Use of GIS for Spill Response Planning to Protect a Critical Watershed

By

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Abstract

A reoccurring theme associated with major spills or releases is that there is confusion and uncertainty for first responders in the initial 6 to 12 hours following an event, and it is during those early hours when the opportunity to contain the spill may still exist. As part its drinking water source protection program, Eugene Water & Electric Board (EWEB) worked closely with 27 other Federal, State, and local agencies to develop a watershed emergency response plan using Geographic Information System (GIS) technology. The McKenzie Watershed Emergency Response System (MWERS) application was developed to make it easy for first responders to use without being GIS experts.

The plan contains GIS information on: watershed characteristics; threats; critical resources; spill response strategies to protect critical resources; response equipment; emergency contact and notification information; and incident communications. First responders and others are able to use this GIS application in the field to efficiently and effectively stabilize accidental or intentional chemical releases as soon as possible and avoid the initial confusion associated with spills.

Introduction

The McKenzie River watershed is located in the Southern Willamette Valley east of Eugene, Oregon (Figure 1). The Eugene Water & Electric Board (EWEB) was formed in 1911 to provide reliable and safe drinking water to over 200,000 people in Eugene and surrounding areas. The McKenzie River

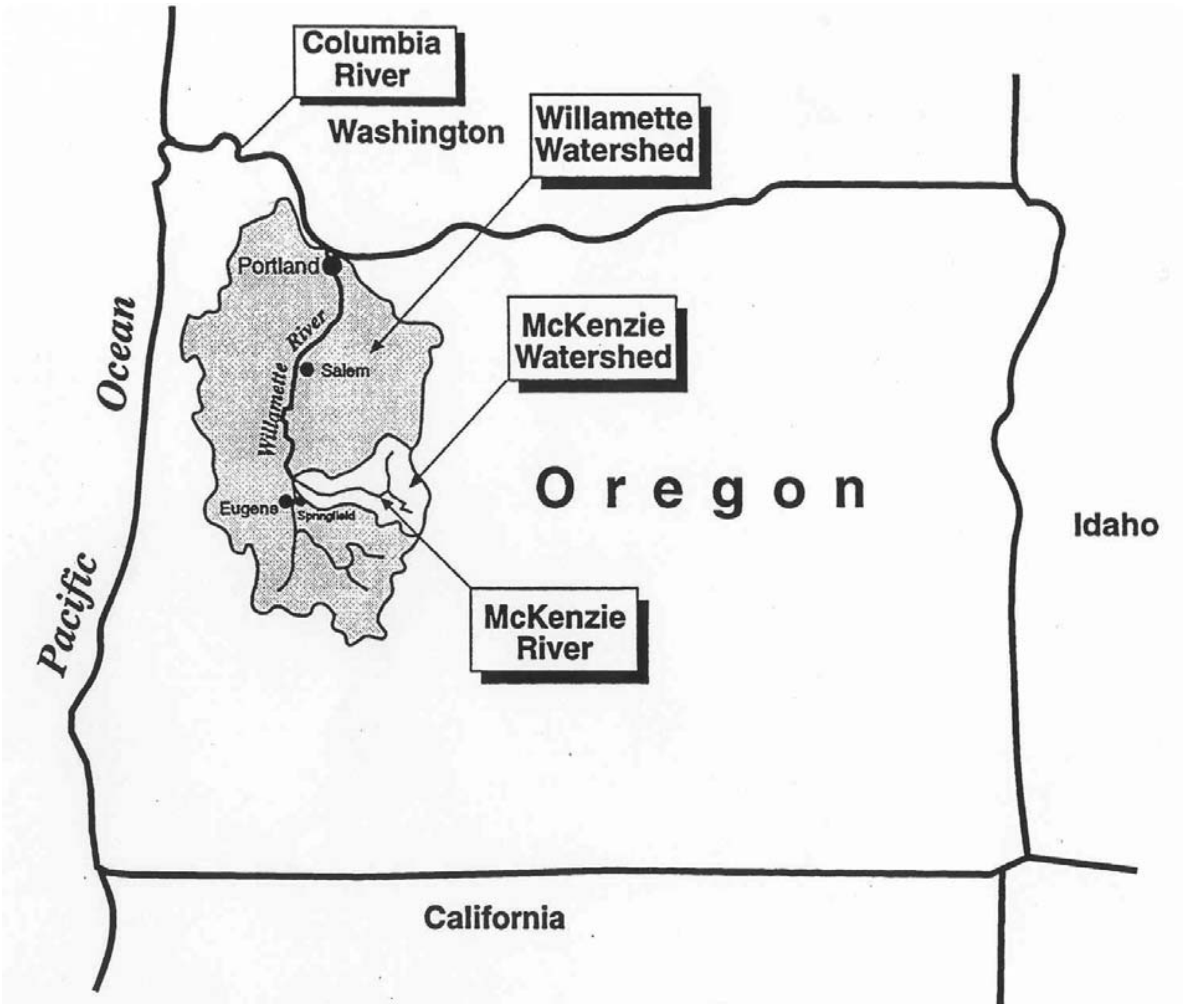

Figure 1: Location of McKenzie River watershed.

is the sole source of this water. Five hydroelectric projects are located in the McKenzie Watershed and provide electricity to the region. The McKenzie also provides critical habitat for a number of endangered or threatened species including: spring Chinook salmon, bull trout, spotted owl, Oregon chub, osprey, and western pond turtle. The McKenzie River has one of the last remaining native bull trout and spring Chinook salmon populations in the Pacific Northwest.

