

## GEOGRAPHICAL INFORMATION SYSTEM IN THE WESTERN RIVER BASIN DISTRICT

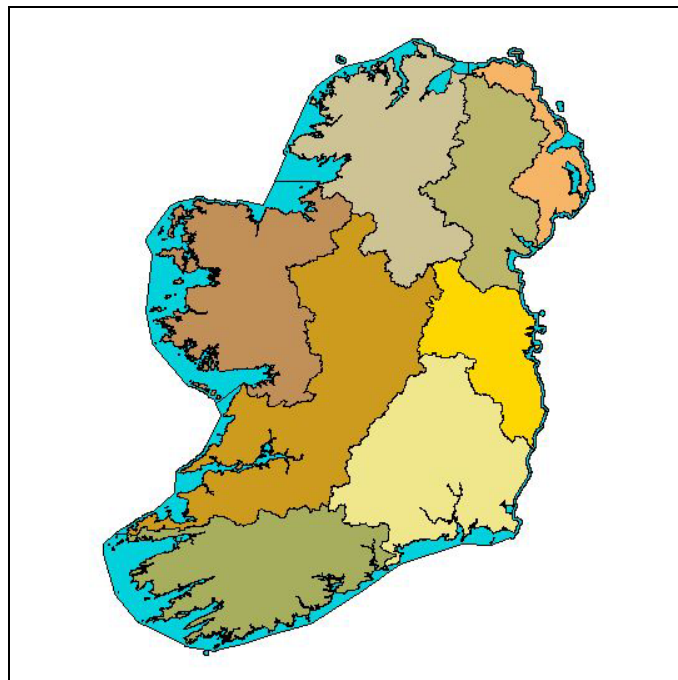
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The Western River Basin District Project is being undertaken as part of the implementation process of the *Water Framework Directive (WFD) of the European Parliament and Council* across Ireland. This Directive is the most important piece of European Water Legislation ever implemented. A European wide initiative aimed at halting the deterioration of all water bodies in Europe will see all bodies restored to a defined minimum good status.

Surface waters, such as rivers, lakes, estuaries and coastal waters will achieve, at the very least, a status whereby the influence of human activities has little or no impact on the ecology sustained by these waters in comparison to such waters where human activity is absent. Required groundwaters targets are to maintain the good status in terms of quantity and quality.

The WFD was adopted into Irish law in December 2003. In compliance with the Directive Ireland has been divided into eight River Basin Districts (RBD). These RBD's but follow rather natural hydrometric boundaries not political or administrative boundaries. The 8 Irish RBD's are as follows and shown in **Figure1** below:

- ▶▶ Eastern RBD
- ▶▶ Neagh Bann RBD
- ▶▶ North Eastern RBD
- ▶▶ North Western RBD
- ▶▶ Shannon RBD
- ▶▶ South Eastern RBD
- ▶▶ South Western RBD
- ▶▶ Western RBD



**Figure 1:** River Basin Districts in Ireland

A process of evaluating each RBD in terms of the significant pressures acting on waters is being undertaken. This will determine whether they will achieve the required status set by the WFD or not. The assessment will indicate what further initiatives in terms of monitoring and programme of

measures are required to bring about the required status in the most cost effective manner possible. Management of the objectives, programmes of measures and targets will be undertaken through River Basin Management Plans. This plan must be in place by 2009, to ensure that all waters in each district achieve “good status” by 2015 and are managed in a sustainable fashion.

Table 1 below shows the Timescale of the Water Framework Directive. The current phase is due for completion on 22<sup>nd</sup> December 2004. This phase requires that “an analysis of pressures and impacts on our waters has to be completed including an economic analysis – Characterisation Report”. This characterisation report involves carrying out a risk analysis on all waterbodies. All waterbodies must be classified into distinct categories:

- ▶▶ **At Risk (1a)** - Waterbody at significant risk
- ▶▶ **At Risk (1b)** - Waterbody probably at significant risk
- ▶▶ **Not At Risk (2a)** - Waterbody probably not at significant risk but available information could be improved
- ▶▶ **Not At Risk (2b)** - Waterbody not at risk and available information is comprehensive and/or conclusive

Key Dates	Requirement
December 2003	National and Regional water laws to be adapted to the WFD. River Basin co-operation to be made operational.
December 2004	An analysis of pressures and impacts on our waters has to be completed including an economic analysis – Characterisation Report.
December 2006	Monitoring programmes have to be operational as a basis for the water management.
December 2008	River Basin Management plans to be presented to the public.
December 2009	First River Basin Management Plans to be published.
December 2015	Waters to meet ‘good status’.

