EU WATER FRAMEWORK DIRECTIVE
MANAGING FRESHWATER MORPHOLOGY IN IRELAND

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1.0 Introduction

Systematic monitoring of morphology conditions and control of physical modifications to rivers is a relatively new discipline in Ireland. The EU Water Framework Directive (WFD) has introduced hydromorphology as a supporting element to Ecological Status raising its profile within water quality management and, presenting a need for a management framework that will ensure compliance with WFD objectives.

Figure 1 illustrates the role of hydromorphological elements in determining ecological status according to the WFD.

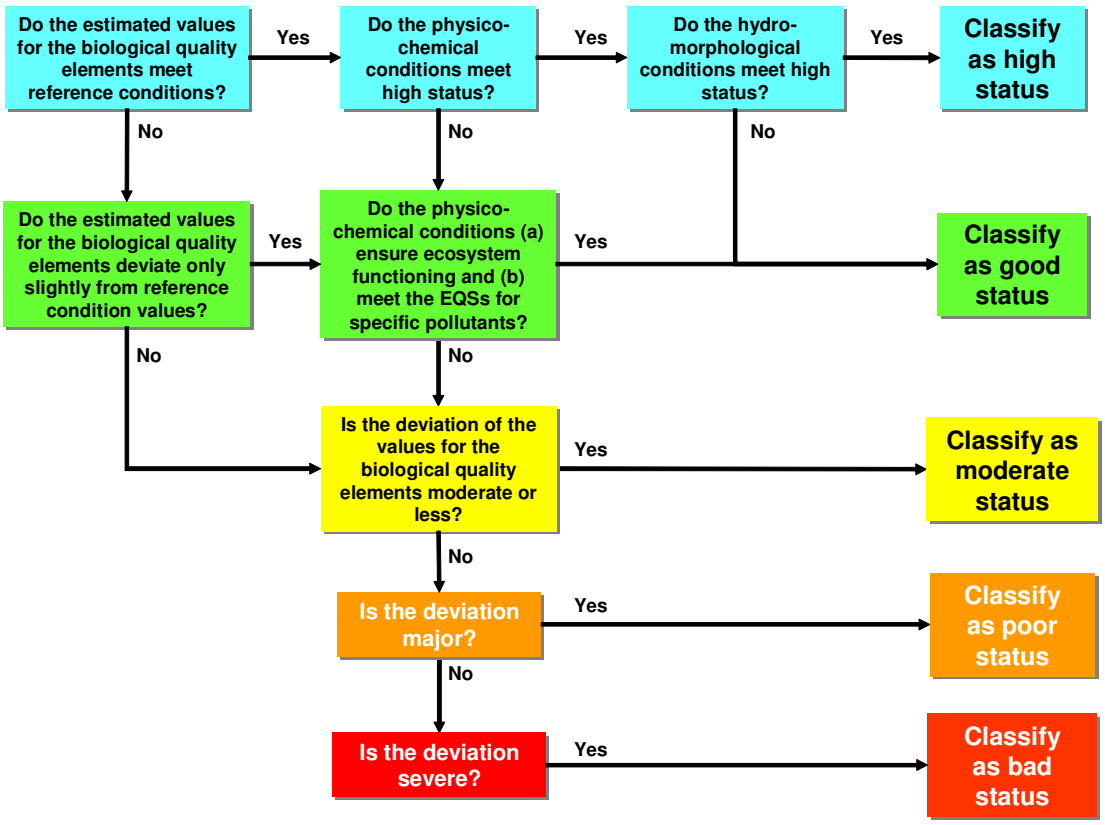

Figure 1: Hydromorphological elements contribution to 'ecological status' (Source: UK Technical Advisory Group)

A waterbody cannot be classified as High Ecological Status unless the hydromorphological conditions are also high. In addition, if the overall status of a waterbody has been impacted by morphology, measures must be taken to restore good status, generally by 2015.

A national Freshwater Morphology 'Programmes of Measures and Standards' Study (hereafter termed "PoMS Study") was commissioned through the Shannon International River Basin District (IRBD) Project in 2006 to develop a management framework, and to provide a technical basis on which morphology Programmes of Measures within River Basin Management Plans could be prepared.

