



## THE APPLICATION OF GIS IN SUPPORT OF FLOOD EMERGENCY RESPONSE MANAGEMENT

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*The Rivers Agency is an Executive Agency within the Department of Agriculture and Rural Development in Northern Ireland. The agency aims to protect people and property from flooding from rivers and the sea; in pursuit of this aim the Agency provides an emergency response service, in support of key responders, in situations where lives or property are at risk of flooding from open or culverted rivers, or the sea. The Agency's Flood Management Strategy recognised the need for improved information systems to manage the emergency response, and the archive of flood calls that had been received from the public over decades. An online Flood Reporting system was therefore designed and developed to automate the process; and standardise the recording of information from initial call, address-matching and emergency response through to a multi-media archive of event related documents. The system has been operational since 2003, and now includes a flood archive going back roughly 20 years. This paper describes the concepts behind the system design, and reviews the operation of the system since implementation. It also considers the potential future direction, given the recent Flood Management Policy Review, and the Review of Public Administration in Northern Ireland.*

Keywords: GIS Data & Applications, Flood Reports, Flood Archive

### 1. INTRODUCTION

The Rivers Agency is an Executive Agency within the Department of Agriculture and Rural Development in Northern Ireland, and aims to improve social conditions and to support economic development in Northern Ireland through the following main aims: -

- Reducing risk to life and damage to property from flooding from rivers and the sea
- Preserving the productive potential of agricultural land.

**Organisation.** The Agency is headed by a Chief Executive supported by a Senior Management Directorate and employs some 458 staff, made up of 134 Professional & Technical staff, 56 Administrative staff and 268 industrial staff. The Headquarters of the Agency is located at Hydebank in Belfast with two Regional Offices in Lisburn and Omagh and Area Offices in Coleraine, Craigavon, Lisburn and Ballinamallard, which services the Fermanagh Sub-Area.

**Emergency Planning.** In conjunction with the Agency's aim to reduce risk to life and damage to property from flooding from rivers and the sea, the development and promotion of Emergency Planning is given high priority within the Agency. Consequently there is an increasing emphasis on Civil Protection and in particular the outworking of the Northern Ireland Civil Contingencies Framework, which will place an increasing emphasis on emergency planning within the Agency.

**Emergency Response.** For many years the Agency has responded to emergency calls for assistance from members of the public whose property may be under threat of flooding from watercourses. The Agency has no statutory responsibility to respond to flooding, however in accordance with its main aim in relation to flood risk, it operates emergency call-out arrangements, and in the event of watercourse related flooding incidents, staff will provide assistance in order to protect life and property. Also, attendance at watercourse related flooding incidents by Agency staff is beneficial in gathering information that will support follow-up investigations or flood alleviation considerations (e.g Post Flood Event reports that will feed in to pre-feasibility reports).

In responding to flooding incidents, the Agency seeks to:

- Advise the public on what to do, and when assistance can be expected;
- Arrange the appropriate inspection and action to help minimise the damage to businesses and properties
- Dispatch staff and equipment as soon as possible (Response time will depend on the number of simultaneous incidents);

As an operational target the Agency aims to attend 80% of watercourse related flooding incidents within 3 hours of receiving the call;

The emergency response to flooding can involve a number of different bodies, sometimes dependent on the scale of the event and the flood risk. The emergency services (Fire and Rescue Service, Police Service NI) along with NI Water, Roads Service and local councils all have resources that may be deployed. Rivers Agency co-operates with the Roads Service and NI Water on an Inter-Agency basis via the Flood Strategy Steering Group and Flooding Liaison Group (FLG) to engender a co-ordinated approach to flooding issues and problems across Northern Ireland. In addition local councils arrange liaison meetings in the form of resilience forums to confirm and establish contacts between all emergency services in their Districts. Each Agency involved in emergency response already has established incident response procedures covering a wide range of events and incidents; for example NI Water operate a 24/7 telephone helpline called Waterline that deals with flooding from watermains, blocked sewers and that also deals with customer complaints.

The FLG has developed “Best Practice Guidelines” that establish lines of communication and reporting across the Agencies. The FLG has also improved communication with the public by placing advertisements in telephone directories, producing leaflets, and providing a consistent message on each Agency’s website in terms of who to contact in relation to particular types of flooding. The FLG has also established a list of “flooding hotspots”, that detail recurring flooding problems and identify the lead authority and local contacts.

## 2. ONLINE FLOOD REPORTING SYSTEM

**Background.** The Rivers Agency’s Flood Management Strategy recognised the need for improved information systems to manage the Agency’s Emergency Response and Flood Data Archive – the Archive supports various other business functions (see below). Consequently In 2003/04 a project was initiated to put in place a real-time flood information recording system. The concept for the system design was devised in-house, and the delivery of the software solution was provided by ESRI Ireland.

