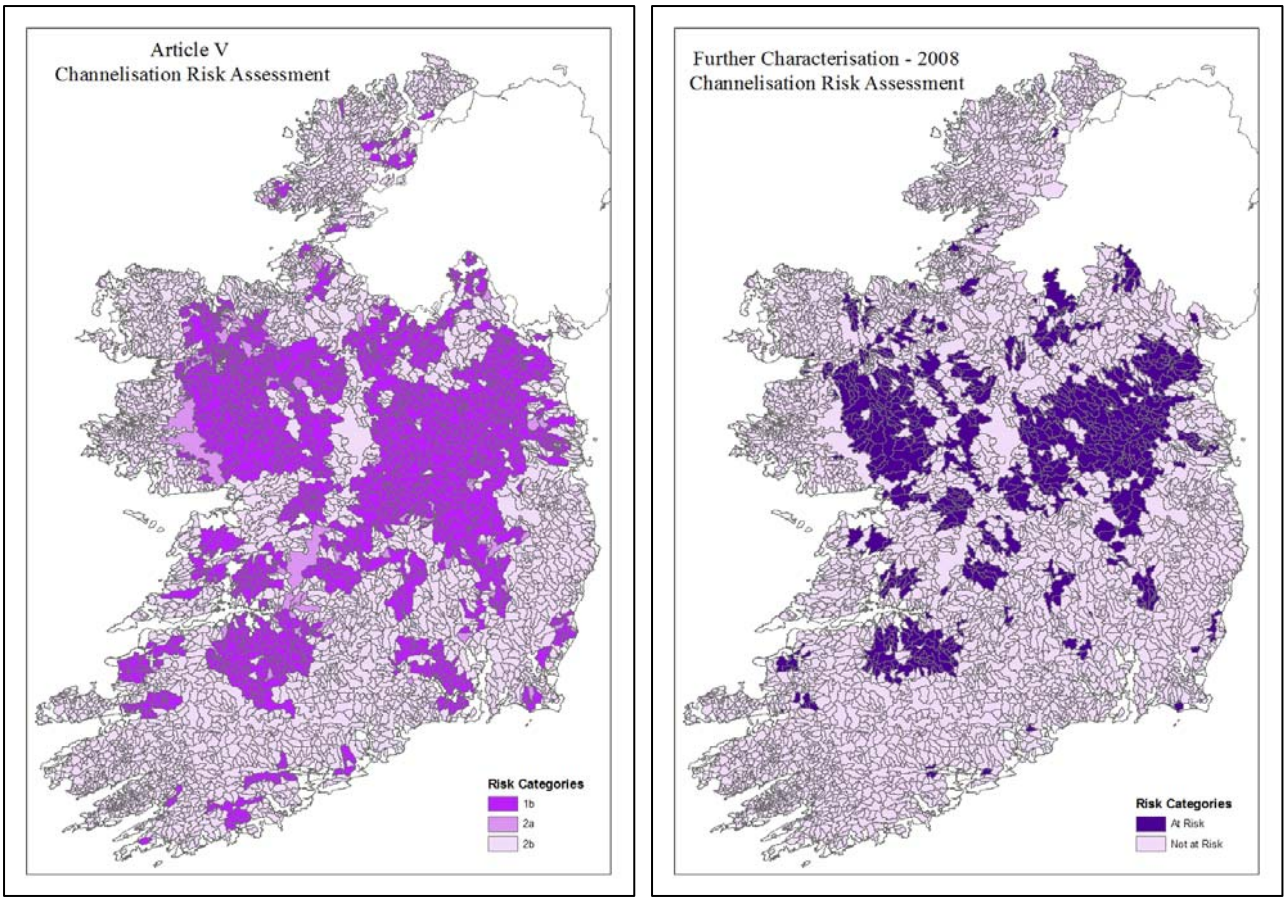

Figure 1: Article 5 and 2008 (Further Characterisation) Channelisation Risk Assessment

The cap of 1b "probably at risk" no longer applies. The results are now categorised into "at risk" and "probably at risk". The total number of "at risk" waterbodies due to channelisation has been reduced from 1048 to 580. Table 1 indicates the breakdown of these results per River Basin District (RBD).

Table 1: 2008 Channelisation Risk Assessment Results per RBD

RBD	Total No. River Waterbodies (Incl X Border)	No River Waterbodies at risk due to channelisation	% No. Waterbodies at risk due to Channelisation
ERBD	356	94	**26**
NWRBD	701	28	**4**
WRBD	951	150	**16**
SWRBD	885	9	**1**
SHIRBD	879	225	**26**
SERBD	655	38	**6**
NBIRBD	93	36	**39**

These results plus the omission of the ILU assessment have been incorporated into the overall risk assessment results for morphology as indicated by Figure 2.