In April 2001, EWEB initiated a drinking water source protection program to safe guard the McKenzie River as a critical resource (EWEB, 2001). As part of this effort, chemical spills from transportation accidents and/or releases from fixed facilities were identified as one of the highest threats to the watershed (EWEB, 2000). Following the events of September 11, 2001, protection of critical infrastructure from terrorist activities was also identified as a high priority. In response to these threats, EWEB took a lead role in the coordination, design, and development of a geographic information system (GIS) based watershed emergency response plan. The goal of the watershed emergency response plan is to provide first responders with the information, support, equipment, and training to efficiently and effectively respond to and stabilize a major chemical spill or release and avoid the initial confusion associated with spill response.

Approach To Watershed Emergency Response

The approach EWEB took to design, develop, and implement a coordinated and effective watershed emergency response plan involved four important components:

1) Developing effective partnerships among federal, state, and local agencies that may play a role in response to a large scale incident in the McKenzie River watershed; Focusing initial planning efforts on a single threat (i.e., hazardous materials);
2) Using GIS as the tool to deliver the necessary information to first responders that allows them to quickly stabilize a major hazardous material incident; and,
3) Raising the level of preparedness among all partner agencies through training and conducting drills together.

As with most regional planning efforts, the key to success is tied to the development and nourishment of partnerships among agencies and organizations that normally would not work or plan together. EWEB and the main first responder in the watershed, McKenzie Fire & Rescue, took a leadership role in forming good working relationships and building trust among the 27 different agencies. The watershed emergency response approach allows the coordination of individual agency emergency planning efforts and sharing of resources among the participating agencies. These agencies and organizations include:

U.S. Forest Service	Springfield Public Works
U.S. Bureau of Land Management	Springfield Fire & Life Safety
U.S. Environmental Protection Agency	Springfield Environmental Services Division
U.S. Army Corps of Engineers	McKenzie Fire & Rescue
Oregon Fish & Wildlife	Mohawk Rural Fire District
Oregon Dept. of Environmental Quality	Upper McKenzie Rural Fire District
Oregon State Police	Region 2 HazMat Team
Oregon Dept. of Transportation	Springfield Utility Board
Oregon Water Resources Division	Rainbow Water District
Oregon Health Division	Eugene Water & Electric Board
Lane County Public Works	Eugene Fire & EMS
Lane County Sheriff	McKenzie Watershed Council
Lane Council of Governments	Weyerhaeuser Company
Lane Regional Air Pollution Authority	

The focus of the initial watershed emergency response plan is to address hazardous material incidents (accidental or intentional). The ability to have an efficient and effective response to a hazardous material incident establishes a good foundation for development of other regional emergency response plans (i.e., terrorist incident response, forest fire assessment and response, and natural hazards response).

GIS was identified as the tool that would be most effective in managing the large amounts of spatial data and other response information collected from partner agencies and allow first responders to have easy access to this critical information during incident response. The advantages of having a GIS-based watershed emergency response plan are:

- It allows access to the data in many different ways (workstations, laptops, hand held devices, secured web site) from a single spatial database;
- Applications can be developed to make use of and access to GIS data by first responders easy;
- Its ability to generate excellent quality maps for use in reports and/or during the incident response;
- Its ability to easily update the data and distribute updated information;
- It provides a powerful query and data presentation tool; and,
- It allows agencies to use the same information for emergency response planning, as well as for other purposes.
- Provides the ability to analyze large amounts of spatial data to evaluate threats, locate "hot spots", prioritize response efforts, and develop specific response strategies based on the most probable threats and "hot spot" areas.

GIS Application Development

A review of typical information requirements for the emergency planning and incident response provided insight into current response practices and the specific information needs during hazardous material responses. Given the advantages of GIS and the spatial nature of the information being collected as part of this effort, a spatial database was developed at the onset of the planning process to address the information needs associated with incident response.

The challenge for developing a GIS-based emergency response system is to make the system easy to use allowing first responders to quickly extract the information they need to do their jobs. In addition, it is important to make this response information available to participating agencies in many different formats including GIS for laptops and workstations (ArcGIS 8.3 or ArcView 8.3 software), GIS for hand held devices (ArcPad software), GIS via internet access (a future project using ArcIMS and ArcSDE software), and hard copy reports with detailed GIS generated maps. This takes advantage of having a single spatial database that can be served on multiple platforms (Figure 2).