In terms of **Emergency Response**, the system is designed to:

- Provide a concise and effective system for recording and processing calls received from the public in a flood emergency situation.
  - Previously calls from the public were recorded on non-standard paper forms – difficulties arose in gauging the overall scale of the emergency, knowing which engineer was dealing with which call and in which locality, and in keeping track of what had been actioned (i.e. what resources had been sent to site) to deal with the emergency and how they were progressing on site.
  - Basic address information was often poorly recorded – the GI system is designed to validate addresses and to automatically create a point location on the Agency’s corporate GIS, thus enabling the engineer to quickly assess any problems that might be encountered on site.
- Provide facilities to allow Agency engineers to e-mail any flood report to their counterparts in other Government Agencies or the Emergency Services.
- Provide reporting facilities that allow the user to quickly gather information that can be communicated to Agency management for further dissemination as deemed appropriate.

In terms of a **Flood Archive**, the system now holds an archive of flood calls received by the Agency over a period in excess of 20 years. The archive not only includes the database of flood calls, but has the facility to incorporate any supporting information which may have been gathered by the emergency response or flood data collection personnel, e.g. digital photographs, reports on the flood event, scanned maps showing the extent of the flooding, media clips. The system is designed to support subsequent processing of this information by the Agency’s GIS team in HQ, to supplement the corporate GIS flood mapping dataset.

The Flood Archive (contained within the onLine Flood Reporting system, and associated GIS), supports the following business functions:

**Regional Knowledge Base.** Previously flood calls were recorded on a paper based system only and filed chronologically in each Regional Office. A wealth of local knowledge had been built up, but was difficult to access; use was heavily based on personal recall and with turnover of staff, particularly retirement, there was a danger of the information being lost – When was the last occasion this location flooded? How many times have there been floods here before? How did we deal with this problem previously? Are we planning to do any works to relieve the flooding?

**Aerial Photography** – In major events aerial photography is used to record the flood extents; knowing the geographic extent of active flood calls helps the Flood Data manager to decide when and where to deploy aerial photography.

**Development Advice** – the Agency has a role as a consultee within the planning process, both in terms of the development of Area Plans, and in responding to individual planning application referrals. The Flood Archive, in terms of the onLine Flood Reporting archive and the flood mapping dataset inform the resources, (in-house staff or external consultants), engaged in these work processes.

**Flood Alleviation Schemes** (via Capital Works procurement) – again the Flood Archive is one of the information resources used during pre-feasibility studies for flood alleviation schemes.

### 3. DESIGN CONCEPTS

The online Flood Reporting system is intended to have an easy to use user-interface that is designed around help desk concepts – all interaction revolves around a single screen comprising filters, a summary list of calls, a tabbed form for call details, and a toolbar for editing, reporting and GIS functionality.