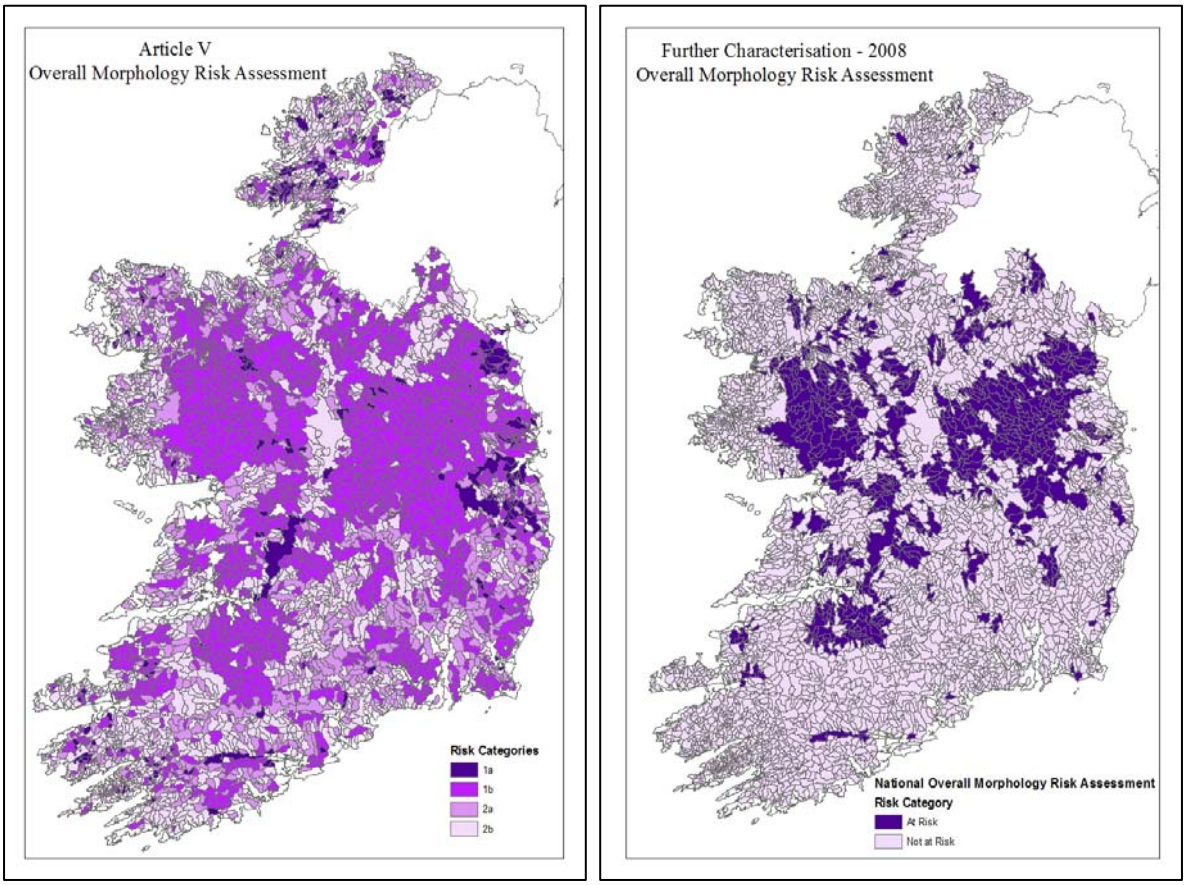

Figure 2: Article 5 and 2008 (Further Characterisation) Overall Morphology Risk Assessment (channelisation, embankments, water regulation)

The total number of waterbodies “at risk” has been reduced from 1720 to 618 overall.

3.4 Additional Risk Assessments

The POMS Study also identified additional pressures that should be accounted for in the morphology risk assessment, to ensure that appropriate measures to address them are included in River Basin Management Plans.

3.4.1 Overgrazing

Whilst the GIS based approach to ILU was not considered robust enough, overgrazing was highlighted as a significant ILU pressure that must be addressed, since it is not being addressed through other Programmes of Measures (i.e. Forestry, Urban related pressures or peatlands). Central Fisheries Board was consulted to identify “at risk” waterbodies using their expert knowledge and experience.

142 waterbodies were identified in the Western River Basin District as indicated by Figure 3.