The PoMS Study was guided by a Technical Steering Group comprising members from the following organisations:

- Office of Public Works
- Environmental Protection Agency
- Department of Environment, Heritage and Local Government
- Northern Ireland Environment Agency
- Marine Institute
- Department of Agriculture, Fisheries and Food
- National Parks and Wildlife Service
- Loughs Agency
- UK Technical Advisory Group (UK TAG)

This paper outlines the key areas addressed through the Study and the recommendations made in relation to future morphology management.

2.0 Management Framework for Morphology

The key elements in a management framework are:

- Identification of key pressures that could be impacting waterbodies
- Field based or Remote Monitoring and Assessment to observe impact
- Application of improvement measures where needed
- Control or Regulation of future pressures to minimise future impact
- Decision Support Tool to store relevant data and aid decision making

In terms of freshwater morphology, all of these elements required development through the PoMS Study.

2.1 Development of a Technique for Assessing Morphology in the Field

No field based survey method was in use in Ireland prior to the introduction of the WFD. Since classification of morphological status is required for WFD reporting (refer to Figure 1), a field technique and an associated scoring system had to be established for use by the Environmental Protection Agency (EPA) within WFD monitoring programmes and to determine impact on the ground to confirm where morphological measures are needed.

Trials of existing methods currently used within the UK were undertaken. The methods investigated were:

1. Morphological Impact Assessment System (MImAS), used by 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

MImAS is an impact assessment tool to support river engineering regulatory decisions and classification. The term MImAS refers to an overall assessment procedure which includes a field survey to collect pressure data where needed. Both the channel zone and riparian zone are assessed separately in terms of the river's capacity to accept further morphological change.

R.A.T. is a field technique, developed in light of the WFD, which assigns a classification for a waterbody based on the departure from reference condition for the channel type. Channel typology influences the attributes assessed in the field. The technique assigns a morphological classification directly related to that of WFD – high, good, moderate, poor and bad.

RHS scores do not equate to the WFD status classes, but record the level of modifications based on inventories of features (GeoData, 2007).

The main aim of the national trials was to test each technique in terms of the results they produce, their ease of implementation in the field, and their ability to be rolled out on a national basis in an overall morphological assessment framework.

The trials were undertaken both in Ireland through the Shannon IRBD, but also in Northern Ireland in conjunction with NIEA. The process was facilitated through fieldwork trials of the three methods, and comparison with expert judgement both in the UK and Ireland through a national workshop.

The general approach was that each survey method would be undertaken at a range of pilot river sites. The methods would be compared against each other in terms of ease of implementation and efficiency. In terms of results, the scores obtained would be compared against an expert assessment made by UK and Ireland geomorphologists and river managers. This would indicate the method which produced results most closely aligned to expert based assessments of Irish rivers.

R.A.T. emerged as the simplest, most cost effective and flexible technique in the field. This was agreed by the majority of river management experts in Ireland and Northern Ireland including representatives from the agencies responsible for WFD morphological monitoring – NIEA in NI and EPA in Ireland. It was considered most conducive to making a simple rapid assessment in the field to classify high, good, moderate or poor morphological status. It also aligned satisfactorily with expert judgement results. However modifications were made to reduce subjectivity and provide a more repeatable survey.

Further to the R.A.T. recommendation, monitoring staff in EPA and NIEA undertook training and independent trials to ensure consistency between surveyors and the results obtained. The R.A.T. monitoring system is now established. Morphological impact (i.e. deviation from reference condition) at river sites can now be observed in the field and scored as part of the WFD classification system.

2.2 Identifying Key Pressures that Could Adversely Impact Waterbody Status – Risk Assessment

Identification of where morphology pressures could be adversely impacting on waterbody status enables a more focussed approach to both monitoring and identification of mitigation measures. Pressure identification and assignment of risk to status has been undertaken using a combination of GIS assessment and expert judgement depending on the datasets and methods available. Table 1 indicates the key morphology pressures and how at risk waterbodies have been identified. However national datasets depicting the extent of certain morphology pressures in Ireland remain limited, and as such, there has been a reliance on expert judgement in some cases.