Data Requirements

The spatial database contains a variety of data types from numerous sources. The data can be grouped as follows: basemap, critical resources, potential threats, and response resources.

<u>Basemap</u>

These datasets are either shapefiles that present planimetric information, or image catalogs. Shapefiles include: roads, hydrography, political boundaries, 10-meter contours, city boundaries, and towns. The image catalogs include digital versions of the 1:24k USGS topographic maps and recent black and white aerial photographs (corrected to account for elevation changes on the

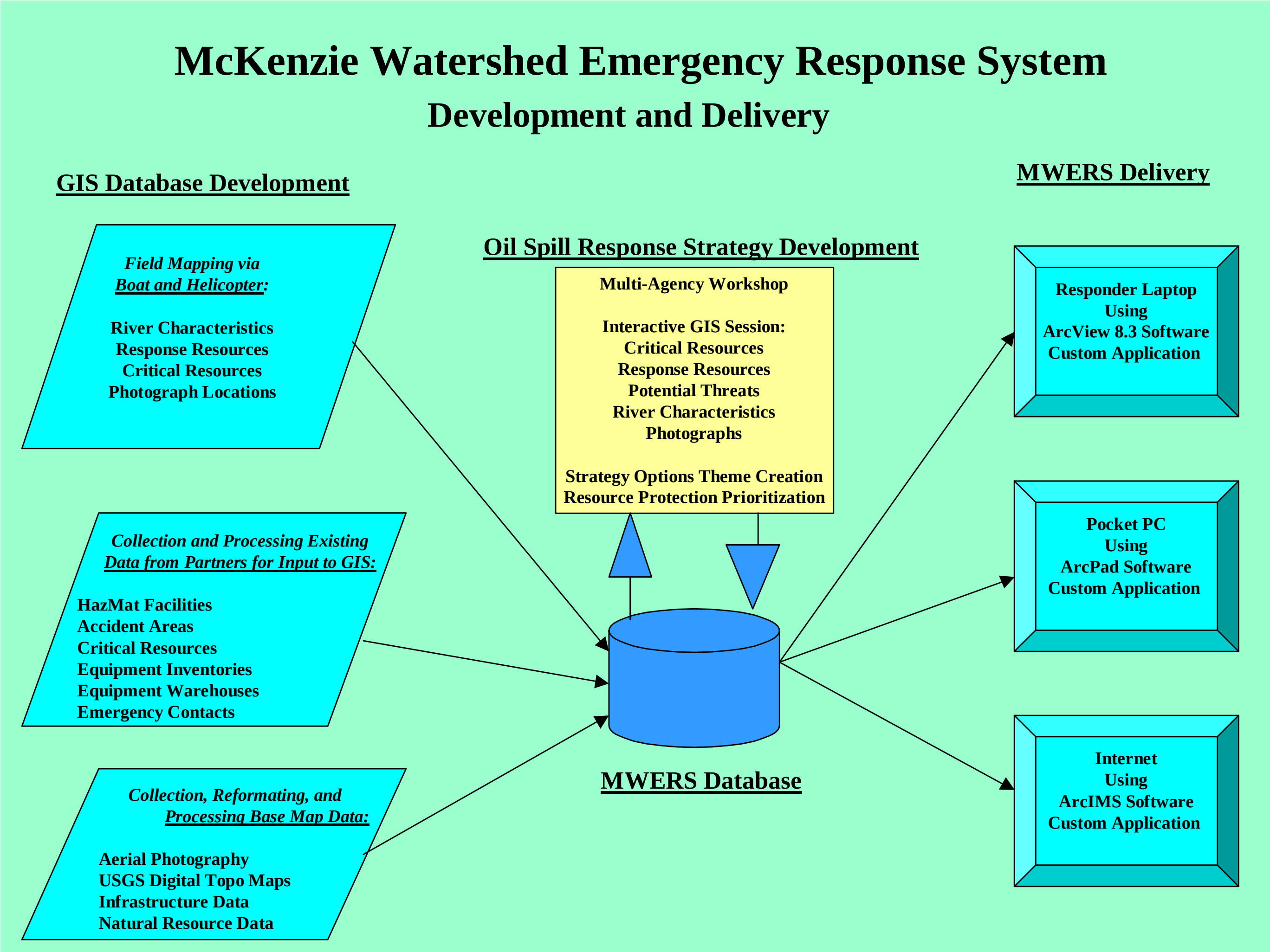

Figure 2: Overview of the GIS-based McKenzie Watershed Emergency Response System.

ground surface).

<u>Critical Resources</u>

These datasets represent a resource potentially impacted from an incident, which includes surface water intakes, threatened and endangered species, fish habitat, spawning gravels, wetlands, municipal wells, and individual intakes and wells (Figure 3).

