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List of Acronyms

AOC	Area of Concern
DoW	Description of Work
ESRI	Environmental Systems Research Institute
EU	European Union
GIS	Geographical information system
IMS	Integrated Management System
RCRA	Resource Conservation and Recovery Act
SWMU	Solid Waste Management Unit
WELCOME	Water, Environment, and Landscape Management at Contaminated Megasites

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Deliverable 11.1 Procedure for GIS based description of structure elements of the megasite and water quality

1.0 Introduction

The WELCOME project takes three contaminated sites (megasites) containing multiple contamination sources/types and receptors as an example in developing an integrated management system (IMS) framework. The three megasites examined in this study include: Port of Rotterdam, the Netherlands; Katowice, Poland; and Bitterfeld, Germany.

Within the WELCOME project title is the word *Landscape*. The concept of landscape management is included in order to give focus to the megasite scale and spatial attributes. Landscape planning is also part of the site's boundary conditions. The boundary conditions include stakeholder concepts, which are related to the future land use and restoration of the site, within local economic and social constraints. These spatial concepts (functional use) are directly tied into the goal of water quality. In WELCOME the spatial decision making units are called "structural elements" or "clusters".

Clustering is based on the categorisation of receptors and the evaluation of risks (emissions) to these receptors. This evaluation uses databases, geographical information systems (GIS), models and new site and research data. A GIS is any organised collection of geographic data and software or hardware designed for capturing, storing, updating, manipulating, analysing, and displaying all forms of geographically referenced information (ESRI 1992 - 1998). WELCOME uses GIS throughout the IMS process. In this aspect, it is used for overlaying map information to aid in the development of clusters as the basis for management scenarios.

This report describes what structural elements are for a megasite. It also describes the issues associated with these including these spatial components into a GIS description to make further decisions about water quality at the megasite.

2.0 Structural Element Concept

It is not new to identify spatial elements for a site. In the environment naturally there can be found 'clusters' and aggregations. These are at the ecosystem scale, a specific organisational cluster related to the landscape and the landscape flows (Forman 1995).

For a megasite we add the anthropogenic factor to this concept and have the end goal as the risk reduction measure and management scenario. What defines a cluster or spatial unit (the structural element) of a contaminated megasite?

It has already been defined in many ways. A solid waste management unit (SWMU) aggregation is used in the U.S. under the Resource Conservation and Recovery Act (RCRA) law. This means that it is a "discernable unit at which solid wastes have been placed at any time…including any area of a facility at which soil wastes have been routinely and systematically released" (RCRA 1976). SWMUs can be for example a specific production area. Also from the US legislation is an area of concern (AOC) a spatial unit described, which covers a delimited degraded area. Other researchers have used spatial elements to help with risk assessment at megasites (see Wilson, Charbeneau, Maidment 2000).

The WELCOME general definition of cluster is:

Cluster =	Sources	+	Receptors	+	Management
	(contaminant type)		(soil, groundwater)		(planning for land use)

Clusters are:

1. changeable in scale
2. flexible depending on the site
3. there can be different receptors in one cluster
4. occur at different sections within the IMS

From this definition it is easy to see that depending on the megasite, the clustering process will also differ to some extent. The next section describes how the WELCOME megasites developed this concept.

3.0 Procedures of the WELCOME GIS Based Descriptions of Structural Elements

For the Rotterdam megasite, a regional approach is essential because the area of influence of emissions and measures exceeds the scale of single locations. For WELCOME, the Rotterdam megasite is defined as the entire harbour area, which together with the municipality of Rotterdam (ABIS) and the polder areas, covers an area which approximates the so-called *Rijnmond* region (Figure 1).

Figure 1 A GIS map of Rotterdam

The goal of WELCOME is to divide the region into risk-based clusters for each receptor. To begin this process the Rotterdam site defined the cluster as:

- a part of the megasite, where the risks for receptors are comparable and for which a similar set of management options can be applied.

As an example, a cluster can be an area where, as a result of heavy industry and unfavourable geohydrological conditions, there is a high flux of chlorinated solvents towards the surface water. A cluster can also be an area which is strongly contaminated with aromatic hydrocarbons, but as a result of the presence of confining layers, has a low risk for spreading to the deep groundwater.