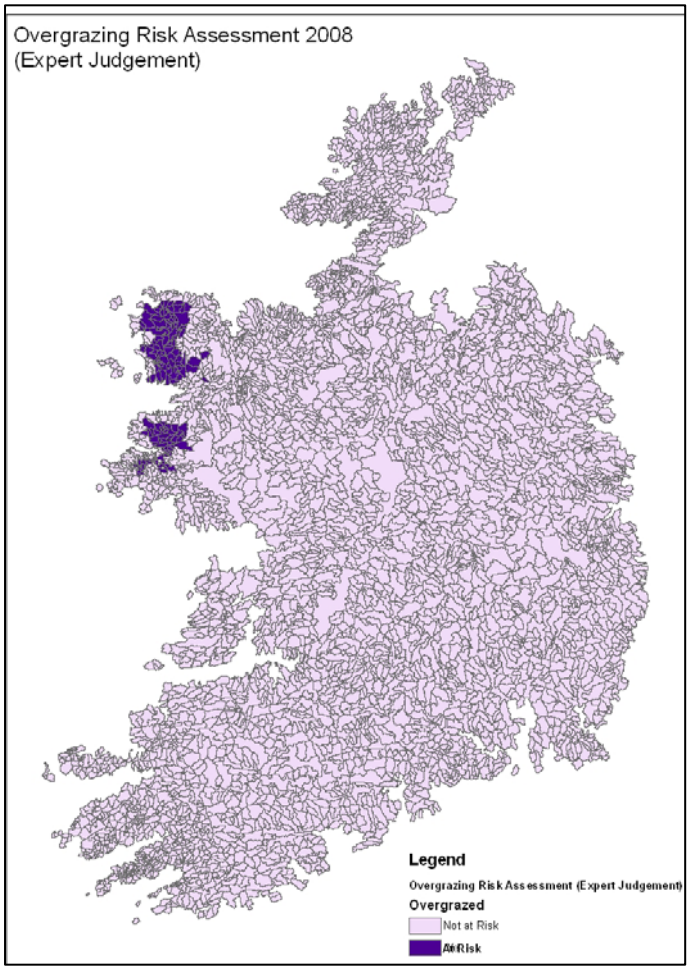

Figure 3: Waterbodies at risk due to Overgrazing

The intensity of overgrazing has reduced in recent years due to measures such as de-stocking programmes. Whilst it is still a pressure, it is considered that enhancement schemes could be applied to these river waterbodies to re-stabilize eroded banks and sedimentation regimes, since the extent of the pressure has been reduced.

The river names and associated overgrazed catchments are illustrated by Figure 4. The catchments and sub catchments include Corrib, western part of Moy, Erriff, Dawrow, Srahmore, Bunowen, Carroniskey, Bundorragh, Owenmore, Owenduff, Glenamoy, Newport, and Ballynahinch.