**Table 1:** Timescale of the Water Framework Directive

Characterisation reports must be supplied to the Environmental Protection Agency (EPA) in the form of Environmental Systems Research Institute (ESRI) Personal Geodatabase files by December 22<sup>nd</sup> 2004 by each RBD. The EPA will provide the schema for the format of the Geodatabase file. It is the responsibility of each RBD to supply characterisation reports to the EPA in the specified format .

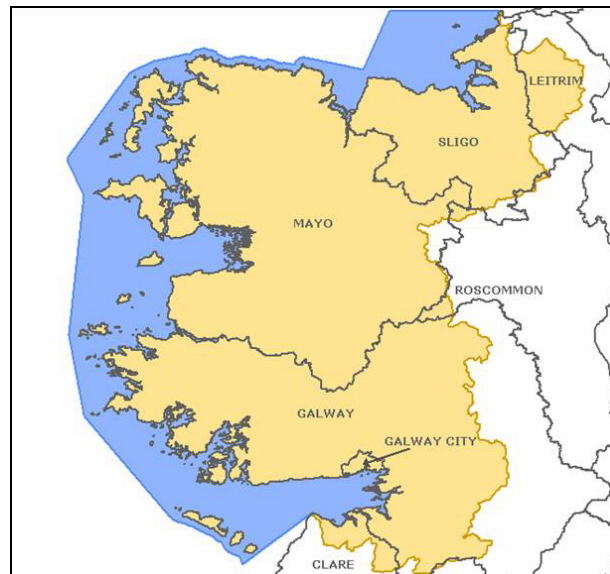
The Western River Basin District (WRBD) is one of Ireland’s eight River Basin Districts (**Figure 2**). It includes all rivers, lakes, estuaries, coastal waters and groundwaters in parts of counties Clare, Leitrim, Mayo, Roscommon, Sligo, Galway and Galway city.

The WRBD encompasses a land area of 12,193 km<sup>2</sup> with over 5,600 lakes of total area 517 km<sup>2</sup>. Of these 69 are greater than 50 hectares in size, 292 are greater than 10 hectares and the rest are small being less than 10 hectares in size. There are over 14,200 km of river of which 52% are first order streams. The coastal and transitional (estuarine) waters comprise a further 4,683 km<sup>2</sup> with 438 km<sup>2</sup> of islands and a total coast length of 2,700 km.

The population of the Western River Basin District numbered over 374,000 persons at the last census. The basin district has a rich heritage of clean rivers, lakes and seas which are not only of vast socioeconomic importance to the region but also define the regions natural and cultural heritage, its uniqueness and great natural beauty.

**Rivers and Lakes:** The WRBD comprises 950 draft river water bodies which must be assessed. These are distinct geographic basin areas associated with river lengths. The WFD requires all lakes over 50

hectares to be assessed together with those lakes which are used for water abstraction and which are associated with protected areas.



**Figure 2: WRBD**

**Coastal and Transitional Waters:** The coastal water area within the basin district is broken up into a total of 19 distinct water bodies for the purpose of management. There are a further 22 transitional waters also identified as distinct water bodies.

**Groundwaters:** 63 draft groundwater bodies have been identified within the basin district. These groundwater bodies include a number of different aquifer types depending on location. The pressure from abstraction and pollution of these groundwater bodies is being assessed.

The WRBD Project comprises of the following structure levels:

- ▶▶ Management Group,
- ▶▶ Steering Group (Public Authorities)
- ▶▶ Project Coordinator (Pat Canney)
- ▶▶ Project Manager (Paddy Kavanagh, ESBI)
- ▶▶ Consultants (ESBI, ESBIC, White Young Green, O'Neill Ground Water Engineering Ltd., WRc and others)
- ▶▶ State Agencies and the DoEHLG

#### **THE USE OF GIS IN THE WRBD:**

Geographical Information Systems (GIS) is a **system** of computer software, hardware, data and personnel to help manipulate, analyse, and present information that is tied to a spatial location. GIS is essentially “smart maps”, that is, linking database information to a spatial location or map. GIS is now a popular and essential tool for the day-to-day operations of many organisations and in particular to the Public Authorities that supply the data for the Water Framework Directive.