For the Bitterfeld site, clusters are formed using hydrogeological and hyrdobalance information. This is added to the contaminant situation of the groundwater and also the potential receptors.

The clustering follows a methodology consisting of various steps, which considers the different properties of the individual clusters. The main criteria are:

1. the contaminant situation of the soil and groundwater
2. the groundwater flow direction
3. the potential receptors at the site.

To consider the different requirements of the different classifications, in the first step they are gathered and mapped in a GIS system to combine the different information in the next step:

1. classification of the contamination (following the historical structure at the site) and record of hot spot areas of the soil and the groundwater
2. classification of hydraulic balance areas
3. classification of areas of potential receptors.

The classification is carried out taking into account the different goals, which are compiled in the following table:

Table 1: Goals and criteria for different clusters at Bitterfeld

	Contamination Cluster	Hydraulic balance cluster	Potential receptors cluster
Criteria of clustering	Different maps for soil and groundwater Historical structure (use- oriented)	Groundwater flow conditions Groundwater dynamic (model oriented)	All kind of potential receptors Groundwater levels referring to altitude (areas which are directly influenced by groundwater)
Extension of the areas	The whole mega site	The whole mega site	Single potential receptor areas
Goal of clustering	Detection of hot spot areas and remediation measures (sources)	Planning of hydraulic protection actions (safety measures)	Identification of potential receptors of different priorities

The single maps are the base for the derivation of the risk clusters for the site, which are the base for risk assessment as well as for an effective monitoring concept at the site.
After clustering of the single risk criteria (contamination, hydraulic situation, potential receptors), the risk clusters of the mega site are to derive by combination of all these information. Figure 2 shows the steps of this methodology.

At Katowice, Poland, also they are using a similar approach as the Rotterdam and Bitterfeld sites.

4.0 Generic GIS/Clustering Procedure

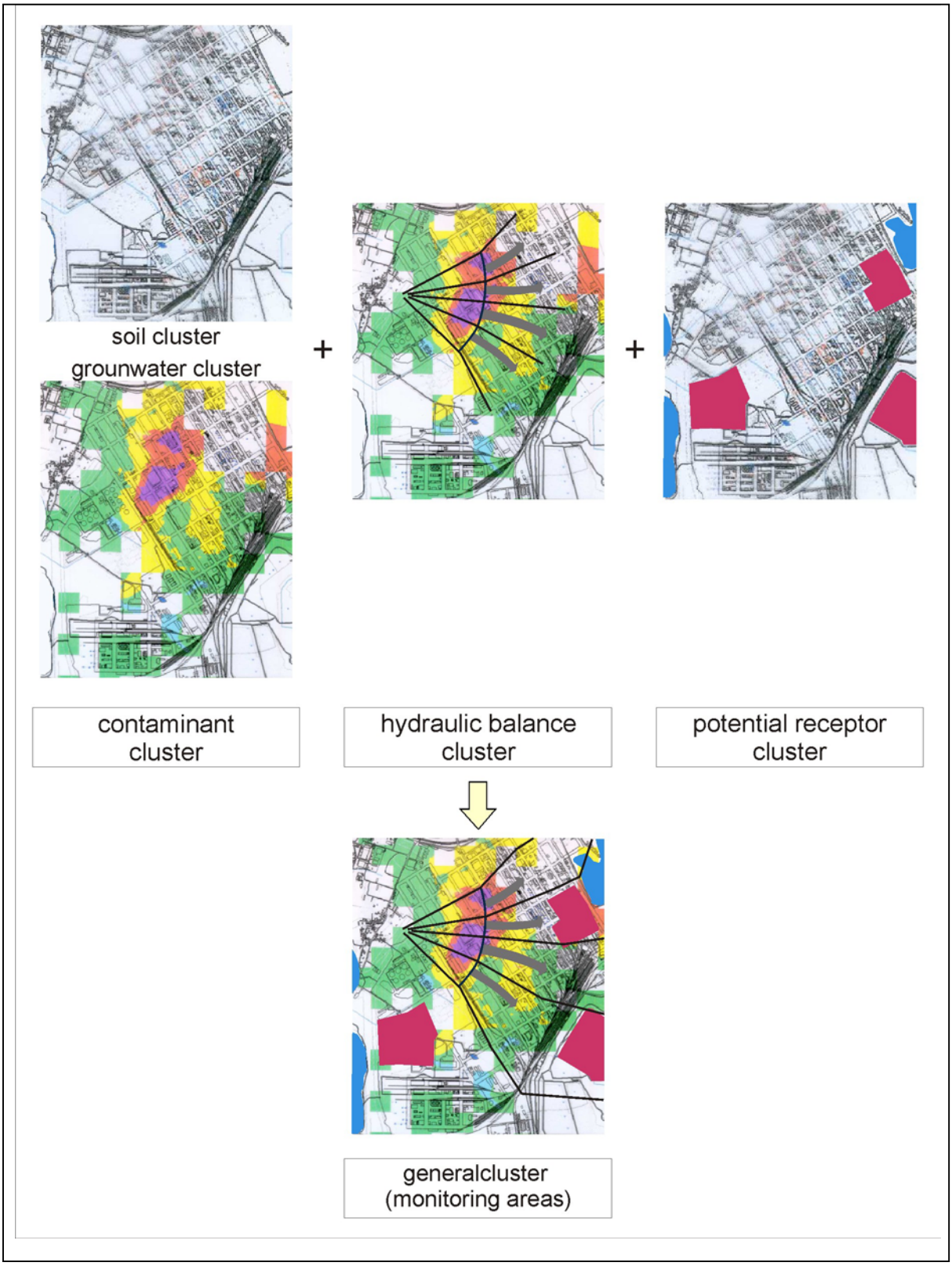
For this project, Arc Info was chosen by the three sites and used as the preferred GIS tool. However other GIS's can be used for the IMS. From the examples and work done at the WELCOME megasites, several general points of attention arose in dealing with GIS procedures. These points can be described in many GIS references. In general there are:

- GIS software issues
- Aggregation and scale issues
- Data issues
- Interpretation issues
- Organisational/Infrastructure issues

From the megasite methods used in WELCOME, a list can be made to make a description for the GIS related to water quality and structural elements. It is recommended the following information first be obtained from megasites:

1. Aggregation unit (in this case structural element/cluster)
2. Conceptual model (from Section 2 of the IMS)
3. Contamination information (from Section 2 of the IMS)
4. Boundary conditions information (from Section 2 of the IMS)
5. Characterisation of potential receptors
6. Knowledge about the data and databases in respect to quality

Figure 2: Method of Clustering



After clustering the megasite regarding groundwater flow conditions and deriving priority contaminants, all information about the site itself are taken into consideration for each cluster to characterize the transfer pathways for relevant pollutants.

At Bitterfeld, as part of the GIS analysis, risk clusters were combined with geological information including the locations of the old lignite mines. This is one example of the way clusters are currently being used.

5.0 Conclusion

At the three WELCOME megasites, spatial aggregation units are used to help define a risk based approach for the IMS. These units or clusters are based on risk of receptors, which are for WELCOME, the water bodies. WELCOME defines a risk cluster to be a combination of source, receptor and management planning data combined in a GIS. The definition is flexible to take into account the different situations in megasites.

The outcome of the aggregating/clustering is that they will be integrated with the risk assessment and serve as the basis of the monitoring and management scenarios for the megasite.

5.1 Eastern and Central European Context

There has been an intensive debate within WELCOME during its first year, concerning the usefulness, characteristics, and definition of a structural element/cluster. This is likely to also occur in the eastern and central Europe context. There may be some points specific for this region which will add difficulty to the process of spatial analysis (GIS) and clustering. Historical site information may be difficult to obtain or not available. If this is the case, site contamination may be more difficult to understand.

With all three WELCOME megasites, a GIS had already been used actively for the site. This may not be the case in other countries. With a lack of data or pre-existing GIS database, or lack of information on contamination potentials, it will take a longer time to move through the clustering procedures.

6.0 References

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