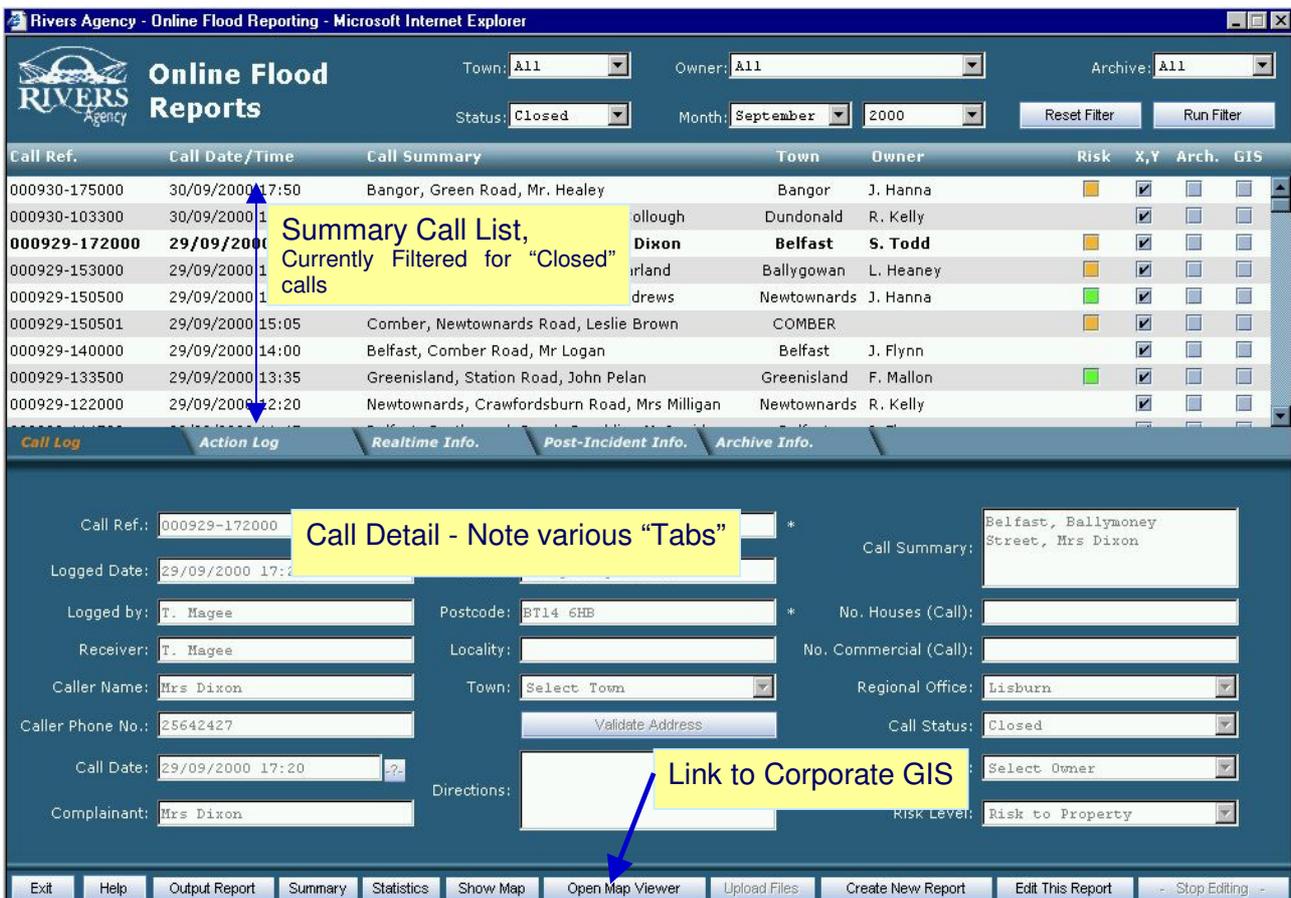


Figure 1 – online Flood Reporting – Main Screen

The system is designed to introduce concepts of problem ownership and workflow to the emergency response function – calls are recorded as “New”, then progress to being “Assigned” to a problem owner (the engineer) and are finally “Closed” when the flood event is over. The initial call is received by administrative staff who complete the initial “Call Log” details. This includes an address matching function that checks for a valid address against the OSNI Pointer address database. Not all flood reports relate to a property and the system also includes a map tool that allows the user to point and click on a map in order to assign the flood location. Once the report is saved the Agency’s corporate GIS automatically creates a point feature (representing the flood report) at the defined location. This flood report is then immediately visible and accessible to all Agency staff using the Corporate GIS, in the form of an ArcIMS web-based flood mapping system (see Figure 2).