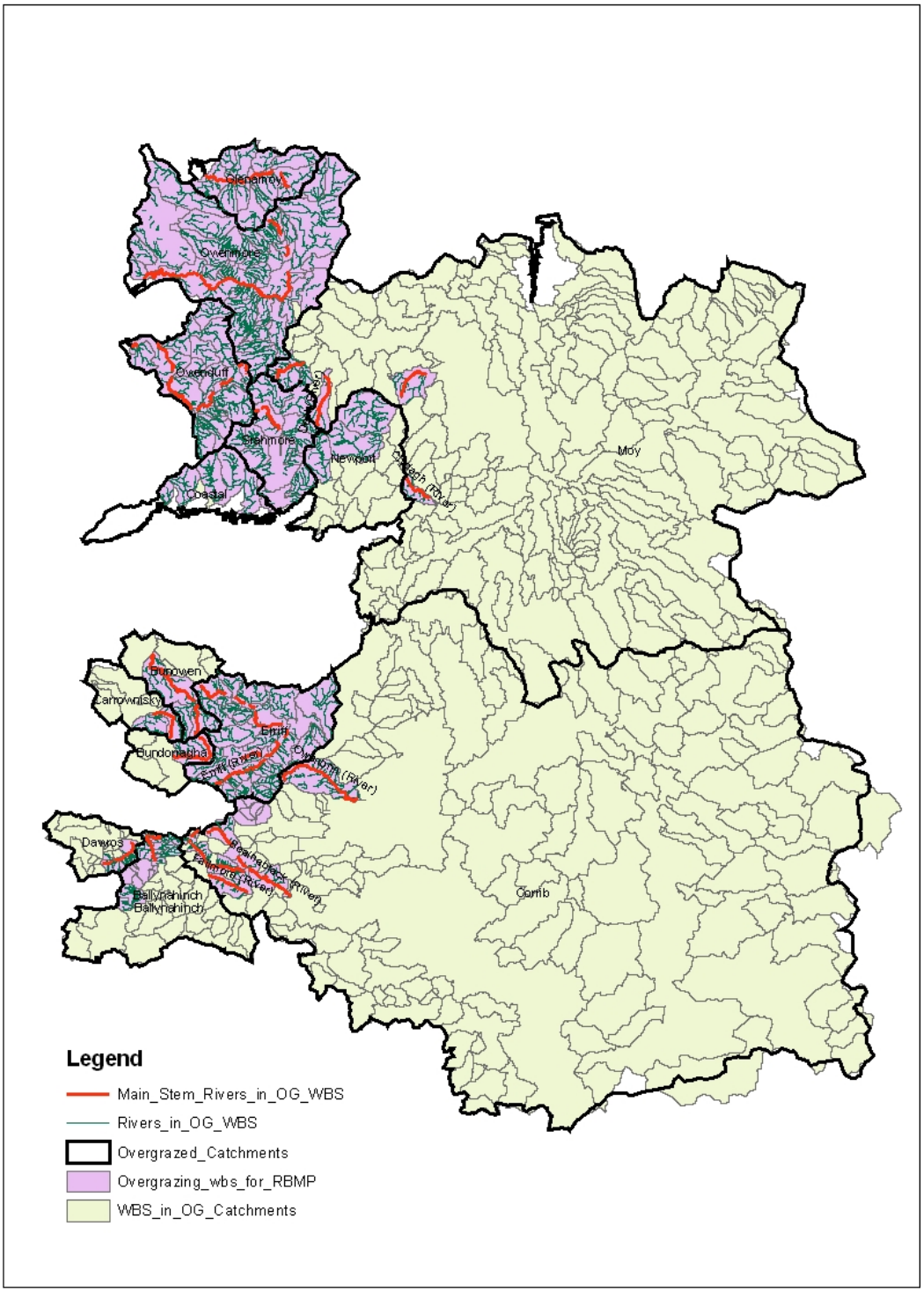

Figure 4: Overgrazing – Catchments and River Names

3.4.2 Barriers to Fish Migration [4]

In stream structures such as weirs, bridge aprons and culverts can impede or prohibit the passage of migratory species, and hinder their life cycle. Assessing this risk, involves a combination of 2 key elements:

1. Assessing the impassibility of the structure itself
2. Assessing the potential loss by quantifying fish presence and the location of spawning and nursery habitats upstream of the structure, to determine if access is being gained or not.

A methodology combining these elements in a GIS based risk assessment was not available for application. The POMS Study commissioned Central Fisheries Board to work on a case study on the Nore Catchment, which had been initiated by the Southern Regional Fisheries Board.

The Study has identified high risk barriers to migration within the Nore Catchment and made recommendations for national roll out of a risk assessment as follows:

- Undertake field survey of all potential barriers and classify the risk of preventing upstream migration for each fish species
- Ground truth this field assessment by electro-fishing and determine the relative abundance of fish species relative to other catchment sites
- Map the potential for spawning throughout the catchment. Further mapping of productive nursery habitat is also desirable
- Map the physical catchment chrematistics (i.e. gradient, stream order, geology) relative to the target species
- Map the quality of the habitat in terms of water quality, habitat quality, habitat use, (afforestation, lakes, Special Areas of Conservation, etc)
- Undertake risk analysis by species based on the criteria set out (i.e. presence of spawning potential, gradient, etc)
- Re-classify barriers for each species based on the results of the risk analysis
- Determine the potential gains (length of channel, quantity of wetted area, quantity of prime habitat) of achieving fish passage
- Undertake a cost/ benefit analysis after prioritizing barriers for remedial works
- Undertake an analysis of the priority barriers based on a multi-species approach to achieve maximum benefit
- Prepare list of priority candidate barriers for remedial works

The Nore Catchment Case Study has undertaken the aforementioned steps, with the exception of cost/benefit analysis and subsequent prioritisation. Barriers have been identified which when assessed through field survey and combined with fish data, are confirmed as high risk since spawning areas are available upstream and are not accessible. Figure 5 indicates the high risk barriers within the Nore Catchment.