GIS was the obvious tool to use to collate, disseminate and analyse the data for the entire project due to the nature of the data involved in the Water Framework Directive. The vast majority of Public Authorities involved in the WFD including EPA, Dept. of Marine, Geological Survey of Ireland (GSI), Office of Public Works, Dúchas and Local Authorities supply data in GIS format. This data generally takes the format of ESRI, MapInfo and AutoCAD files. Due to the variety of data formats supplied, each RBD must have the necessary software and skills to enable them to manipulate data supplied.

As stated earlier all characterisation reports must be supplied to the EPA in the form of ESRI Personal Geodatabase files by December 22<sup>nd</sup> 2004 by each RBD

The Western River Basin district utilises MapInfo Professional Software as it's primary GIS tool and Oracle Spatial as the data storage tier of it's GIS environment. The decision to use MapInfo as the GIS tool is a unique step in terms of other RBD in Ireland. The majority of RBD's use ESRI ArcGIS as their primary GIS tool and hold data in flat file or Geodatabase formats. A number of factors lead to the WRBD implementing MapInfo and Oracle as the GIS solution. These factors included:

- ▶▶ MapInfo is the primary GIS software package used by approximately 80% of Local Authorities in Ireland. Due to the volume of data supplied from Local Authorities the use of MapInfo by the WRBD resulted in a reduction of time being spent on data translations.
- ▶▶ MapInfo has in-built translators or direct read facilities for a wide range of datasets including ESRI Shape, ESRI ArcInfo Export, AutoCAD files, Microstation files, Excel Spreadsheets, Access Databases, DBF Tables etc. These translators enabled the WRBD to import data from non-MapInfo sources quickly, easily and with confidence of the accuracy of the translation.
- ▶▶ MapInfo has in-built translators to export data in a number of data formats including AutoCAD DWG/DXF, ESRI ArcInfo Export, ESRI Shape, Intergraph/Microstation Design. This allows the WRBD to supply data to partners and public authorities in a wide range of formats.
- ▶▶ The use of Oracle Spatial ensures that the WRBD becomes an open, enterprise GIS solution. Spatial databases are a way of storing information in a manner that enforces consistency, facilitates access and ensures reasonable performance without constraining how the data is correlated or presented. Other advantages of using Oracle include:
  - ▶▶ Data is centralised in one place accessible to all users.
  - ▶▶ Database security can be used.
  - ▶▶ Multi-user transaction processing is supported.
  - ▶▶ Queries on large data tables can be executed quickly using spatial indices.
  - ▶▶ Different client systems can access the same data.
  - ▶▶ Automatic backups and logs can prevent data loss.
  - ▶▶ Spatial and non-spatial data can be easily integrated and analysed.

## **WRBD CHARACTERISATION**

The Water Framework Directive requires each River Basin District to have an environmental and economic characterisation carried out on it by December 2004. Characterisation aims to describe and provide a better understanding on the current and predicted future state of aquatic environments. Essentially the 'characterisation' of the river basin provides a full description of the basin, the existing water quality status and uses, the economic value of waters, the extent of protected areas, the nature and magnitude of pressures acting on the water status and an assessment of the impact of anthropogenic (human) activity. The Pressure and Impact assessment reviews the impact of human activity on surface waters and groundwaters and identifies those water bodies that are at risk of failing to meet the Directive's environmental objectives. The risk posed to all water bodies in terms of whether they will achieve good status by 2015 or not is assessed based on both impact data derived from existing monitoring and from predictive tools using readily available information and established relationships. The characterisation is undertaken largely in GIS format for ease of understanding and data use. This is undertaken in the context of guidance documents provided by the EU, the UK TAG, SEPA and by the Environment and Heritage Service of Northern Ireland. The guidance documents specify data sets for use in the risk assessment process. Their applicability to the Irish situation was assessed by the river basin projects and they were adapted to fit the Irish data set availability. The developed methodologies were tested and applied as part of the risk assessment process in each RBD resulting in water bodies been designated as either at risk or not.