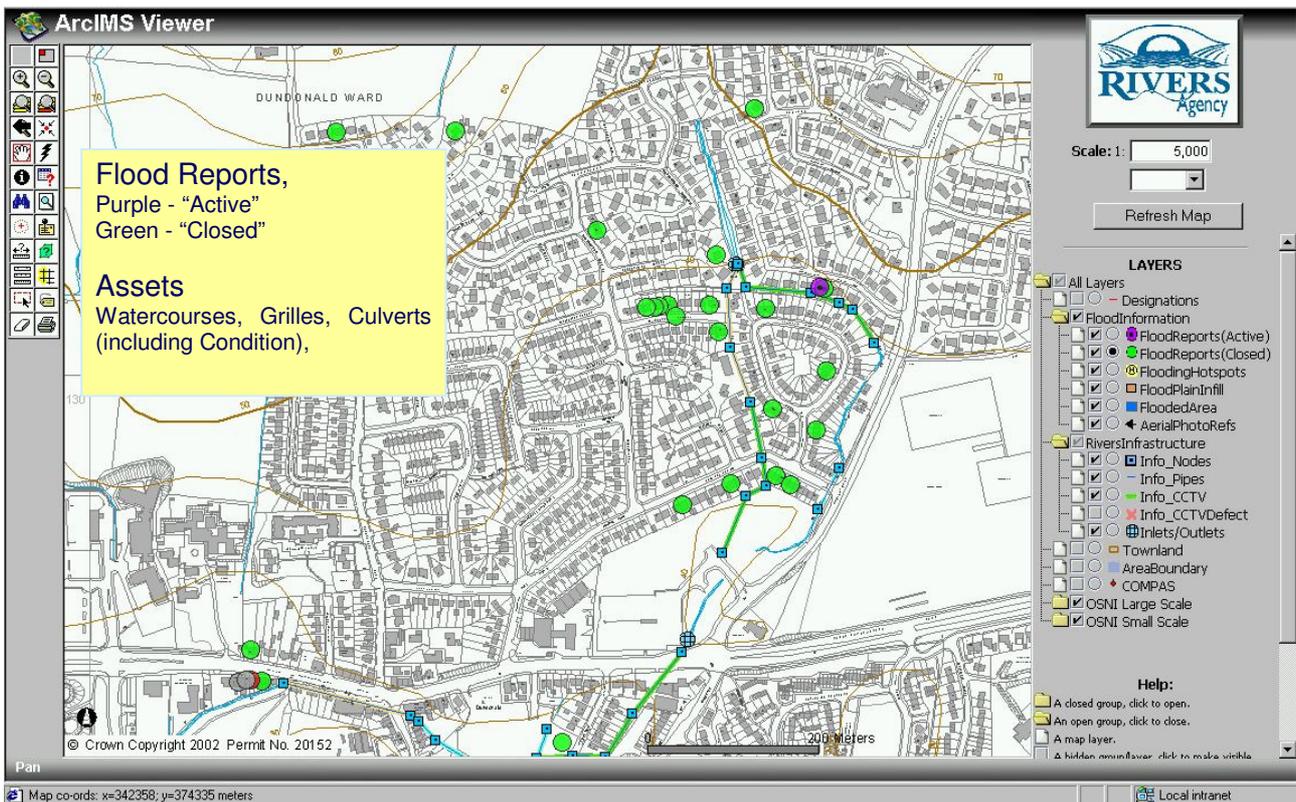


Figure 2 – Corporate GIS (ArcIMS viewer)

Figure 2 above illustrates how the reports appear on the Corporate GIS. Flood reports that are “active” are symbolised with a purple shading; archive reports are represented in various colours that are used to indicate the authority that has lead responsibility for the type of flooding that occurred (i.e. Rivers Agency, NI Water or Roads Service).

Scale-dependent viewing is applied for the Flood Report layers such that archived calls are only visible when the user is zoomed in below a certain scale threshold. This allows the user to get a feel for the overall extent of flooding when zoomed out province-wide, without the added clutter of 20+ years of archive flood reports. Yet when zoomed in to detail level, the engineer can visualise what properties have flooded in this locality previously and consider any additional measures that might be required in the field.

The Corporate GIS hosts a wealth of other information that is accessible to the engineer using the system. This includes e.g. grille locations, culvert asset information, flood defences, and historic flood outlines. Other supporting information is also accessible that could help the engineer direct resources on site. Each grille has an associated “Grille Risk Assessment” that includes a photograph and map of the grille along with the risk assessment (See Figure 3 overleaf). Hard copies of the same risk assessments are also carried by the emergency response operatives in the field.

The system is designed such that the engineer can record his communication with field staff (under the "Action Log" tab). This puts a date & time stamp against the engineers comments which are appended to the Action Log each time the report is saved. This provides an audit log for each flood report.

Further tabs are available that are designed to be completed "after the event". For example the "Archive Info" tab contains a tool that allows the user to browse to any number of electronic documents e.g. photographs, a post event report, a multimedia clip; and to upload such documents to a folder associated to that flood report. Flood reports that have associated archive information are flagged as such within the online Flood Reporting system (See "Archive" column in Figure 1), and are symbolised slightly differently on the Corporate GIS – Reports with archive information are symbolised with a black dot in the centre of the usual symbol.

