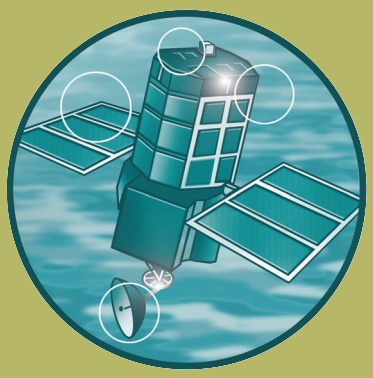
Joint Defra/EA Flood and Coastal Erosion Risk Management R&D Programme

Improving Data and Knowledge Management for Effective Integrated FCERM

Development of Ontology

R&D Technical Report FD2323/TR1



Environment Agency

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Department for Environment Food and Rural Affairs

Joint Defra/Environment Agency Flood and Coastal Erosion Risk Management R&D Programme

Improving Data and Knowledge Management for Effective Integrated Flood and Coastal Erosion Risk Management

Work Package 1 Development of Ontology

Final Report

R&D Technical Report FD2323/TR1

Produced: September 2007

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Statement of use
This is the final report of work package 1 from FD2323 'improving data and knowledge management for effective integrated FCERM.' It explains and illustrates the development of an 'ontology' to provide a systematic representation of the links from FCERM objectives through to data required to underpin their delivery, including the associated information exchange network. Its intended users are managers, suppliers, producers and users of FCERM information both within and outside the FCERM industry.

Dissemination status
Internal: Released Internally
External: Released to Public Domain

Keywords:
Informal ontology; flood risk; coastal erosion; information exchange; data needs; legislation; databases; data research

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www.defra.gov.uk/environ/fcd

Published by the Department for Environment, Food and Rural Affairs (Sept 2007). Printed on material that contains a minimum of 100% recycled fibre for uncoated paper and 75% recycled fibre for coated paper.

PB No. 12527/15

Executive summary

Flood and coastal erosion risk management (FCERM) usually involves managing dynamic systems onto which loadings are continually acting, leading to responses which change the state of the system. Relevant, accurate and up-to-date information about the drivers of this change and their effects is necessary for effective FCERM. A review of approaches within the FCERM industry to planning data collection and the management of the data once obtained shows that there is a tendency to focus on data, as opposed to the business objectives for which the data is required to support. This data-led culture has resulted in an ineffective approach to data management, where the cart is effectively driving the horse. This current approach has given rise to:

- Inability to determine the optimum amount and quality of data required and hence justify the procurement of additional data when needed
- Data in the wrong form, requiring a lot of additional work to convert to useful information
- The duplication of data and its management, due to lack of awareness of data that already exists
- Data redundancies due to lack of objective-led planning
- The inability to re-use or maximise the use of data due to lack of knowledge about other parts of the business requiring the same data
- The inability to share data due to lack of knowledge about others requiring the data and inconsistent standards

Following earlier reviews of data issues within the joint Defra/Environment Agency R&D programme, Defra commissioned the FD2323 project to develop a strategic approach to FCERM data management, to ensure it effectively feeds into knowledge about the business and the delivery of FCERM objectives.

The FD2323 project involved the development of a framework for improving data and knowledge management through a move into a more objective-led approach to data management. A number of techniques and tools were developed within the project to support the culture change required to deliver the objective-led approach. The FD2323 project was carried out within five work packages. The key outcomes of work packages 1–4 (FD2323\TR1–4) feed into the principal output of the project, FD2323\TR5, which provides a guide to support a more effective management of data and knowledge within FCERM. This document (FD2323\TR1) develops the concept of objective-led data management and the systematic representation of the links from FCERM objectives through to data required to underpin their delivery (termed as ontology). It focuses on flood risk (tidal and fluvial), in relation to inland watercourses in rural and urban environments, and coastal erosion.

This Technical Report employs ontology theories to dissect the FCERM domain into rules governing it, which provide clear links to the data, information and knowledge required to support them. This objective-led approach identifies the responsibilities within FCERM and the bodies involved. These bodies were further explored and the data needs to secure the delivery of their remits were

mapped as data requirements flow charts. The data requirements flow charts show that FCERM data originates from a range of spheres; environmental, economical and social. There are commonalities in data types, reinforcing the importance of taking an objective-led approach to identify data needs and manage it effectively.

The current information exchange and relationships between organisations have been illustrated using information fountain diagrams, which illustrate the cyclic motion of data flowing from sources, feeding up as information through organisations to support more strategic needs and then cascading out to provide a wider context to a more local delivery and management. They also show that, the data and information networks do not necessarily mirror the management structures.

The main outputs of the developed ontology for data, information and knowledge management within FCERM are:

- A base of the principal and influential (current and future) drivers for data, information and knowledge in FCERM
- A process to derive data and information needs from business objectives;
- The information and data needs charts illustrating and mapping the relations between business objectives and the data to deliver them for FCERM operating authorities;
- Key organisations directly and indirectly involved in FCERM;
- The information fountain diagrams illustrating and mapping the exchange and flow of data and information within operating authorities and between organisations;
- A base awareness of systems holding and advertising FCERM related data and information; and
- A base awareness of ongoing research on data, information and knowledge management.

The outputs provide the foundations for the other work packages, which will improve data and information re-use, sharing and interoperability between systems (benefits of using ontology). FD2323\TR2 develops tools to provide provenance to FCERM data, improve consistencies and the ability to share data. FD2323\TR3 develops a knowledge management tool mimicking the links between business management objectives and relevant available information, connecting users and suppliers of data. FD2323\TR4 develops a methodology and tools for appraising the value of data to support business decisions for optimum data acquisition.

It is recommended that the data requirements and information flow charts are enhanced and agreed by different functions within the FCERM business to fully understand the data needs and interactions. This should foster the ownership and FCERM-wide awareness necessary to deliver the required culture change.

Contents

Appendices

Figures

Tables

Boxes

1. Introduction

1.1 Project Background

The success of integrated flood and coastal erosion risk management (FCERM) is underpinned by the used of good data, information and knowledge management.

This project (FD2323 Improving Data and Knowledge Management for Effective Integrated FCERM) was carried out within the Joint Defra/Environment Agency R&D programme. Its purpose, following on from previous research and studies, is to produce tools and best practice guidance for effective data, information and knowledge management related to FCERM. The commission is split into four different components (Work Packages). This report (on Work Package 1) forms the foundations for the development of the other components and the guidance. Taking an "objective-led" approach, it explores the bodies with a FCERM remit and maps the data required to secure their delivery together with the relationships and information exchange needs between organisations (conceptually called 'ontology').

The need for this project was identified within a preceding project, also commissioned under within the joint R&D programme 'A Position Review of Data and Information Issues within Flood and Coastal Defence' (FD2314). In order to facilitate a more effective and integrated flood and coastal erosion risk management at all levels, the FD2314 project identified an urgent need to understand and communicate the:

- Need, availability, quality of data and information and audit processes.
- Current roles and responsibilities related to data and knowledge management.
- Need and availability of policies, processes, research and development.
- Need and availability of enabling tools and techniques.

These recommendations, and building on other initiatives such as the Environment Agency's Data and Data Management Strategy, form the basis for this R&D project FD2323 to improve data and knowledge management for effective integrated FCERM within England & Wales.

1.2 Project objective and approach

The project has been developed with the following overall objective:

> To document a structured process which will assist FCERM managers to assess their data needs and maximise the knowledge available on associated information in improving efficiencies in sourcing and management of information they require to carry out their business.

The package of work undertaken to fulfil the objective is summarised below and the relationships between them are illustrated in Figure 1.2.1:

- Work Package 1 (FD2323\TR1) – The development of an 'ontology' to provide a systematic representation of the links from FCERM objectives through to data required to underpin their delivery and the associated information exchange network;
- Work Package 2 (FD2323\TR2) – The development of an ISO 19115 compatible metadata standard for FCERM data and its management through an ISO 19135 compatible format;
- Work Package 3 (FD2323\TR3) – The development of a knowledge management tool to support the ontology by providing an interactive link between management objectives, tasks within these and available information;
- Work Package 4 (FD2323\TR4) – Development of a methodology for appraising the value of data to support business decisions; and
- Work Package 5 (FD2323\TR5) – The development of a best practice guidance for improving data and knowledge management from the outputs of the above research and development work.

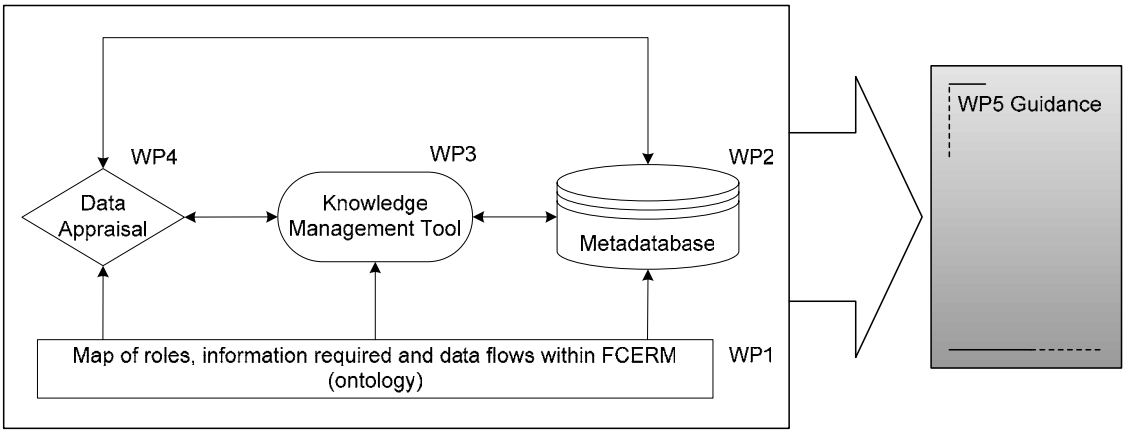


Figure 1.2.1 Overview of FD2323 Work Packages and links

The overall approach of the project team to the delivery of the improvement of data and knowledge management within FCERM is a culture change to embrace "objective-led data management". The whole of the project plan has been designed around the achievement of this culture change and the provision of tools and guidance to support this change.

1.3 Approach to development of Ontology

First the definition of Ontology was investigated and how it ties into FCERM data, information and knowledge management. After gaining an understanding of the principles, scoping studies were carried out by project team experts to capture the availability, provision, structure and responsibilities of data, information and knowledge in FCERM areas:

- Rural land management and flood risk (Cranfield University, Silsoe)
- Urban environment and flood risk (Pennine Water Group)
- Estuarine and coastal flood and erosion risk (ABPmer)
- Inland watercourses and flood risk (Royal Haskoning)

During these studies, targeted discussions and meetings were held with practitioners and stakeholders in FCERM. For instance, experiences and information were gathered from Local Authorities (e.g. Bradford Metropolitan District Council) and water industry (e.g. Anglian Water) in the urban environment, as well as Local Authorities in the coastal environment (e.g. New Forest District Council and Sefton Metropolitan Borough Council). In relation to inland watercourses and flood risk, meetings took place with Internal Drainage Boards (e.g. Kings Lynn Consortium) and the Environment Agency (Asset Management, Strategic Planning and Data Management). Information and knowledge from these studies (originals stored as Project Records) were extracted and used to develop the ontology for data, information and knowledge management in FCERM.

Following an "objective-led" approach, the organisations with an FCERM remit from legislation, policies and strategies were identified. These FCERM responsibilities of the operating authorities were linked to the information required i.e. what is required to fulfil them, and subsequently the data needed to derive the required information. Figure 1.3.1 illustrates this process to identify the information required and data needs of the operating authorities. Charts were created to map the relationships between FCERM activities and data needs of the FCERM bodies (see Section 5).

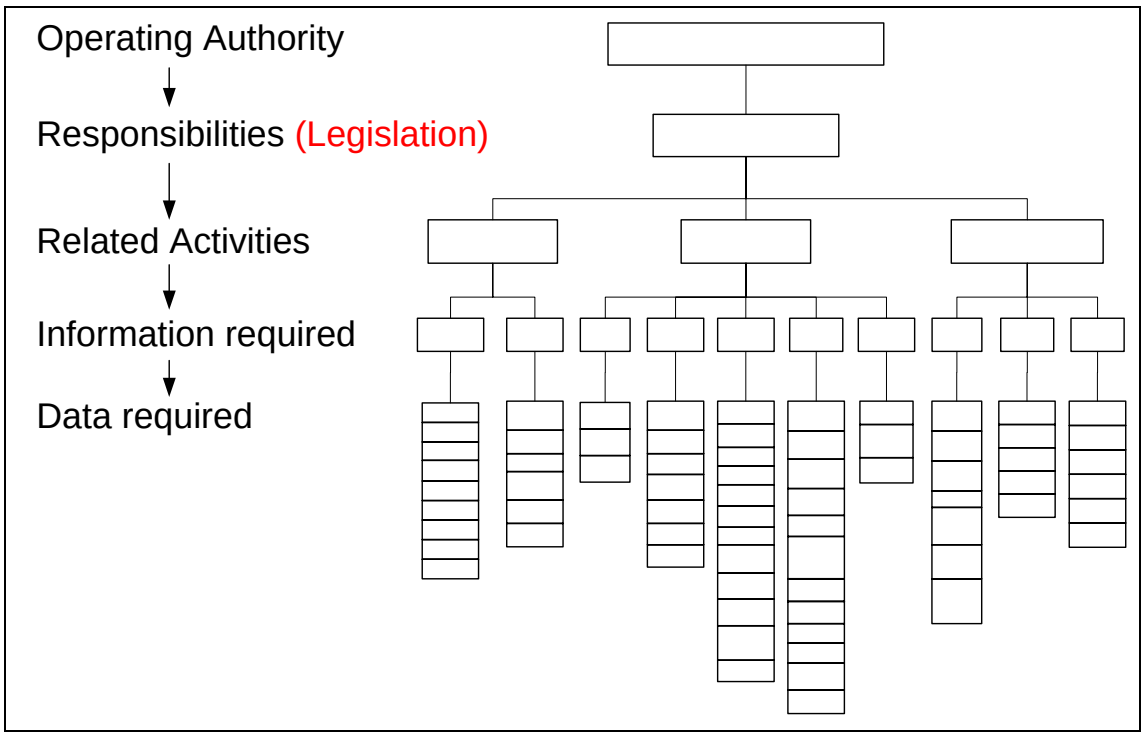


Figure 1.3.1 Objective-led process employed to identify information and data needs

The network of the exchange of information, linking the needs for FCERM data and information to the sources was investigated. Data and information flows into operating authorities, up their management hierarchy (local delivery to policy development) and then cascades back down again within the operating

authorities. At various points in the hierarchy, information and knowledge flows out of the operating authorities to other organisations with an interest in FCERM. Figure 1.3.2 illustrates this movement of data, information and knowledge in FCERM. The information flows between organisations have been mapped using similar diagrams, termed "Information Fountains" according to the nature of the flow of information (see Section 7). These help to demonstrate the complexity of the inter- and intra-relationships in the FCERM world.

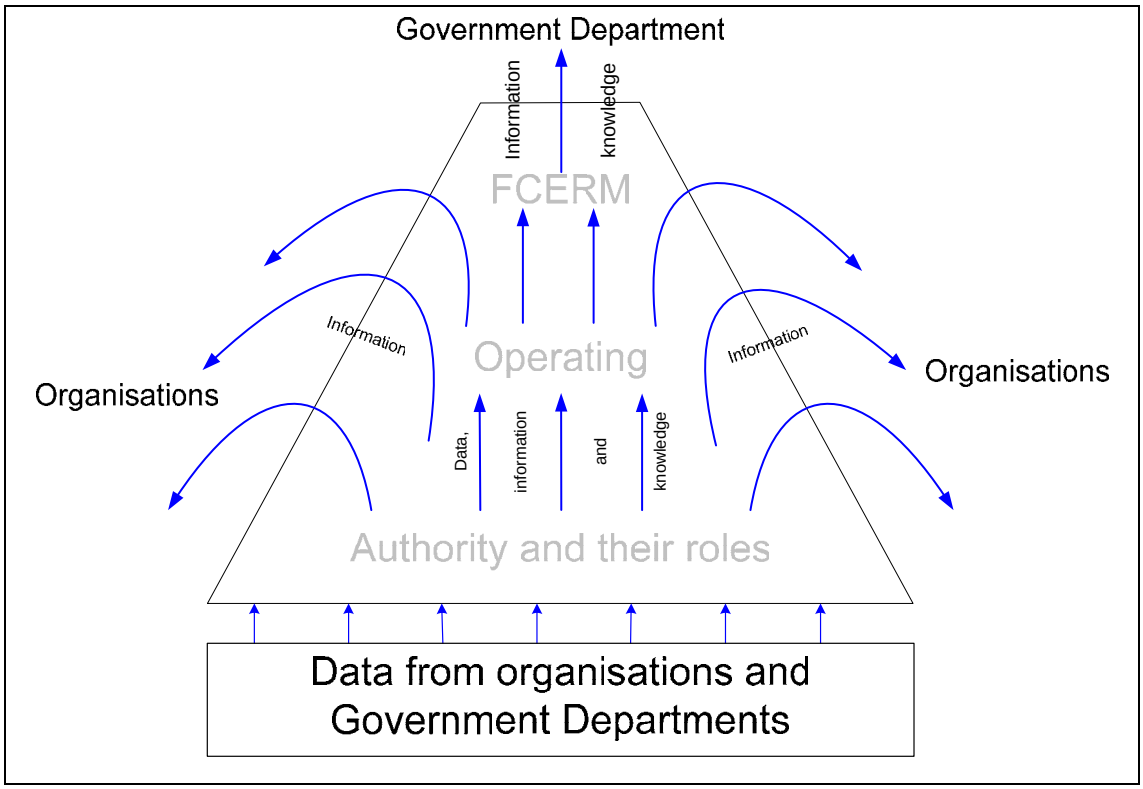


Figure 1.3.2 Illustration of the information fountain

After mapping the exchange of information, the methods to synthesise and aggregate data into useful FCERM information were researched. Tools and techniques were also investigated to store FCERM data and information, such as initiatives and management systems.

Looking to the future, pressures on data and information management were assessed by researching natural, policy and technological changes and issues.

To facilitate the development of the ontology, meetings were held with the Project Board that was composed of stakeholders and experts in data and knowledge management and FCERM. The project board members are found in Appendix A1. A Technical Steering Workshop was also held on 18 March 2005, where the principle elements of the overall research project and the ontology were presented. The Workshop attendees are provided in Appendix A2. Their feedback and input on the information fountains and storage of FCERM data in management systems were invaluable. Issues raised in the workshop have been acknowledged and have steered the development of this work package or the other work packages.

Case studies and scenarios were carried out within the project to develop, test and demonstrate the ontology. They allowed the ontology to be reviewed through a bottom up process, providing a vehicle for identifying gaps and inconsistencies. They have subsequently led to improvements in the ontology.

1.4 Structure of Report

The report develops the ontology of data, information and knowledge in FCERM. First the concept of Ontology is explored in Section 2, together with its origin and contemporary use. The principles are drawn out and their application in the study is described.

Following on from the understanding of ontology, Section 3 puts the terminology of data, information and knowledge into perspective, with the use of examples. Section 4 presents an overview of the four key areas (rural, urban, coastal and fluvial) within which FCERM was reviewed.

Although the preceding R&D project (Defra, 2004d) contained parts of the FCERM structure, Section 5 brings together the entire FCERM structure, the bodies involved and their associated responsibilities from legislation, policies and strategies. This section then presents the charts that illustrate the relationships between FCERM activities, information required and data needs of the FCERM bodies.

Following the identification of FCERM organisations, it became apparent that there are organisations and people who do not have direct FCERM responsibilities but either require FCERM information to achieve their own activities or can provide data and information that is useful for FCERM. These organisations are recognised in Section 6 by pursuing the Source-Pathway-Receptor approach.

Section 7 presents and discusses the “Information Fountains” that map the transfer of information (information network). The synopsis also compares the “fountains” with the charts from Section 5 on information and data requirements, revealing gaps and issues.

The sources and storage of FCERM data and information is explored in Section 8. Methods to synthesise and aggregate FCERM data as well as data initiatives and management systems designed for FCERM and other purposes are described within this section.

The future impacts on data, information and knowledge management, as well as needs, are assessed in Section 9 in response to policy, natural and technological changes, including ongoing R&D studies.

Section 10 summarises the findings of Work Package 1 and the implications for data and knowledge management in the FCERM community.

2. Application of Ontology concept

In order to develop Ontology for data, information and knowledge in FCERM, there is a need to appreciate the meaning behind Ontology. Ontology is widely interpreted as,

> 'A shared conceptualisation of a domain of interest'
> (Gruber, 1993).

In other words, reality (domain of interest) is dissected into concepts, relations and rules (Audi, 1995), and agreed between knowledge users. The origin of Ontology dates back as far as 340 BC and can have philosophical or artificial intelligence meanings (Appendix B1). It has evolved through the World Wide Web (Appendix B2) and its modern applications are far-reaching from taxonomies to GIScience (Appendix B3). Ontology facilitates knowledge management, which benefits inter-operability, re-use and sharing.

The FD2314 project defined Ontology as a 'map' to show the existence and the relationships of the data, information and knowledge applied to for the full range of FCERM decisions, and the current roles and responsibilities for collection, management and the use.

This work package applies the principles of ontology concept to investigate the relationships of data and knowledge management in FCERM. It takes a Domain-specific and 'task orientated' approach (Appendix B3) using natural language (formal, machine readable, language is developed in Work Package 2).

Following Noy and McGuinness (2003), competency questions, below, have been used to define and limit the scope of this ontology. These questions have helped target the research in developing the ontology for data, information and knowledge management in FCERM.

- **What is the domain that the ontology will cover?**
  The domain of interest is data, information and knowledge for flood and coastal erosion risk management (FCERM). Initial scoping reports have been produced from experts in the domain to obtain consensual knowledge. Throughout the development of the ontology knowledge users have also been consulted and their comments have been integrated.

- **For what are we going to use the ontology?**
  The report provides an understanding of data, information and knowledge requirements for FCERM and existing relationships. This understanding supports the remaining parts of the project that develop data consistency/documentation supporting interoperability (metadata standards in Work Package 2), sharing (knowledge management technology and tools in Work Package 3) and knowledge management (data appraisal and justification in Work Package 4).

- **For what type of questions should the information in the ontology provide answers?**
    1. Why do we need data/information?
    2. Who needs it?
    3. What do we need?
    4. Where do we get/collect it?
    5. How is it exchanged and transferred?
    6. How is it stored?

In essence, the ontology breaks down the FCERM domain into the rules (present and future) governing it, thus providing clear links to data, information and knowledge required to support them. It systematically represents the structure of information exchange improving the knowledge about the sources and management of data.

3. What are data, information and knowledge?

CIRIA C541 guide focused on maximising the use and exchange of coastal data. It defined terminology of data (extracts in Box 3.1). It importantly recognised that information and data can, physically, be the same, but it is the context that defines its value. Taking this a step further, the context is defined by the objective of the decision maker. Therefore maximum value can be derived by focusing on the objective rather than focusing on the data.

Data	Representations or analogues, often numeric, of phenomena
Information	Data that can be directly interpreted for decision-making or management purposes.
Knowledge	Understanding, achieved through the result of using information.

Box 3.1 The language of data (extracts from CIRIA, 2000)

To make a significant step change in this area there is a need for a culture change from 'a data centric focus' to 'an objective led information management,' within which the requirements for data and its management is developed.

The link between data collection, analysis and management and use of data, information and knowledge is described by the following scenario description and Figure 3.1 below.

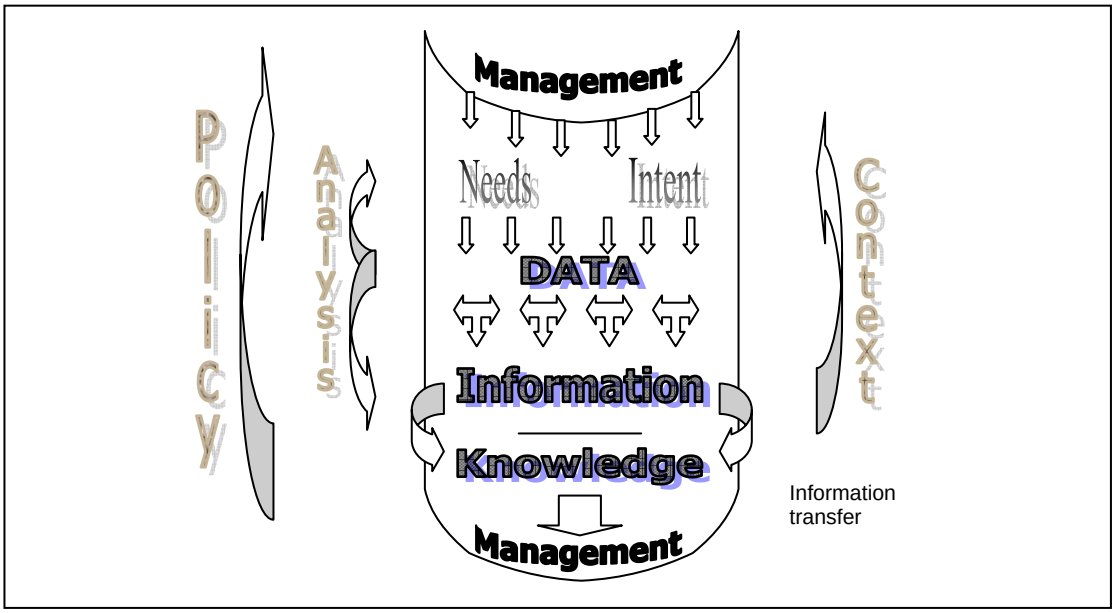


Figure 3.1 Conceptualisation of data, information and knowledge

Data is what is collected or measured; and in this sense is individual, relates to an individual attribute: for example beach level, water level, land level or bird count. It has no identity beyond the attribute upon which it is focused. It is not specifically referenced to any other data and in itself is means nothing. That a structure is at -10m ODN, on its own has no value. It is only in combination with other data, creating a data set, that specific data has use. The structure is at -

10m, the water level is +10m. Information is created that the structure is below tide level. The information is that there is a risk of the structure being flooded.