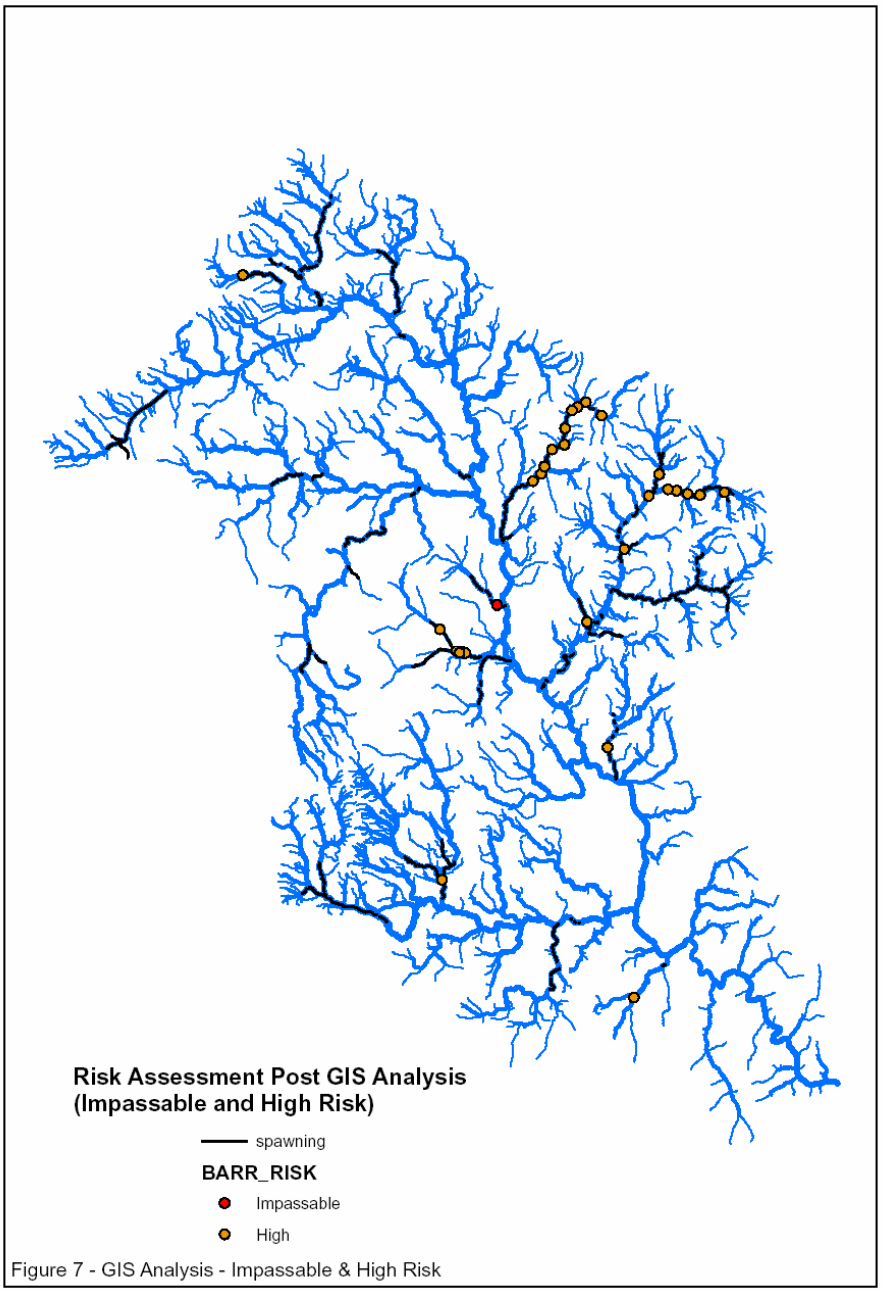

Figure 5: Impassable and High Risk Barriers in Nore Catchment (CFB, 2008)

These barriers should be further investigated in River Basin Management Plans i.e. apply technical feasibility and economic tests (refer to Chapter 4.0).

4.0 Programmes of Measures for Freshwater Morphology [5,6]

4.1 Basic Measures

Basic Measures apply to all waterbodies and consist of legislative measures to control impact to waters. In the case of freshwater morphology, existing legislation does not achieve this [6]. Therefore additional basic measures in the form of risk based regulations are recommended. Recommendations for this are as follows:

- Existing regulations / and acts should be fully enforced for all surface waters including Planning and Development Environmental Impact, Arterial Drainage, Fisheries, Agriculture and IPPC.

- DEHLG to establish and implement new risk based regulations to control physical modifications including codes of practice, and varying levels of authorisation – registration / notification and licensing.

- Based on Section 53 and 54 of the EPA Act, 1992 it is recommended that EPA become the regulating body, particularly in relation to higher risk activities since morphological assessment is relatively new and the relevant expertise may be restricted. Splitting responsibility by assigning regulation of lower risk activities to Local Authorities is also an option.

- Morphological assessment of applications within the regulation process should make use of risk assessment information from 2008 and allow re-run of the risk assessments based on the proposed activity for a particular waterbody. This will enable assessment of the change in risk to status by increasing a particular pressure. R.A.T surveys and remote sensing techniques should also be used where the data is available. These assessments should be undertaken using a decision support tool driven by a morphological database.

- Activities related to abstractions should be regulated under the proposed Abstraction Regulations for which recommendations will emerge through the Eastern River Basin District Abstraction POMS Study.

The proposed regulatory process is illustrated by Figure 6.