It is important to distinguish between actual water status and the 'risk' status resulting from the risk assessment process. Placing a water body 'at risk' may not mean that the water quality or status is

actually bad. However it does indicate that a pressure acting on that water body has been identified which if it materialises in sufficient magnitude would result in that water body failing to meet the required status. Understanding the nature of the pressure and how it acts allows a necessary measure to be designed and introduced to prevent further deterioration and restore water bodies already degraded.

It should also be noted that the assessments represent an initial characterisation of water bodies, with the Directive requiring further characterisation for 'at risk' water bodies.

## DATA COLLECTION

Data for the WRBD project has been collected from a wide and varying range of sources. To date, the volume of data collected for the project is in the range of 7.5 Gigabytes of data in flat file format. Some of the suppliers of data include Local Authorities, Central Statistics Office, Coillte, Dept. of Marine, Dúchas, Environmental Protection Agency, Geological Survey of Ireland, Marine Institute, Met Éireann, Office of Public Works, Ordnance Survey of Ireland(OSI) and Teagasc.

Data is supplied to the project in a wide range of formats including text files, Microsoft Excel Spreadsheets, Microsoft Access Database Tables, Microsoft Word document, HTML files, MapInfo Tables, ESRI Shapefiles, ESRI ArcInfo Export files, ESRI ArcGIS Geodatabase files.

Data starter packs for all RBD's were supplied by EPA, GSI, and Teagasc. Starter packs included basic data required for the WFD such as rivers, lakes, catchments, groundwater bodies, soil types etc. All other datasets were collected by direct request to organisations by members of the WRBD project team. Questionnaires were distributed to each Local Authority in the WRBD area to establish data available, formats of data and accessibility to data. In some instances personnel from the WRBD team were assigned to visit data suppliers to locate paper records of data that had not been transferred into digital records. Other public authorities were directly contacted by the WRBD team to establish data availability for the project and gather it in a usable format.

Due to the volume and format of data collected the WRBD initiated an internal procedure of creating data definition documents for all datasets collected for use in the project. The data definition documents allow for information to be stored in digital format in relation to the source, quality and structure of each dataset. This is a laborious, on-going task but is an essential element of data control for the project. It allows for a tracking procedure to be implemented to verify and control where, when and how data was gathered for the analysis phase of the project. The data definition documents essentially provide metadata for all datasets used on the project. These data definition documents are also a critical element in the design of the Oracle database as they aid in the database schema design,

## DATA

Data is the heart of any GIS system, the data used in a GIS is eventually analysed and a decision made based on that data. It is therefore of paramount importance that data in any GIS is both accurate and up-to-date. This project saw a number of stages involved to reach this goal, at each stage data quality and accuracy was the overriding driving force. These stages involved:

- Data Collation
- Data Verification
- Data Analysis
- Data Storage

### **Data Collation:**

During data collection phase the WRBD project found that much data required for the project was potentially available. Unfortunately, a lack of consistency in data management, format and supply between the organisations holding data made collation and conversion relatively time consuming and

expensive. Data was supplied to the project in a wide range of formats and structures. A number of procedures were carried out on datasets before they could be used in the project. These included:

- ▶ Transformations: Datasets were provided to the project in projections other than Irish National Grid e.g. Latitude/Longitude.
- ▶ Conversion: Datasets were converted where necessary to formats where they could be read by the GIS. In some cases spatial data was provided in non-spatial formats. An example of this is where X, Y coordinates were provided in Excel Spreadsheets and these were used to create spatial point files for the GIS. Other conversion processes carried out included the conversion of data from Vector Data Models to Raster Data Models for data analysis procedures e.g. for the Characterisation Report of Groundwaters all data analysis was carried out on Raster Data Models using MapInfo Vertical Mapper.
- ▶ Cleansing: Cleansing proved to be very resource intensive in the project and will continue as an on-going procedure during the life of the project. Some datasets were provided to the project in useable formats but most datasets required some form of cleansing. For example a number of organisations use formulas in Excel spreadsheets that do not easily import into GIS. In some cases Excel Spreadsheets had columns and rows of no data, field names that were spread over multiple cells, long field names, spaces in field names etc. All these factors lead to clean-up procedures being necessary on files before they could be used in the GIS.