The difference between data and information also depends on the purpose or objective. So while information may have some meaning for one purpose, it may be considered data for another purpose. For example, beach profiles may give information on the evolution of the coastline, however, if you want to know the standard of defence, it is data and you still require wave data and water levels.

Knowledge comes from understanding this information. That there are defences and that therefore the level of risk is limited; that such and such water level is of such and such a probability and that the actual risk is what ever the loading on it; the structure is disused and the implications of it flooding are irrelevant.

In the report, there has been much deliberation not to confuse data, information and knowledge and use them according to the purpose. Having said this, it does recognise that the distinction between data and information is not always clear-cut and is often skewed by perspectives or contexts.

4. Review of Flood and Coastal Erosion Risk Management

The study focuses on FCERM data, information and knowledge management. FCERM involves the management and reduction of risk to people, property and environment, while also encouraging sustainable development. This risk in FCERM can be divided into four areas:

- Rural land management and flood risk
- Urban environment and flood risk
- Estuarine and coastal flood and erosion risk
- Inland watercourses and flood risk

These areas form the scope for the study and are explained below.

4.1 Urban environment and flood risk

In 2002 a report was prepared for the Office of the Deputy Prime Minister, "A Review of Urban and Rural Area Definitions." The report concluded that no single definition of urban and rural could meet the needs of all users and there was a lack of clarity around the definition and choice of definitions. However, in 2003 an "Urban and Rural Areas Definitions: A User Guide" was produced. There are two recommended definitions, one of Urban Settlement based on land use and the second of Administrative Area Classification based on socio-economic variables. Hence, there is still some lack of clarity about the definition of an urban area. In this project, the 'urban' area is considered as related primarily to larger communities that have a substantial sewerage system.

Within urban areas several mechanisms may give rise to surface water flooding, moreover the mechanisms may occur independently or in conjunction with each other. The mechanisms that have been identified for the purpose of this project are:

- Pluvial flooding characterised by the surface runoff and inundation occurring before runoff enters a drainage system
- Flooding caused by the overflow or ejection of flows from drainage systems such as watercourses, drains or sewers where the capacity of the system to handle the incoming flows is exceeded
- Flooding caused by the lack of effective performance of drainage system or asset failure. The lack of performance or provision of an adequate level of service is linked to 'failure' of or within the drainage system that as a consequence affects the capacity of the system, such as blockages, collapses or equipment failure
- Coincidental flooding when tidal or fluvial waters inundate urban areas resulting in backflow in urban drainage systems; overwhelming of flood defences (urban drainage systems inoperable)

4.2 Rural land management and flood risk

Rural land is taken to include that which is not subject to major urban and industrial development and is thereby distinguished from the urban environment. It typically comprises those parts of the open landscape occupied by agriculture, woodlands and forestry, as well as areas managed to varying degrees of intensity for the purposes of nature conservation, recreation and amenity.

Rural land use has a potentially important part to play in flood risk management in so much as runoff from rural land may act as pathway for water that accumulates to cause flooding in receptor areas. Badly managed rural land can significantly increase soil erosion and hence sediment loads downstream, silting up flow pathways. In some cases, the receptor areas may be rural, occupied for example by agricultural or conservation land. The resultant damage depends on the intensity of land use and its sensitivity to flooding. In some cases, however, the receptor areas may be urban areas or settlements in rural areas, resulting in very high damage costs and social disruption.

There is a growing concern that changes in land use in rural areas have increased the exposure of urban settlements to flood risk, not only at a local level but also possibly at the catchment scale. This has led to calls for interventions to reduce the potential run-off from farmed land and in some cases to reduce the degree of protection afforded to farm land in order to provide storage of flood waters. This potential contribution to flood risk management has also been linked to the potential benefits of enhanced biodiversity and reduced sources of diffuse pollution (Morris *et al*., 2004; O' Connell *et al*., 2004). In this context, it is perceived that measures to control run off from, and to provide temporary storage on, rural land could help reduce flood generation and associated risks.

4.3 Estuarine and coastal flood and erosion risk

Estuarine and coastal flooding or erosion risk occurs when the coastline or sea defences are either overtopped or eroded by tides and waves or sea defences fail. In relation to this it is also important to consider the behaviour of the coastal process linkage in terms of maintaining sediment supply, understanding currents and future change or pressure for geomorphological change. In addition, there may be significant feedback between parameters such that erosion or sea level change may lead to increased wave exposure, resulting in increased erosion or increased sediment supply. Intervention may then result in increasing or decreasing pressure, affecting systems as well as local conditions. Underlying this, systems may cross thresholds, particularly associated with estuaries, where radically different regimes come into play.

Compared to flooding from inland waters, coastal flooding has the potential to cause more damage with increased recovery periods due to the associated pollution, corrosive effect and higher wave and currents. While flood land, properties or communities can recover over time following damage, the consequence of coastal erosion on the other hand is irreversible loss to the sea.

The highly interactive nature of coasts and estuaries often imply wider information need to assess the risk.

4.3 Inland watercourses and flood risk

Inland watercourses consist of fluvial rivers (Main and non-Main) and drains that serve as conduits for rural and urban run off, connecting them to the sea. At their lower reaches they are often tidal, sometimes acting as high level carriers (in lowland areas), requiring installation of point structures such as pumps and sluices to operate efficiently. They can create a flood risk to adjacent land (floodplains) when the capacity of the channel is exceeded or when defences fail. The capacity of a channel may be exceeded not only by an inability to convey flows, but also by restriction of discharge to receiving watercourses or to tide.

The sources of water within inland watercourses could be directly from pluvial, urban, rural underground or a combination of sources. Watercourses could be relatively free flowing or restricted at the outfall by tides, outfall structures or higher level carriers. Assessment of their capacity and risk of inundation to adjacent land and associated damage/loss requires an understanding of these sources as well as the pathway and receptor information, state, susceptibility and resilience. Making long term management decisions with this information also requires the need to assess pressures and trends on this information into the future. The boundaries of inland watercourse effects and required information are primarily the associated catchment. Information and understanding of the catchment and associated systems and interactions therefore form the basis for managing the sub-systems and local flooding issues within it.

5. FCERM structure and data needs

The current structure of management of flood risk and coastal erosion is determined by legislation and policies, which ascribe duties, powers and responsibilities. It is this management structure that will be the principal driver for data, information and knowledge with different roles and responsibilities having different needs.

There are a number of organisations with responsibilities for FCERM, which can sometimes be overlapping and conflicting. This results in a complex management structure with different organisational duties making up the overall hierarchy. This complexity is likely to also lead to some degree of challenge in terms of data and information management with each of the organisations with a FCERM role or responsibility.

In addition, each of these organisations may also fulfil some form of data collection and supply roles as part of their activities. The data collection may be of direct value internally within an organisation, while also being aggregated to provide internal management information or being passed onto other organisations in the fulfilment of their responsibilities. However, whilst recognising this, it is also important to note that in terms of data collection and supply, organisations are involved that are in fact outside of the direct FCERM management structure (i.e. they do not have a direct FCERM responsibility, such as the Met Office). This issue is addressed further in Section 6.

5.1 Legislation and responsibilities

The division of responsibilities for implementation and the setting of policy in FCERM have a number of drivers in the form of a body of legislation. This body of legislation, being both in the manner of giving power to act and responsibilities or duties to the public, therefore provides the highest-level driver for FCERM and hence data, information and knowledge needs. Each piece of legislation can be considered to be either a direct or an indirect driver for FCERM. Direct drivers are items of enabling legislation that specifically address FCERM issues. Direct drivers include:

- Coast Protection Act 1949 (CPA);
- Local Government Act 1972 (LGA);
- Reservoirs Act 1975 (RA);
- Highways Act 1980 (HA);
- Water Act 1989 and 2003 (WA);
- Land Drainage Acts 1991 and 1994 (LDA);
- Water Industry Act 1991 (WIA);
- Water Resources Act 1991 (WRA);
- Environment Act 1995 (EA);

The duties and powers transferred by these drivers are explained in further detail under each FCERM organisation.

Indirect drivers are items of legislation that do not necessarily relate to FCERM but have implications for it and will exert an influence on the nature of knowledge required and hence to data and information needs to provide this knowledge. A couple of important ones are briefly summarised below.

- Habitats Directive (1992). Concerned with the conservation of natural habitats and promoting biodiversity. There is a need within FCERM for data, information and knowledge to (1) ensure defence schemes do not adversely impact upon designated areas and (2) develop opportunities to integrate FCERM with biodiversity targets and habitat management;

- Water Framework Directive (2000) (WFD). Concerned with the protection of the ecological status of all water bodies, including rivers, estuaries and coastal waters as well as individual water bodies. As such it impacts on all aspects of FCERM. There is a requirement to consider the impact of any defence works on hydromorphology and pollution, dictating both the need for defence and the manner of management. Information about factors affecting the ecological status and the effect of FCERM on them is required to ensure FCERM complies with the requirements of the WFD i.e. to ensure FCERM actions do not adversely impact upon the achievement of good ecological status. In addition, there is an overlap of data needed for the individual functions of FCERM and WFD.

5.1.1 Defra and WAG

The Department for Environment, Food and Rural Affairs (Defra) and the Welsh Assembly Government (WAG) have an overall policy responsibility for flood defence in England and Wales respectively. They provide and administer a statutory framework, in the shape of strategic guidance to Operating Authorities. Figure 5.1.1 maps the position of FCERM within the government and shows a hierarchy of management. They also provide grants for improving flood defences, flood warning and R&D work related to risk management.

The policy framework for flood and coastal erosion risk management in England and Wales has recently moved forward. The 1993 National 'Strategy for Flood and Coastal Defence' by the then Ministry of Agriculture, Fisheries and Food (MAFF)/ Welsh Office has expired. A proposed strategy for the next 20 years in England, 'Making Space For Water' (MSFW), has been published. A public consultation exercise on the proposed strategy took place towards the end of 2004 (Defra, 2004c). In March 2005 the Government published its first response to the consultation setting out clear policy directions, advocating an integrated approach to water management overall. The Welsh Assembly Government plans to undertake a similar exercise. The aim of Defra's new strategy is,

> 'To manage the risks from flooding and coastal erosion by employing an integrated portfolio of approaches which reflect both national and local priorities, so as:
>
> - to reduce the threat to people and their property; and

- to deliver the greatest environmental, social and economic benefit, consistent with the Government's sustainable development principles.

To secure efficient and reliable funding mechanisms that deliver the levels of investment required to achieve the vision of this strategy.'
(Defra, 2005b)

However, Defra recognises that further work/evidence is required to develop a detailed strategy. Hence a three year Delivery plan (programme products in Appendix C2) has commenced to gather further evidence and carry out further scoping to enable production of a final strategy and achieve the vision set out in MSFW (Appendix C1). In the meantime FCERM is continuing within the Government First Response strategic direction (Table 5.1.1) enhanced by detailed Policy Statements as they become available. Future implications on data, information and knowledge management in FCERM from MSFW are discussed in Section 9.

Themes	Strategic Direction
Land-use Planning	Encourage inclusion of Flood Risk Assessments (FRA's) at all levels of planning process. Gateway questions to determine need for FRA's in Standard Planning Application
	Environment Agency to become statutory consultee, subject to consultation
Rural Land-use	Multi objective approaches to make space for water, such as creation of washlands/ wetlands and managed realignments of coasts and rivers
	Continue research on role of rural management and generation of flooding
Coastal	Review of institution arrangements and legislation with the Environment Agency taking a strategic overview to coasts
Groundwater	Environment Agency will assume strategic overview of groundwater monitoring till Spring 2006
Urban Drainage	Pursue integrated urban drainage management. Continue pilot studies to test different approaches to integrated management.
	Ensure flood risk is appropriately considered in the transport network
	Potential to transfer private sewers to sewerage undertakers. Ofwat (now Water Services Regulation Authority) to ensure water companies deal with sewer flooding
	Encourage land management practices, such as SuDS (including recycling and re-use), and so not overload urban drains
Flood Warning	Feasibility studies to expand flood warnings for different forms of flooding, such as urban, pluvial, groundwater and flash floods

Table 5.1.1 Strategic directions from the Government's First Response to *Making Space For Water*

In the keeping with the strategy aim of MSFW, a new 2004 Spending Review target (SR04) was issued to cover the period 2005-8 for managing the risk of flooding and coastal erosion:

'Defra will manage flood and coastal erosion risk so as to contribute to sustainable development, including minimising loss of life and improving

the standard of protection for at least 100,000 households using efficiency savings to maintain outputs at equivalent levels to 2005-6.'

In 1999 the Ministry of Agriculture, Fisheries and Food (MAFF) set 14 High Level Targets (HLTs) in order to secure the delivery of MAFF's (now Defra) three objectives of the 1993 Strategy for Flood and Coastal Defence. Although many of these HLTs fell under the powers bestowed to the operating authorities from Acts, the targets gave them an impetus to carry out their roles. An elaboration of the Environment Agency's flood defence supervisory duty was also produced in parallel with the targets.

A revised set of HLTs took effect from 1 April 2005 which operates on an interim basis pending the introduction of performance measures and Defra's new strategy for FCERM. Many of the previous targets were short term and are no longer relevant. The new HLTs are streamlined to focus on what still needs to be done to ensure a more certain delivery of Defra's FCERM policy aim and its changing (more strategic) role. There are now only 6 High Level Targets, as outlined below:

HLT 1 Policy Delivery Statements
HLT 2 Information on the National Flood and Coastal Defence Database (NFCDD)
HLT 3 Shoreline Management Plans
HLT 4 Biodiversity
HLT 5 Development in areas at risk of flooding and coastal erosion
HLT 6 Internal Drainage Board organisation and administration

The High Level Targets are a driver for much of the upward information generation. The HLTs are referred to while presenting the responsibilities of the operating authorities in the Sections 5.1.4 to 5.1.6.

Defra also made three Flood Management Service Delivery Agreement (SDA) Targets which were agreed with the Treasury in the 2002 Spending Review:

SDA 26 To aim, by the encouragement of sustainable defence measures (including timely and effective flood warning systems), to have no loss of life through flooding.

SDA 27 By investing £397 million over the Spending Review 2002 period (2003-06), Defra will reduce the risk of flooding to life, to major infrastructure, environment assets and to some 80,000 houses.

SDA 28 Defra will implement the conclusions of the Flood and Coastal Defence Funding Review including the development of proposals for new funding streams and initiatives to reduce the percentage of overheads involved in the provision of flood defences, to an agreed implementation plan to be developed by March 2003.

SDA 28 relates to the implementation of the conclusions of the Funding Review. Following the government's Spending Review 2000, a review of flood and coastal funding mechanisms was undertaken for England and Wales. The conclusions of the Funding Review for England were announced in March 2003. A plan by Defra to implement the conclusions was delivered in England, in June 2003, which consisted of 8 strands:

Strand 1: Critical Ordinary Watercourses (COWs);
Strand 2: Improved arrangements for IDBs and review of EA supervisory duty;
Strand 3: Single tier flood defence committees;
Strand 4: Capital block grant;
Strand 5: Revenue block grant;
Strand 6: New funding streams;
Strand 7: Reduction of overheads including streamlined scheme approval procedures;
Strand 8: Three-year review.

Strand 6 sought to identify new funding streams, including a more direct contribution from beneficiaries. However, no agreements on this were reached at the time that the Funding Review conclusions were announced, and subsequently it is being taken forward as integral to the new Strategy for FCERM 'Making Space for Water.' The other strands are expanded under the relevant operating bodies with which they apply to.

The conclusions of the funding review in Wales were announced in June 2004. An implementation plan reflecting the above workload strands has been developed and implementation of the new arrangements in Wales is planned for completion by 2006.

5.1.2 Office of the Deputy Prime Minister

The Office of the Deputy Prime Minister (OPDM) is responsible for development planning and the Town and Country planning system In England. It covers policy on planning with regard to flood defence projects and development. The Department for Environment (DoE) was originally responsible and published Circular 30/92. Then the office became the Department for Environment, Transport and Regions (DETR) which published Planning Policy Guidance (PPG) 25 on 'Development and Flood Risk' (2001) to control flood risk issues related to new development.

In March 2005 ODPM and Defra made a joint announcement on a package of proposals that included strengthening planning policy. As part of this package, ODPM is consulting to review and revise PPG25 with a new Planning Policy Statement (PPS25) to provide a more strategic approach to the management of flood risk. A consultation draft of PPS25 was issued in December 2005. It emphasised on the need to consider flood risk as early as possible in the planning process, focusing core policies that are clearer and easier to understand with strengthened guidance on the need to include Flood Risk Assessments at all levels of the planning process (Defra, 2005b). Following consultation, it expected that the new PPS25 is published mid 2006 along with a

standing planning Direction on flooding, if it is supported by the consultation responses.

A similar document for Wales, Technical Advice Note (TAN) 15 'Development and Flood Risk', was published in 2004 by WAG.

The renewed focus from defence to FCERM through an integrated portfolio of measures requiring improved links between government policies from Defra (overall policy) and ODPM (planning policy) to manage, in particular development and flood/coastal erosion risk, signals an increasing role fro ODPM activities within FCERM.

5.1.3 Office of Water Services

The Office of the Water Services (Ofwat) is the economic regulator for the water and sewerage services in England and Wales, established under the Water Act 1989. Ofwat is a non-ministerial government department with powers to enforce water companies to carry out their responsibilities under the Water Industry Act 1991 (see Section 5.1.7) while encouraging them to be more efficient.

The interests of water and sewerage customers in England and Wales are represented by an independent body, WaterVoice, whose aim is:

> 'to be an effective and influential voice for water and sewerage customers in England and Wales, in promoting their interests in respect of price, service and value for money' (WaterVoice, 2005).

Similarly there is an association that represents all the water and wastewater service suppliers, called Water UK, who seek to develop policy and improve understanding in areas that involve the industry, its customers and stakeholders. It should be noted that Ofwat are not responsible for the regulation of private sewers.

In accordance with the Water Act 2003, the structure and provision of water regulation is changing. In April 2005 better regulation provisions were implemented in relation to the Regulator's new statutory duties, social and environmental guidance, standards of performance, financial penalties, reasons for regulator's decision, and revised enforcement procedures. From October 2005 WaterVoice was replaced by the Consumer Council for Water. In April 2006 Ofwat will become the Water Services Regulatory Authority.

The move from flood defence to management of flood risk is leading to improved focus on urban drainage as an integral part of flood risk. This inevitably means more links between water and sewage authorities and FCERM. This need is already well recognised in Making Space for Water and the associated Delivery Plan.

5.1.4 Environment Agency

The Environment Act (EA) in 1995 established a new operating authority, the Environment Agency as the guardian and regulator for land, water and the environment. The Environment Agency took over the responsibilities of the National Rivers Authority (NRA).

Section 6 (4) of the EA 1995 transfers a duty to 'exercise a general supervision over all matters relating to flood defence,' which includes sea defences. Consent from the Environment Agency is also required to carry out works on, in or over a main river (s.109 WRA 1991). However, the Environment Agency must delegate its own land drainage functions to Regional Flood Defence Committees (RFDCs) according to s.106 WRA 1991.

The Environment Agency is empowered by the Water Resources Act (WRA) 1991, Section 165 (1), to:

(a) maintain existing works – cleanse, repair, maintain watercourses;
(b) improve existing works – deepen, widen, straighten existing watercourses/ remove weirs and obstructions; and
(c) construct new works – make any new watercourse/ drainage work.

Section 166 of WRA 1991 empowers the Environment Agency to provide flood warning systems and provide, install and maintain apparatus for this purpose. However, the above executive powers of the Environment Agency are permissive, whereby they can choose to carry out works at their discretion. These powers refer to main rivers, tidal rivers, estuaries and coastal areas.

The Environment Agency has a duty to carry out surveys of areas where it carries out flood defence functions (s.105 (2) WRA 1991) and to copy the results to Local Planning Authorities (LPA) to inform development planning and development control functions (DoE Circular 30/92 para.7). The Environment Agency is also a statutory consultee in the preparation of development plans and guidance to LPA (DoE Circular 30/92).

In 1999 an elaboration of the Environment Agency's flood defence supervisory duty was produced, in parallel with the old 1999 High Level Targets (HLTs), under the following sections:

1. Condition of flood and coastal defences and critical ordinary watercourses
   1.a Flood Defences
   1.b Critical Ordinary Watercourses
   1.c Coastal Defences
   1.d National Flood and Coastal Defence Asset Database
2. Assessment of flood risk
3. Achievement of Defra high level targets
4. Emergency response to flooding incidents
5. Awareness of flood risk in the community
6. Future development proposals that have potential impact on flood risk
7. Regulation of others

8. Application of conservation duty and environmental impact

Many of the 1999 HLTs were related to the Environment Agency's supervisory duties and, while they have been superseded by a new set in 2005, they have since become incorporated into the Environment Agency's Corporate Plan, such as flood warning and improvements to flood defences.

HLT2 deals with operating authorities recording the remaining information on flood and coastal defences, including the results of inspections, on the National Flood and Coastal Defence Database (NFCDD) according to Environment Agency specifications. The creation and role of NFCDD is explained further in Section 8.

The second generation of Shoreline Management Plans (SMPs) are required under HLT3. The Environment Agency is likely to play a greater part in these plans in line with the extension of their strategic role to coastal erosion according to Making Space for Water. Targets to take forward Catchment Flood Management Plans are stated in the Environment Agency's Corporate Plan (CFMPs). The purpose of these plans and the data and information held within them are described further in Section 8.

In accordance to HLT4 the Environment Agency receive reports from all operating authorities on all loses and gains of habitats covered by UK Biodiversity Action Plans resulting from flood and erosion risk management operations. Subsequently an annual report summarising this, and other biodiversity information, must be delivered to Defra from the Environment Agency.

HLT5 considers development in areas at risk of flooding and coastal erosion. The Environment Agency has to report annually to Defra and ODPM on Local Authority development plans and their response to planning applications on flood risk grounds.

The Environment Agency is also the competent authority in England and Wales for implementing the Water Framework Directive (WFD) that will have a bearing on FCERM. The new strategy for FCERM, Making Space for Water, has an aspiration that the Environment Agency takes a strategic overview of all flooding and coastal erosion. The implications of this strategy are explored in Section 9.

With respect to urban flood risk, the Environment Agency appears to have limited direct responsibilities. It is required to exercise its functions at a distance through the provision of information, advice and comment with limited powers of persuasion or coercion. In practice the Environment Agency would have an interest in:

- Pluvial events in adjacent rural areas causing flooding within urban areas i.e. upstream effects; and
- Fluvial flooding caused by watercourse or coastal water inundation into urban areas.

However, the interest only relates to those watercourses and defences that would fall within the Environment Agency's remit. Given the numbers of calls on its resources and the potential for a blurring of duties and responsibilities within urban areas, it would appear that the Environment Agency is not in a strong position to exercise significant influence over urban flood risk management other than for main rivers and sea defences and through consents for any form of flow restriction, such as culverts or bridges (s. 23 LDA 1991 and s. 109 WRA 1991).

With respect to rural areas, there is less of a priority for the Environment Agency in terms of flood risk management, except where significant settlements exist. However, the management of flood risk is highly affected by environmental protection, conservation and heritage issues. In addition, an increasing public desire for environmental protection and enhancement and less pressure on flood protection is changing priorities in this area.

Peak flood flows from new developments are controlled by reference to the stated hierarchy in PPG25. Although local authorities administer the planning consents, the Environment Agency is required to check the storm flow management arrangements in accordance with the hierarchical approach currently in PPG25. PPG25 is being updated and strengthened with PPS25, which was issued at the end of 2005 for consultation and the final document will be published summer of 2006.

The Environment Agency is also integral to the delivery of the Funding Review conclusions. Strand 1 (COWs) transfers the responsibility of ordinary watercourses that create the greatest flood risk to the Environment Agency. COWs have already been identified and are currently being transferred. It will be possible to contract day-to-day work back to Local Authorities (LAs) and Internal Drainage Boards (IDBs) where these bodies are willing and have a good track record in managing the watercourses. The changes should streamline management of high flood risk areas and make responsibilities clearer to the public.

Strand 3 creates a single tier of flood defence committees by abolishing Local Flood Defence Committees (LFDCs), which will took effect from 1 April 2005. The aim is to reduce costs of servicing the committees, prevent second guessing of decisions and make accountabilities clearer. The power to abolish LFDCs and create RFDCs has been provided within the new Water Act 2003.

Strands 4 and 5 change the way the Environment Agency is funded by introducing block grant aid to the Environment Agency replacing the scheme specific grant and the Environment Agency levies on LAs. The Water Act 2003 enables the scheme-specific grant to be replaced. So approvals will generally be taken at a strategic level rather than a scheme level. However, Defra and WAG will continue to approve Environment Agency schemes above specified thresholds and individual schemes forwarded by IDBs and LAs. The Strands also aim to have new risk based prioritisation arrangements in place for 2006-7.

The Water Act 2003 makes the Environment Agency the enforcement authority of the Reservoirs Act 1975 in England and Wales. Prior to 1st October 2004 the enforcement of the Act in England and Wales was the responsibility of 136 Local Authorities. The primary objective of the Act is to prevent uncontrolled release of water from raised reservoirs, leading to flooding of lower land and communities. As the Reservoirs Act's Enforcement Authority, the Environment Agency is responsible for ensuring that the Undertakers commission regular inspections of all large raised reservoirs by appropriate panel engineers. They can also request Flood Plans to be produced for specified reservoirs.