Table 1: Key Morphology Pressures and Assessment of Risk

Morphology Pressure	Description	Assessment of Risk
Channelisation & Embankments	Arterial Drainage of Rivers Flood Protection	Use of OPW GIS layers to quantify extent of pressure and apply a threshold above which a waterbody is at risk
Water Regulation	Locks and Weirs	Use of GIS layers denoting presence of water regulation structures. Waterbody at risk if present.
Overgrazing	Overgrazing of land causing disturbance to sediment regimes	Expert Judgement to identify overgrazed areas.
Barriers to Migration	In stream structures such as weirs and bridge aprons impeding migration of fish	Expert judgement using results of case study undertaken by Central Fisheries Board

Channelisation is the most significant morphology pressure in Ireland. In 2005 UK TAG had recommended that a risk threshold of 15% be applied to drained waterbodies whereby rivers with more than 15% drained length are "at risk" of failing to meet WFD objectives. This threshold was applied in Ireland and placed 1048 waterbodies at risk.

Investigation through the POMS Study involving comparison of the extent of channelisation against R.A.T. scores (denoting impact) found that this threshold was too conservative. Many waterbodies were placed unnecessarily at risk having recovered post channelisation.

Consequently, the threshold was increased to 50%, reducing the number of "at risk" waterbodies to 580. Figure 2 indicates those waterbodies with greater than 50% of river length drained, and as such require further investigation to confirm that status has indeed been impacted, and what measures should be applied to address the problem.

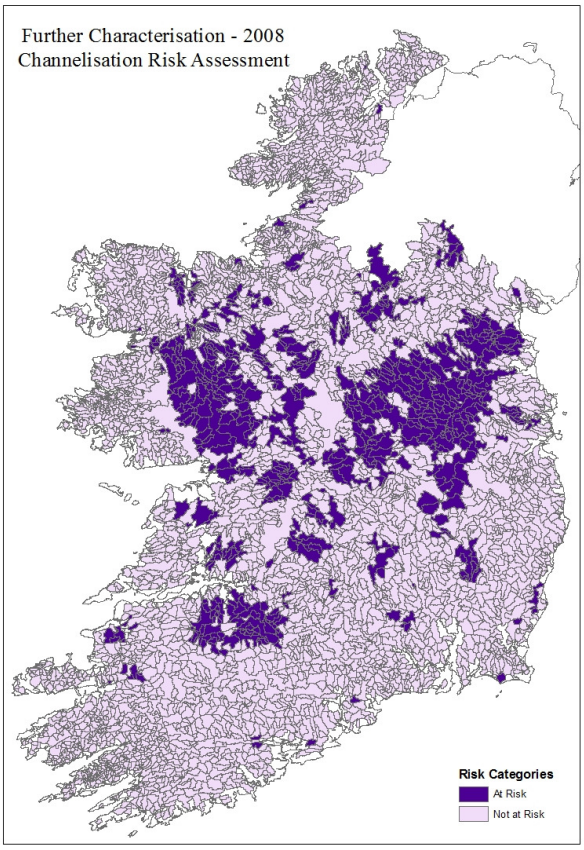

Figure 2: Channelisation Risk Assessment Results 2008

2.3 Programmes of Measures in River Basin Management Plans

The WFD requires that Member States prepare Programmes of Measures to address water quality issues within River Basin Management Plans. Having identified key morphology pressures and potential problems areas through risk assessment, then confirming that status has been impacted by these pressures, measures must be taken to address these problems.

There are two types of measures included in the Programmes:

1. Basic Measures
2. Supplementary Measures.

Basic measures apply to all waterbodies and comprise of existing directives and national legislation that protect waterbodies and prevent deterioration. In terms of morphology, there is an existing legislative gap to protect waterbodies from future impact. As a result, a new basic measure in the form of regulatory controls is required (refer to Chapter 2.4).

Even with all basic measures in place, there are cases where they do not go far enough to restore good status in areas where pressures have impacted waterbodies in the past. Further actions are required to improve morphological condition so that good status can be restored. These further actions are termed "Supplementary Measures".

The PoMS Study has developed a Best Practice Measures Toolkit which lists all of the available measures that can be applied to address a range of morphology pressures and sub pressures, (refer to Table 2). The concept of Reduce and Remediate is used to identify supplementary measures by referring to the Toolkit and where they should be applied.