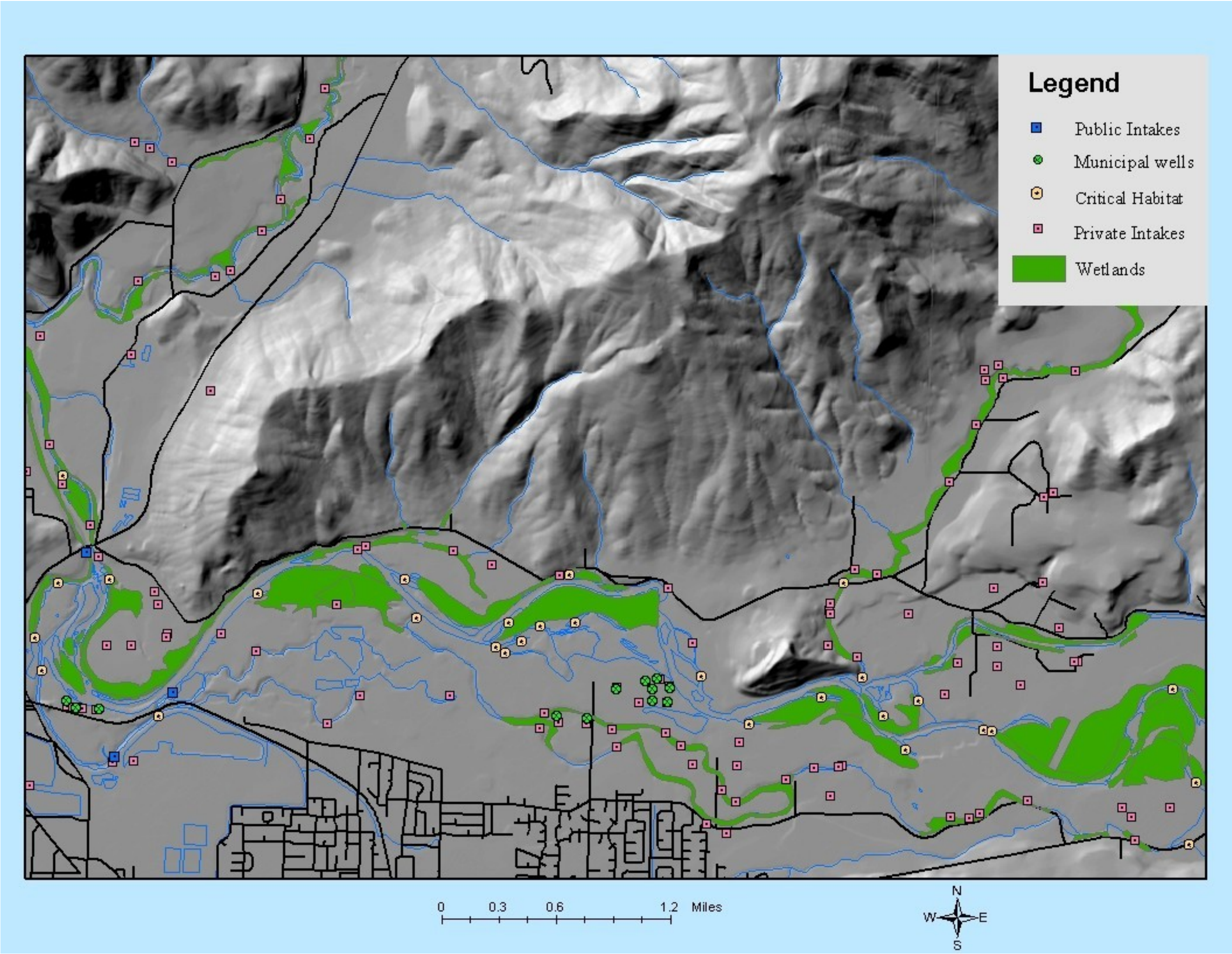

Figure 3: Sample of critical resource information in lower McKenzie River watershed.

<u>Potential Threats</u>

Potential threats from the storage and/or use of hazardous materials and the potential for transportation accidents along the McKenzie River were integrated into the spatial database (Figure 4). The location information associated with these various sources of data ranged from providing latitude and longitude data for each facility to just providing addresses, which were used with address matching tools to generate location information.