5.1.5 Internal Drainage Boards

Internal Drainage Boards (IDBs) exist in some low-lying areas in England and Wales where flood protection and land drainage are deemed necessary to sustain both agriculture and developed land use. Under the Land Drainage Act (LDA) 1991 and 1994, IDBs are defined as statutory drainage bodies and given a duty to exercise general supervision over all matters relating to drainage of land within their Internal Drainage Districts. They are empowered to undertake works (construction, improvements and maintenance, including operation of pumping stations) on all watercourses in their area. If another body, such as the Environment Agency or the Highways Agency, wishes to carry out work then consent is required from the Drainage Board. IDBs are also under obligation to consult with statutory and non-statutory bodies to ensure no damaging effect from flood defence works on nature conservation (LDA 1991 and 1994).

The majority of Internal Drainage Districts do not fall within administrative areas of metropolitan LA's and so play a minor role in urban FCERM. However, it is with respect to either upstream or downstream effects of developments or associated run-off on urban areas that there is a need for care and attention to be exercised. This relates particularly to the coordination between the various responsible parties.

There are currently 188 IDBs in England and Wales (ADA, 2005). There used to be more but some have merged or formed consortia to improve efficiency. Strand 2 of the Funding Review delivery plan promoted further use of amalgamations and consortia of IDBs to improve their effectiveness and broaden membership. Annual reports on the implementation of amalgamations, consortia and membership are submitted to Defra by the Association of Drainage Authorities in accordance with the previous HLT14, now superseded by the new HLT6.

As part of Strand 2, IDBs now come under the jurisdiction of the Local Government Ombudsman (LGO) to facilitate dealing with complaints. Other Procedures under which IDBs operate are currently undergoing a major review. In accordance with the government's 1999 HLT3, IDBs are also responsible for emergency response in conjunction with the Environment Agency and LAs. The approach to this role is recorded in the Policy Delivery Statements (new HLT1), along with approaches to environmental issues, developer contributions and development control.

IDBs are funded by charging drainage rates to the occupiers within their districts, as well as grants from Defra and WAG for capital schemes. However, the new strategy 'Making Space for Water' is looking at new funding streams. The changing priorities towards sustainable agricultural and environmental practices may open up more funding opportunities, with IDBs increasingly expected to achieve a multitude of environmental and land drainage objectives.

5.1.6 Local Authorities

Local Authorities (LAs) have powers under the Local Government Act 1972 to incur expenditure in order to "avert, alleviate or eradicate" the effects of an emergency. Recently the Civil Contingencies Act 2004 has updated existing legislation to give powers to local authorities and other public bodies to deal with emergencies and civil defence. Clause 1 of the bill provides a broad definition of an emergency including '….damage to human welfare, the environment, security' which includes flooding or threat from erosion.' Clause 2 provides a duty for public bodies to assess, plan and advise upon emergencies.

The Coast Protection Act (CPA) 1949 is the primary body of legislation relating to protection against coastal erosion. (Note: coast protection is defined here as protecting the land against erosion or encroachment by the sea). It enables Local Authorities (LAs) to carry out coast protection works. The legislation covers construction, alteration, maintenance or removal of coast protection works. It also imposes an obligation to consult with statutory and non-statutory bodies to ensure no damaging effect from coast protection works on nature conservation. CPA 1949 empowers LAs with an advisory and regulatory function in a situation where another body wishes to undertake some form of coast protection works or other activity, for example removal of sediment.

LAs are also defined as drainage bodies in the LDA 1991 and have 'powers to make or maintain works for drainage of land' (s.72 LDA 1991). In this context LAs consist of English district or borough councils and unitary councils, as in Wales. Under the LDA 1991 they have powers for flood prevention and maintaining flows in watercourses. These powers relate to non-main rivers that are not within an internal drainage district. LDA 1991 and 1994 also imposes an obligation to consult with statutory and non-statutory bodies to ensure no damaging effect from flood defence works on nature conservation.

LAs are also required under PPG25 (in England) and TAN15 (in Wales) to consider flood risk within proposed developments; their impact upon flood risk as well as the impact of flooding upon the development. In this context English county councils also have a role in FCERM. PPG25 is being updated and strengthened by PPS25 mid 2006 following consultation.

It is in the area of planning policy and guidance that urban flood risk management may be addressed. In the first instance there has been guidance and calls for both risk assessment and management plans that provide a background to and information for planning processes. In other words they are there to inform the relevant bodies and authorities in the event that such

information is required. Secondly, guidance is developing that seeks to provide a broad framework of conditions and circumstances under which issues of flood risk management are material to development and what actions and bodies could be called upon to provide advice and information to inform the decision making process. Figure 5.1.2, from an on-going EA/Defra project captures elements of the current situation (FD2320 - Flood Risk Assessment Guidance for New Development, News Bulletin – August 2004).

Area wide Local Plans and Unitary Development Plans (the core of the development planning process and revised every 5 years) as required under PPG12, are now being superseded by more dynamic 'Local Development Frameworks'. Planning Policy Statement 12 Local Development Frameworks (PPS12) is intended to streamline the local planning process and promote a 'proactive, positive approach to managing development'.

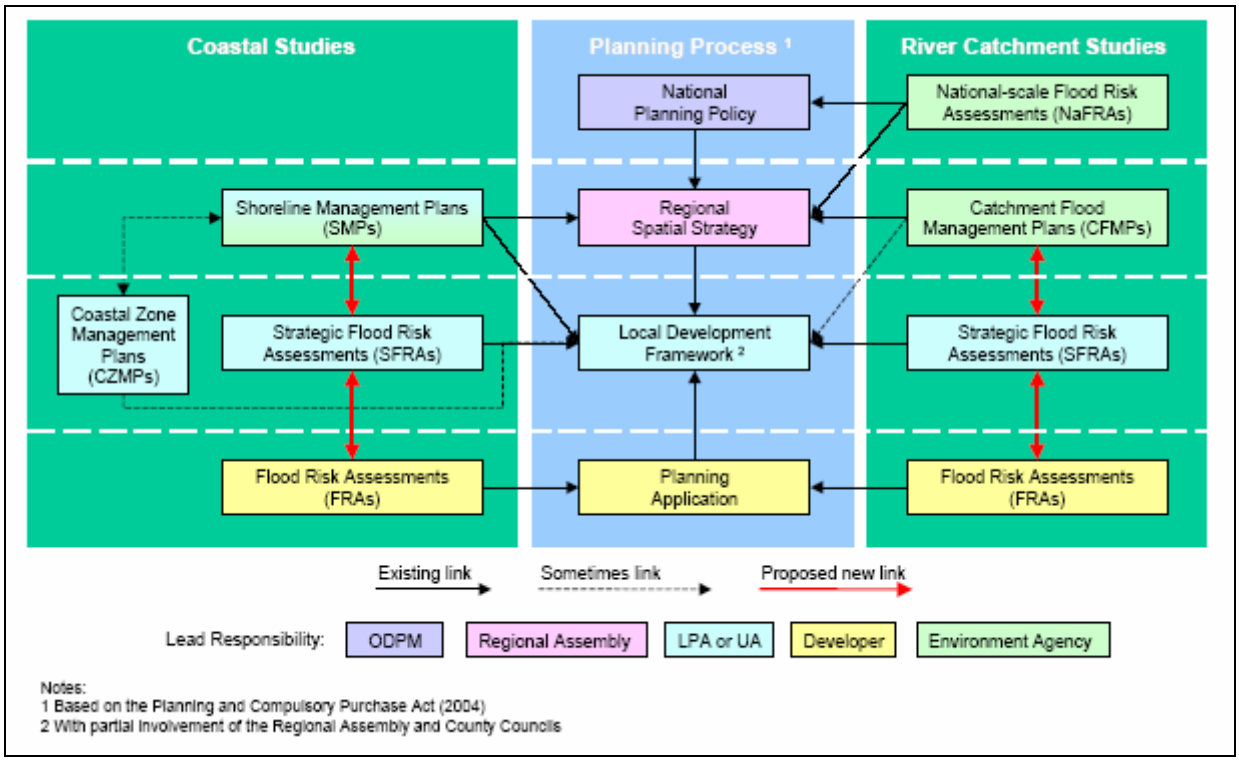


Figure 5.1.2 Interaction between the Planning Process and Types of Assessment Studies (Defra, 2005c)

Within the development planning arena there are guidance notes on the historic environment (PPG15) and archaeology (PPG16), stressing that planning decisions should always be informed by an understanding of their impact on historic assets, recognising that they are non-renewable. This ethos is also recognised in PPG20: Coastal Planning, advising that historic sites should be avoided or alternatively preserved in situ wherever practicable. There are, however, certain types of development that do not require planning permission provided by the Town and Country Planning (General Permitted Development) Order 1995. The types of development were reviewed by ODPM in 2003 and include development associated with agricultural uses and forestry uses of land.

In conjunction with the Environment Agency, LAs are also responsible for emergency plans and response according to the old 1999 HLT3. The approach to this role is recorded in the Policy Delivery Statements (new HLT1), along with approaches to environmental issues, developer contributions and development control. However, it should be noted that there are no requirements or statutory drivers that require Local Authorities to maintain records of flooding events, still less an agreed format for such information. Any incentives to do so have effectively been removed from LAs, as functions have been re-assigned to other bodies such as Water Service Providers, the Environment Agency and the Emergency Services.

Local Authorities, as the Local Highway Authority, also have statutory duties laid out in the Highways Act 1980, New Roads and Streetworks Act 1991, Road Traffic Acts and the Transport Act 2000 which have an impact on water management. In practice this often means the sweeping of highways and emptying of road gullies sometimes directed at helping householders.

5.1.7 Water Industry

The Water Act 1989 privatised the water authorities, creating 10 water and sewerage companies. In some areas, the companies provide both sewerage services and water supplies, while in other areas companies only deal with the supply of potable water. With respect to urban flood risk management, the water industry is responsible for wastewater collection and the drainage of urban areas through public sewers, treatment and disposal of sewage according to the Water Act 1989 and the Water Industry Act 1991. The sewerage system comprises of underground sewers and associated surface assets, for example sewage treatment works, sewage pumping stations and sludge treatment facilities (National Audit Office, 2004). Sewers handle four main categories of flow:

- used/foul water from domestic and business customers;
- most surface water running off properties after rainfall, in some cases from additional connections (such as newly built properties) for which the existing system was not originally designed but for which detailed studies have been made;
- some surplus surface water draining from highways and other urban spaces after rain; and
- water entering the public sewer system through defective joints, cracks, manholes and flap-valves, which can contribute a significant proportion of flow in some networks.

Failure of the sewerage system can lead to flooding as a result of a collapse, blockages or the system being overloaded by heavy rainfall (hydraulic overload) or a pump failure. Sewers that are most likely to have serious consequences, in terms of engineering costs and traffic delay costs, were they to fail are classified as ‘critical’ sewers according to the Water industry Research Council’s Sewer Rehabilitation Manual (National Audit Office, 2004).

In England, the water and wastewater service suppliers have to meet prescribed levels of service laid down by the Regulators, principally Ofwat (Office of Water Services) but also the Environment Agency. Broadly this translates into a responsibility to provide and maintain a sewerage system that can accommodate set levels of loading (threshold is events with a return period of up to one in ten years) without causing flooding, and generally includes stormwater collection as well, but only up to the connection to a property. These are triggers to prioritise actions, however, in practice higher service levels are provided depending upon location (according to the consensus on satisfactory performance in BS EN 752).

There is a right for developers of new developments to connect to existing public sewers (Section 106 agreement) irrespective of whether or not it will overload the system downstream; the standards for which are set out in Sewers for Adoption (currently 5th Edition). Similarly the water industry can be responsible for land and road drainage when connected to their assets. The water industry must check what the impact of the additional loading will have on the receiving sewer system and especially check if this potentially could lead to overloading or compromise of the required levels of service. In the event that there appears to be such a risk then the developer will be restricted in terms of additional storm water input rates and/or alternative remedial action is required of the water industry. The Water Act 2003 contains enabling powers to allow private sewers to be transferred to the sewerage undertakers.

The water industry play a very important role in the management of the whole water cycle, especially with respect to the management of water resources through upland water storage (reservoirs and impoundments) and groundwater abstraction schemes and the associated land. These can all have an influence on flooding. In the case of water reservoirs these are subject to the Reservoirs Act (1975) in terms of operation, inspection and safety. Since the water industry can also be riparian owners, they are responsible for land management, usually entailing drainage systems that can have a significant impact on downstream flooding.

5.1.8 Riparian/ land owners/ occupiers

Government and the law see the primary responsibility for flood management as remaining with the landowners (including developers and land occupiers). Case law has imposed a duty upon riparian owners to take reasonable action to maintain the watercourses and the flow of watercourses so as to prevent flooding.

Case law (Menzies v Breadalbare 1828 3 Bli.Ni.414) allows owners to take measures to protect their property from destruction although this may not be at the expense of other landowners. Therefore the downstream effects of any actions taken must be carefully considered. Similarly consideration has to be given to the impact on coastal and estuarine systems. It should also be noted that they also have a duty of care as well as responsibility to accept flood flows through their land, even if caused by existing inadequate capacity up or

downstream, but there is no common law duty to improve a watercourse only to maintain the passage of water.

It is against this background of such obligations under common law that the various planning guidelines may be seen, as they give detail and direction as to what may be reasonably required of the riparian owner. Hence the drawing up of PPG25 (to be superseded by PPS25 mid 2006), PPG20 (Department of the Environment, 1992) in relation to coastal areas, PPG3 Planning Guidance on Housing (physical and environmental constraints on the development of land for housing including flood risk) and PPG11 Regional Planning Guidance - identification of principal areas where flooding issues are of regional significance (superseded by PPS11 Regional Spatial Strategies.

Landowners/ occupiers are also responsible for any drains or private sewers that carry household waste away from their property, both inside and outside the property boundary until the point where they connect with the public sewers (WaterVoice, 2002). Although people have the right to connect into a sewer, they also have a duty to report such connections to the Local Authorities.

5.2 Data requirements

From the legislation, organisations with FCERM responsibilities have been identified which also defines their roles. By understanding these roles, the information required to perform the organisations FCERM roles can be determined, which in turn define the data needs.

Defra and the WAG set policies and strategies for FCERM. Therefore they require up-to-date information on current issues and scientific practices. They also set High Level Targets to monitor delivery of their objectives. Subsequently they need information on the achievement of HLTs and the progress to date. Defra and WAG also provide grant aid to the Environment Agency, IDBs and LAs. In order to justify the funding, they need information such as the state of defences, the population at risk, the level of risk and the effect of spend in reducing the risks.

The other FCERM organisations' roles, related activities, information required and hence data requirements have been mapped out into flow charts:

Figure 5.2.1 Environment Agency;
Figure 5.2.2 Internal Drainage Boards;
Figure 5.2.3 Local Authorities;
Figure 5.2.4 Water Industry; and
Figure 5.2.5 Riparian/Land Owners/Occupiers.

Taking inspiration from other ontologies, such as Noy and McGuinness, 2001, spheres of data (sub-groups) have been used to help show commonalities, patterns and relationships (class hierarchies). The Spheres were created using "top-down" and "bottom-up" approaches. The "top-down" approach considered the higher level using the three elements of Sustainable Flood Risk Management:

1. Environment;
2. Social; and
3. Economics'

However, the "bottom-up" approach related 'data required' with sub-groups and groups using terms like "part of" and "type of" or "has input." The spheres of data are illustrated in Figure 5.2.6.

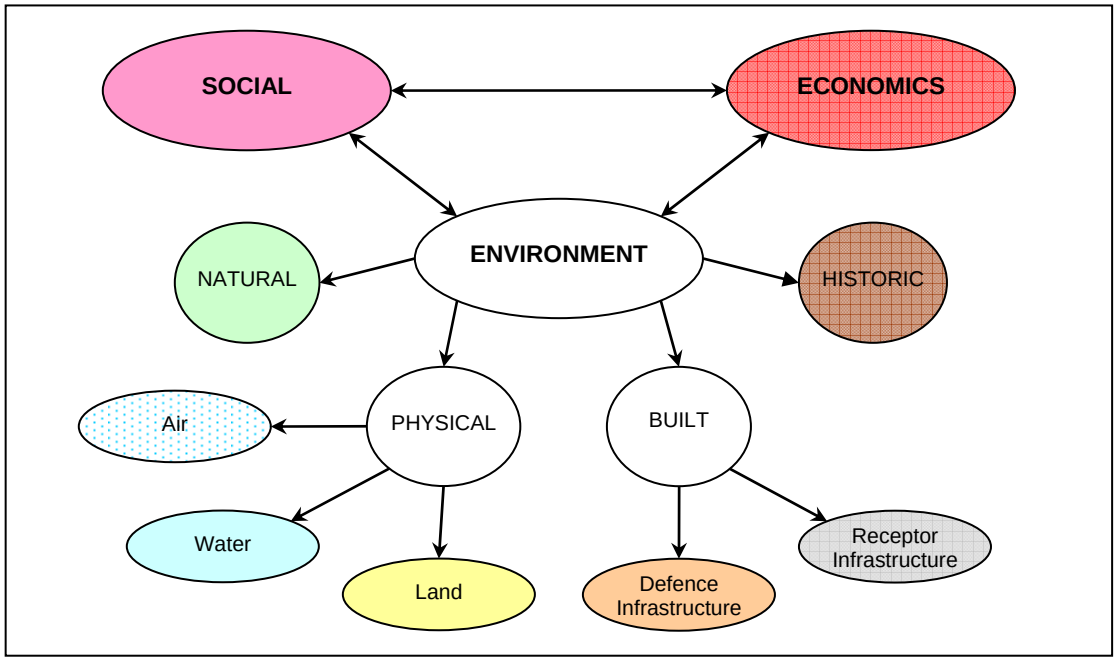


Figure 5.2.6 Spheres of data in FCERM

Economics, Social and Environment form the core spheres and all inter-relate with each other. For instance the built receptor infrastructure has social and economic implications. The Economic sphere covers human activities and structures in monetary terms. The Social sphere considers data and information on the behaviour, distribution and response of people.

The Environment, however, has been divided up into other groups and sub-groups due to many layers within the element. The Natural Environment consists of fauna and flora information, including management of habitats. The Historic Environment includes information on heritage and archaeology.

The Physical Environment covers processes of Air, Land and Water. The Air Sphere contains atmospheric processes relating to climate and weather, such as wind and temperature. The Water Sphere uses the hydrological cycle to group data and contains coastal, estuarine and fluvial aspects. Since there are interactions in the environment, some aspects are influence by atmospheric processes but the data has been grouped under Water, such as wave and tide levels. The Land Sphere consists of Geotechnical elements, for example geology and sediment.

The Built Environment has been divided into Defence and Receptor sub-groups. The Defence Sphere comprises of data and information related to the structures that protect against flood risk and coastal erosion. The Receptor Sphere consists of building, infrastructure and land that may be at risk from flooding or coastal erosion, or even generate flood risk.

5.3 Discussion on data requirements charts

The Environment Agency is the primary operating body in FCERM in terms of its duty to 'exercise a general supervision over all matters relating to flood defence.' Part of this role involves making strategic plans and so requires information on the risk of flooding. Although models and tools are employed to create flood risk/ extent maps, the data needed to derive this information is shown in the data requirements charts. Within the activity of regulation, the Environment Agency is also statutory consultee on Structure Plans and defined applications. The emergency flood response role under the superseded High Level Target 3 has been considered within maintaining and operating flood defences. Although the 1999 HLT3 no longer exists, the responsibility still exists and the approach is recorded in the new HLT1 Policy Delivery Statements.

It can be seen that some of the information and data, such as asset details, hydrological conditions and topographic data, are common to different roles and activities. For example flood warning and guidance on developments need to know where is at risk and the level of risk. Therefore it is important that such information is easily accessible and held centrally for all to use.

IDBs have similar responsibilities as the Environment Agency and so require similar information and data. For example, any works carried out in their districts requires their consent, consequently they need to understand the effect of any development or changes on the system. Therefore they should know the operation of the drainage networks including pumping stations' capabilities. Since many of their inland drain outfalls discharge into Main Rivers (some of which are tidal) or the sea, IDBs also require external information to design and operate their systems. Some IDBs are still responsible for daily management of COWs in their districts.

Local Authorities play similar roles as the Environment Agency. Although Local Authorities have responsibilities in relation to coastal erosion under their regulatory duties from the Coast Protection Act, the Environment Agency has an extended strategic overview role on coastal erosion following the Government's First Response to MSFW. Outside IDB districts, Local Authorities cover ordinary watercourses. While COWs are being enmained by the Environment Agency, some LAs are still responsible for the day-to-day management of the watercourses. However, their main FCERM activities are related to coastal protection.

The operating authorities (Environment Agency, Internal Drainage Boards, and Local Authorities) have responsibilities regarding planning control and so information on the proposed activities is required. However, a column has not

been provided for this information in the charts since the applications are ad hoc and also the data is dependent upon the type of application.

Comparing the charts, it can be seen that as organisations have fewer FCERM responsibilities, the amount of data and information required diminishes. Also it appears that the FCERM bodies that have fewer FCERM responsibilities, such as private landowners, actually require more information than data. There are recurring themes of information for FCERM activities:

- the definition of the area over which flood management interventions have an impact and the activities contained therein;
- the definition of flood and water level regimes;
- the characteristics of flood defence (including coastal protection) and land drainage infrastructure;
- land use management;
- conservation management,
- the design and implementation of interventions which contribute to FCERM.

The charts also reveal that FCERM activities require data from a range of components of Geography; data is not only drawn from environmental aspects but also social and economic. Therefore the sources of data are not likely to be all found within the FCERM operating authorities. This may have implications for knowledge sharing, such as different standards of data and format. The exchange of data and information is investigated in Section 7.

The focus of the charts was to derive the types of data and information required by the FCERM bodies, however, the charts could have a 3D nature with management hierarchy and data quality forming the other elements. According to the level at which an activity is carried out, the required quality of data and information changes. For example, a designer of a sea defence requires a higher degree of detail on extreme waves than a person formulating policy for a coastline. For further discussions on quality, see reports on Work Packages 2 and 4.

6. Non FCERM organisations

There are organisations that have an interest in flood and coastal erosion risk management either because, floods affect their operations or their activities have an impact upon flood risk. These organisations can be divided into two groups. First there are organisations ('Producers') that collect data and information relevant for their own purposes but are of relevance to FCERM. Data provided from these non-FCERM organisations will vary in nature depending on the specific use. The other non-FCERM organisations ('Users') need FCERM data to carry out their activities. However, some of these organisations can also provide data and information for FCERM purposes.

Non-FCERM organisations have been identified using the source-pathway-receptor approach depending on where data and information relates to. Table 6.1 summarises specific National organisations and generic regional/local groups. Some of the key organisations that can provide FCERM related data and information are further elaborated below. The interactions within FCERM organisations are described and illustrated in Section 7 and their systems/ initiatives are summarised in Section 9.

The Met. Office collects meteorological data (such as rainfall, snowfall, wind), which are important for the prediction of flood event conditions and consequently flood warning. The Met. Office also operates tide and wave models to predict coastal events. The systems used are further described in Sections 8 and 9. The Proudman Oceanographic Laboratory (POL) runs the UK National Tide Gauge Network and provides data to the Environment Agency and Met Office. POL also develops and maintains models used by the Met Office.

The Centre for Ecology and Hydrology (CEH) collects and stores hydrological data, such as flow and water level records. This data can be supplied to organisations to aid calculation of flood probabilities.

The Forestry Commission is responsible for regulating and promoting sustainable forest estates. It implements policies and delivers strategies for forest management. Forest management techniques are useful to FCERM organisations for controlling flood generation. They also carry out research on topics related to forest and woodlands. Therefore there is a need for data and knowledge to support strategic and operational aspects of forestry management as they interface with FCERM.

English Nature (EN)/Countryside Council for Wales (CCW) are responsible for habitat and species management in England and Wales respectively. Therefore they can provide information on the location of protected areas and the sensitivity to change. Some sites have the need to control field and ditch water levels. In terms of FCERM, information on water management is beneficial to operating authorities. Alternatively the existence of conservation sites is affected by floods and so EN and other conservation organisations, such as RSPB, require information on flood risk. Maritime conservation bodies,

such as CEFAS, also stake an interest since flooding and coastal erosion affect the entity which they are trying to protect or conserve.

Table 6.1 Some relevant non-FCERM organisations according to fields of activities

	User Organisations	Producer Organisations
Source	Government Departments and Offices (e.g. Office of Science & Technology) Universities/ Academic organisations	British Atmospheric Data Centre British Oceanographic Data Centre Meteorological Office (the Met. Office) United Kingdom Hydrographic Office (UKHO) Universities/ Academic organisations
Pathway	British Waterways Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Centre for Ecology and Hydrology (CEH) Countryside Council for Wales (CCW) English Nature(EN) Forestry Commission Highways Agency Joint Nature Conservation (JNC) National Farmers Union (NFU) Aggregate Dredging Companies Engineering Institutions Local Port and Harbour Authorities Universities/ Academic organisations	
Receptor	Cadw (Historic environment agency within the WAG) Countryside Council for Wales (CCW) English Heritage English Nature (EN) Forestry Commission Joint Nature Conservation (JNC) Ministry of Defence (MoD) National Farmers Union (NFU) National Trust Railtrack Royal Society for the Protection of Birds (RSPB) Emergency Services Government Departments and Offices Insurance companies Universities/ Academic organisations	
	Highways Agency Regional Government Office Energy companies Land managers/owners/occupiers Mortgage companies Utility companies	British Geological Society Office for National Statistics Ordnance Survey

English Heritage is the Government's advisor on all aspects of the historic environment (including historic buildings, landscapes and archaeological sites) in England and is sponsored by the Department for Culture, Media and Sport (DCMS), which has overall responsibility for heritage policy in England. English Heritage is also responsible for maritime archaeology in English coastal waters, thus it requires information on flooding and coastal erosion which may affect archaeological sites, historic buildings, and registered landscapes such as parks, gardens and battlefields. It can also supply information, such as location of historic assets and their value, to FCERM organisations to influence their policy and decisions. Cadw is the Historic environment agency within the Welsh Assembly Government and undertakes a similar role as English Heritage.