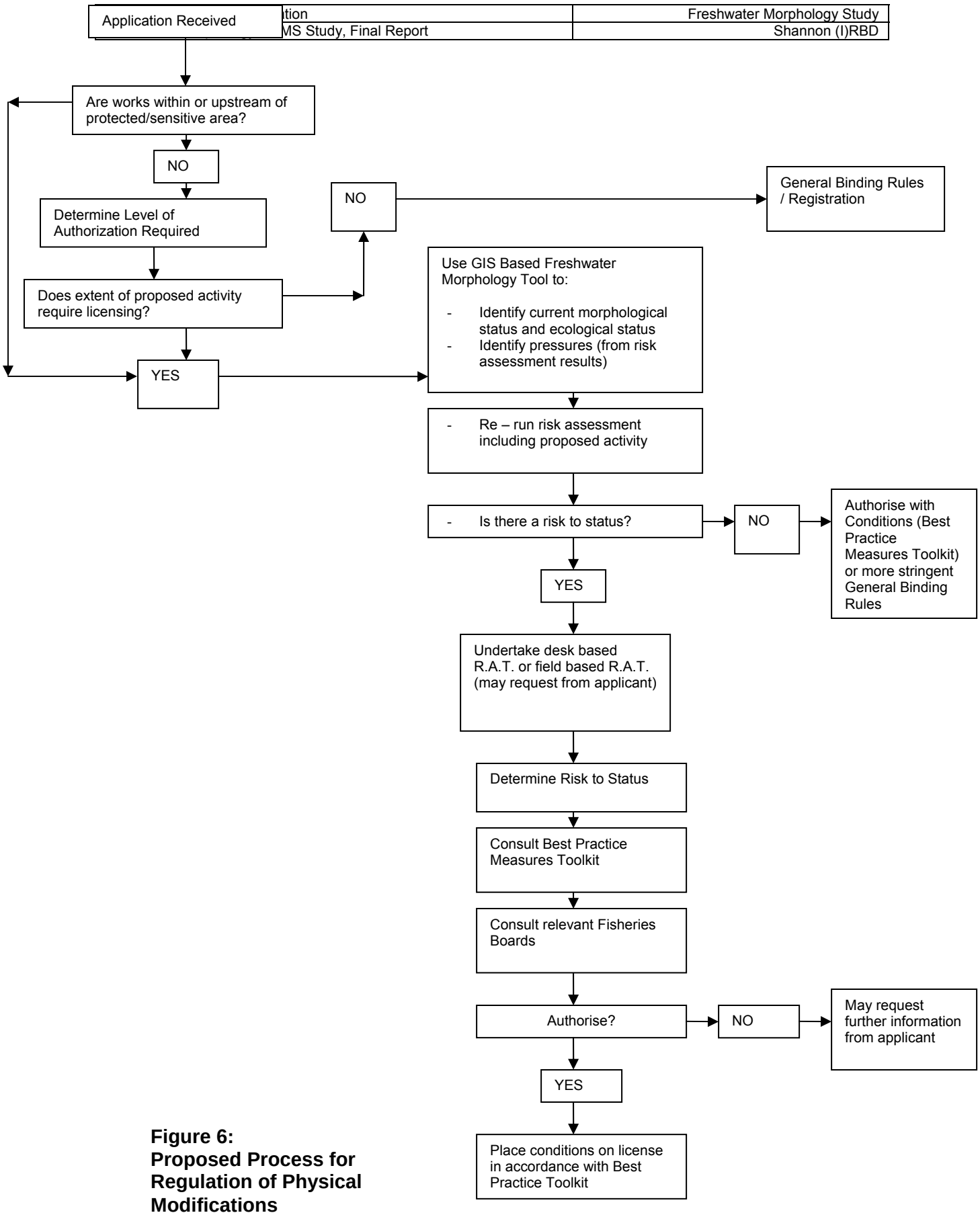

Figure 6:
Proposed Process for Regulation of Physical Modifications

4.2 Supplementary Measures

Whilst fully implemented basic measures will achieve control on future physical modifications, thereby controlling impact, there are waterbodies for which historical impacts need to be addressed. Supplementary measures are required in these cases to restore Good Status.

Reduction of pressures can be achieved by applying codes of practice when undertaking works with rivers and lakes, and by managing land use practices.

Remediation works may be applied to assist recovery and restore good status.

The process by which supplementary measures are assigned to impacted waterbodies is illustrated by Figure 7.