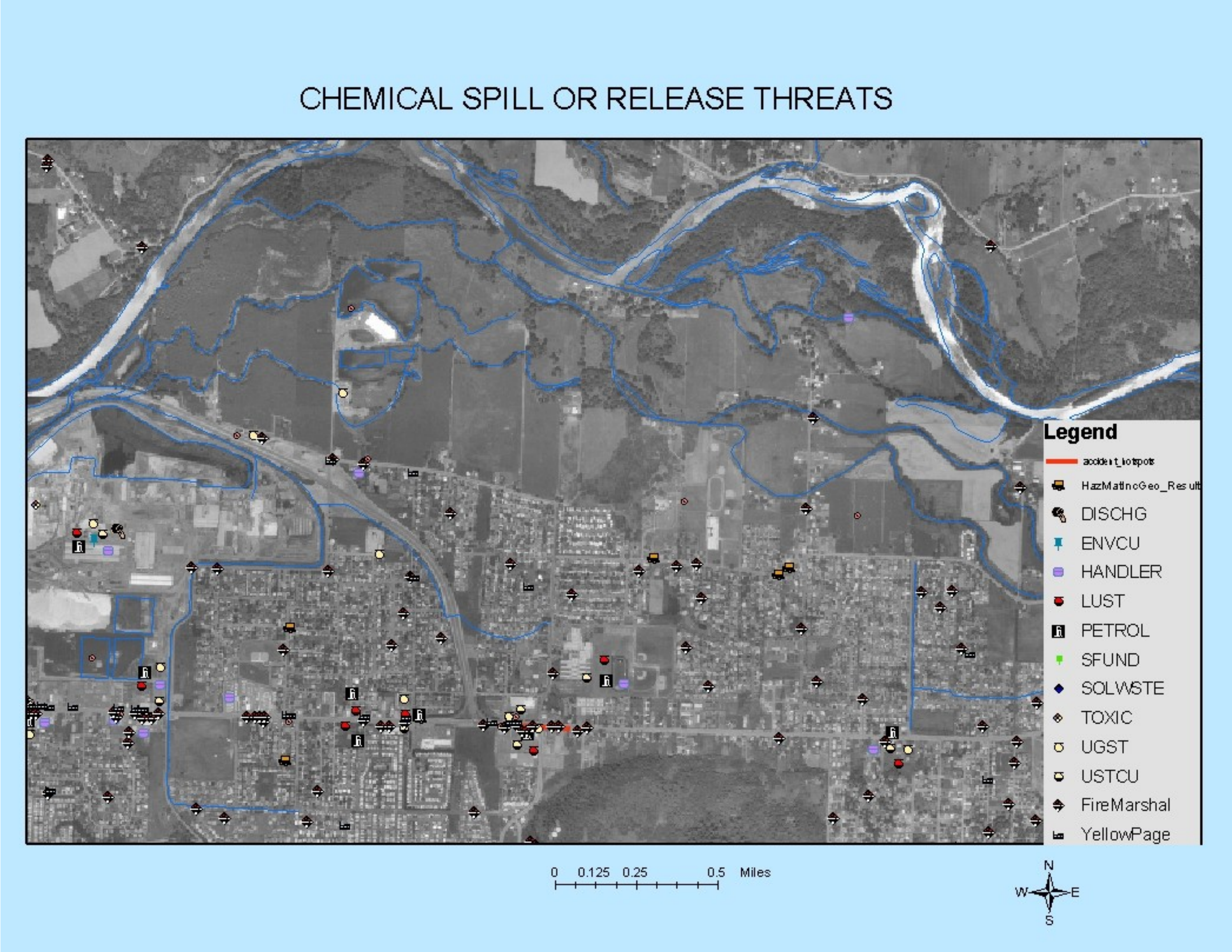

Figure 4: Chemical threats located in the Springfield area of the McKenzie River watershed.

<u>Response Resources</u>

These datasets represent a resource that potentially can aide in the response to an incident. Included are boat ramps, staging areas, equipment warehouses, highway culvert information, storm sewer drains and routes, and river aerial photographs (Figure 5). Certain river characteristics (i.e., river flow rate, river eddies, and slow water areas) were collected to assist first responders during an oil spill on the McKenzie River. These data layers were used extensively during development of specific response strategies.

Response Strategy Development

Development of specific response strategies to protect critical resources is one of the most important aspects of the watershed emergency response plan. A two-day workshop was held to prioritize critical resources that need to be protected and develop integrated response strategies to protect these critical resources. Approximately 35 people representing twenty-three different agencies participated in the workshop. It was important to orchestrate the interactive workshop to accomplish the objectives in an efficient manner that actively involved participants. Hardcopy maps, a large screen with projected river aerial photographs, and a GIS session displayed on a second large screen were interactively used in the development of incident response strategies during the workshop.

After prioritizing critical resources, participants focused on high priority areas of the watershed for development of response strategies. Response strategies were developed for all slow moving water areas in these high priority river segments. Boom placement for specific strategies was added in a live GIS editing session, general attribute information such as strategy type, boom type, boom length, and spill collection areas were entered during the workshop, and general agreement was reached on the approach to each strategy.

A response strategy report was created (as an Adobe Acrobat pdf file) that briefly discusses strategy implementation (Figures 6a and 6b). The response strategy pdf files are hyperlinked to the slow moving water feature they were developed for or the critical resource they were designed to protect within the spatial database. In this way, a first responder can pull up a strategy report by clicking on the hyperlink feature displayed on the screen or select the report from the MWERS menu. The response strategy reports are also available in the hard copy version of the McKenzie Watershed Emergency Response Plan.