There are also large-scale landowners, such as the National Trust and the Ministry of Defence (MoD), who have an interest in the effect of flood and coastal erosion risk on their property, but also can provide environmental information (built and natural) within their land to FCERM organisations.

Academia, research organisations and consultants are useful sources of information. Typically they are commissioned by operating organisations and Defra/ WAG to carry out studies or research such as flood risk assessments and flood damage to built properties. So they collect and assimilate data to produce information and knowledge for the organisations. This information aids decision-making within the FCERM organisations.

Other Government Departments, Offices and Agencies are involved in supplying information to FCERM organisations. For example the Valuation Office Agency holds information on property values which can be used in project appraisals. The Association of British Insurers (ABI) can also supply information on the value of properties and flood damage. Insurance companies also require information in the form of level of flood risk for their own business i.e. to calculate insurance premiums.

7. Existing FCERM data, information and knowledge flows

7.1 Development of information fountains

This section maps out the existing flow of data, information and knowledge for each of the FCERM organisations. Diagrams have been created, called 'Information fountains,' for the operating authorities. These illustrate data and information moving from various sources, up through operating bodies and then flowing out to other sectors of FCERM. The FCERM operating authorities – Environment Agency, Internal Drainage Boards, Local Authorities and Water Industry – form the focal points of the 'fountains' due to their ascribed FCERM duties, powers and responsibilities. Although separate 'fountains' have not been created around the other organisations involved in FCERM, they do feature prominently in the 'fountains'. The organisations positions in the 'fountains' are discussed, in particular Defra, WAG and riparian/land owners/occupiers who form the ultimate source of information requirement or need.

Before presenting the 'information fountains' the structure of the Environment Agency is explained due to its principal role, as it influences the level of data and information required. The organisation of the Environment Agency has evolved to reflect the shift in focus from flood defence to flood risk management. Data and information moves in a cyclic fashion from Areas to Regions and then National and then back down again to Areas, or indeed Regions. It is of note that the regions currently have a relatively diminished role as compared to National (Policy and Process development) and Area (Delivery). The other FCERM organisations are not broken down for this analysis since their internal structure is not as complex and would only lead to unnecessary complication. Also the FCERM activities of Local Authorities, Internal Drainage Boards and Water Service Providers are, on the whole, carried out in their local areas. Even though they perform similar strategic and local delivery activities they have less of a formal hierarchal national, regional, area element.

7.2 Defra and WAG position in information network

Defra and WAG not only sit at the top of the fountains, being a primary source of information requirement, they also sit at the bottom feeding/disseminating information to the operating authorities. Information and knowledge from lower levels and National level are used to set the national strategy, develop policies and ensure that objectives are being met. For instance, operating authorities submit annual reports regarding their achievement of High Level Targets. While HLTs report on Shoreline Management Plans indicate if appropriate coastline management is being undertaken. Some of the information, such as state of the defences, can also influence the allocation of money for flood risk management.

They also commission research to gain a better understanding on National FCERM issues, such as land use and flood generation, or climate change. This leads to other organisations, for instance universities and consultants, being involved in the super-highway of data and information. These research organisations then collect data on a needs basis from other organisations including the Environment Agency, IDBs, LAs, CEH and the Met Office, or may indeed orchestrate new data collection programmes. The research aids the development of guidelines to ensure consistent approaches are taken and flood risk considered, for example PPS25 and Project Appraisal Guidance (PAG). These guidelines/policies cascade back down to FCERM operating authorities, thus generating the need/steer for upward information from operating authorities.

7.3 Environment Agency

7.3.1 Structure of the Environment Agency

Flood risk management forms just one part of the Environment Agency's many functions. During the development of the Ontology, the Environment Agency's structure changed. Previously the focus was on Flood Defence Management and the Environment Agency's structure reflected this. However, in recent years the emphasis has switched to Flood Risk Management and so from May 2005 the Incident and Flood Risk Management (IFRM) structure mirrors this. The IFRM structure aims to deliver a consistent level of flood incident response, remove duplication, reduce cost, clarify accountabilities, be driven by national priorities and apply lessons learnt from previous flood events. In order to help explain the new structure of the Environment Agency, the superseded structure is also referred to.

The Environment Agency is split into two parts: Function and Operation. "Function" is where Policy and Process are developed (at National/ Head Office level), while "Operation" is the delivery route (at Regional and Area levels).

Flood Risk Management Policy team (formerly Flood Defence Policy) liaises with national stakeholders and consists of:

- Policy Flood Risk & Planning (previously Flood Defence Strategy & Risk) – flood data, mapping & modelling, Catchment Flood Management Plans (CFMPs), flood risk planning and land-use planning
- Policy Flood Incident Management (previously Flood Defence Flood Event Management) – flood warning, flood forecasting, event recording, event management, flood planning and urban flooding
- Policy Business Development & Science (previously Flood Defence Research & Development) – includes climate change
- Policy Asset Management – improvements, operations, biodiversity, Habitats Directive and Water Framework Directive.
- Making Space For Water – project co-ordinator

The Flood Risk Management Process team develops guidance, procedures and tools at the national level. It consists of the following management teams:

- Flood Incident Management (previously National Flood Warning) – sets the standard of service, investment strategy, warning and response, detecting and forecasting, telemetry as well as account for Met Office
- Flood Risk Mapping and Data Management
- Strategic Planning & Development Control (previously National Regulation and separately National Strategic Planning) – link with customer services, Town and County planning and the Environment Agency legal team
- Operations Delivery (previously National Operations)
- Asset Management and Enforcement (previously National Improvements)
- National Operational Systems - National flood forecasting & detection; National flood warning & dissemination; National Flood Warning & Information Service
- Reservoir Safety

"Operation" is where much of the Environment Agency data and information is collected. Figure 7.3.1 illustrates how the new teams in Regions and Areas (under Operation) relate to Flood Risk Management Process (under Function at National level). There were formerly five teams at Regional and Area level, each of which carried out specific roles, which correlated to the Environment Agency's responsibilities. The new IFRM teams at Region and Area are listed below with the corresponding previous teams where appropriate:

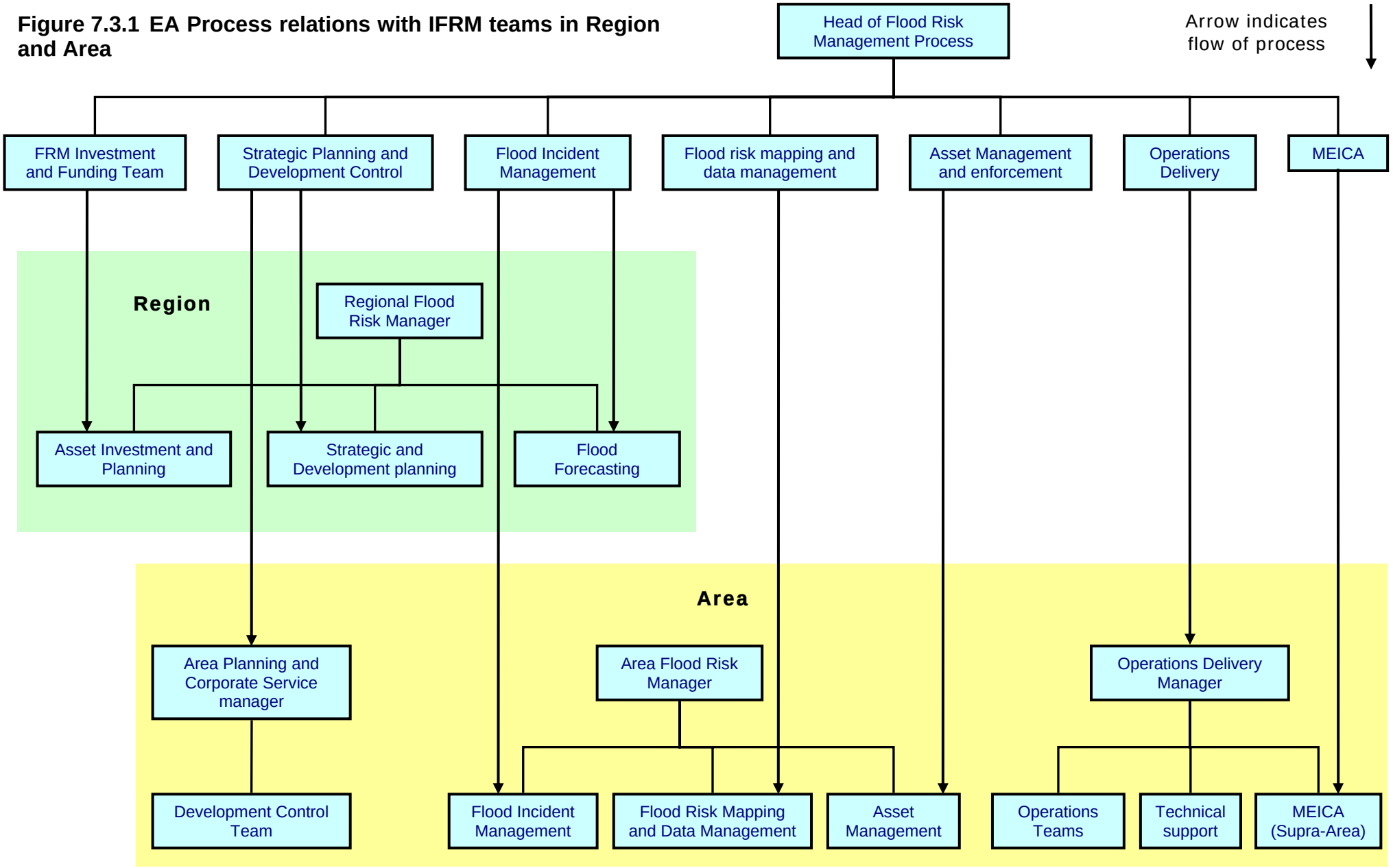
At the Region level

- Strategic and Development Planning (new team but similar roles as previously Strategic Planning and Regulation teams) – strategic and regulatory influence, define and manage CFMPs programme
- Asset Investment and Planning (new team but similar roles to previously Improvements team) – programming for committees and for the business
- Flood Forecasting (previously Flood Warning team) – regional wide flood forecasting, regional planning for flood events

At the Area level:

- Asset Management (new team but similar roles as previously Area Improvements and Operations and Maintenance team) – enforcement, scheme preparation, development of plans
- Flood Risk Mapping and Data Management (new team but similar roles as previously Strategic Planning team) – flood risk mapping and development enquiries, data systems management, reporting and High Level Targets

Figure 7.3.1 EA Process relations with IFRM teams in Region and Area



- Flood Incident Management (previously Area & Regional Flood Warning team) – flood warning service, incident plans, liaison with local stakeholders, flood event management including arrangement of data collection
- Operations Delivery (previously Operations and Maintenance and the Emergency Work Force teams) – planning and engineering, operate structures and deliver 'on the ground' incident response, asset inspections, management of work
- Development Control (previously Planning and Regulations team)

7.3.2 Environment Agency information network

Taking the "objective-led data management" approach of this study, data and information flows have been mapped under the three main FCERM responsibilities of the Environment Agency according to legislation:

- General supervision for all matters relating to flood defence
- Maintain, operated and improve flood defences
- Provide flood warning service

The current structure of the Environment Agency has not been used to map the flows since it is changing and, as history has shown, its structure is likely to change in the future. Also the data and information network does not necessarily represent the management structure. Indeed the mapping of the responsibilities, the data and the data flows should define the organisational structure. Therefore the legislation, which is more static, has been used to promote the longevity of the study.

While mapping the flow of data and information it became apparent that data and information flowed up the Area-Regional-National hierarchy and then cascades as information and knowledge downwards from the upper tiers back to Regions, Areas, other EA teams or external organisations. The information fountains within the Environment Agency, with regards to flood risk management, are illustrated in Figures 7.3.3, 7.3.4 and 7.3.5. It is noted that information enters the Environment Agency at all levels, however, in order to reduce complication, the information is simply shown as entering the system. For example, at the National level the Environment Agency obtains datasets that are necessary at all levels (Regional and Area) to carry out FCERM activities. These include:

- Land valuation data (from the Land Valuation Office);
- Population Statistics (from the Office of National Statistics);
- Agricultural Land Classification (from Defra);
- Land Cover Map 2000 (from CEH);
- Ordnance Survey maps (from OS)

General supervision for all matters relating to flood defence

This role is currently delivered via Strategic and Development Planning at the Region and Flood Risk Mapping and Data Management at the Area (formerly Strategic Planning and Regulations). In order the make informed decisions on flood defence matters (including sea defences), information about the probability and impact of floods are required. Some of the data gathered to produce this information comes from within the Environment Agency, such as channel surveys from Areas and recorded water levels from Water Resources. The Environment Agency also obtains a lot of coastal loading data (waves, tides) from the Met. Office. Tools are used to synthesise data into information, such as FEH (Flood Estimation Handbook) and hydraulic models. These are further elaborated in Section 8. This information on the probability of flooding then feeds the strategic level and provides information to external organisations and land owners, as shown in Figure 7.3.2.

Also at the area level, Standard of Protection studies (SoPs) are undertaken to determine the current standard of defence and so the probability and extent of flooding. SoPs are typically contracted out to consultants but the data and information are sourced via the Environment Agency. The information from SoPs is used within the Environment Agency (by Area teams as a baseline), other operating authorities and stakeholders.

Some of the Government's High Level Targets (HLTs) require the creation of reports on their achievements and progress. Under HLT4, the Environment Agency is required to produce a report on losses and gains of habitats covered in Biodiversity Action Plans (BAPs). This information is collated from LAs and IDBs as well as from within the Environment Agency. Under HLT5, the Environment Agency, in partnership with LPAs, also submits annual reports to Defra/ WAG and ODPM on the planning applications where the Environment Agency sustained objections and on LA Development Plans.

Under the regulation of others, the Environment Agency also submits a report to Defra/ WAG on the applications for consent. LAs and IDBs also contribute by supplying information on the use of their statutory powers.

Maintain, operate and improve flood defences

This role is covered by Asset Management at Area level and Asset Investment and Planning at Regional level (formerly Operations and Improvements). The day-to-day work is carried out at the Area level while strategic investment planning occurs within the Region.

At the local level the Environment Agency collects data on the condition and state of flood defence assets (embankments, floodwalls, river channels) and structures (sluices, outfalls, trash screens, pumping stations, weirs). Asset data collection is prescriptive depending on associated risks. However, inspection of bridges, pumping stations and other structures are carried out on a local needs basis. This information is stored in the National data repository called the National Flood and Coastal Defence Database (NFCDD), which is also used by

the Environment Agency as its primary infrastructure database. This system, a requirement of the 1999 HLT4, is further explained in Section 9. The new HLT2 deals with the necessary information that should be entered into the system by operating authorities.

The information from the Area feeds upward National and Region needs as well as horizontal (day-to-day management) needs, Figure 7.3.3. For example, information on the state of defences is used to create annual reports at the National level for Defra/ WAG. They also help to develop maintenance programmes. A programme for regular inspections is established in line with the new streamlined HLT2 (superseding the 1999 HLT5). Asset dimensions and crest levels are also used within the Environment Agency to aid flood risk assessments and mapping.

In order to aid maintenance programmes and investigate the impacts of new works, GIS layers on habitats and environmental sites, such as Sites of Special Scientific Interest (SSSIs), can be accessed. This information is supplied and updated by English Nature and other conservation groups. Feasibility studies also require social and economic information to carry out Cost Benefit Analysis of proposed schemes. Tools are used to produce useful information from data, such as the Multi-Coloured Manual (MCM) for flood damage information. Some of these tools are described in the next Section.

Also at the Local level, the Environment Agency operates flood defences to minimise the damage from flooding. So flood forecasting and warnings are provided from within the Environment Agency. The asset data on NFCDD can help identify low spots and locations where reinforcement is required. During a flood event, the Environment Agency also collects data about the event, which can then be used within the Environment Agency to calibrate models, aid flood damage studies or help identify flood warning zones.

Prioritised forward programme of capital and maintenance works is submitted annually to Defra/ WAG as stated in the Environment Agency's Corporate Plan (previously in line with the 1999 HLT7). Therefore information on cost of defences and maintenance passes up to the national level.

Provide flood warning service

The provision of a flood warning service requires local information on weather, river and coastal conditions in order to forecast flood events. Real-time weather information is supplied from the Met. Office's system, STORM. The Met. Office also supplies information on predicted sea and surge levels. Within the Environment Agency, the Water Resources division delivers real-time water levels via the Environment Agency's telemetry system.

Figure 7.3.4 shows that local information feeds flood warning decisions at the strategic level, where flood warnings are disseminated to external organisations. In order to determine the flood warning area, flood extent/ probability information is supplied from within the Environment Agency. Also historic event data aids the definition of flood warning areas, which may also

come from land owners/ occupiers. These types of information highlight areas that are susceptible to flooding which is passed to other operating authorities to prepare emergency plans.

At the National level, the Environment Agency reports annually to Defra/ WAG on the achievement of service standards, as documented in the Environment Agency's Corporate Plan (previously an obligation HLT2). Therefore information on the service standard is gathered such as local performance/ failure of forecast/ warning.

7.4 Internal Drainage Boards information network

Compared to the Environment Agency's FRM structure, IDBs are much simpler but still collect similar data and information, Figure 7.4.1 They have surveys for flood defence assets and some of the larger ones have flood risk assessments of their districts to determine standards, for example Kings Lynn Consortium and Bedford Group.

IDBs have a direct link to the Environment Agency Flood Warning teams which provides them with flood alerts and severe weather warnings. IDBs also have rainfall gauges to monitor rainfall amounts. Some IDBs, such as the Kings Lynn Consortium, have their own telemetry system that records pumping station operating hours and water levels (upstream and downstream stations). Since many districts pump into Main Rivers, the Environment Agency requires water quality information and so IDB may also record other environmental information such as salinity and temperature.

As part of their role of emergency response, IDBs collect data on operational activities such as resource use to help make emergency plans, such as time to deploy and employ.

In order to fulfil their planning/development control advisory role within their districts, many IDBs have commissioned strategic flood risk assessments which aid decision-making when granting consents and assessing new development proposals.

Some of the operational data collected helps to develop maintenance programmes, for example maintenance records, resource costs, use and efficiency. Where carrying out maintenance work in an environmentally designated area, IDBs need consent from English Nature/ CCW before carrying out works. IDBs may create a matrix of standard methods for particular channels using information from English Nature and CCW (season, location of SSSIs etc). For example, King's Lynn Consortia clear channels with a flood defence function to maintain conveyance, while more conservation is allowed for channels with less of a flood defence function. Similarly information is required from English Heritage or Cadw where structures of historical or archaeological importance may be affected.

Although IDBs FRM functions are similar to the Environment Agency's, the focus of data collection is on a needs basis, with a particular emphasis on cost-

effectiveness and efficiency. For example IDBs record costs of equipment (maintenance and repair) to determine which equipment is more efficient or cost-effective.

Some IDBs, such as Kings Lynn Consortia, are currently converting their data into GIS formats for an oracle based system. NFCDD could supplement IDBs' knowledge of systems next to their districts, as well as sharing knowledge on operation and maintenance. However, it may not necessarily replace their management system.

Transfer of information with the Environment Agency is carried out in an ad hoc fashion, for example IDBs ask for advice when carrying out capital works since they need the Environment Agency's consent or during operational management of flood extents. However, IDBs have more direct links with Local Planning Authorities on developments within their district.

IDBs submit information to Defra/ WAG on the prioritised capital and maintenance works for the current and following 3 year period (according to previously HLT7 and now documented under the new HLT1 in Policy Delivery Statements). IDBs also have to inform the Association of Drainage Authorities (ADA) on the efficiencies of amalgamations or consortia since ADA have to report to Defra on the progress of implementing guidance, a condition of the new HLT6 (previously HLT14).

Under HLT4, (previously HLT9) IDBs also have to report to the Environment Agency on all losses and gains of habitats covered by Biodiversity Action Plans (BAPs) as a result of their flood defence operations. Therefore they receive BAPs from conservation bodies and LA's in order to determine any losses and gains.

7.5 Local Authorities information network

Since many Critical Ordinary Watercourses (COWs) are now under the jurisdiction of the Environment Agency, the need for use of permissive powers for operation/ maintenance/ improvement with regards to flooding is significantly reduced for Local Authorities (LAs). Therefore emergency response and development planning have become their primary FCERM roles. However, the use of permissive powers for coastal LAs tends to be largely related to their coastal protection role.

The role and responsibility of Local Authorities in coastal and estuarine management has been defined in Section 5. However, in practice the involvement of a specific local authority will vary according to the length and nature of coastal frontages within the authorities' boundary. Accordingly, the role of local authorities in data, information and knowledge management can vary greatly. In some cases a local authority may collect, collate, store and utilise very little FCERM related data and information and hold little knowledge regarding FCERM. In this case the local authority may be reliant on consultants obtaining what is required on a project specific basis. In other cases however, an authority may be active in the collection of data, processing to generate

information and the holding of knowledge, may exchange regularly with the Environment Agency and may contribute data to the NFCDD. A good example of the latter high degree of involvement would be East Riding of Yorkshire Council who are actively involved in coastal data and information management and hold considerable knowledge. An inland example is Bradford Metropolitan District Council (BMDC) who is proactively gathering data and information for water management. As a result of this large variation it is difficult to define the structure of data, information and knowledge management within local authorities to the same extent as is presented for the Environment Agency. Figure 7.5.1 illustrates the fountain of data and information for Local Authorities.

Local Authorities powers with respect to coastal and estuarine FCERM mainly relate to coastal erosion, although they do have powers to undertake measures relating to prevention of flooding from the sea. Their involvement in data and information management is accordingly tailored mainly to coastal erosion. The two primary types of data and information relate to physical processes data and the defence structures.

In terms of physical process data, many local authorities undertake a structured monitoring programme on beach profiles, cliff recession or instability, waves and water levels. This data provides information for producing Shoreline Management Plans (SMPs) which can then be used to inform decisions on locations of new developments. SMPs hold information on areas of coastal erosion which is also useful to land owners and conservation bodies. These strategic plans are further explored in Section 8.

In terms of defence structures, Local Authorities involvement cover data and information related to determining standards of service, which can be issued to riparian owners and the Environment Agency. They also collect data on the age and condition of the defences in order to determine the need for maintenance. LA's must have a programme in place to ensure regular inspections of coastal protection assets, under the new streamlined HLT2 (superseding the 1999 HLT6). They are also required to report annually to Defra/ WAG on the risk of coastal erosion, action taken and the progress remedying deficiencies highlighted in the previous report. Similarly, LA's have to provide Defra/ WAG with a prioritised programme of capital and maintenance works for the current and following 3 year period (according to previously HLT7 and now documented under the new HLT1 in Policy Delivery Statements). Therefore LA's record the cost of maintenance and calculate the cost of new works, as well as its benefits in the form of feasibility studies.

While the Environment Agency is required, under s.105 WRA 1991, to supply LPAs with flood risk surveys, some LAs have carried out Strategic Flood Risk Assessments to aid development of Local Plans. These are generally contracted out to consultants who gather data and information from the Environment Agency. While they are primarily developed to aid strategic planning and development control, the strategic flood risk maps also aid the LAs emergency response plans by knowing which areas to target and plan for.

The response to flooding incidents depends upon the scale of the emergency, which can range from a minor, highly localised incident that lasts a couple of hours to the other end of the scale, such as the floods of the year 2000, lasting for an extended period, affecting large areas of land and numbers of people. At the end of the scale where the problem may be considered to be minor, localised and limited institutional response will be confined to that of the Local Authority.

When the situation is of a more serious nature (major incident) there are more parties that have a role to play. The dissemination of flood information is effected through the Environment Agency, who works in conjunction with Local Authorities in urban areas.

Local Authorities also have emergency planning units (following Civil Contingencies Act) that are charged with preparing and maintaining emergency plans that detail how incidents will be responded to, what actions will be taken, which services would be involved, and coordination and communication procedures. However, in the case of major incidents it is the emergency services, particularly the police and fire service, which provide leadership and coordination with the Local Authority acting in a supporting role, maintain council services, especially to victims and the affected communities and co-ordinating the work of voluntary groups. Therefore information is gathered from emergency services on how efficiently they can be deployed and which areas are covered.

Under HLT4, (previously HLT9) LAs have to report to the Environment Agency on all losses and gains of habitats covered by Biodiversity Action Plans (BAPs) as a result of their coastal protection operations. Therefore they collect data on conservation from conservation bodies, such as English Nature and CCW. The creation of BAPs is generally lead by English Nature in partnership with other organisations such as LA's, the Environment Agency, RSPB and local land owners.

LAs also produce annual reports on the use of their statutory powers on ordinary watercourses to the Environment Agency, who has to produce annual statistics on applications for consent to carry out works.

7.6 Water Industry information network

Although the Water Industry is not an FCERM Operating Authority they have a responsibility to operate their sewerage system and meet prescribed levels of service without causing flooding. Therefore they gather data on their assets to determine their performance, Figure 7.6.1. Although Ofwat now requires the Water Industry to report external flooding incidents as well as internal, the industry has been collecting the information since the 1980s.

Water and wastewater service suppliers require information from the Environment Agency's and LAs' flood defence operations as they may have an impact on their assets and sewerage system. Similarly they require information from LAs on new connections to the sewerage system that could overload the

capacity. Flood warnings from the Environment Agency allow the water industry to plan for events. The Environment Agency also requires information on the performance of the sewerage system as it may highlight potential areas of urban flood risk.

Despite the complexity and rapidly changing nature of urban areas, the approach to sewer management is similar to management of rivers. In order to assess flood risk, the Water Industry collects data on rainfall, topography/asset size and location. However, the Industry has long recognised the limitations of modelling (particularly overland flow pathway), in that it is indicative and not absolute.

Although the water industry is not a statutory consultee in the planning process, they are consulted by some LAs. The Water Industry takes a keen interest in such matters because of the potential impact of developments on their infrastructure, especially with regard to the management of stormwater and flooding.