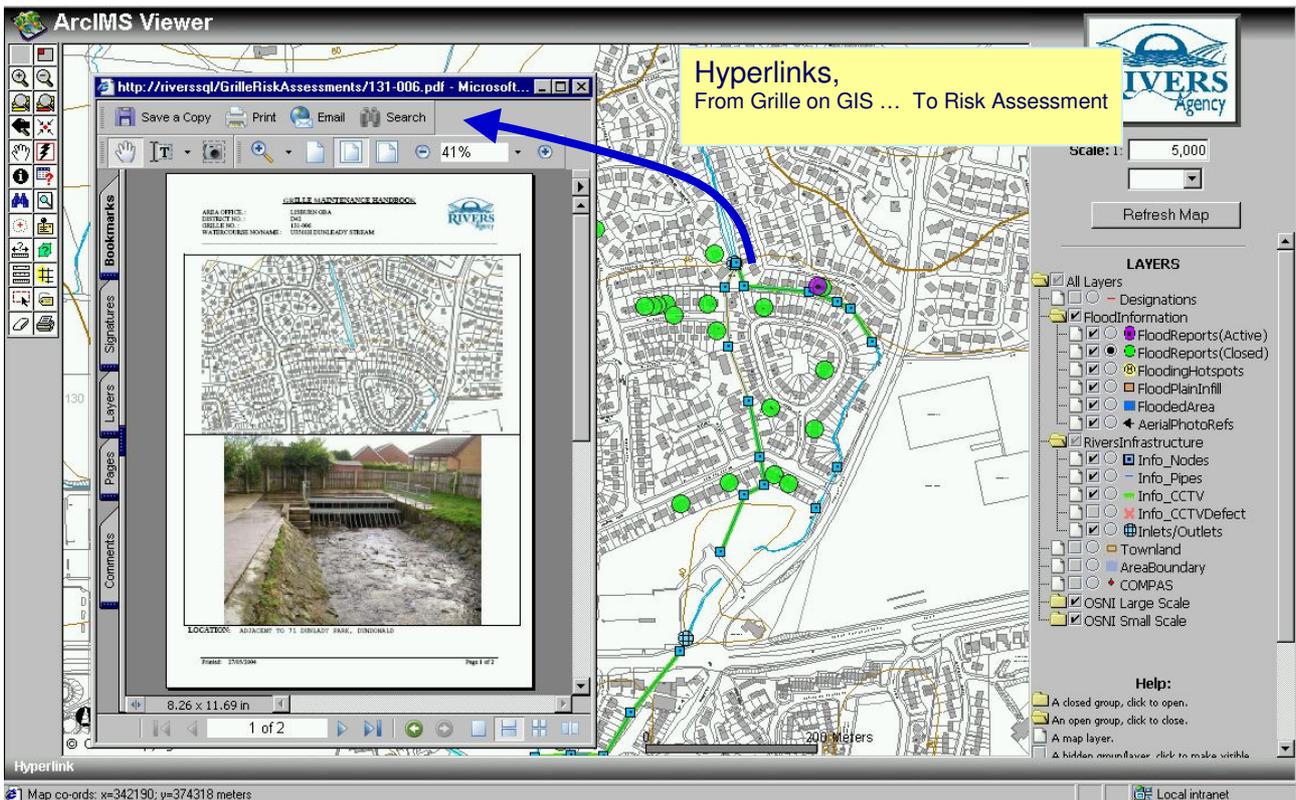


Figure 3 – Using the Hyperlink tool the engineer has immediate access to engineering information.