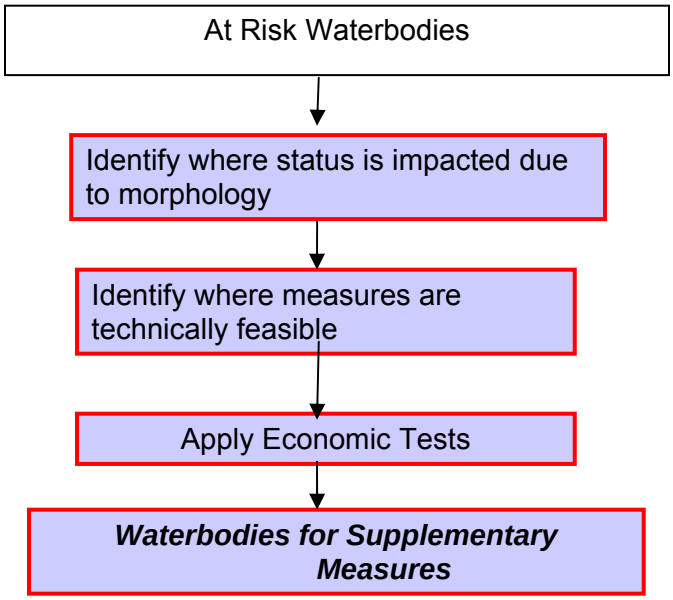

Figure 7: Identifying Supplementary Measures for Freshwater Morphology

Using the results of the risk assessments (refer to Chapter 3.0), a step by step process in determining impact, technical feasibility and cost-effectiveness is required to confirm supplementary measures.

4.2.1 Confirming Impact to Status

The risk assessment indicates where pressures are likely to be impacting on status. This needs to be confirmed by the waterbody status results. In terms of morphology impact, biological Q scores may provide a short term indication, but fish status is considered the key element in indicating status change. [7,8] Furthermore, Q status must be at least moderate to confirm that the impact to status is due to morphology pressures, and not pollution pressures.

At present, a classification tool for assigning fish status to waterbodies has not been established. As an interim solution, fish status has been assigned to 500 waterbodies across Ireland using a combination of electro-fishing data and expert judgement.
Of the waterbodies at risk due to channelisation and embankments, 11 waterbodies can be confirmed as impacted using fish status and Q status as described above. The remaining at risk waterbodies require investigation to confirm morphology status, fish status and/or Q Status before appropriate supplementary measures can be assigned.

4.2.2 Technical Feasibility of Supplementary Measures

A Best Practice Measures toolkit has been produced through the PoMS Study.[5,9] The toolkit outlines the morphological pressures, the associated sub-pressures and the available measures that may be employed to address them. There are 23 measures in total. The 23 measures range in scope from large scale, such as re-meandering of straightened rivers, to more operational measures such as adopting OPW's Environmental Drainage Maintenance Guidelines, to linking with more high level measures such as Rural Environmental Protection Schemes (REPS). This toolkit is the first point of reference in choosing appropriate supplementary measures.

River enhancement schemes are considered the most appropriate supplementary measure in assisting recovery from channelisation and overgrazing pressures. They can be applied at varying degrees of work involved. In terms of technical feasibility, recommendations are listed below based on work undertaken through the POMS Study in conjunction with OPW and CFB [8,10].

- A river steeper than 3% will not exhibit productive results in terms of fish if enhanced. It is too steep to retain gravels placed on the bed, and the energy levels are too high;
- Stream gradient lower than 0.2% (2m / km) is not suitable for enhancement;
- Rivers with Biological Q value less than Q3 are unsuitable (moderately polluted or worse)
- In OPW drained rivers, a minimum flow conveyance of 1 in 3 year flood must be maintained, therefore all enhancement features must be at a low level within the river so as not to reduce channel capacity at high flows
- Enhancement programmes are not as effective in channels with catchment areas ≤ 4.5 km^2

In determining technical feasibility of enhancement schemes, a screening process incorporating these recommendations is required.

A GIS layer indicating slope suitability at a river segment level has been produced through the POMS Study. This has been issued to Central Fisheries Board so that it can be aligned with their work of a similar nature through the OPW Enhancement of Drained Rivers Programme. It is recommended that further research into accurately calculating river slope is undertaken to continuously improve desk based approaches to morphological assessment and management.

In terms of determining background pollution, this information is not always available for specific rivers under consideration. It is recommended that further investigation is undertaken to collect this data as similarly outlined in Section 4.2.1.

Whilst GIS based screening to determine suitability is possible when the necessary data is available, it is recommended that ground-truthing and baseline surveys are undertaken prior to the undertaking of enhancement schemes[7].

4.2.3 Economic Tests

Economic tests are the last step in confirming supplementary measures. Economic Consultant's Goodbody's are developing a method to calculate the cost effectiveness of measures using:

- Time taken to achieve good status
- Incremental steps (improvements) towards achieving good status
- Initial costs (capital costs)
- Recurring costs (maintenance and monitoring)

The Freshwater Morphology POMS Study has assisted Goodbody's by providing example case studies addressing channelisation, overgrazing and barriers to migration pressures. These examples were complied using an average cost per kilometre of a typical enhancement scheme, based on practical experience of OPW and CFB, as approximately €34,375.00 [10]. This includes a 25% addition for life cycle costing.