7.7 Riparian/ land owners/ occupiers information network

Riparian/ land owners/ occupiers tend to absorb FCERM data and information not only to fulfil their FCERM roles but also to ascertain the flood and coastal erosion risks to their properties and day-to-day activities. However, there is no consistent/coordinated attempt to collect data about property flooding. Not all property owners report flooding (as it reduces property value) and many LAs do not have the resources to collect it. Within LAs, information on flood risk and coastal erosion either comes from Environmental Health Officers (EHOs) or largely tends to be in the heads of LA engineers.

Riparian owners are allowed to defend their property against flooding and coastal erosion provided they do not obstruct or hinder flows and cause detrimental harm to others. Therefore they obtain strategic information from Operating Authorities. They can also obtain information on ownership of watercourses and coastlines from the Land Registry.

The larger land owners, such as English Nature and Forestry Commission, are more aware of their responsibilities and may provide operating authorities with information on their land management practices which may affect flood risk.

7.8 Information exchange synopsis

In order to provide an insight into the flow of data, information and knowledge amongst the FCERM community, the information ‘fountains’ do not show all the exchanges as this would make the diagrams too complicated to understand. The ‘fountains’ do, however, provide a useful illustration of the complexity of the relationships between organisations within FCERM and external organisations. They reveal the organisations that have an interest in FCERM information as well as those who may hold data and information which is of interest to the FCERM operating authorities. These sharing linkages are developed further in Work Package 3 (FD2323\TR3) within a knowledge management tool, which

aims to help reduce duplication and also locate appropriate data and information.

The data needs charts in Section 5 take a top-down approach in seeking the data needs from legislation, while the information fountains use a bottom-up approach following data collection by organisations and the flow of information between them.

While carrying out the review, it became apparent that experiences and practices are very disparate and inconsistent among organisations, particularly LAs and IDBs. While some LAs are proactive in data collection and have established links with other organisations, others have a very *ad hoc* approach. This can be related to risk or perception of risk i.e. not a problem until there is a flood or coastal erosion incident. Similarly the approaches to data management are inconsistent between regional and local organisations, perhaps due to an inequality in resources (staff, money and time) or difference in priorities. The national organisations need to recognise these discrepancies and ensure that their systems can link to others and integrate their data.

Comparing the charts and fountains, it can be seen that some data is obtained for the purpose of good housekeeping i.e. basic necessities for functions, such as watercourse and defence locations. Also many of the organisations have internal audits to improve their business and services, but they are not imposed by legislation. Data collected for such purposes has not been shown in the "fountain" diagrams.

In between the 'top down' approach charts and the 'bottom up' approach fountains, there also lies good practice information. The dissemination of experience and lessons learnt to others are just as important and valuable as datasets.

The fountains reveal that there are gaps in the data needs charts, when data is collected for research purposes and when ownership of responsibilities are unclear, such as responsibility for pluvial flooding in rural and urban environments. However, FCERM research is encompassed within the overarching objective of managing and reducing risk (present and future) to people, property and the environment. Section 9 discusses future issues and their implications on data needs. When the data needs are defined by the user then one can determine if indeed data gaps exist. Work Package 3 (FD2323/TR3) incorporates this philosophy to develop a knowledge management tool. Work Package 4 (FD2323/TR4) develops a framework to appraise the improvement of data and information for FCERM, as well as discussing data justification in collecting data for research and FCERM.

8. Sources and storage of FCERM data and information

8.1 Synthesised and aggregated sources

Section 7 shows the exchange and flow of data, information and knowledge between organisations. While pursuing these exchanges, the sources and storage of the data, information and knowledge were revealed, which are explored below.

Although the objective of a user can define if data is information or simply data, there are other means that convert data and information into knowledge. There are different types of data and information; simple, synthesised and aggregated. Simple data can be thought of as raw or collected data. Synthesised data refers to groups of data that has been transformed using tools and computer models or programs. Simple or synthesised data and information can be brought together to form aggregated information imparting knowledge to the reader.

8.1.1 Tools for synthesis

There are many tools used within FCERM for synthesising data into useful information and knowledge; some of the common and emerging ones are described below. Some of them are products from research commissioned by Defra and the Environment Agency.

FEH – The Flood Estimation Handbook was developed by CEH Wallingford (formerly the Institute of Hydrology) and published in 1999. It largely supersedes the Flood Studies Report (FSR) of 1975. It gives the "standard of practice" (CEH website, April 2005) in the UK for rainfall and river flood frequency estimation, which can form the base for flood risk maps and aid design of hydraulic structures.

STFS - The Storm Tide Forecasting System plays a critical role in coastal flood forecasting. This consists of a surge model, developed and maintained by Proudman Oceanographic Laboratory (POL), operated by the UK Met Office and funded by Defra. The model is run four times a day to produce predicted surge residuals (i.e. the difference between the predicted astronomical tides level and the level including a surge component.) Predictions are provided by the Met Office to the Environment Agency in terms of coastal flooding, surge and wave activity and warnings of hazardous situations developing.

RASP – Risk Assessment for flood and coastal defence for Strategic Planning is a probabilistic process-based methodology based on the source-pathway-receptor concept. It considers the "systems" of defences, the probability of failure using tools such as 'fragility curves' and so the resultant likelihood of flooding. The consequence of flooding is aided by databases and tools such as for flood spreading, asset location, topographic survey/mapping and damage/vulnerability assessments. It provides broad-scale information to aid

strategic planning/resource allocation, the prioritisation of maintenance, inspection and target flood warning and emergency preparedness. It can also be used to assess the social vulnerability of communities

MDSF – The Modelling Decision Support Framework aids the production of catchment flood management plans using a GIS platform to display and analyse catchment characteristics, demographic information, flood maps, environmental designations and urban areas. It enables comparison of flood management and catchment change scenarios to assist in developing flood management policies for the particular catchment.

Hydraulic Models – Computer models are employed to create knowledge on the probability and extent of flooding i.e. flood hazard maps. Examples of data/ information needs are land use, asset data, hydrodynamics, bathymetry and terrain levels.

Urban Drainage tools – Urban drainage tools support the assessment of drainage capacity and design improvements. The 'Wallingford procedure' and the 'Urban Pollution Management' (UPM) manual are two of the most important tools in urban drainage.

8.1.2 Aggregation of information

Strategic plans assemble data and information into one publication and are often produced in partnership with other organisations. Some of them are required under High Level targets and so aid the implementation of responsibilities, while others are the result of planning guidance.

Shoreline Management Plans (SMPs) provide a large scale assessment of the risks associated with coastal processes and presents a long-term policy framework to manage those risks and further sustainable. The first generation of SMPs were originally a requirement under superseded High Level Target 8. The second generation of SMPs are a requirement under HLT3, which will build on the first plans using further collected information, results of further analysis or changing circumstances, for example relating to:

- Hydrodynamics (tidal levels, waves etc);
- Geomorphology and geology (sediment dynamics);
- Land use;
- Defence works;
- Economics;
- Environmental data.

Catchment Flood Management Plans (CFMPs) are policy documents for the catchment-wide management of flood risk. They look at a 50-100 year horizon, attempting to identify the policies required for successful and sustainable flood risk management within that time frame using integrated approaches. In common with SMP's, CFMPs draw together a wide range of data, information and knowledge in order to provide large-scale planning of risk to river catchments. These documents hold data, information and knowledge on:

- Hydrodynamics (water levels, flows etc)
- Geomorphology and geology;
- Land use;
- Defence works;
- Economics;
- Environmental data; and
- Climate change and impacts

Strategic Flood Risk Assessments (SFRAs) are carried out by Local Authorities to support decisions on development and planning according to planning policy. They are a more detailed local assessment of flood risk than CFMPs and can help determine areas where development is suitable/ unsuitable. They require specific data and information to understand what the residual risk is. The assessments incorporate the following data and information:

- Hydrodynamics (water levels, waves, flows etc)
- Bathymetry/ topography;
- Land use;
- Defence systems;

Regional Development Plans and Unitary Development Plans are drawn up by Local Authorities and hold information on planned areas of development. These are useful for development control in the Environment Agency and also for Water Service Providers/ Sewage Undertakers as they may affect their assets.

Drainage Area Plans provide operations managers (in the Water Industry) with an understanding of their sewerage systems and their condition within a catchment. They help to ensure that capital investment is only proposed where absolutely necessary and facilitates the most cost-effective and sustainable solutions.

There are some studies that, although do not implement FCERM, do have an influence upon FCERM plans (CFMPs and SMPs) and strategies. For example Coastal Habitat Management Plans (CHaMPs) should be considered in the future revisions of SMPs under HLT3 and hold information on ecology, geomorphology, designations and coastal protection works.

More detailed studies are carried out at the local level that aggregate data and information, such as:

- Specific scheme design (covering flood defence or coast protection schemes);
- Flood warning and emergency procedures;
- Environment Impact Assessments (EIAs) are scheme specific and draw together relevant data, information and knowledge on both the natural and built environment.

- Feasibility studies for schemes contain cost benefit analysis which draws upon economics and land use;

8.2 FCERM data and information storage

In addition to the routine collection and use of relevant data and information by both FCERM organisations and non-FCERM organisations, it is also important to recognise the role played by initiatives and management systems. In many cases these initiatives and systems are run by one or, more often, a number of the organisations discussed in the preceding sections. In some cases the initiatives are part of the fulfilment of the legislation obligations of FCERM organisations and in other cases the data management systems may be used to display data that is commercially available.

Table 8.2.1 shows initiatives and management systems that hold FCERM data and information. Since different (quality) levels of data and information are required for different levels of decisions, the systems have been grouped according to the spatial scale (resolution) that the data and information are gathered. 'Large' scale refers to greater than 1:25,000; 'Medium' scale is from 1:25,000 to 1:250,000; and 'Small' scale refers to data smaller than 1:250,000 (INSPIRE, 2002). Coverage concerns the extent of the initiative – Local, Regional and National. For example, HiFlows contains high flow measurements from gauging stations on a large scale, but the system contains records for stations for the whole of England and Wales i.e. the system has a National coverage. It is worthwhile to note that data can be grouped by other attributes to help differentiate levels of data. For instance, resolution can also be defined temporally (such as data collected daily or monthly). Work Package 2 defines the attributes that can describe data.

Some of the systems relate directly to data and information collected / collated for the benefit of FCERM, however, some systems are outside of the direct realm of FCERM but do yield useful data and information. The purpose of the system and the sources are noted and, where possible, a website. Features of the initiatives are summarised by the format and coverage. Where a number of similar initiatives exist, an example has been provided in Table 8.2.1 to show the types of data and information held. For instance, an example of a monitoring programme in the UK is given for the South East and an example of a regional sediment study is the Southern North Sea.

While the list of initiatives and systems is comprehensive, it is important to realise that new ones will be created and so users, and indeed suppliers, should maintain their awareness by subscribing to FCERM newsletters and other publications produced by FCERM organisations.

The National Flood and Coastal Defence Database (NFCDD) is an integral part of FCERM and so has been further elaborated in a sub-section below.

8.2.1 National Flood and Coastal Defence Database

The NFCDD is a Defra funded initiative being undertaken by the Environment Agency in partnership with local authorities and IDBs. The development of the database is a requirement under the Defra high level targets for flood and coastal defence operating authorities. The original vision of NFCDD was,

> 'To provide an easily accessible and definitive source of all data on flood and coastal defences in order to make better informed decisions on defence operations and long term needs and measures.'
>
> (Environment Agency, 2000)

Defra states that through the development of NFCDD, it will:

- Provide data on flood and coastal defence need
- Facilitate the prioritisation of investment
- Inform management decisions
- Measure the achievement of policy aims

The development of NFCDD also coincided with the need to update the Environment Agency's FDMS (Flood Defence Management System), where flood defence data was previously stored, and the proposed amalgamation of FDMS with FPI (Flood Plain Information), a GIS system which stored flood models and extents. While NFCDD has taken the data storage aspects of the former systems, other functionalities, such as justification and prioritisation of works are being progressed elsewhere to justify maintenance programmes.

The accountability for data management in the Environment Agency for FRM and associated data sets lies with Flood Risk Mapping and Data Management Team in Areas. The teams oversee data management in NFCDD, the central data repository.

The NFCDD is a useful tool to share and transfer data and information within the Environment Agency. It is GIS based and currently contains fluvial information on assets (defences and structures), such as elements, height, cross section, last inspected and ownership, as well as indicative floodplain maps (IFMs). However, IFMs have been replaced by flood risk maps (Flood Map) as part of Phase 3 in March 2005. Phase 3 also enters further information including Standards of Protection (SOP), address point data, crest levels, flood warning information, as well as addressing coastal aspects.

There is some data that is not only used by one group to carry out its roles but also used by other groups. For example, Flood Risk Mapping and Data Management produce flood risk maps, however, all the other teams Flood Incident Management, Operations, and Asset Management) also use the data for their own functions. Therefore the data is stored in NFCDD where various groups can access the data, Figure 8.2.1.

Since the database is supposed to be national, the Environment Agency is keen for external bodies to use NFCDD and share their information on defences. NFCDD has been designed with a web based front and so external bodies can view the information. However, the NFCDD was developed primarily around Environment Agency data needs, and so there are ongoing pilot studies to improve it for coastal and IDB information.

The design, implementation and subsequent uptake of the NFCDD are a critical aspect of data, information and knowledge management within FCERM. Although inevitably, data and information will always be required that is outside of the NFCDD from both FCERM and non-FCERM organisations, the development of the database represents a coordination and single source of defence data and information.

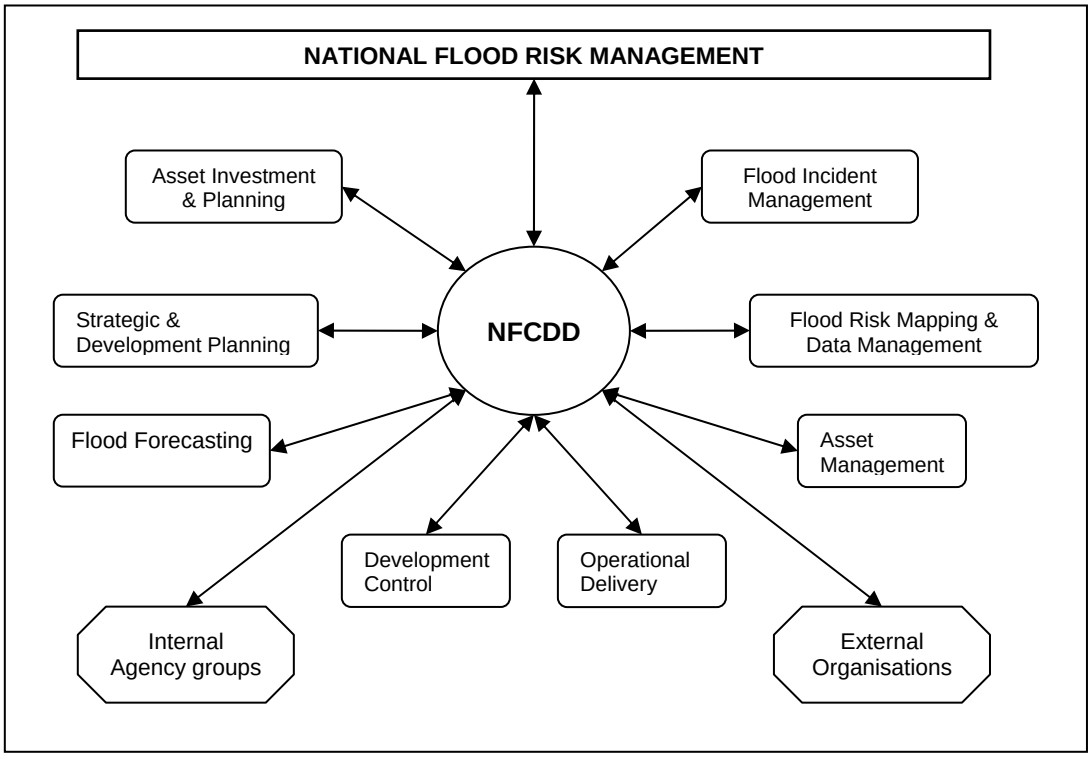


Figure 8.2.1 NFCDD information flows

The Environment Agency also has some other data and information services:

- Scientific and Technical Information Services (SATIS) is responsible for developing and implementing Environment Agency data policy including public access provision, and establishing data partnerships.

- At a national level, the National Centre for Environmental Data and Surveillance (NCEDS) forms the single point of delivery of national data to outside bodies. It holds datasets such as digitised boundaries. It also procures data from outside bodies for use in the Environment Agency, such as Ordnance Survey digital maps. Another national centre with appreciable holdings is the National Centre for Risk Assessment and Options Appraisal.

- There are also Area Customer Service Centres and Public Enquiries Unit that provide the public with information, as well as the National Library and Information Service (NLIS) that is open to members of the public.

Table 8.2.1 FCERM data and information initiatives

Scale	System/ Initiative	Data	Owner/ Source(s)	Purpose/ Comments	Electronic	GIS-based	Coverage		
							Local	Regional	National
LARGE	RAINARK	Archived rainfall (amount and intensity)	Met Office, Environment Agency		✓				✓
	Telemetry	Real-time water levels & flows	Environment Agency		✓	✓			✓
	Telemetry	Real-time water levels & flows	IDBs	Not all IDBS have telemetry	✓	✓		✓	
	WISKI	Archived water levels, flows, groundwater, rainfall and current meter gaugings	Environment Agency		✓	✓			✓
	National Water Archive	Archived rainfall (accumulations with return periods), Archived river flows, Archived groundwater levels	NERC; www.nwl.ac.uk/ih/nrfa/		✓				✓
	National River Flow Archive (NRFA)	Daily and monthly flow, monthly catchment rainfall	CEH; www.nwl.ac.uk/ih/nrfa/	Now has Spatial Catchment Information for 1200 gauged catchments on elevation, geology, land use and rainfall	✓	✓			✓
	National Groundwater Level Archive	Groundwater levels and hydrographs	BGS; www.nwl.ac.uk/ih/nrfa/groundwater/index.htm		✓	✓			✓
	WellMaster	Hydrogeological data (recorded groundwater levels)	BGS/ CEH	Historic value for modelling of water resources and climate change in the UK	✓	✓			✓
	HiFLOWS	Rating curves, Peak flows (POTs)	DEFRA/ Environment Agency	Aim to improve data for estimating peak flood flows by FEH methods	✓	✓			✓
	National Abstraction Licensing Database (NALD)	Abstractions and impounding license data (who, where, quantity)	Environment Agency	The system is based on Oracle and can produce certain standard reports	✓	✓			✓
	National Flood and Coastal Defence Database	Main River location, COW locations, asset location, asset type, asset dimensions, asset elements, asset composition, asset photograph, asset owner, Flood storage area, Flood watch area, Flood warning area, Flood zones, Defended areas, flood risk area, Flood event outlines, Flood event probability, flood event photograph	Environment Agency	National dataset. See subsection for more explanation	✓	✓			✓

Scale	System/ Initiative	Data	Owner/ Source(s)	Purpose/ Comments	Electronic	GIS-based	Coverage		
							Local	Regional	National
LARGE	CMMS	Operational structures	Environment Agency	Computerized maintenance management system	✓				✓
	WSP asset database	WSP asset information (position, condition, category)	Water Companies		✓	✓			✓
	UK Estuaries Research Programme (ERP1)	Bathymetric profiles, historical bathymetry, CASI false and true colour composite images, CASI intertidal classification, Instantaneous water levels, Current data, Saltmarsh boundaries, Water quality, Wave data, Tide gauge data; Beach profiles, Salinity and nutrient data, Environmental data, Sediment properties/ texture	DEFRA/ Environment Agency	Aid research of 6 estuaries: The Humber, Blackwater, Southampton Water, Tamar, Mersey and Ribble	✓	✓		✓	
	South East Regional Monitoring Programmes	Land based topographic surveys (baseline beach surveys, beach profiles, post storm beach surveys), Airborne remote sensing topographic surveys (annual beach monitoring survey, aerial surveys and photogrammetric profiling, digital aerial photos, LiDAR surveys of cliffs and saltmarshes), Bathymetric surveys of nearshore sub-tidal zones (hydrographic surveys, bathymetric survey techniques), Waves (measured nearshore bouys, synthetic offshore and modelled nearshore wave data), Tidal measurement	CCO; www.channelcoast.org	Regional pilot model that may later be applied to other regions of the UK. Datasets collected determined on a 'risk basis', where more data is collected for sites that are most vulnerable.	✓			✓	
	Land Cover Map 2000 (LCM2000)	Land cover	CEH; www.ceh.ac.uk/data/lcm/LCM2000.shtm	Computer classification of satellite scenes	✓	✓			✓
	Port of London	Navigation data, environmental sites and legislations	Port of London; www.portoflondon.co.uk		✓			✓	
	National Marine Monitoring Programme	Physico-chemical and environmental variables	CEFAS; www.cefas.co.uk	Long-term trends in the quality of the marine environment	✓	✓			✓
	SeaZone	Locational Data (raster and vector data, wrecks and obstacles, oil and gas installations, bathymetry, practice and exercise areas (PEXA), lights and buoys, and maritime jurisdiction), Sedimentary and Temporal Data (seabed sediments, tides and oceanographic features)	UKHO, OS; www.seazone.com	Hydrospatial baseline data for use in asset management, decision-making and environmental modelling applications	✓	✓			✓

Scale	System/ Initiative	Data	Owner/ Source(s)	Purpose/ Comments	Electronic	GIS-based	Coverage		
							Local	Regional	National
LARGE	Irish Sea Pilot	geophysical, hydrographical, nature conservation, ecological and human use data	DEFRA; JNNC; www.jnnc.gov.uk	Help develop a strategy for marine nature conservation that could be applied to all UK waters		✓			✓
	Countryside Survey 2000 (CS2000)	Habitats, plants landscape features and land types	CEH; www.cs2000.org.uk	Includes surveys over last twenty years	✓	✓			✓
	National Biodiversity Network (NBN)	Biodiversity datasets (species, habitats and sites)	JNNC; www.searchnbn.net	Search engine to help find biodiversity information published on the websites of partners	✓	✓			✓
	National Monuments Records	Historic Environment	English Heritage		✓	✓			✓
	Historic Environment Records	Designations (historic, listed)	Local Authority		✓	✓	✓		
	National Property Database (NPD)	Property type, Property location, Property value	DEFRA		✓				✓
	Multi-Coloured Manual (MCM)	Flood damage/ coastal erosion costs to property, infrastructure and environment. Intangible (social) impacts	Flood Hazard Research Centre (FHRC)	Data and techniques for assessing the benefits of flood alleviation and coast protection					✓
	DG5 register	Number of properties at risk from sewerage flooding	OFWAT		✓	✓			✓
	National Statistics	Population demography, social deprivation	ONS; www.statistics.gov.uk		✓				✓
MEDIUM	Rain Radar	Rainfall (intensity)	Met Office, Environment Agency	There are 15 radars in the UK, each with a 75km range	✓	✓			✓
	Land Information System	Soil and soil related information (geology, ecology, land)	NSRI	National computerised database	✓				✓
	CORINE Land Cover Map 2000 (CLC2000)	Land cover and Land use classes representing the major surface types across Europe	European Commission	Designed to be used at 1:100,000 scale	✓	✓			✓
	Agricultural Land Classification	Land use	DEFRA		✓	✓			✓
	UK Estuaries Research Programme (ERP1)	Bathymetry, River monitoring sites, detailed estuarine coastlines, tidal characteristics, Estuary properties, chart datum & ordnance datum offsets, Environment Agency LiDAR coverage polygons	DEFRA/ Environment Agency	National datasets	✓	✓			✓

Scale	System/ Initiative	Data	Owner/ Source(s)	Purpose/ Comments	Electronic	GIS-based	Coverage		
							Local	Regional	National
MEDIUM	FutureCoast	Bathymetry, Physical controls, tidal data, seabed sediment, seabed features, offshore sediment transport trends, inshore wave data, onshore geology (drift and solid), nearshore sediment transport, backshore and inter-tidal geomorphology, estuary limits, EA indicative coastal floodplain mapping, built defences, historic shoreline movement, historic foreshore change, future shoreline and foreshore change. Oblique aerial photographs	DEFRA	Help provide predictions of coastal evolutionary tendencies over the next 100 years to feed into next phase of Shoreline Management Plans	✓				✓
	Regional Sediment studies	Mobility and transport of sediment around UK coast	Environment Agency; Local Authorities; www.sns2.org (Southern North Sea)	Inform existence of relevant literature and data sources	✓	✓		✓	
	Multi-Agency Geographic Information for the Countryside (MAGIC)	Soilscape data, Landscape data, Environmental schemes, Environmental designations	DEFRA; Environment Agency; English Nature; English Heritage; Countryside Agency; Forestry Commission; ODPM; www.magic.gov.uk	National and regional levels. Website provides links to relevant section of other organisations	✓	✓			✓
SMALL	National Tidal & Sea Level Facility	Tide Gauge data (archived and real-time). Monthly mean, surge and extreme values also available	POL; www.pol.ac.uk		✓				✓
	WaveNet	Real-time wave data in areas of known flood risk	CEFAS; www.cefas.co.uk/wavenet/	Strategic long-term wave monitoring of England and Wales	✓			✓	

9. Future issues

9.1 Introduction to current/future pressures

There are environmental, economic and social issues which are creating pressures on FCERM. Consequently the government and other bodies are responding with new legislation and strategies. These will have an effect on the existing system. Key areas are summarised below.

A summary of some of the key pressures and responses is illustrated in Figure 9.1.1.