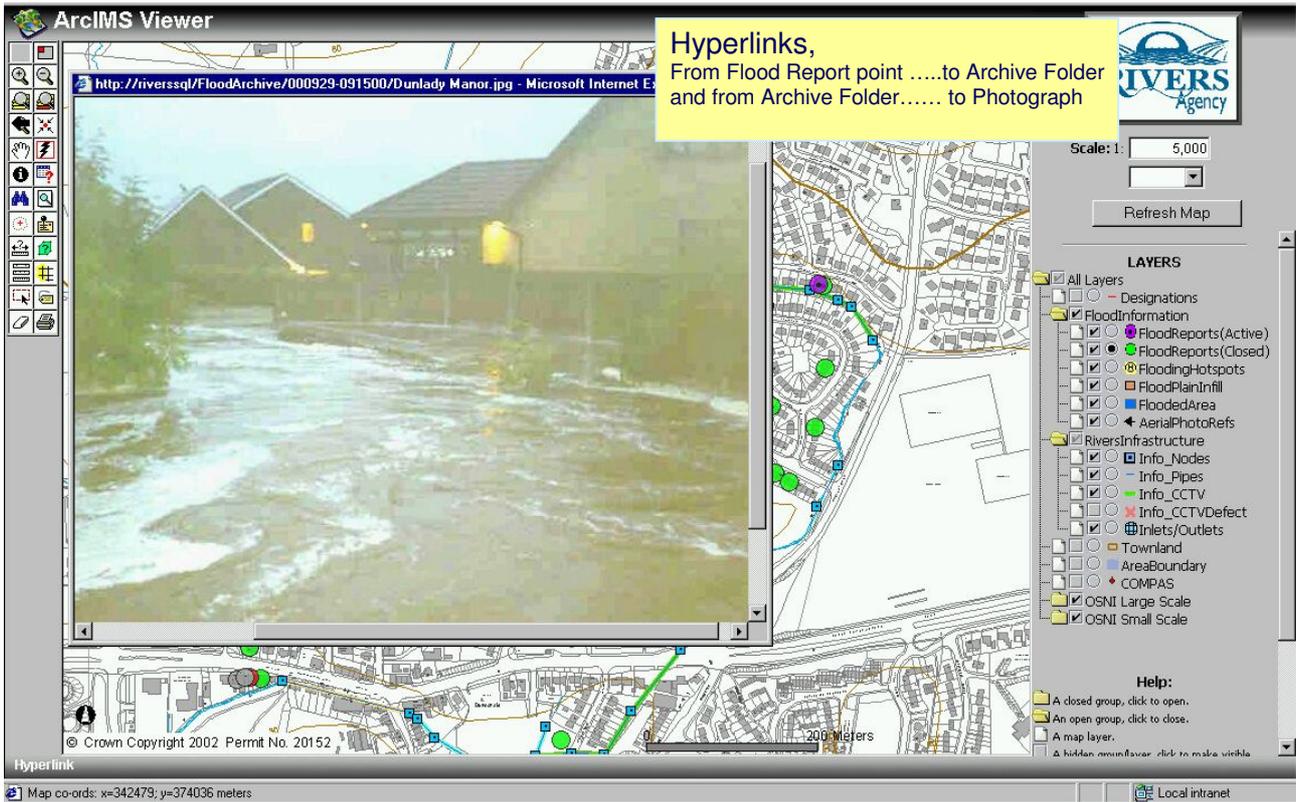


Figure 4 – Documents in Archive folders are accessible from both interfaces i.e. from within online Flood Reporting system; and from within Corporate GIS.

**Calls outside Office Hours.** Of course not all floods occur between 9am and 5pm and arrangements are in place for calls that are outside of normal office hours to transfer to the appropriate duty officer (at home). The duty officer completes a hard copy input form that is consistent with the Flood Reporting system (see Figure 5 below).

## Flooding Report

Paper Form,  
to cover calls outside office hours.

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**Logged By Details**

Call Ref:

Logged Date:

Logged By:

Received By:

**Caller Details**

Caller Name:

Caller Phone No:

Call Date / Time:

Complainant:

Call Status:

**Incident Location / Directions**

House No:

Street:

Locality:

Town:

Post Code:

**Directions**

**Call Summary**

Owner Name:

Regional Office:

Risk Level:  Life  Property  Other

Caller Actual

Num Houses:

Num Commercial:

Field Operator:

Date Time

Field Op. Referred:

Field Op. On Site:

**Cause of Flood**

River Out Of Channel:

Flood Defence Breach:

Flood Culvert Grille:

Storm Sewer Overflow:

Surface Runoff Roads:

Surface Runoff Fields:

Other Cause:

**Complaint Action Log**

Use to record supplementary information, eg. from the caller or a field operator. If the call is related to a flooding issue which is the responsibility of another Agency, then that information should be recorded here - i.e. who it was referred to in the other Agency and when.

**Actions Taken**

Grille Culvert Cleared:

Pumping:

Sand Bags Placed:

Sand Bags Provided:

Other:

**Flood Archive**

Record following for Flood Archive:-  
Witness Accounts; Photo Ref Nos; Addresses of Properties Flooded;  
Flood depths above floor level;  
Use a separate map to show:-  
The Extent of the flood; the Path the flood waters took; the Location of flood marks;

**Follow-up Action**

Responsible Authority:

Follow-Up Action Required:

File Reference:

Figure 5 – Flood Report form to cover calls outside office hours.

These forms are then input immediately by administrative staff once the office opens the next day; or if the event was more significant the duty officer may arrange for a Flood Control Centre to be opened at the Regional Office and for additional resources to be mobilised to record information and direct the emergency response.

#### 4. IMPLEMENTATION & OPERATION OF THE SYSTEM

A number of initiatives were taken forward to try to ensure that the system use was embedded in to normal working practice:

- An online help system was incorporated within the software solution.
- Call scripts were devised for the administrative staff who would be taking the initial call so that they would gather all the appropriate information from the public in a structured conversation, and in doing so populate the online Flood Reporting system.
- A training course was developed and training was provided for all the Agency's administrative and engineering staff that would be using the system.
- Refresher training has also been provided, to ensure that all new staff and existing staff are fully briefed on how the system should be used.

The most successful aspect of the system has been the creation of the computerised flood knowledge archive, which as stated previously now covers a period in excess of 20 years; The archive is accessible both from within the online Flood Reporting system, and from the Agency's corporate GIS; and the information contained therein is used routinely by engineering staff throughout the Agency. The introduction of the system has also ensured standardisation in the recording of flood calls from the public.

In terms of real-time information, the operation of the system is not wholly successful – administrative staff and engineering staff have a range of duties, and flooding is not a daily occurrence. Agency administrative staff are not dedicated call centre staff; hence when a flood call is received the tendency is for the information to be recorded on paper, passed on to the engineer in the same fashion, and entered on to the flood reporting system later. The volume of flood calls can also be an issue particularly when there is a significant event, or series of events.