Reduce – these measures involve reduction of existing land use and direct morphological pressures and also provide future control by applying codes of practice when working with rivers or their surrounding lands to ensure the direct or indirect impact is minimised.

Remediate – these measures assist recovery by applying soft engineering solutions, such as river enhancement schemes to boost physical condition and aid progress towards good status.

Table 2: Best Practice Measures Toolkit indicating measures to address Morphology Pressures and Sub Pressures (Johnston, 2007)

Pressure	Sub-pressure	Impact	No.	Measures	
Channelisation & Flood embankments	Channel alteration - straightening, deepening, widening of channel	Loss of morphological and ecological diversity	1	Re-meandering of straightened channels	
			2	Narrowing of channels	Assisted natural recovery
			3	Re-construction of pools	
			4	Substrate enhancement	
		Loss or impairment of riparian zone	5	Fencing programmes to exclude livestock	
	Flood walls and embankments	Reduced floodplain area/ loss of riparian zone and marginal habitats/ reduced connectivity with floodplain/ entrapment of sediments	6	Removal or re-location of flood banks	
	Drainage maintenance works (dredging and control of vegetation)	Loss of morphological and ecological diversity Disturbance of riverbed and banks/ mobilisation of sediments/ loss of instream and riparian vegetation	7	Application of OPW Environmental Drainage Maintenance guidelines	
			8	Incorporation of river restoration & fisheries enhancement projects (see Measures 2-4)	
			9	Measures to facilitate natural recovery	
	Hard protection - sheet piling, vertical walls	Loss of riparian zone and marginal habitats / loss of lateral connectivity / loss of sediment input	10	Removal of hard bank reinforcement / revetment, or replacement with soft engineering solution	
	Culverts	Loss of morphological diversity and habitat	11	Re-opening of existing culverts	

Table 2 (Cont'd): Best Practice Measures Toolkit indicating measures to address Morphology Pressures and Sub Pressures (Johnston, 2007)

Pressure	Sub-pressure	Impact	No.	Measures
Impoundments & Regulation	Dams & weirs	Loss of morphological and ecological diversity in impounded reach / Reduction in productivity / Accumulation of sediment upstream / Loss of sediment input downstream	12	Removal of structure and de-silting of impounded reach
		Inadequate residual flow downstream	13	Adoption of operational protocols
Intensive land use	Over-grazing & bank trampling	Bank erosion/ over-widening of channel/ sediment deposition in watercourses Loss of riparian zone	14	Stabilisation of river banks
			15	Application of REPS special measures
			16	Fencing programmes to exclude livestock
	Forestry operations	Increased run-off rate through drainage systems / silt deposition in watercourses / shading effects	17	Application of best practice guidelines
	Peat extraction	Peat silt run-off and deposition in watercourses	18	Operation and maintenance of silt traps
			19	De-silting of affected reaches
	Hard surface run-off - urban drainage, roads etc	Run-off of silt and deposition in watercourses Increased peak flows Bank erosion	20	Incorporation of SuDS processes
Barriers to migration	Dams, weirs, bridge aprons, & culverts	Lack of continuity Obstruction to migration of fish and invertebrates	21	Removal of structures
			22	Structural modification - construction of fish passes etc
			23	Adoption of operational protocols

Waterbodies deemed "at risk" due to the pressures acting on them are compared with status results. If status has been impacted, and it is confirmed that morphological pressures are the cause, supplementary measures will be required with the objective of restoring good status by 2015. The process by which waterbodies requiring supplementary measures are identified is illustrated by Figure 3.

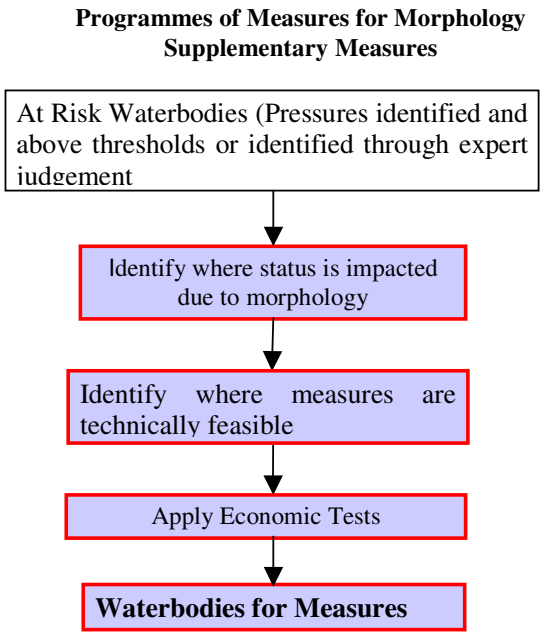

Figure 3: Decision Making Process in Identifying Impacted Waterbodies for Supplementary Morphology Measures