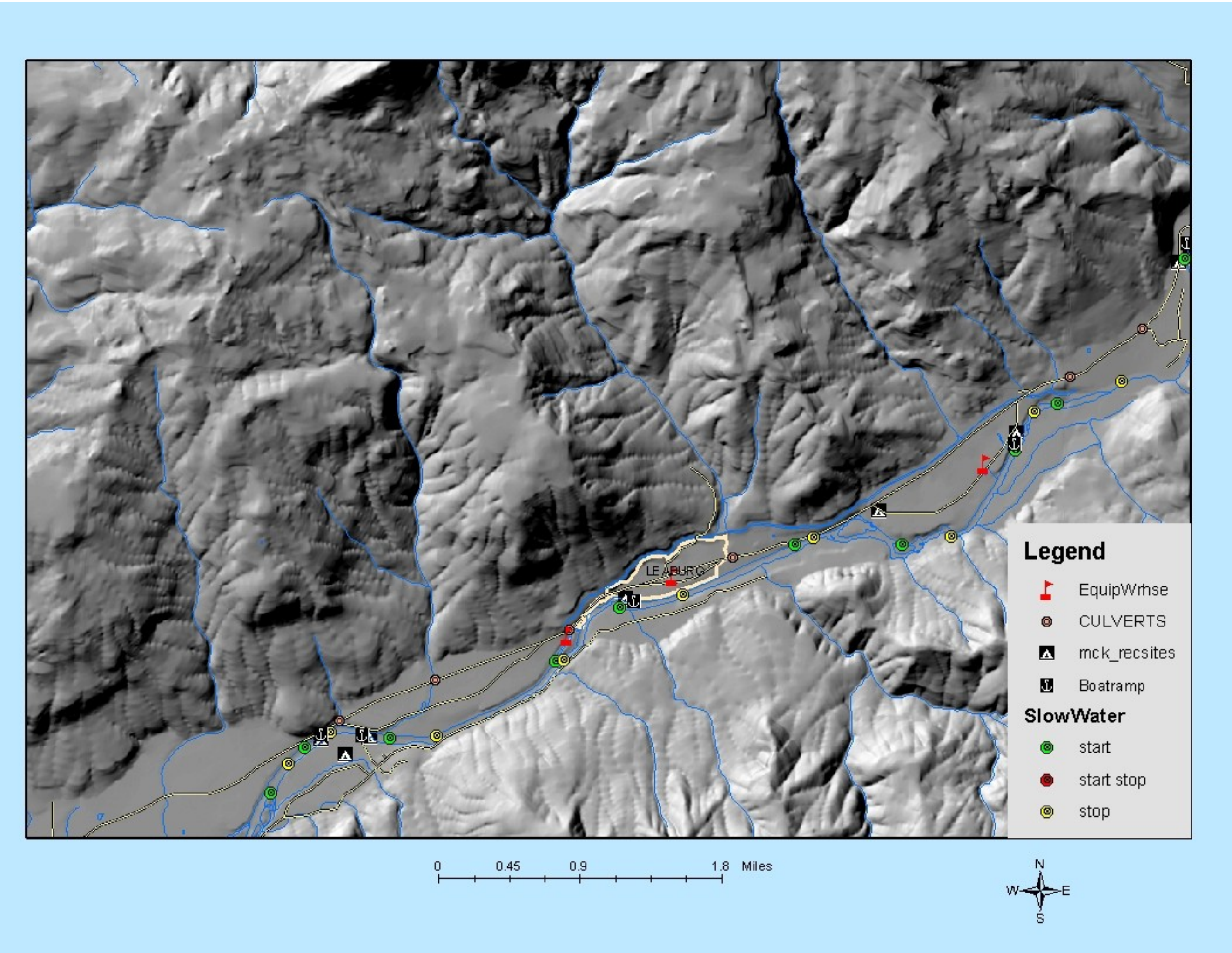

Figure 5: Sample of response resources in area of Leaburg, Oregon.

McKenzie Watershed Emergency Response System (MWERS)

In order to provide first responders and other partner agencies with the ability to query and interact with the spatial database during an emergency, a laptop computer based response tool was developed. This allows responders to have access to information that is not available in the response strategy reports, which are fixed documents. For example, spill travel times to each downstream critical

Figure 6a: Sample response strategy showing boom placement and response resources.

resource can be calculated after entering spill location and river flow rate. Also, if specific equipment listed in the response strategy is "out" at another incident, a spatial search for that equipment would indicate equipment status and availability. The MWERS is a Visual Basic for Applications (VBA) customized ArcView 8.3 application. Specific menu and button driven functions were developed so that responders could retrieve information quickly and easily without having to be an experienced ArcGIS user. At the same time, an experienced user can access the full capability of ArcGIS and do more advanced query and analysis of response information.

Strategy Number 13
Hendricks Bridge Area

Response Objectives:
Diversion, Protection, and Collection

Critical Resources to be Protected:
- Head gate/intake to Cedar Creek.
- Small spawning area (1 redd) @ River Mile 23.9.
- Western pond turtle habitat in side channels along south bank of river.