The recent flooding in June '07 is an example of where the Agency resource to record information on-line was overwhelmed, such that a significant percentage of call details were not entered until after the event. Delays in input of data result in the system not being effective in presenting an up to the minute picture of the scale of flooding, in terms of its spatial extent and severity. Nevertheless the actual emergency response provided by operational staff was effective, given the suddenness of the event, the intensity of the rainfall and the limited resources available. The effectiveness of the response was more allied to the local knowledge and expertise of the engineers and industrial staff, as opposed to the information gleaned from the online Reporting system and associated GIS.

#### 5. THE FUTURE

**Policy Review & Business Need.** The recent Flood Management Policy Review in Northern Ireland inter-alia recognised the potential for changing roles and responsibilities in respect of Emergency Response and Recovery. The Post Public Consultation – Discussion Document refers to the Review of Public Administration which states that responsibility for Civil Contingency Planning should rest with the proposed new Councils. It also expresses the opinion that over time, through their over-arching civil contingency planning role, the Councils may be better placed to lead and co-ordinate all emergency response functions; and that under this umbrella, Rivers Agency would continue to play a key role.

The Agency's role would involve

- Undertaking emergency operations within rivers, e.g. maintaining grilles, clearing blockages, and protecting property e.g. through use of sand bags or demountable defences.
- Post event review – flood data collection and examination of the factors that led to the flooding incident.

As regards business need, and the use of GI systems, it is taken as read that there will be an on-going requirement to manage flood calls from the public, and to record flood event data. The challenge is how to streamline this so that there is a consistent record regardless of which public body received and acted upon the call.

**NI Executive - Action Plan.** In light of the recent (June / July '07) flood events there is political interest in flooding issues. The NI Executive has asked for a thorough review of emergency planning processes with a view to strengthening existing procedures and highlighting areas for improvement. An Action Plan covering

a wide range of issues has been circulated to the various Departments / Agencies involved – it is expected that feedback on the review will be available for the Executive in October. One of the action points being taken forward, in relation to public communication, is the development of a three-digit telephone number, covering all responding agencies and supported by a designated call centre-type facility. At time of writing no conclusion on this topic is available.

**Technical Developments – Opportunity to Host Online Reporting system** . The MOSAIC Geohub is the implementation phase of the Northern Ireland Geographic Information Strategy. The project is being progressed through the Department of Culture Arts & Leisure through its agency – OSNI. The Geohub will consist of a web-based system with embedded GI technologies and a spatial data warehouse. The project has a number of objectives as listed below:

- To assist in policy making in Northern Ireland government
- To facilitate the sharing of spatial data across government
- To make government spatial data available to citizens and the private sector
- To eliminate duplicated effort in capturing and maintaining spatial data
- To increase demand for public sector spatial data