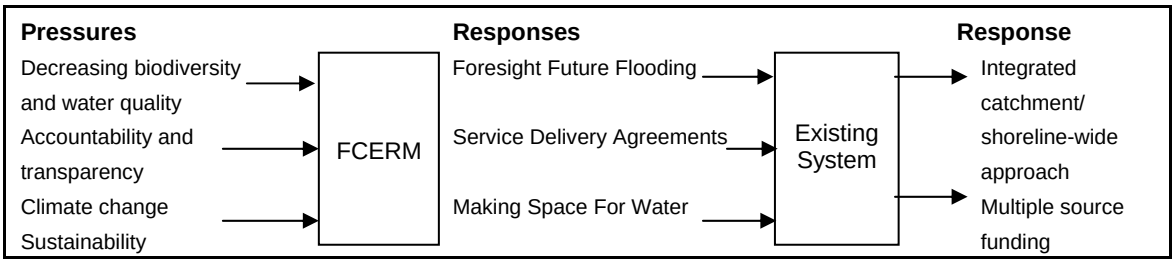


Figure 9.1.1 Current/ future pressures on FCERM

9.2 Foresight Future Flooding

The Office of Science and Technology commissioned an independent study, Foresight Future Flooding (2004), to quantify the possible scale of future flooding facing the UK. Its primary aim was,

> 'to use the best available science to provide a challenging vision for flood and coastal defence in the UK between 2030 and 2100 and so inform long-term policy.'

It identified the main drivers of future risk, Table 9.2.1, and analysed the influence on flooding by considering different economic, social and environmental scenarios. Drivers with the most impact are also the most uncertain – scientific understanding as well as international community success. Therefore the study stressed it is important to develop policies that can cope with a wide range of possible futures and which can respond flexibly to an evolving world.

Table 9.2.1 Foresight main drivers of future risk

Main Drivers of future risk	Influence	Implications
Climate change	Precipitation will increase risks by 2-4 times. Specific locations could experience larger changes exceeding this range.	
Urbanisation	Especially in flood prone areas, could increase rainwater runoff, increasing flooding risk up to 3 times. New developments and weak planning controls (type, densities and number of new buildings) could also increase.	Importance of urban development to future flood risk.

Main Drivers of future risk	Influence	Implications
Environmental regulations	Could be risk-neutral or could affect flood pathways by constraining maintenance and flood risk management along rivers, thereby raising risk	Integrated approach to decisions on flood management and environmental regulation in order to achieve multiple benefits for people and nature.
Rural land management	Substantial evidence that current land-management practices have led to increased surface runoff at the local scale. However, there is a general absence or uncertainty of evidence of impacts at catchment scale. Also lack of knowledge of how small scale impacts combine at larger scales.	Further research has been recommended to explore possible impacts of land-management practices at both local and catchment scales.
Increasing national wealth	Increases the value of buildings and assets at risk and is therefore a strong driver of economic impacts.	
Social impacts	Difficult to quantify but the analysis showed a large increase in social risks in all scenarios, by 3 – 20 times.	Unless these risks are managed, significant sections of the population could be blighted.

9.3 Making Space for Water

A Delivery Plan (Defra, 2005b) has been published to implement the outcomes of the Government's 'First Response to *Making Space For Water*, taking the new strategy forward' (Defra, 2005c). The strategic direction of the Government for FCERM is set out. The approach will '*involve taking account of all sources of flooding, embedding flood and coastal risk management across a range of Government policies, and reflecting other relevant Government policies and operations of flood and coastal erosion risk management'* (Defra, March 2005). The overall approach adopts integrated catchment/ shoreline management and adaptability to climate change. The strategic directions set out in the First Response are summarised in Table 9.3.1 together with their potential implications on data and knowledge management.

Table 9.3.1 Strategic directions from the Government's First Response to *Making Space For Water* and implications for data and knowledge management

Themes	Strategic Direction	Potential implications for data and knowledge management
Land-use Planning	Encourage inclusion of Flood Risk Assessments (FRA's) at all levels of planning process. Gateway questions to determine need for FRA's in Standard Planning Application	Ease of access to probability and extent of flooding information. Good quality data for gateway questions.
	Environment Agency to become statutory consultee, subject to consultation	
Rural Land-use	Multi objective approaches to make space for water, such as creation of washlands/ wetlands and managed realignments of coasts and rivers	Potential for multiple funding so require ease of exchange of information between other government offices and NGOs.
		Good quality data on receptor to assess cost-benefit of schemes
	Continue research on role of rural management and generation of flooding	Improve data and knowledge through empirical research at field scale, combined with hydrological modelling at the catchment and sub-catchment scale.
Coastal	Review of institution arrangements and legislation with the Environment Agency taking a strategic overview to coasts	Greater need for access to and sharing of coastal information

Themes	Strategic Direction	Potential implications for data and knowledge management
Groundwater	Environment Agency will assume strategic overview of groundwater monitoring till Spring 2006	Access to groundwater monitoring databases
Urban Drainage	Pursue integrated urban drainage management.[1] Continue pilot studies (e.g. AUDACIOUS[2]) to test different approaches to integrated management.	Pilot studies continue till 2009 but initial results suggest need to share information better through partnering and work across agencies. Also responsibilities and arrangements are likely to be better defined.
	Potential to transfer private sewers to sewerage undertakers. Ofwat (now Water Services Regulation Authority) to ensure water companies deal with sewer flooding	Transfer of ownership requires ease of information exchange.
	Encourage land management practices, such as SuDS (including recycling and re-use), and so not overload urban drains	Ease of access to good practice techniques and socio-economic data
Flood Warning	Feasibility studies to expand flood warnings for different forms of flooding, such as urban, pluvial, groundwater and flash floods	Knowledge on organisations that have collected data during flood events to aid development of forecasting techniques.

[1] The response to MSFW envisages a hierarchical management framework encompassing urban areas, with emphasis on strategic approaches focussed on where the risks reside. i.e. if these are fluvial then the EA would be main authority, if sewer then the water industry etc. The approach envisages a 'nested solution' system.
[2] AUDACIOUS (Adaptable Urban Drainage – Addressing Changes in Intensity, Occurrence and Uncertainty of Stormwater) is a cross disciplinary project to develop tools for assessing and mitigating the effects of climate change on urban drainage systems.

Projects are being carried out under the following themes to improve understanding to produce a final strategy:

- Holistic approach to managing flood and coastal erosion risk
- Achieving sustainable development
- Increasing resilience to flooding
- Funding

Although the recommendations of the urban integrated drainage pilots will not be published till spring 2008, it would be wise to consider the appropriate management of the data and information generated from them at an early stage.

In relation to the extension of the Environment Agency's strategic role to cover coastal protection, the population of NFCDD with coastal asset data should facilitate this extension.

The cross government nature of the MSFW Delivery Plan signifies an increase in the involvement of other government departments, such as the Department for Transport in urban flood risk management and ODPM in planning and flood risk management. As a consequence, there is a need for more access to a wider range of data and information.

The strategy also supports continued research and monitoring of climate change and its impacts. Therefore the value of associated data and information, particularly monitored data (such as rainfall, flows, sea levels and ice melt), will not be realised until the future but it is important to capture the appropriate quality and manage it in a transparent fashion.

9.4 European drivers

The European Directive 2001/42 EC requires that environmental assessments are carried out for a range of plans and programmes likely to have an effect on the environment. It applies to plans and programmes from 21 July 2004 and is commonly referred to as the SEA (Strategic Environmental Assessment) Directive. The objective is "to provide a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation of plans and programmes with a view to promoting sustainable development "(ODPM, 2005).

It applies to a wide range of plans and programmes prepared by statutory agencies, regional planning bodies, local authorities and others. It should include the likely effects on the environment, including issues such as biodiversity, population, human health, fauna, flora, soil water, air, climatic factors, cultural heritage, landscape and the interrelationships. Therefore FCERM authorities need to know where to find this sort of information when making plans.

The key principle of the Water Framework Directive (WFD) is achieving 'good ecological status' defined by physico-chemical and hydromorphological (hydrology and morphology) parameters. The WFD also requires that River Basin Management Plans are produced. Therefore FCERM authorities need to know where different levels and quality of data is stored or can be accessed. Once the directive kicks in there will be a large focus on water quality management as well as quantity of water.

9.5 Funding Review

The process of enmaining COWs will require good data exchange between the Environment Agency and the other operating body (LAs or IDBs) to ensure all maintenance and operation information (programmes) are transferred.

The Funding Review will also have implications for the current system. For example, the block grants and use of multiple funding sources may mean that there is a trend for multi-beneficial schemes, where a flood defence scheme incorporates an environmental benefit. Therefore the need for access to non-FCERM information will increase.

9.6 Organisational change

One thing certain in life is change. This creates a big challenge to constructing ontologies and keeping them up to date. These challenges have been well articulated (Brewster *et al*, 2003).

There are changes occurring in FCERM: MSFW is paving the way for a review of institution arrangements and legislation that may change the face of FCERM; in line with the Water Act 2003, a new water regulation structure commenced from 1st October 2005 with Consumer Council for Water replacing WaterVoice and in April 2006 Water Services Regulatory Authority will succeed Ofwat. Also

from time to time, the Environment Agency changes its structure, for instance to reflect the shift in focus from flood defence to floor risk management. Considering the influence of MSFW, there is an increasing focus on integrated rural and rural flood risk management that may shape the Environment Agency in the future.

In order to help manage organisational changes in the future, automatic and semi-automatic ontologies are being developed (Brewster *et al*, 2003).

9.7 Ongoing research

There is a lot of research being carried out within the FCERM world. It is necessary not only to be aware of this research but also share good practice and lessons learnt. It is better to,

> "learn from the mistakes of others - you can never live long enough to make them all yourself" (John Luther).

9.7.1 Future data needs

There are trends occurring at the moment due to recent R&D work that will have an impact upon the current system. For instance, the ongoing development of risk management methodologies and tools such as RASP and PAMS (Performance-based Asset Management Planning System) should enable improved strategic management and targeting of FCERM resources according to a flood and coastal erosion risk. This should lead to better targeting of information requirements and hence smarter data collection and use.

Emerging areas for which data and knowledge are required include the potential for rural land management to contribute to:

- the control of runoff and flood generation;
- flood storage; and
- simultaneously meet flood management, biodiversity and rural income objectives through options such as flood washlands, wetlands, river and floodplain restoration, and coastal realignment.

There remains considerable uncertainty about the potential contribution of rural management to the generation of floods and the extent to which changes in rural land management practices could help alleviate flood risk (O'Connell *et al*., 2004). This is especially the case at the catchment scale and for extreme precipitation events. There is a need to improve data and knowledge through empirical research at the field scale, combined with hydrological modelling at the catchment and sub-catchment scale. While responsibilities are divided on pluvial flooding, and so it is unclear which organisations need the data and the standard of data, the data should be stored and managed to ease exchange.

The EPSRC, in collaboration with Defra/Environment Agency Joint R&D programme on Flood and Coastal Defence, UKWIR, NERC and ESRC are currently funding an interdisciplinary research consortium investigating the

prediction, prevention and mitigation of flooding; the Flood Risk Management Research Consortium (FRMRC). The multidisciplinary consortium is undertaking an integrated programme of research covering land use management; real time forecasting; infrastructure management; whole systems modelling; urban flood management; stakeholder and policy; morphology and habitat; risk and uncertainty. The research is likely to unearth new data and information needs as well as create an abundance of information that should be managed efficiently and be made available to the FCERM world.

The Foresight future flooding report (OST, 2004) confirmed the need for more flexible and adaptive approach to FRM due to the uncertainties inherent in future flood risk. R&D is currently looking at how these approaches can be delivered. It is very likely that such approaches will require significant monitoring of feedback and associated data management.

9.7.2 Future ontologies

In addition to this work carried out within this project, other ontologies are being developed within the environmental sector and so links are being established to minimise the risk of duplication and maximise efforts. The project ORCHESTRA (Open Architecture and Spatial Infrastructure for Risk Management) is part of the Sixth European Union Framework Programme (FP6) for Research and Technological Development. It is acknowledged that Risk Management activities involve a range of different organisations at various administrative levels with their own systems and services. ORCHESTRA is responding to the challenge to get these systems to interoperate and share information. The overall goal of ORCHESTRA is to design and implement an open service oriented software architecture that will improve the interoperability among actors involved in Multi-Risk Management.

Ordnance Survey is a partner in the ORCHESTRA project and is developing methods to systematically construct conceptual and logical ontologies for flood risk management, while considering the requirements for interoperability between geographical and risk analysis information. Ordnance Survey is also collaborating on a PhD project 'Towards interoperability between ecological and topographical data through the application of ontologies' with Oxford Brookes University. This ontology is also being developed with the Science Division of the Environment Agency in the context of the Water Framework Directive.

9.7.3 Future sharing issues

Some of the R&D work being undertaken relates to the ‘Making Space For Water’ strategy, for instance Sustainable Management of Urban Rivers and Floodplains (SMURF) and AUDACIOUS are helping the development of integrated urban drainage management. Once responsibilities are allocated and defined better between organisations then data needs can be more certain. It is envisaged that the operating organisations, in particular the Water Industry, need to share information and knowledge in a more ordered fashion.

A European concerted research action, COST C22, is also being undertaken on Urban Flood Management. Founded in 1971, COST is an intergovernmental framework for European CO-operation in the field of Scientific and Technical Research, allowing the co-ordination of nationally funded research on a European level. The main objective of this C22 Action is to increase knowledge required for preventing and mitigating potential flood impacts to urban areas by exchanging experiences, developing integrated approaches, and by promoting the diffusion of best practices in Urban Flood Management. Secondary objectives are to gather and share information on subject across Europe; process and present the information in a form that others can learn from it; stimulate national R&D initiatives; increase awareness of the importance of UFM; and secure good dissemination of results. Establishing links with such research could aid the development of integrated urban drainage management under the MSFW strategy.

The European Commission is funding, under the Sixth Framework Programme, a project called FLOODsite, which aims to address the complex interactions needed to achieve the goal of future integrated flood risk management in Europe. The project covers the physical, environmental, ecological and socio-economic aspects of floods from rivers, estuaries and the sea. It covers 30 tasks arranged into seven themes covering: risk analysis; risk management; technological integration; pilot applications; training and knowledge uptake; networking, review and assessment; co-ordination and management. 13 countries within the European Union are working on the project, which started in 2004 and is scheduled to run over five years.

FLOODsite Partners need to import, analyse, generate and exchange a large and diverse range of data sets. Therefore a protocol for data exchange and storage has been adopted from an approach developed within the EC NOKIS project for the description and recording of datasets. The NOKIS system complies with current metadata standards and although the system does not store data itself, it stores the availability of data and contact details to access the required data.

It would be wise to establish links with FLOODsite and share experiences on knowledge management tools and determine if the systems can be integrated.

Another project that has created a web enabled metadatabase is the Integrated Coastal Hydrography (ICH), a practical partnership between the United Kingdom Hydrographic Office (UKHO), the Environment Agency, Ordnance Survey and the Maritime and Coastguard Agency (MCA). Previously the coastal zone community had to consult data holders independently and there was no easy way to discover what survey data currently exists, along with metadata describing the data and the contact details. The project has allowed a more effective and efficient framework for the delivery of coastal Hydrographic information. Lessons learnt from making the metadatabase should be shared as well as ensuring that any future FCERM metadatabase can talk with other such systems.

The delivery of MSFW, EU directives and R&D implies that as we move into the future, there is likely to be more requirements of integration and interaction between FCERM related data from various sources. The need for consistency and provenance will be critical for the necessary ease of access, sharing, update and interoperability. The use of a FCERM metadata standard, developed in Work Package 2, can help show the provenance of data as well as improve accessibility and consistency. A knowledge management tool, developed in Work Package 3, would also aid the search for appropriate data and information.

9.7.4 Future initiatives

Initiatives are also being developed that may eventually hold relevant FCERM data and information. For example members of COREPOINT (**Co**astal **Re**search **Po**licy **Int**egration) are concerned with issues on ICZM in Northwest Europe (Ireland, Wales and Scotland). The partners are developing a Virtual Coastal Resource Centre for NW Europe. The centre will house the following features:

- A GIS (Geographic Information System) Coastal Atlas for NW Europe
- Local information system (LIS) decision making tools for local authorities
- A Media Information Resource Centre

10. Summary and implications

The objective-led approach is fundamental to improving effective data, information and knowledge management. The ontology helps dissect the intricacies of data in FCERM, which then eases the targeting of improvements. The main outputs of the developed ontology for data, information and knowledge management in FCERM are as follows:

- A base of the principal and influential (current and future) drivers for data, information and knowledge in FCERM
- A process to derive data and information needs from business objectives;
- The information and data needs charts illustrating and mapping the relations between business objectives and the data to deliver them for FCERM operating authorities;
- Key organisations directly and indirectly involved in FCERM;
- The information fountain diagrams illustrating and mapping the exchange and flow of data and information within operating authorities and between organisations;
- A base awareness of systems holding and advertising FCERM related data and information; and
- A base awareness of ongoing research on data, information and knowledge management.

The outputs of the developed ontology have then shaped the development of the other project work packages and good practice guide.

The user's need for data, which is established from the required information, dictates the level of data quality required. It is possible that different roles can require the same type of data but at varying quality. The concepts related to data quality and justification are discussed and developed for a data and information appraisal framework in Work Package 4 (FD2323/TR4).

The information fountains and data needs charts reinforce the fact that organisations use similar types of data, which can originate from diverse and disparate sources. This has implications for collection, storage and exchange of data, information and knowledge if synergy is to be achieved. It is important that a common and consistent standard is used within the FCERM community, thus allowing interoperability between systems. Also the value of databases depends on the context but knowing the provenance, via metadata, provides further benefits. Work Package 2 (FD2323/TR2) develops a FCERM metadatabase based on the ISO19115 standard that will also help systems to communicate with each other using the same 'language'.

The objective-led approach can be employed to determine if there are data gaps. For example, as policies and strategies transform (with the Government's new, imminent flood and coastal strategy Making Space for Water in mind) then future responsibilities and information requirements can be determined. Then data needs can be derived to deliver the information and compared to existing data. Work Package 3 (FD2323/TR3) incorporates this philosophy to develop a

knowledge management tool, which aids the retrieval and exchange of appropriate data and information.

Data needs and information flow charts have been provided for key FCERM organisations and roles. Further development of these charts by the business will be necessary to fully understand the data needs and interactions. At the detailed level, supporting tools such as semi-automated ontologies may be useful to capture the intricacies, as they may otherwise become too unwieldy. It is recommended that this is carried out with the involvement of different functions and agreed by FCERM industry. This will also aid the population of the knowledge management tool in FD2323TR3. The process of development and agreement will foster the ownership and FCERM-wide awareness necessary to deliver the required culture change.

In conclusion, a culture change into an objective-led approach is clearly of significant benefit to FCERM. Methods and tools to support it must be made available to enable FCERM to meet the needs of a dynamic environment. The Good Practice Guide, written as Work Package 5 (FD2323/TR5), makes a considerable contribution for effective data, information and knowledge management in FCERM.

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Http://www.defra.gov.uk/wildlife-countryside/resprog/findings/irishseapilot/ - visited 19 April 2005

Http://www.eu-orchestra.org/index.shtml

Http://www.foresight.gov.uk/

Http://www.met-office.gov.uk

Http://www.nao.org.uk/publications/ nao_reports/03-04/0304161.pdf – visited 19 April 2005

Http://www.odpm.gov.uk/stellent/groups/odpm_control/documents/contentservertemplate/odpm_index.hcst?n=4136&l=2 – SEA Directive visited 14 April 2005

Http://www.ofwat.gov.uk/aptrix/ofwat/publish.nsf/Content/navigation-homepage (ofwat)

Http://oiled.man.ac.uk

Http://www.ontoknowledge.org/oil/

Http://www.ordnancesurvey.co.uk/oswebsite/partnerships/research/collaboration/semanticinter.html

Http://www.pol.ac.uk/ntslf/

Http://www.se.coastalgroup.org.uk

Http://www.water.org.uk/

Http://www.watervoice.org.uk/aptrix/ofwat/publish.nsf/Content/navigation-watervoice-homepage

Figures

Figure 5.1.1 Position of Flood and Coastal Erosion Risk Management (FCERM) within the Government

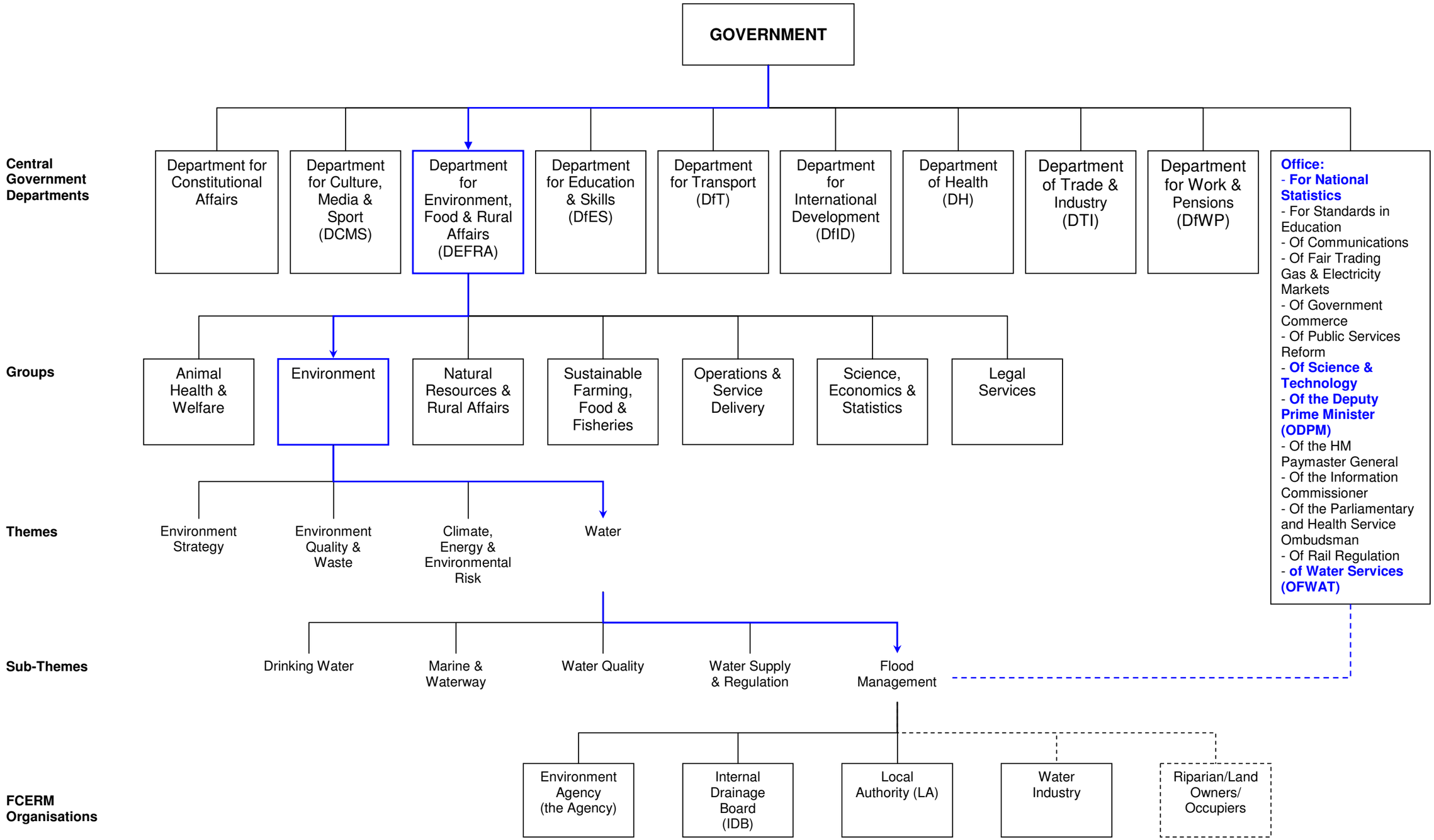


Figure 5.2.5. Riparian/Land Owners/Occupiers FCERM responsibilities and data requirements flow chart

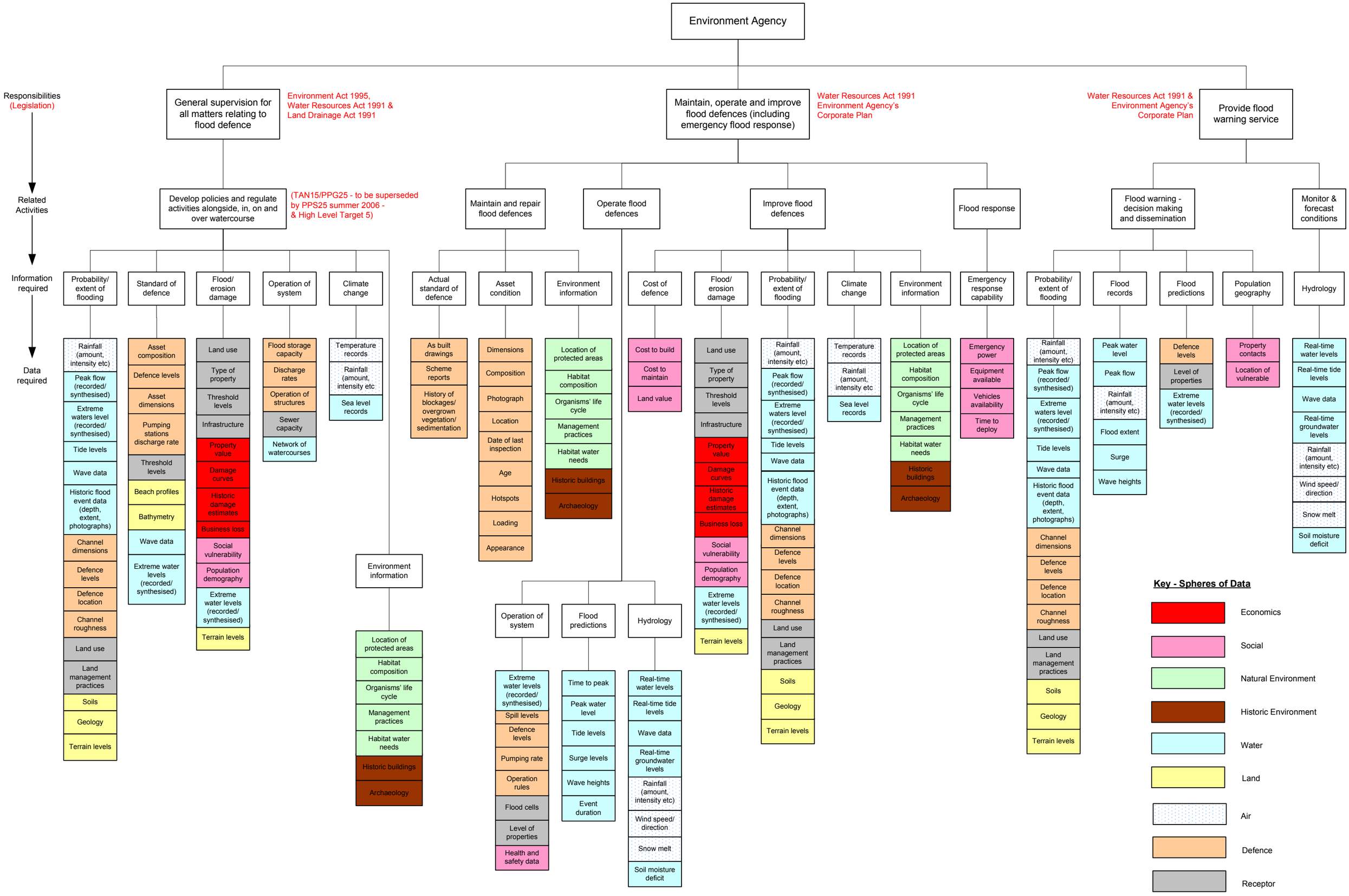


Figure 5.2.1. Environment Agency FCERM responsibilities and data requirements flow chart