Location:
Hendricks Bridge located east of Springfield 3.2 miles
44 03' 22"N/122 49' 44"W
Highway 126E Milepost 11.4

Description of Response Tactics:
- Block highway drains on Hendricks Bridge (if vehicle spill on bridge).
- Deploy approximately 1,000 feet of 4x4 or 6x6 hard boom with curtain from south bank or anchor near south bank (upriver from bridge if spill originating from upriver) and angle to just upriver of boat ramp at natural eddy for collection.
- Deploy approximately 1,000 feet of 4x4 or 6x6 hard boom with curtain from southern most bridge pier to residential property along north bank for collection.
- the southern bank to protect habitat and head gate or intake structure.
- Close head gates to Cedar Creek (Contact is William Rennie 747-1946).
- Deploy four 300-foot sections of 4x4 or 6x6 hard boom with curtain across four channels leading to a slough area along At collection areas protect shoreline with sorbent boom/pads and poly sheeting. Collect product with vac truck, skimmers, or other devices.

Access Areas:
- Hendricks Park Boat Ramp (located immediately east of Hendricks Bridge on north bank of river).
- Closest downriver access is Bellinger Landing @ River Mile 18.9 on north side of river (approximately 5 river miles downstream from bridge).

Staging Areas:
- Hendricks Park is an ideal staging area with open space, parking areas, bathroom facilities and access to the river.
- Nearest equipment warehouse is McKenzie Fire & Rescue Walterville Station (~ ¾ mile north of bridge, west side of Hwy 126).

Equipment Needs:
6-Grate covers for Bridge drains (if spill on bridge)
3200 feet 4x4 or 6x6 boom
600 feet sorbent boom (shoreline protection)
Multiple anchors & rope/cable for boom placement
700 feet x 50 feet of Poly sheeting for shoreline protection and decon area
12 bales sorbent pads
2 cases drum liners (85 gallons)
2 Jet boats (at least) to set boom
2 generators
2 light racks
Decon equipment
Pressure washer
3-4 Containment basins (kiddie pools)
Vac truck
Skimmer or rope mop system

Watercourse Description:
- 0.7 m/s flow during high flow
- No data on depth
- River width = 250-300 feet
- Sand, gravel and cobble bottom.

6b: Sample response strategy report for a slow moving water area.

Specific application functions associated with the MWERS include:

- Entry of an incident location using different reference methods such as: interactive with a cursor; latitude and longitude coordinates in decimal degrees or degrees/minutes/seconds; based on river mile; or based on road mile.
- Automatic zoom "mostly" downstream of the incident.
- Hyperlink to a specific response strategy reports, including hyperlink to an aerial photography library (recent and historical photos – not corrected to account for elevation changes).
- Entry of river flow regimes, used for the calculation of spill travel time to each downstream critical resource and response strategy.
- Creation of on-the-fly reports for critical resources, response resources, response strategy summaries, or equipment inventories and warehouses including resource-specific emergency contact and notification information.
- Calculation of spill travel time to the specific downstream resources based on the entered river flow rate (for critical resource and response strategy summary reports).
- Ability to search spatially for specific response equipment.
- Links to chemical database search capabilities (CAMEO).
- Project and/or response personnel search capabilities to find a specific expertise or qualified equipment operators.
- Placement of radius rings from an incident to calculate population within the distance rings.
- Easy production of incident or other GIS maps based on user inputs.

The development of spill travel time estimates was accomplished by treating the McKenzie River as a route (using USGS river mile designations) in conjunction with a previous river study (USGS, 1968). The USGS study used dye testing to develop a travel rate for high, medium, and low river flow rates. Dye tests were conducted along fifteen segments of the McKenzie River. A flow rate - travel time matrix was developed for the various river segments. Travel time estimates, which are worst-case estimates, are then added as an attribute to the various real-time reports generated by the user for downstream critical resources or response strategies.

The MWERS has built-in functionality to generate real-time reports. For example, the application can develop a pre-formatted report of critical resource information based on the spill location. Specifically the report presents each critical resource type and priority, the travel time for the spill to reach the resource, and the contact information for the resource manager. A GIS map showing the location of critical resources with other user-selected layers (e.g., roads, streams, boat ramps, etc.) can be generated on a variety of base map layers (e.g., aerial photo, USGS topo map, digital elevation model surface, etc.) to accompany the report. Other reports include response resources, equipment search results, and a summary of downstream response strategies.

The equipment search function was created by allowing the user to specify which type of equipment they are searching for, as well as a search radius from the incident or spill event. The application searches the entire equipment database for those records that match, and returns an equipment listing report grouped by the closest warehouse to the spill location. Additionally, the application has links to excel files the user can quickly open that list all equipment at a specific equipment warehouse. All equipment listing or reports provide warehouse contact information.