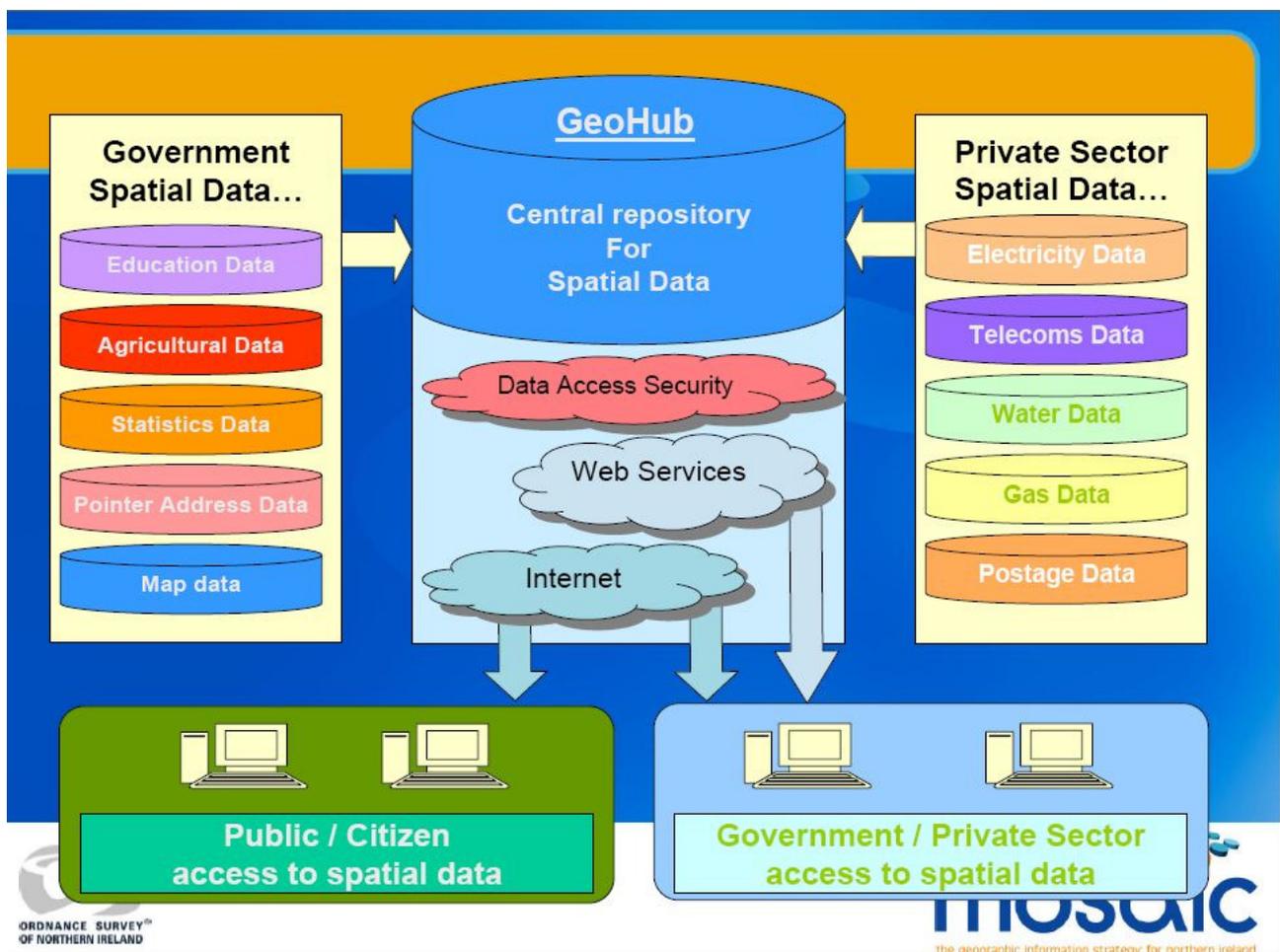


Figure 6 – Geohub schematic (copyright OSNI)

In terms of the future the MOSAIC GeoHub will be the hosting environment for Rivers Agency’s flood mapping website & associated web services. As regards the online Flood Reporting system, there is also opportunity for using the Geohub as the hosting platform; this would provide 24/7 access to the system and allow Rivers Agency management to manage and monitor the emergency response in real time. Indeed this could also facilitate a call-centre facility for dealing with all types of flooding, should government require the same.

There is much scope for further sophistication and application of GIS within this and related business functions – the possibilities for enhancement range from:

- Adding GPS to vehicles to track the location of resources responding to flood events; to
- Sophisticated command and control communication systems that include functionality for incident logging, resource management and messaging, and that provide interoperability with various agencies (such systems are generally used by Fire & Rescue / Police Services); to
- Integration of Customer Relationship Management (i.e. customer complaints), and Works Management Systems – examples of such innovative solutions are in place within Yorkshire Water

However, the investment in technological solutions needs to be commensurate with the business need, and given the scale of operations within Rivers Agency the scope for taking such developments forward is unlikely to proceed in isolation, without the support of the other responders.

## 6. SUMMARY & CONCLUSIONS

The Rivers Agency is an executive Agency within DARD with responsibilities for Flood Defence and Drainage, but no statutory responsibility for flood emergency response. Nevertheless, to protect the public and property from the risk of flooding, the Agency operates emergency call-out arrangements, and in the event of watercourse related flooding incidents, provides assistance. The key responders in respect of flooding are the emergency services, and support is provided by the asset managers - Rivers Agency (in relation to rivers and watercourses), Roads Service (in relation to roadways, footpaths etc), NI Water (in relation to burst watermains or blocked sewers).

The online Flood Reporting system was introduced in support of Rivers Agency's Flood Management strategy - to manage the Agency's Emergency Response and Flood Data Archive, through provision of a simple web-based interface that is integrated with the Agency's corporate GIS.

The operation of the system has had issues in terms of timeliness of input and steps have been taken to reinforce the need to capture and geocode information in real-time, and to ensure that the integrity of the information recorded is complete.

In the future the Councils may have an increasing role in co-ordinating all emergency response functions, and there is likely to be an ongoing requirement to maintain a flood archive of incident reports, such as exists within the online Flood Reporting system.

Technological developments in terms of the MOSAIC Geohub project should facilitate the development of business solutions that will support the flood emergency response, and provide interoperability such that various public bodies responding to flooding can record and coordinate actions.