#### **Data Verification:**

Once data is collected for the WRBD it is carried through a series of data verification procedures. These procedures are necessary to ensure that the data is valid for use in the project and will not lead to inconsistent results in the characterisation report.

- ▶ Gap Analysis: Gap analysis procedures were carried out to ensure that sections of data were not missing. The WRBD covers 7 Local Authority areas and therefore retrieving data over such a large area at times proved difficult. Where data was found to be inconsistent or missing manual verifications were carried out by contacting the relevant data suppliers to validate the cause of the data inconsistency. If an area of data is simply not available the problem is noted to ensure that the characterisation report takes this into account.
- ▶ Cleansing: A large number of datasets were provided to the WRBD in National formats i.e. covering the entire Island of Ireland. In these instances datasets were cleansed to ensure that only data within the WRBD boundaries are included in the characterisation analysis. Other data cleansing operations are also undertaken during the Data Verification phase. . During this process we were able to identify and correct errors of commission and omission, as well as a number of integrity issues which added significant value to the data. Such procedures included removal of unnecessary fields, and in some cases enhanced data by creating attribute such as Area & Length calculations on features.
- ▶ Duplication: Data duplication again proved to be a large resource drain as some data from various sources e.g. EPA and Local Authorities was found to cover the same geographical area with the same datasets. However, in many cases the structure of the data was not identical; for example, attribution of the data was not identical. In these cases both datasets were examined and the “best fit” data was used for the analysis phase. This “best fit” data in some cases was a mix of two datasets from different sources to get the best representation of the feature.

#### **Data Analysis:**

In order to carry out the characterisation reports a number of data analysis procedures are performed on datasets. These analysis procedures vary in relation to the type of data available, the size of the datasets and the characterisation methodology procedures recommended. In some cases, such as the Groundwater characterisation report data analysis procedures were carried out on Raster Data Models. In other cases analysis procedures were carried out on Vector Data Models. Data analysis procedures included common GIS type operations such as:

- ▶ Overlays: Overlay operations are capable of creating composite maps by combining diverse data sets. These outputs can reflect simple operations such as laying a river map over a map of

landuse types, or more sophisticated operations such as multiplying and adding map attributes of different value to determine averages and co-occurrences.

- ▶▶ Intersections:
- ▶▶ Spatial Computations

### Data Storage:

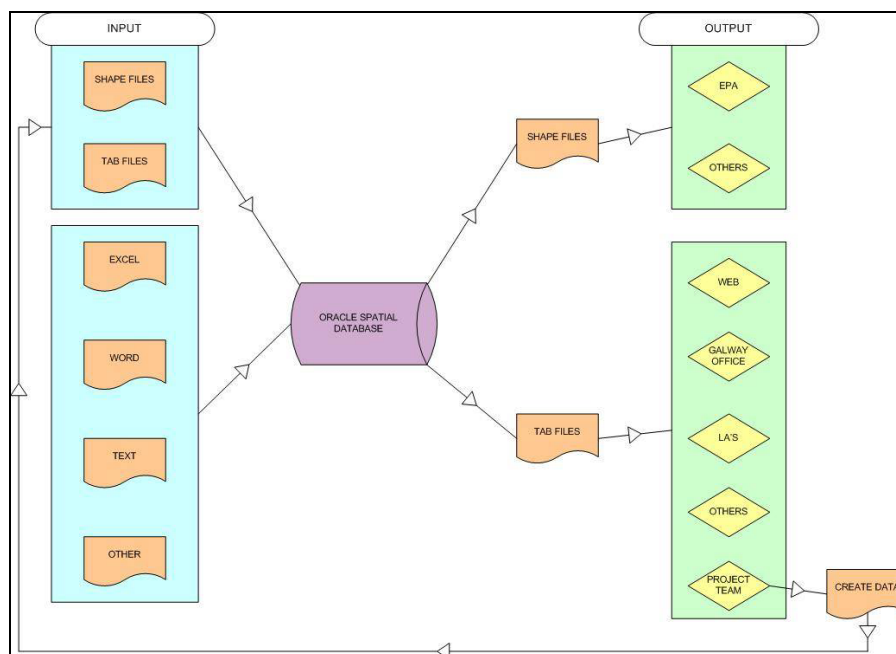
Oracle has been chosen as the data storage tier of the WRBD GIS. Oracle as a data storage tier is an extra implementation phase not experienced by any of the other RBD's. The WRBD project however introduced this tier to the GIS in order to implement an open, future proof GIS allowing for future expansion of the GIS. The implementation of Oracle also allows for standard relational database management procedures to be applied to spatial data such as security, backup and multi-user transaction processing.