Goodbody's are producing a Cost Effectiveness Guidance Manual for use by Local Authorities in developing supplementary measures.

4.3 Results for Supplementary Measures

The range of supplementary measures to be put forward for consideration in River Basin Management Plans is as follows:

Reduction
S1 - Codes of Practice (Best Practice Toolkit) – applies nationally

S2 – Support for voluntary initiatives such as wetland schemes – applies nationally

Remediation – focus on "At Risk" waterbodies
S3 – Impact on status due to channelisation/embankments confirmed, enhancement schemes to be considered

S4 – Impact on status due to channelisation/embankments not confirmed, further investigation required

S5 – Overgrazing – identified and impact on status confirmed by expert judgement, enhancement schemes to be considered

S6 – Barriers to Migration – identified and impact on status confirmed by CFB and SRFB through Nore Case Study

S7 – Barriers to Migration – investigation required to identify risk and confirm impact on status.

Table 2 indicates the number of waterbodies per Supplementary Measure in each RBD.

Table 2: Supplementary Measures per RBD

Supplementary Measure	ShIRBD	SERBD	SWRBD	ERBD	WRBD	NWIRBD	NBIRBD
S1	All	All	All	All	All	All	All
S2	All	All	All	All	All	All	All
S3	2	0	0	2	7	0	0
S4	208	33	8	85	132	25	36
S5	0	0	0	0	142	0	0
S6	0	117	0	0	0	0	0
S7	All	538	All	All	All	All	All

A database specifying waterbody codes within each RBD has been developed to provide input to RBMP and Programmes of Measures development.

WFD monitoring for 2009 should focus on the waterbodies under S4 so that the necessary data can be gathered to confirm status, particularly fish status. This will enable more waterbodies to be considered under S3. Risk assessment on Barriers to Migration should be rolled out nationally.

5.0 Conclusions

The WFD has presented the need for a management framework for freshwater morphology in Ireland. The necessary elements of classification and monitoring, risk assessment, and programmes of measures have all been developed through the Freshwater Morphology POMS Study.

The Rapid Assessment Technique (R.A.T.) has been established as a classification tool for determining morphological status. This has been adopted by both EPA and NIEA, promoting a consistent cross-border approach.

The Article 5 morphology risk assessment has been updated. The threshold for channelisation was increased from 15% to 50% based the results on a Pilot Study which compared observed morphological impact with pressure extent.

The Intensive Land Use risk assessment has been omitted, with necessary measures to address this pressure identified through other national POMS such as forestry, urban pressures and peatlands. In addition, overgrazing which adversely impacts sedimentation regimes has been identified as a key pressure through expert judgement. At risk waterbodies have been delineated and recommended for inclusion in RBMP's.

In stream structures causing barriers to migration has also been included as a key pressure. A risk assessment method has been developed using the Nore Catchment as a case study. This should be rolled out nationally to determine risk.

The results of classification, monitoring and risk assessment have informed the development of Programmes of Measures for morphology. New risk based regulatory controls are recommended as an additional basic measure to manage future physical modifications to rivers and lakes.

Where historical impact needs to be addressed to restore good status, supplementary measures using the ethos of pressure reduction, and remediation have been proposed. A best practice measures toolkit has been developed as a guide to the types of measures available to address various pressures and sub-pressures.

In terms of WFD monitoring, the POMS Study has provided a focus on where monitoring should be undertaken so that the necessary supporting data is available to confirm impact on status where morphology pressures are acting; justify the application of measures; and increase the potential of desk based remote sensing, by increasing the volume of data within the newly developed national morphology database and decision support tool. Confirmation of fish status in 'at risk' waterbodies is of particular importance.

The relationship between morphology and the effect it has on ecological status is not fully understood across Member States. The need for research into this area remains. Similarly, there is a need for research into an appropriate intensive land use GIS based risk assessment, and further refinement of the channelisation risk assessment, accounting for factors such as watercourse maintenance, and channel typology. It is important that the morphological assessment framework developed through this Study is continuously reviewed and refined through research and data collection.

6.0 References

1. Comparative Studies of Morphological Assessment Techniques, Outcome Report, RPS, 2007.

2. Aerial Survey, Feature extraction, typology generation and development of a GIS tool to assist in Irish river and lake morphological assessment, Compass Informatics and RPS, 2008.

3. Risk Assessment, Classification and Management, Outcome Report, RPS, 2008

4. Assessment of the Risk of Barriers to Fish Migration in the Nore Catchment, CFB October 2008

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