A series of technical feasibility and economic tests must also be applied before a final decision is made on the implementation of supplementary measures.

Technical feasibility includes factors such as stream gradient and background pollution which have an effect on the success of enhancement schemes in terms of durability and recovery of key biological indicators, macroinvertebrates, plants, and ultimately, fish (O'Grady, 2007).

At present, data gaps prevent certain status and technical feasibility elements from being confirmed. In particular there are gaps in fish status, which is the key indicator of morphological impact. To address this gap, areas identified as at risk through the PoMS Study should be focussed on with respect to investigative monitoring so that all supporting data in developing Programmes of Measures is available.

Economic tests have been developed for WFD purposes by financial consultants, Goodbody's. The method to calculate the cost effectiveness of measures uses:

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

The PoMS Study has assisted by providing example case studies addressing channelisation, overgrazing and barriers to migration pressures

Goodbody's have produced a Cost Effectiveness Guidance Manual for use by Local Authorities in developing Programmes of Measures.

2.4 Regulatory Framework

River Basin Management Plans will outline measures to be taken that will address historical morphology pressures already adversely impacting waterbody status. There is also a need to ensure future pressures are controlled so that future impact is minimised.

The WFD prescribes the need for morphology control in the introduction of a pre-authorisation system for hydromorphology under Article 11 Clause 3(i). *"For any other significant impacts on the status of water under Article 5 and Annex II, in particular measures to ensure that the hydromorphological conditions of the bodies of water are consistent with the achievement of the required ecological status or good ecological potential for waters designated as artificial or heavily modified. Controls for this purpose may take the form of a requirement for prior authorisation or registration based on general binding rules where such a requirement is not otherwise provided for under Community Legislation. Such controls shall be periodically reviewed, and where necessary, updated"*

Since existing basic measures i.e. legislation, do not provide for prior authorisation, registration, or general binding rules, these controls require introduction in Ireland.

Regulation of Engineering Activities near watercourses has been introduced in Scotland under the Controlled Activities Regulations (C.A.R). The Scottish model is appropriate for application in Ireland since it addresses the WFD objective of preventing deterioration by controlling physical alterations to rivers and lakes.

The system envisaged for Ireland would be risk based where low risk works may be simply registered while higher risk works would be subjected to more detailed assessment and more prescriptive licences issued. The system would apply to both freshwaters and marine waters, subject to Regulatory Impact Assessment.

The Best Practice Measures Toolkit, developed through the PoMS Study can be utilised as a code of practice equivalent to General Binding Rules, particularly in relation to smaller activities of low frequency.

A flowchart outlining the proposed regulatory framework is illustrated by Figure 4.