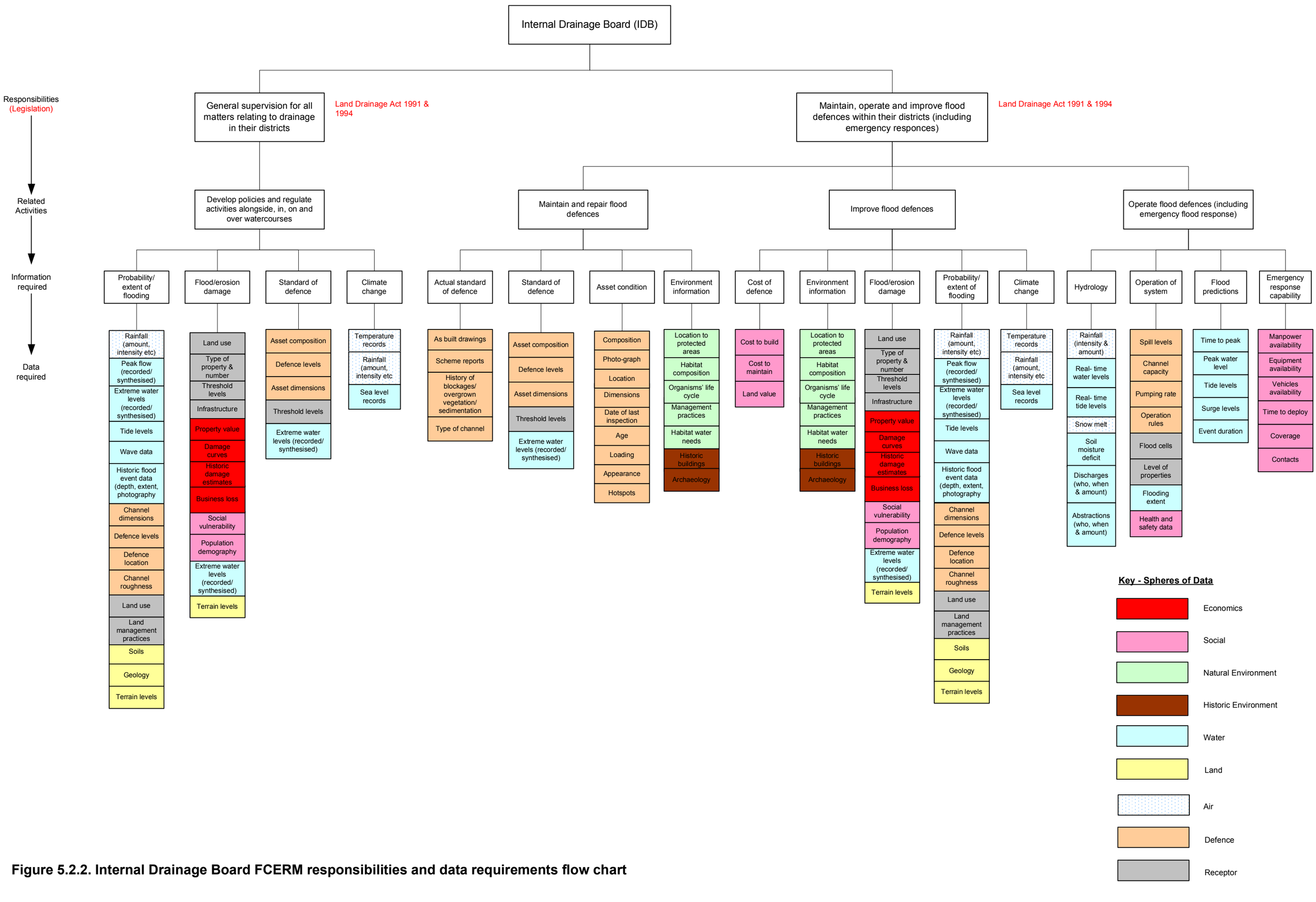


Figure 5.2.2. Internal Drainage Board FCERM responsibilities and data requirements flow chart

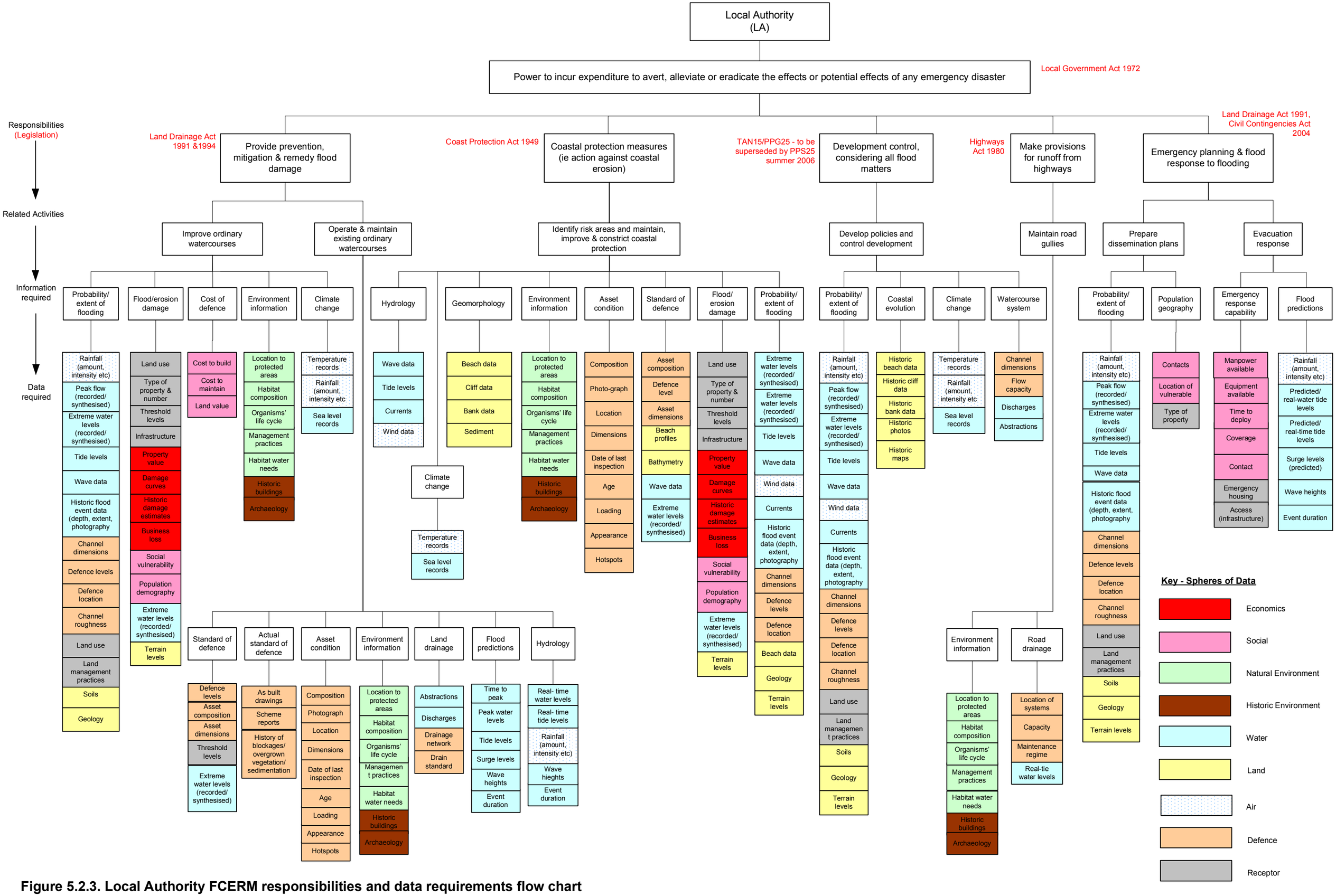


Figure 5.2.3. Local Authority FCERM responsibilities and data requirements flow chart

Riparian/ Land Owners/ Occupiers

Responsibilities (Legislation)

Related Activities

Information required

Data required

Reasonable action to maintain watercourses and the flow to prevent flooding

Case law

Protect their property but not detrimental to others

Case Law- Menezies v Breadalbare (1892) 3Bli.Ni.414

Maintain capacity of watercourses and accept flows

Build defences/ coastal protection

Asset condition
- Dimensions
- Composition
- Photograph
- Location
- Date of last inspection
- Age
- Hotspots
- Loading
- Appearance

Environment information
- Location of protected areas
- Habitat composition
- Organisms' life cycle
- Management practices
- Habitat water needs
- Historic buildings
- Archaelogy

Standard of defence
- Extreme water levels (recorder/ synetheised)
- Network of watercourses
- Watercourse responsibility
- Type of watercourse
- Defence levels

Actual standard of defence
- As built drawings
- Scheme reports
- History of blockages/ overgrown vegetation/ sedimentation
- Type of channel

Watercourse system
- Dimensions
- Loading
- Level of service

Probability/ extent of flooding
- Rainfall (amount, intensity etc)
- Peak flow (recorded/ synthesised)
- Extreme water levels (recorded/ synthesised)
- Tide levels
- Wave data
- Historic flood event data (depth, extent, photographs)
- Channel dimensions
- Defence levels
- Defence location
- Channel roughness
- Land use
- Land management practices
- Soils
- Geology
- Terrain Levels

Flood/ erosion damage
- Land use
- Type pf property & number
- Threshold levels
- Infrastructure
- Property value
- Damage curves
- Historic damage estimates
- Business loss
- Social vulnerability
- Population demography
- Extreme water levels (recorded/ synthesised)
- Terrain levels

Climate change
- Temperature records
- Rainfall (amount, intensity etc
- Sea level records

Hydrology
- Wave data
- Tide levels
- Currents
- Wind data

Geomorphology
- Beach data
- Cliff data
- Bank data
- Sediment

Environment information
- Location of protected areas
- Habitat compostition
- Organisms' life cycle
- Management practices
- High water needs
- Historic buildings
- Archaeology

Cost of defence
- Cost to build
- Cost to maintain
- Land value

Key - Spheres of Data

- Economics
- Social
- Natural Environment
- Historic Environment
- Water
- Land
- Air
- Defence
- Receptor

Figure 5.2.5 Riparian/ Land Owners/ Occupiers FCERM responsibilities and data requirements flow chart

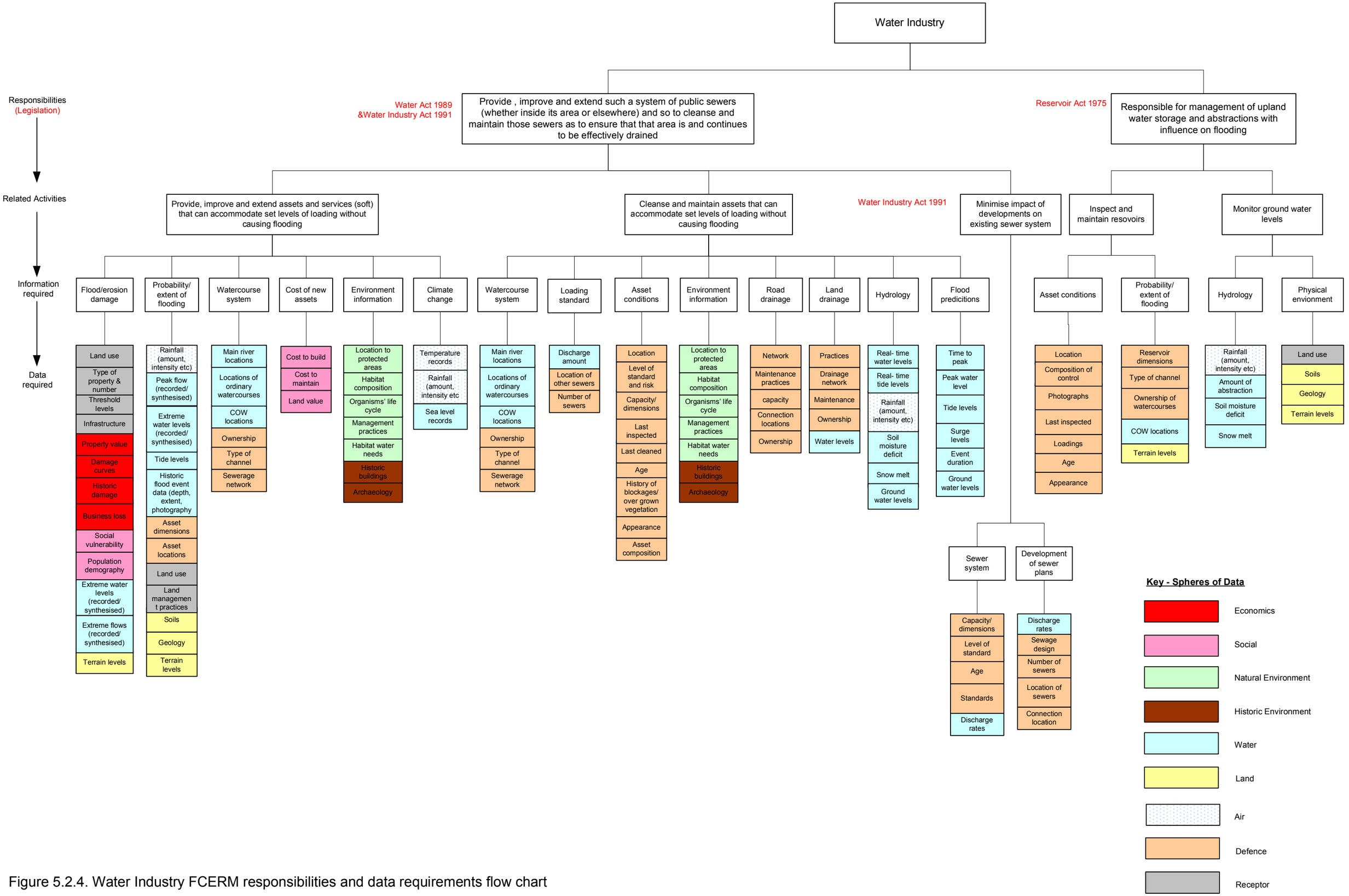


Figure 5.2.4. Water Industry FCERM responsibilities and data requirements flow chart

Figure 7.3.3. EA Information Fountain - General supervision for all flood defence matters

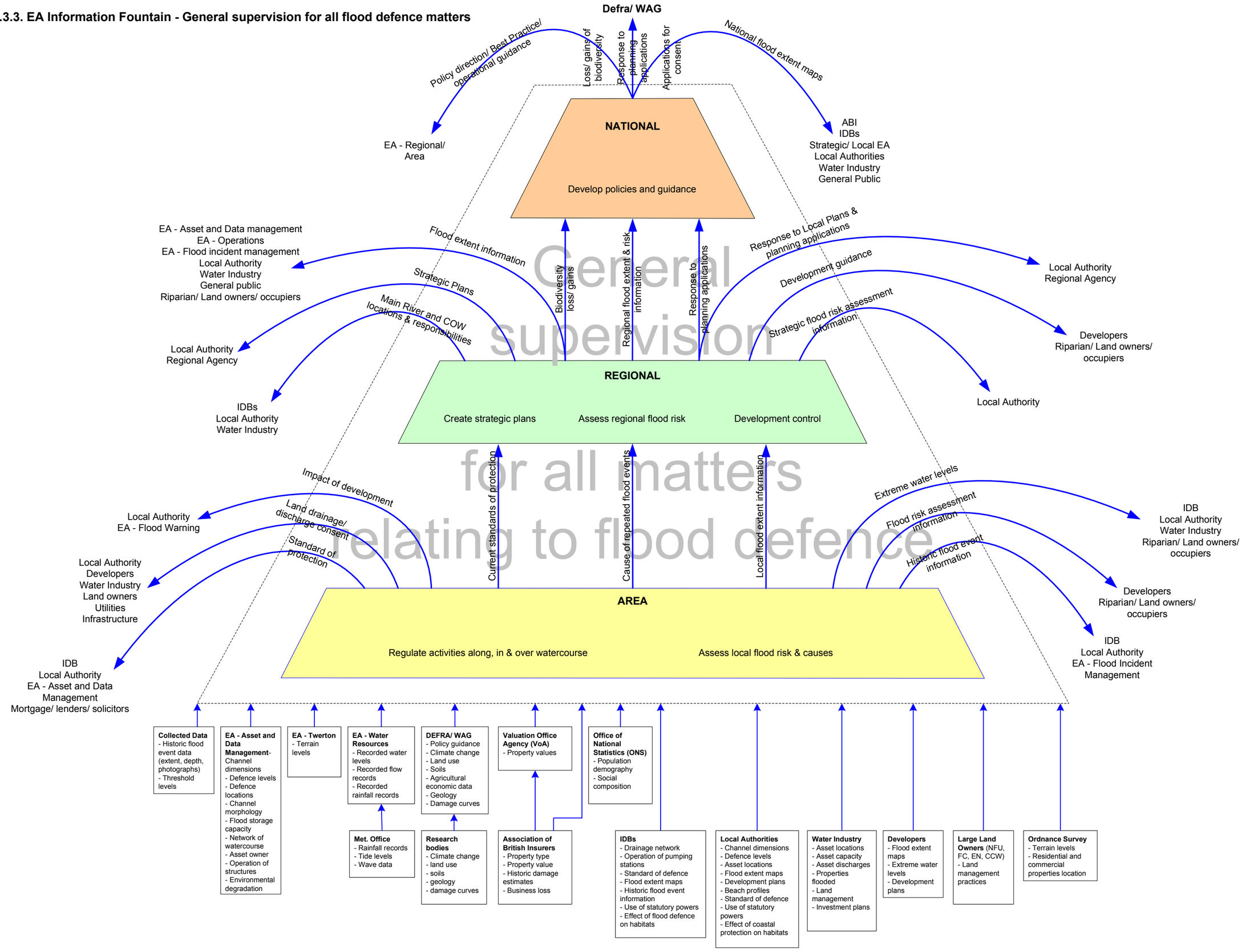


Figure 7.3.4. EA Information Fountain - Maintain, operate & improve flood defences