**Figure 3** shows the Data Storage Tier of the WRBD GIS in terms of the Oracle Spatial Database. All input data is loaded into the Oracle Database whereby it is accessed by all members of the WRBD team. Data can be directly read from Oracle using MapInfo Professional and in the future using the Web Public Interface for data dissemination. Data is also easily output from the Oracle database in various formats for supply to EU, Public Authorities, Consultants and partners of the WRBD.

Data loading into Oracle will be a on-going procedure during the life of the WRBD project. Data will be continuously supplied/gathered by the WRBD team and filtered back to the GIS specialists of the project. These specialists will then be responsible for collating and verifying the data before it is uploaded into the GIS for all parties to access the data from a central source. By storing all data in Oracle the integrity of the data can be relied upon.

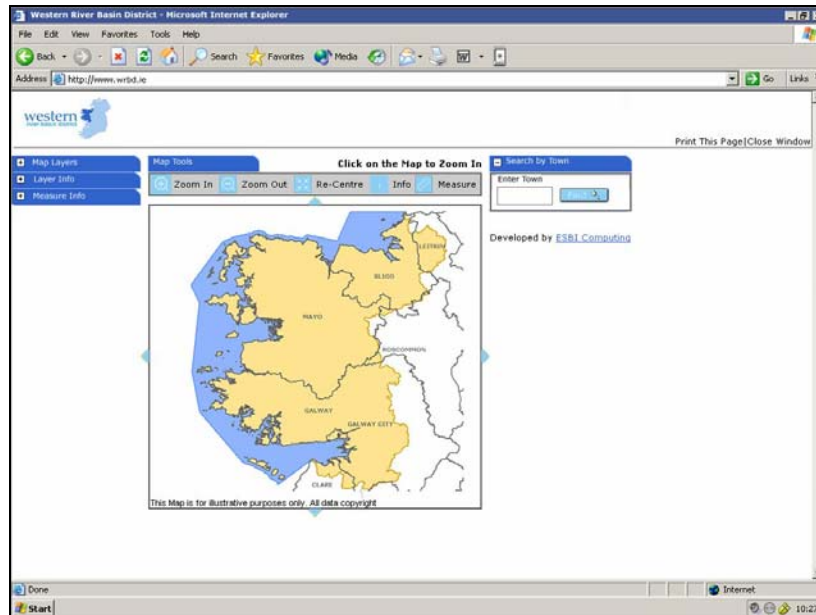
### Web Interface:

As part of the public awareness campaign of the WFD all members of the public must be given the opportunity to participate in the campaign. Members of the public who are expected to contribute to the WFD are those involved in agriculture, waste disposal activities, forestry, quarrying, peat harvesting, general industry, fishing or as a citizen using water every day. Critically, members of the public must participate if they want to have a key role to play in preserving waters for future generations within the Western River Basin District.



**Figure 3:** Data Storage Tier

As part of this public awareness campaign the WRBD will be implementing a web site giving details on the WRBD project. This website will provide the public with full details on the procedures and practices of the WRBD project along with future goals and objectives. A second phase of the WRBD website will be to provide the public with a graphical interface of the WRBD project data (**Figure 4**). This will be achieved by implementing a Web GIS application on the site. This Web GIS application will allow users to navigate maps using simple GIS tools such as Zoom In, Zoom Out, Re-centre, Information and Measure. Members of the public will be easily able to navigate the WRBD area and view maps and characterisation analysis features of the WRBD area.



**Figure 4:** Proposed Web Interface