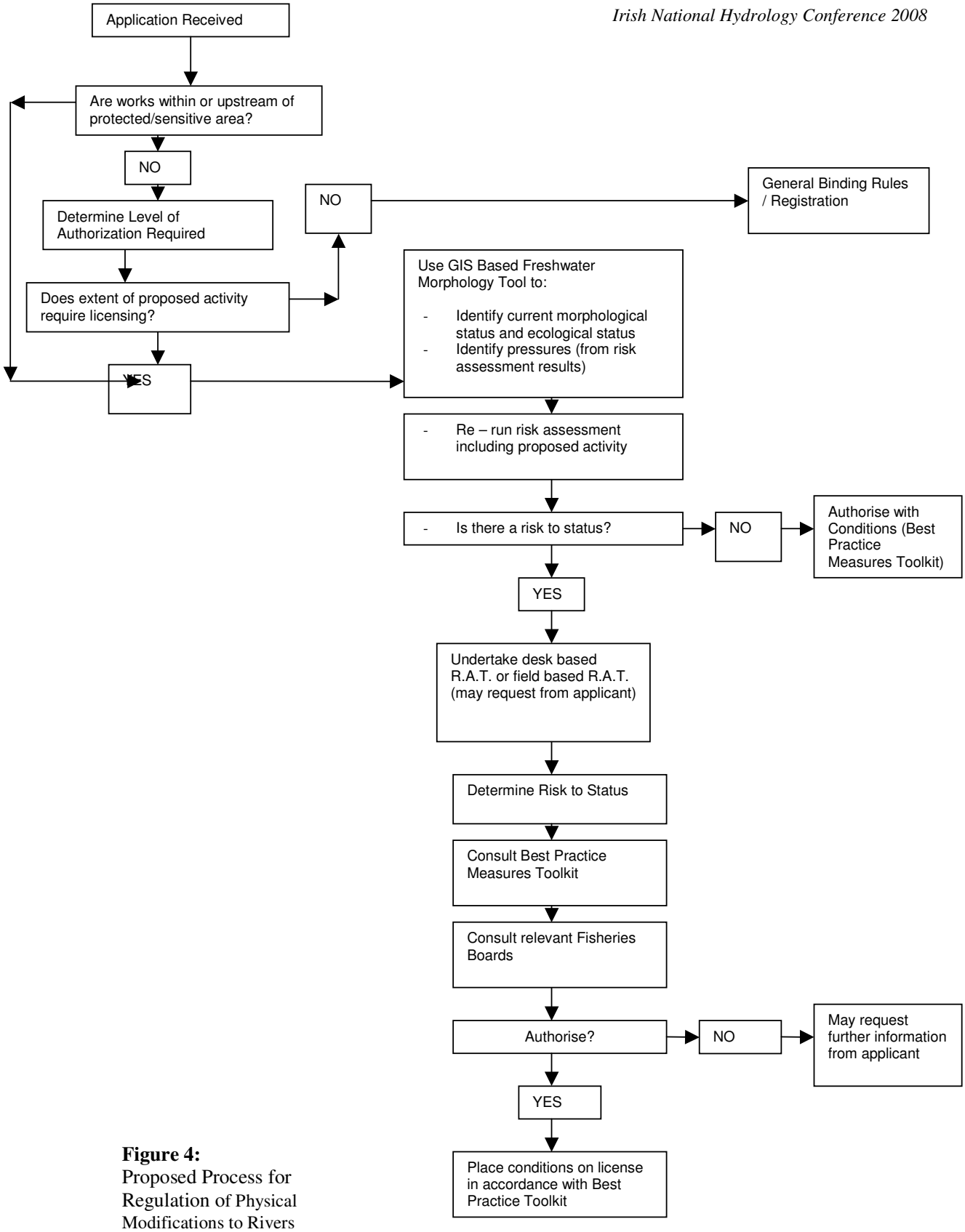

Figure 4:
Proposed Process for Regulation of Physical Modifications to Rivers

2.5 Assessing Impact and Risk to Status

Assessment of impact and risk to status by a proposed engineering activity is the fundamental step in determining the level of authorization required (refer to Figure 3). Whilst R.A.T. provides a field

based system for assessing impact, there is a need for a decision support tool driven by a database containing all available morphology related information, so that applications can be assessed effectively.

The potential for remote sensing in morphological assessment has been assessed through the PoMS Study. Detailed aerial imagery (20cm resolution) has been captured for a sample of Pilot Sites to determine how adequately a morphology assessment can be made. The results have been verified using field based data. The high potential for the use of aerial imagery, enabling more holistic, catchment based assessments is evident.

To this end, a Decision Support Tool has been developed in conjunction with Compass Informatics Ltd. The tool stores all available morphology information including, pressure datasets, aerial imagery, land use, and R.A.T. scores where available. It enables the user to re-run risk assessments based on an increase in pressure extents; conduct desk based R.A.T. surveys, and also enables the identification of suitable monitoring sites on a catchment basis.

Figure 5 is a screen shot of the Tool User Interface. It will be hosted by EPA, and provided to other regulators e.g. Local Authorities as required. The user can locate a particular site of interest, check existing status and risk scores, and assess the impact of a proposed engineering activity upon which a regulatory decision can be based.