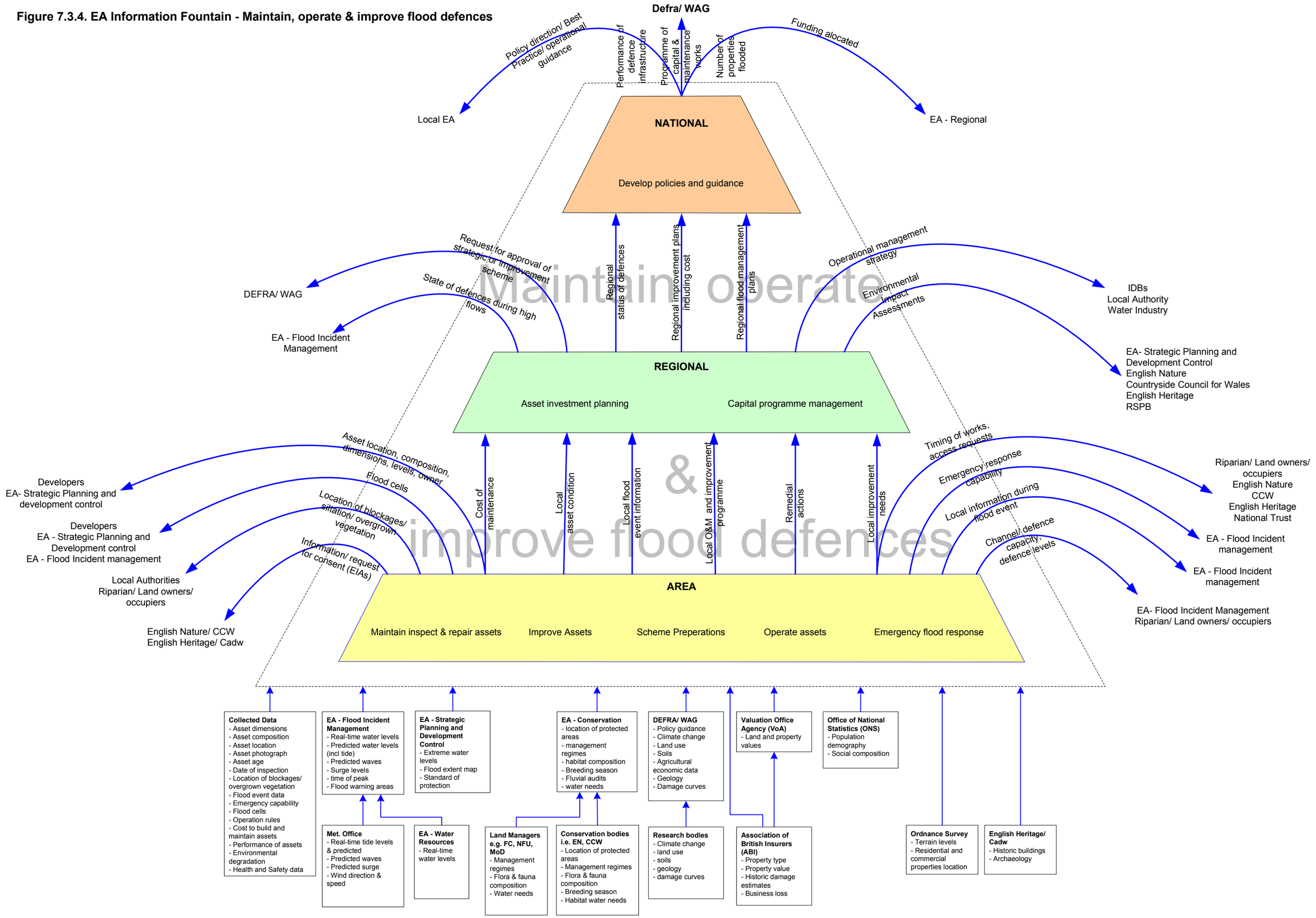


Figure 7.3.5. EA Information Fountain - Provide flood warning service

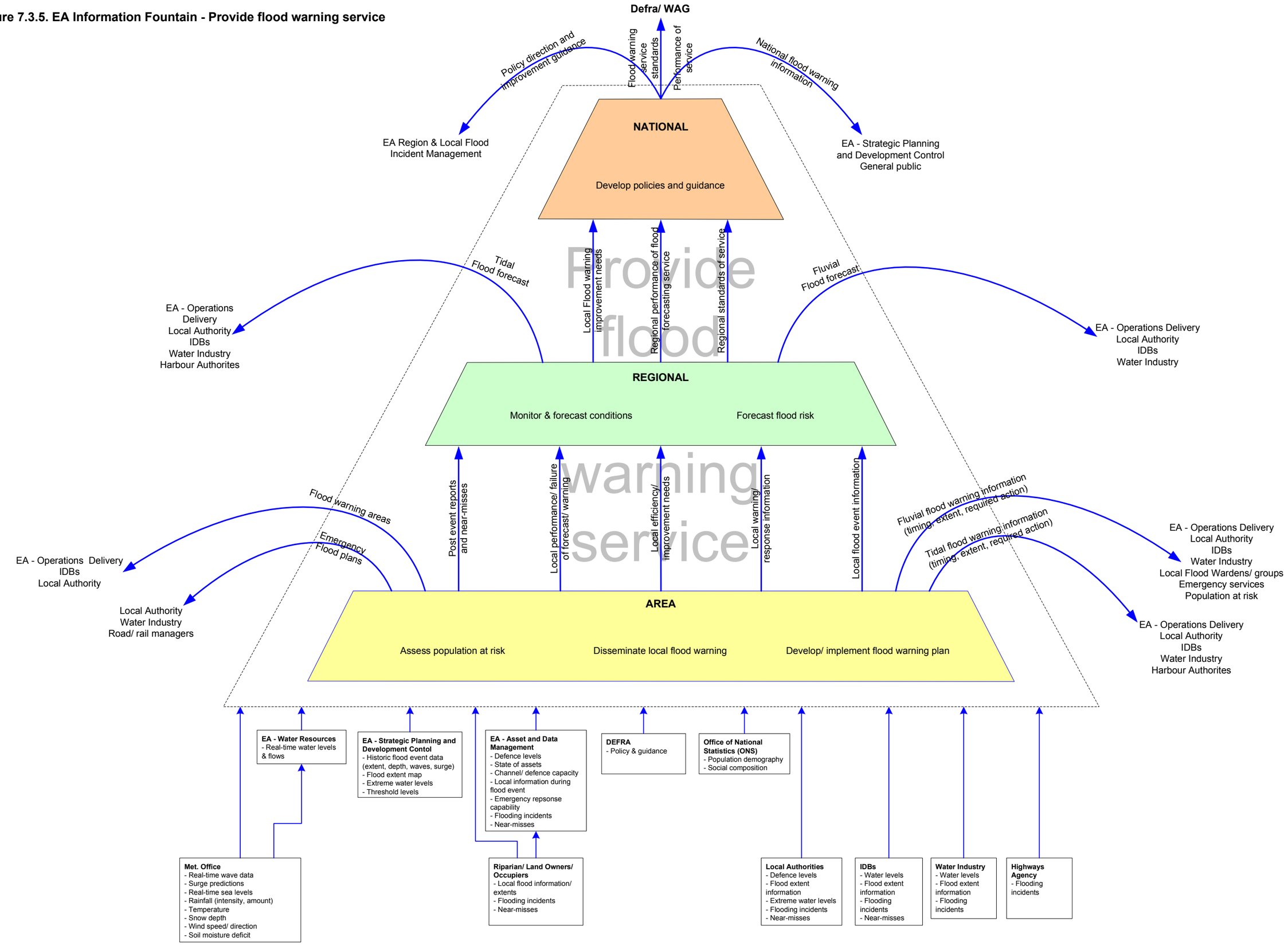


Figure 7.4.1 Internal Drainage Board Information Fountain

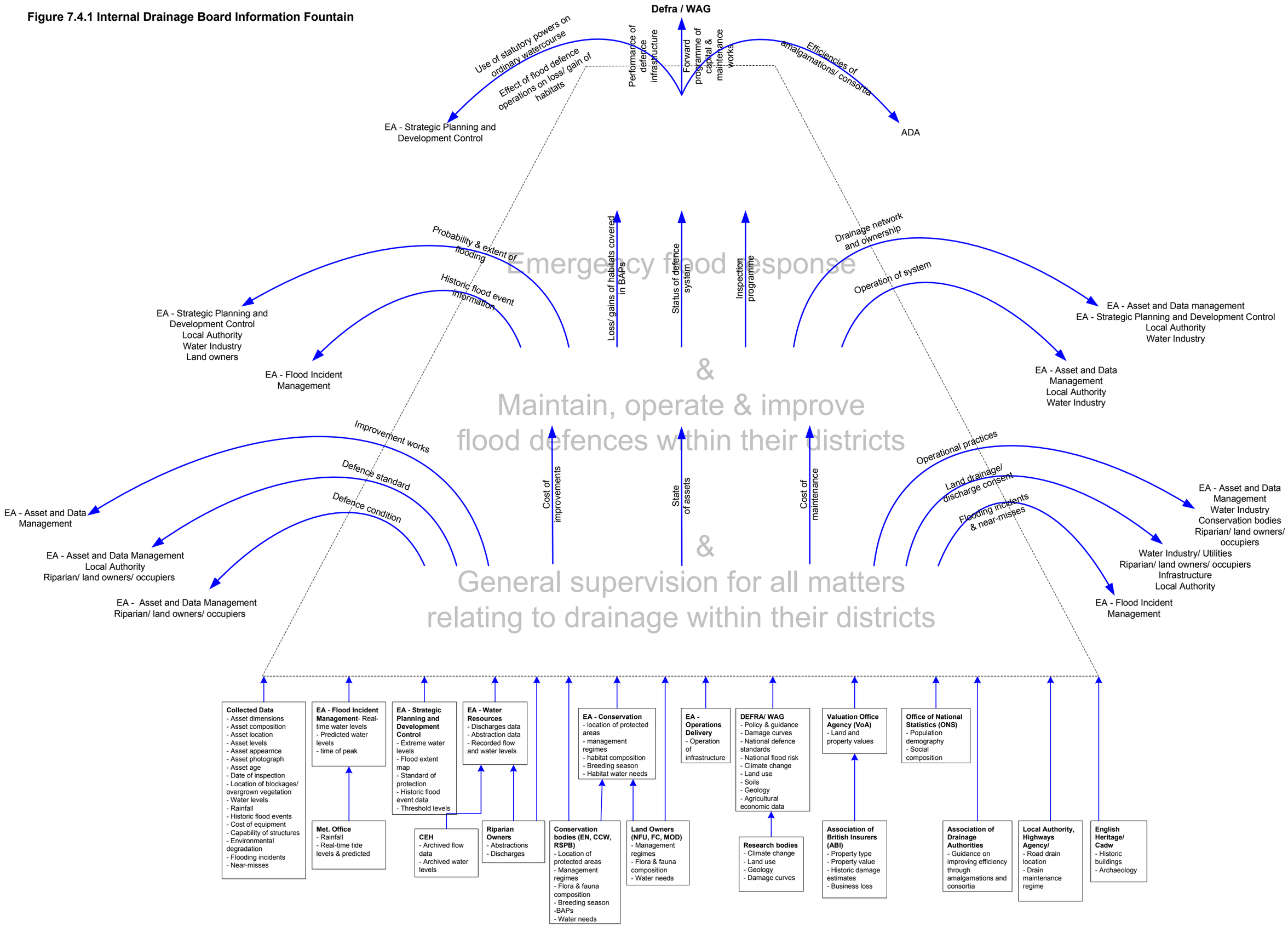


Figure 7.5.1. Local Authority Information Fountain

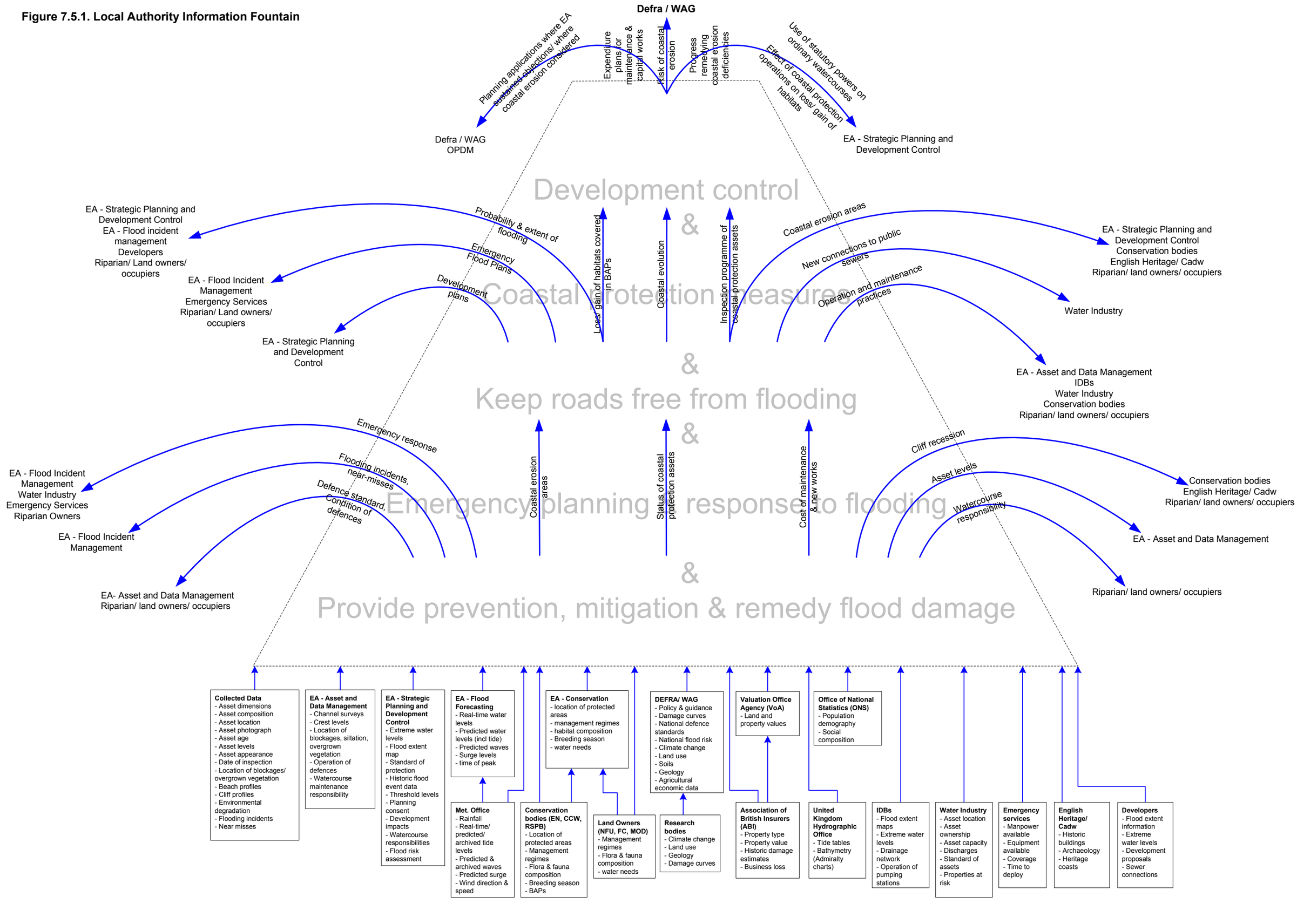
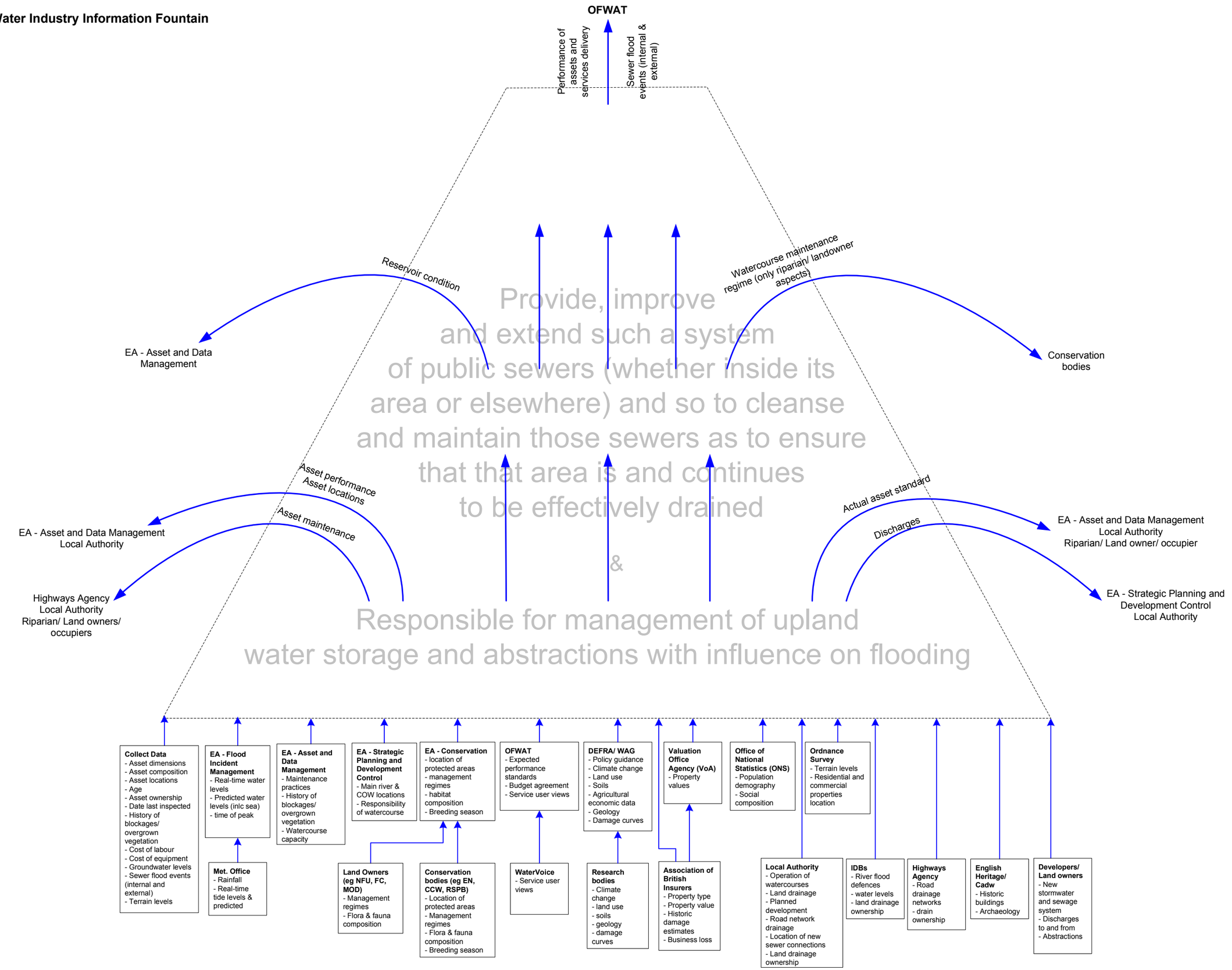


Figure 7.6.1. Water Industry Information Fountain



Appendices

Appendix A – Consultation Groups

A1 FD2323 Project Board Members

Name	Role	Organisation
Charlie Rickard	Independent Reviewer	Independent Consulting Engineer
Suresh Surendran	Client Project Officer	Environment Agency
Trevor Linford	FRM Process	Environment Agency
Bill Rodham	FRM Asset & Investment Planning	Environment Agency
Ian Meadowcroft	Project Executive	Environment Agency
Shirley Greenwood	FRM Policy	Environment Agency
David Morris	Data Management Specialist	CEFAS
John R Goudie	Funder Representative	Defra
David Palmer	Data & Technology	Environment Agency
Chris Hill	Academic Representative	GeoData Institute, University of Southampton
Graham Lymbery	Local Authority Representative	Sefton Metropololitan Borough Council

A2 Workshop attendees

Name	Organisation
Fola Ogunyoye	Royal Haskoning
Andrew Robinson	Royal Haskoning
Greg Guthrie	Royal Haskoning
Tim Burgess	Royal Haskoning
Claire Brown	ABPmer
Alun Williams	ABPmer
Richard Ashley	Pennine Water Group, University of Sheffield
Adrian Cashman	Pennine Water Group, University of Sheffield
Joe Morris	University of Cranfield, Silsoe
John Chatterton	J B Chatterton & Associates
Charlie Rickard	Independent Consultant
Suresh Surendran	Environment Agency
Trevor Linford	Environment Agency
Bill Rodham	Environment Agency
Shirley Greenwood	Environment Agency
John Goudie	Defra
Chris Hill	GeoData Institute, University of Southampton
Graham Lymbery	Sefton Metropololitan Borough Council
Ken Banfield	Anglian Water
Andrew Bradbury	New Forest District Council
Catherine Dolbear	Ordnance Survey
Earl Edwards	University of Nottingham
Jaap Jeroen Flikweert	Royal Haskoning
Cathy Greenall	Environment Agency
Fiona Mactaggart	SNIFFER

Peter Murphy	English Heritage
James Proctor	CIRIA
Sarah Reid	Environment Agency
Simon Tanner	Environment Agency
Paul Wyse	Environment Agency

Appendix B – Ontology: its meanings, history, evolution and modern application

B1 Philosophical v Artificial Intelligence perspectives

The interpretation of Ontology varies depending on the field of activity and application; the main difference is between the philosophical (or meta-physical) viewpoint and that of the Artificial Intelligence (or information systems) approach (Agarwal, 2005).

In dictionaries, ontology is defined as 'the science that deals with the principle of pure being' (Chambers Concise Dictionary, 1993) and the 'science or study of being' (Oxford English Dictionary, 2003) from its Greek origins; 'ontos' meaning 'being' and 'logos' for 'discourse.' Ontologies are employed to study the existence of all kinds of entities, abstract and concrete, that make up the world (Sowa, 2000). The first recorded complete ontology of reality is thought to be in 340 BC by Aristotle in his work 'Categories' (Mann, 2000). He viewed the reality as 'all the species of being *qua* and the attributes which belong to it *qua* being' (Aristotle *Metaphysics* IV.I, from Guarino and Giaretta, 1995:26). The study of explaining reality by dissecting it into concepts, relations and rules has come to be termed as ontology (Audi, 1995). The philosophical ontology is illustrated in the form of taxonomies or hierarchal classifications representing the real world (Agarwal, 2005).

Alternatively there is the Artificial Intelligence (AI) perspective on Ontology. Sowa defines Ontology as 'the method to extract a catalogue of things or entities (C) that exist in a domain (D) from the perspective of a person who uses a certain language (L) to describe it' (2000, p15). This domain-specific viewpoint is the key reason for its application in information science and knowledge engineering. In the informatics community (Staab and Studer, 2003), a widely recognised interpretation of ontology is 'a formal explicit specification of a shared conceptualisation for a domain of interest' (Gruber, 1993). While Swartout *et al* (1996, p38) state that 'an ontology is a hierarchically structured set of terms for describing a domain that can be used as a skeletal foundation for a knowledge base.' Other terminological definitions from users include 'representation or model of knowledge,' 'conceptual structure of a domain' (Brewster *et al*, 2004) and 'formalisation of concepts in the domain of interest, properties of concepts and the relations between concepts' (Noy and McGuinness, 2001).

Studer *et al* (1998, p163) offer an explication of the terms commonly employed for defining ontologies from AI perspectives:

> 'conceptualisation' – an abstract model of some phenomenon in the world by having identified the relevant concepts of that phenomenon;
> 'explicit' – the type of concepts used and the constraints on their use are explicitly defined (definition of FCERM and legislation framework);
> 'formal' – that fact that the ontology should be machine readable; and
> 'shared' – notion that an ontology captures consensual knowledge i.e. accepted by a group.

An ontology is, therefore, the manifestation of a shared understanding of a domain that is agreed between a number of agents, and such agreements facilitates accurate and effective communications of meaning, which in turn leads to other benefits such as inter-operability, re-use and sharing.'

Therefore ontologies reflect interests of the knowledge users, however, a shared understanding can be subjective; dependent on time, place and cultural environment (Brewster *et al*, 2004). Assigning labels to describe the concept of interests to a user is an act of interpretation over the information available.

The two perspectives on ontology provide different principles and approaches for ontology design and development (Agarwal, 2005, p504).

B2 Ontology evolution

In the early 1990s there was a shift in research from 'knowledge transfer' - view on knowledge acquisition - to 'knowledge modelling' - view on knowledge engineering and management (Staab and Studer, 2003) – with the focus on developing knowledge-based systems. Ontologies were classified into the following:

- Domain ontologies – reusable in a given domain, providing vocabularies about the concepts within a domain and their relationships, the activities within that domain, and the theories and elementary principles governing that domain (Mizoguchi *et al*, 1995, and van Heijst *et al*, 1996);
- Method ontologies – Domain-independent formalising the structure of the knowledge roles capturing states, state transitions, preferences and fixes;
- Task ontologies – provide a systemised vocabulary of the terms used to solve problems associated with tasks that may or may not be from the same domain, and these are application-orientated ontologies (Mizoguchi *et al*, 1995, and van Heijst *et al*, 1996); and
- Top-level/higher-order/generic ontologies – reusable across domains. These are bare bones concepts for the domain, including physical objects and classes (Curry, 2000).

Then in the late 1990s, with the vision of the Semantic Web (coined by Tim Berners-Lee, 2001) it was discovered that the executable model of an application domain gave a substantial added value for many types of application scenarios such as knowledge management and eCommerce (Staab and Studer, 2003). In the Semantic Web ontologies present the conceptual foundation for making the semantics of metadata machine interpretable.

There are four types of ontologies depending on the language used to implement them (Uschold and Gruninger, 1996):

1. Highly informal ontologies – written in natural language;
2. Semi-formal ontologies – expressed in a restricted and structured form of natural language (i.e. using patterns);

3. Formal ontologies – defined in an artificial and formally defined language; and
4. Rigorously formal ontologies – defined in a language with formal semantics, theories and proof of properties such as soundness and completeness.

Although not all ontologies are created the same way, standard ontology languages are becoming more common such as Common Logic (CL), Ontology Web Language (OWL), Ontology Inference Layer (OIL) approach and Open Knowledge Base Connectivity (OKBC) model.

B3 Applications of ontology

Ontologies vary widely in complexity, formality and purpose (Brewster *et al*, 2003). They are being used to support information and knowledge exchange between people and organisations (Hamed *et al*, 2004). There are two major application fields for ontologies (Staab and Studer, 2003), knowledge management and issues of interoperability and integration.

Ontologies are key components in Semantic Web and knowledge management. Semantic ontologies provide machine-interpretable knowledge infrastructures. In knowledge management they form a representation of an organisation's world view, corporate memory and a tool for encoding corporate experience and knowledge. (Brewster *et al*, 2003).

In the World Wide Web (Noy and McGuinness, 2003) ontologies range from large taxonomies categorising websites (such as Yahoo!) and categorisation of products for sale (such as Amazon.com). Some disciplines have developed standardised ontologies where domain experts can share and annotate information in their fields, such as SNOMED a structured medical vocabulary (Price and Spackman, 2000)

Agarwal (2005, p 508) states that 'the primary purpose of using ontology in GIScience is to define a common vocabulary that will allow inter-operability and minimise any problems with data integration, both from different systems and between users and systems.'

In GIScience interoperability is a big issue in terms of sharing geographic information (Harvey *et al*, 1999, Riedemann and Kunh, 1999). There are discussions that ontologies could become a standardisation procedure for easier translation between different information sources (Chandrasekaran *et al*, 1999, Smith 1999, Fonseca *et al.* 2002). It can also be employed to systematically capture the universal concepts and meanings that define the geo-spatial domain (Bateman 2003, Bittner and Smith 2003, Frank 2003).

Argarwal (2005) identified that two distinct approaches are followed in GIScience:

1. Philosophical approach – identification of top-level categories from a formal ontology perspective; and

2. Domain-specific and task orientated approach – focused on explicating the actions, terms and relations for a particular specification and ranging from natural language to rigorously formal specifications.

It is worthwhile noting '*there is no single correct ontology for any domain*" (Noy, and McGuinness, 2001). Ontologies not only vary in their content, but also in their structure and implementation. Also a complete ontology is beyond the optimum requirement for most knowledge services to function properly (Brewster *et al*, 2003).

Appendix C – Vision and Delivery Plan of Defra's 'Making Space For Water' strategy

C1 Vision: the future as a result of the strategy

The concept of sustainable development will be firmly rooted in all flood risk management and coastal erosion decisions and operations. Full account will be taken of the social, environmental and economic pillars of sustainable development, and our arrangements will be transparent enough to allow our customers and stakeholders to perceive that this is the case. Account will also continue to be taken of long-term drivers such as climate change. Decisions will reflect the uncertainty surrounding a number of key drivers and will where appropriate take a precautionary approach. Decisions will be based on the best available evidence and science.

Flood and coastal erosion risk management will be clearly embedded across a range of Government policies, including planning, urban and rural development, agriculture, transport, and nature conservation and conservation of the historic environment. Other relevant Government policies will also be reflected in the policies and operations of flood and coastal erosion risk management. There will be a mix of policies designed to minimise the creation of new risks (by the way development policy is implemented in areas of flood risk), to manage risk and to increase resistance and resilience. There will be a clear understanding and acceptance of the respective roles of the state, central and local government, other organisations and agencies, and of individuals. The public will be more aware of flood and coastal erosion risks and empowered to take suitable action themselves where appropriate.

There will be increased use of co-funding with other bodies and other schemes so as to secure sustainable and cost-effective management of flood and coastal erosion while at the same time securing a greater overall contribution to sustainable development than would have been possible without co-operation. The true costs of providing, and not providing, flood and coastal defences and other measures will be reflected to a greater extent than at present in individual and commercial decision-making. Expenditure will be focused so as to achieve value for money, and will be prioritised to deliver maximum benefits in line with this strategy.

There will be local participation in decision-making, in particular through the preparation of Catchment Flood Management Plans and Shoreline Management Plans, within a context of national standards and nationwide information on flood risks and prioritisation.

There will be a holistic approach to the assessment of options through a strong and continuing commitment to Catchment Flood Management Plans and Shoreline Management Plans, within a broader planning matrix which will include River Basin Management Plans prepared under the Water Framework Directive and Integrated Coastal Zone Management.

There will be transparent and measurable targets and performance indicators, in terms of managing risks to people, property and the environment, to ensure those responsible for delivering the strategy can be held to account. These measures will drive performance forward and enable the identification and dissemination of good practice solutions.

The results of the strategy will be seen on the ground in the form of more flood and coastal erosion solutions working with natural processes. This will be achieved by making more space for water in the environment through, for example, appropriate use of realignment to widen river corridors and areas of inter-tidal habitat, and of multi-functional wetlands that provide wildlife and recreational resource and reduce coastal squeeze on habitats like saltmarsh.

(Defra, 2005b)

C2 Delivery Plan key programme

In order to enable the production of a final strategy for flood and coastal erosion risk management in England, as well as to achieve the vision set out in Making Space For Water, projects are being undertaken under 4 themes:

1. Holistic approach to managing flood and coastal erosion risk
2. Achieving sustainable development
3. Increasing resilience to flooding
4. Funding

The key programme products are:

- Ministerial decision on giving the Environment Agency a strategic overview of all forms of flooding and coastal erosion:*
- Ministerial decision on options in relation to adaptation to a changing coast, including realignment;*
- Strengthened arrangements for development control in the floodplain;*
- Resilience grants pilot launched, completed and recommendations on resilience published;*
- Integrated urban drainage pilots launched, completed and recommendations published;*
- Revised Building Regulations addressing flood resilience published and implemented;*
- Revised risk management and scheme appraisal guidance published including climate change allowances and multi-criteria decision making approaches;
- Operational coastal erosion risk maps;
- Operational output and performance measures;
- Innovative projects developed following successful launch of the Flood Risk Management Innovation Fund;
- Feasibility study on expanding flood warning and risk mapping to other forms of flooding published with recommendations;
- Models for taking forward enhanced stakeholder and community engagement published
- Improvements in resilience and emergency planning delivered.

* *Delivery of these products is considered to be critical to the programme.*
(Defra, 2005a)

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