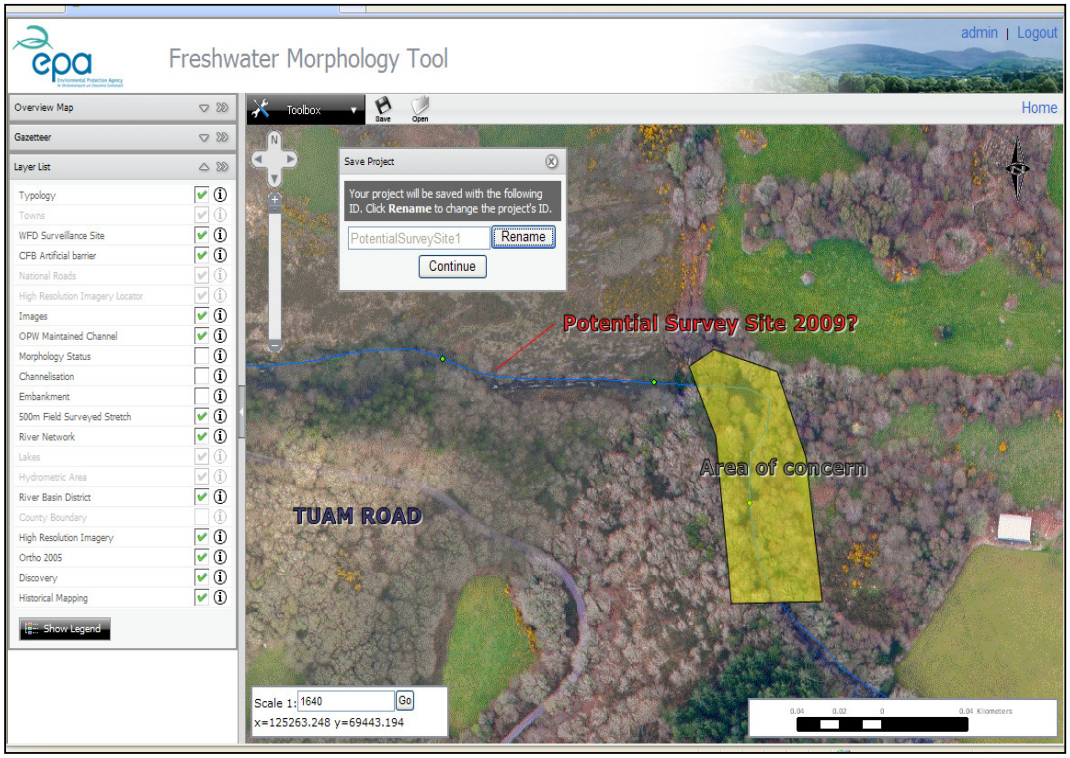

Figure 5: Freshwater Morphology Decision Support Tool (Source: Compass Informatics Ltd, 2008)

3.0 Conclusions

The Freshwater Morphology PoMS Study, through the Shannon IRBD Project has developed a management framework upon which morphology can be improved where needed, and controlled in the future. The key elements developed through the Study are:

1. Development and Adoption of the Rapid Assessment Technique for assessing morphology and observing impact in the field
2. Refinement of pressure based risk assessments for channelisation and embankments as key morphology pressures with recommendations for further assessment of overgrazed areas and barriers to migration as morphology pressures
3. Development of a Best Practice Measures toolkit for use in identifying reduction and rejuvenation measures where improvement is needed, and for use as General Binding Rules in the regulation
4. Development of a recommended regulatory framework for controlling future physical modifications
5. Development of a Decision Support Tool driven by a national Morphology database to aid decision making in determining monitoring programmes, preparing Programmes of Measures in future WFD cycles, and in regulating future physical modifications

These elements provide the foundations which must be built upon to optimise their performance as WFD implementation progresses.

References

Geodata Ltd. 2007, Shannon International River Basin District Project, Freshwater Morphological POMS Study, Fieldwork 2006: Comparative Study of Morphological Assessment Techniques for Rivers

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Shannon IRBD Freshwater Morphology Programmes of Measures and Standards suite of reports; www.shannonrbd.com – to be made available December 2008