Update of MWERS Data

One of the more critical tasks associated with any multi-agency spatial database is making sure it is updated on a regular basis. EWEB's approach to this aspect of the project is to develop an update schedule for the various data sets and send the old data sets to the responsible agency for updating. EWEB would take the role of ensuring that that data is updated and imported back into the spatial database in a timely fashion. A simple routine was developed that allows updated GIS data to be e-mailed as attachments to partner agencies. This routine automates the replacement of the older files from the e-mail attachment to ensure file nomenclature integrity and document when the update occurred. Once a web-based system is developed, data updating can be accomplished through having partner agencies interact with the spatial database via the secured website to update agency specific information and download new versions of the MWERS.

Use By First Responders

MWERS provides several canned functions, as mentioned above, that can aide the first responder. Other inherent ArcGIS functions can also be used depending on the incident in question, and the specific analysis and information needs. Although the possibilities of how the MWERS will be used in a specific incident are numerous and varied, presented below is an example of how the MWERS could be used during a typical response.

- Responder enters the location of the incident via one of several geo-referencing methods (Figure 7a).
- ArcMap automatically zooms to the area, and presents a mostly downstream view (Figure 7b).

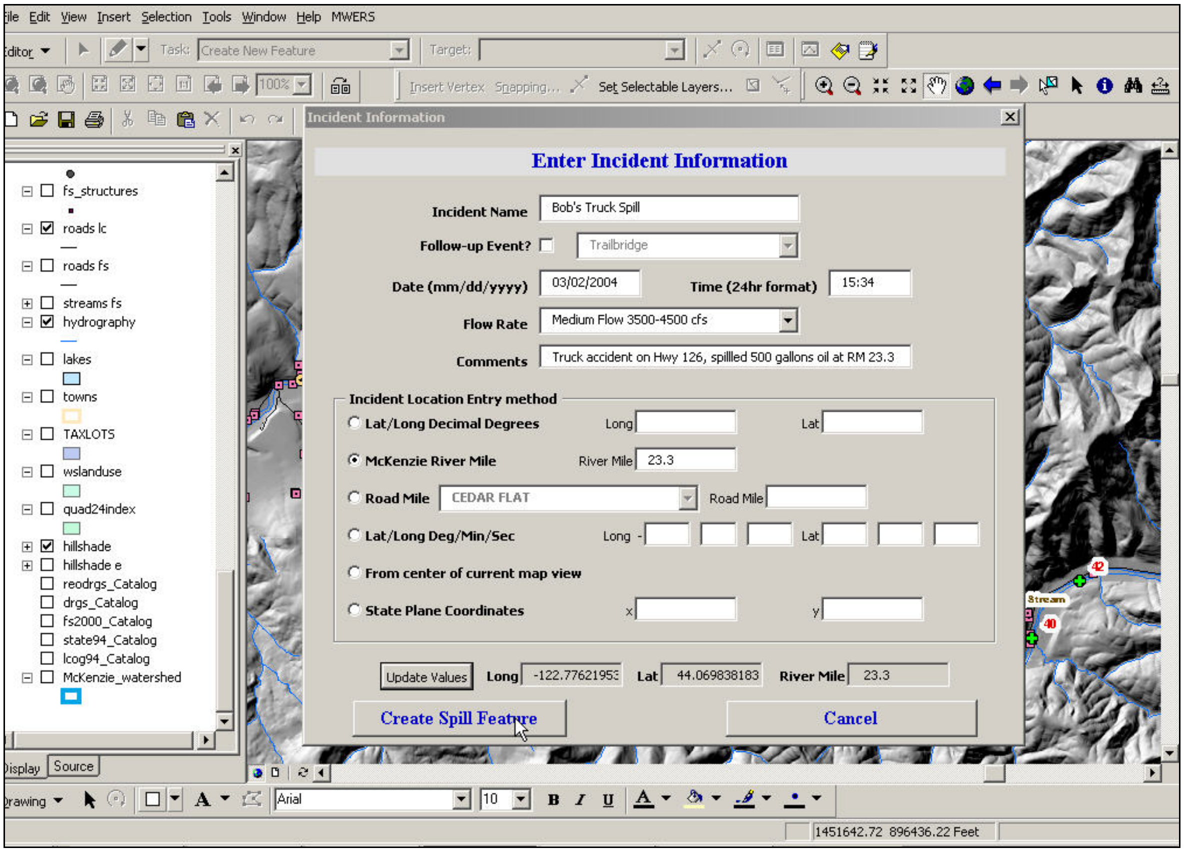

Figure 7a: Enter Incident Menu Screen

- The responder can visually assess closest downstream response strategies and hyperlink to each response strategy report. Each strategy report provides detailed information and instructions that a responder will use to mitigate a spill (Figures 6a and 6b).
- The responder can take the list of equipment needed to implement a response strategy and enter the list into the equipment search function (Figure 7c). This will provide the responder with the location and contacts for the equipment warehouses that have the equipment necessary to carryout the response strategy.
- The responder can zoom in to the spill area and identify storm drains and/or culverts and obtain specific information about those features that allows him to determine the size and shape of

plugs to stop the spilled material from entering storm sewers or crossing under the road into the river (Figure 7d).

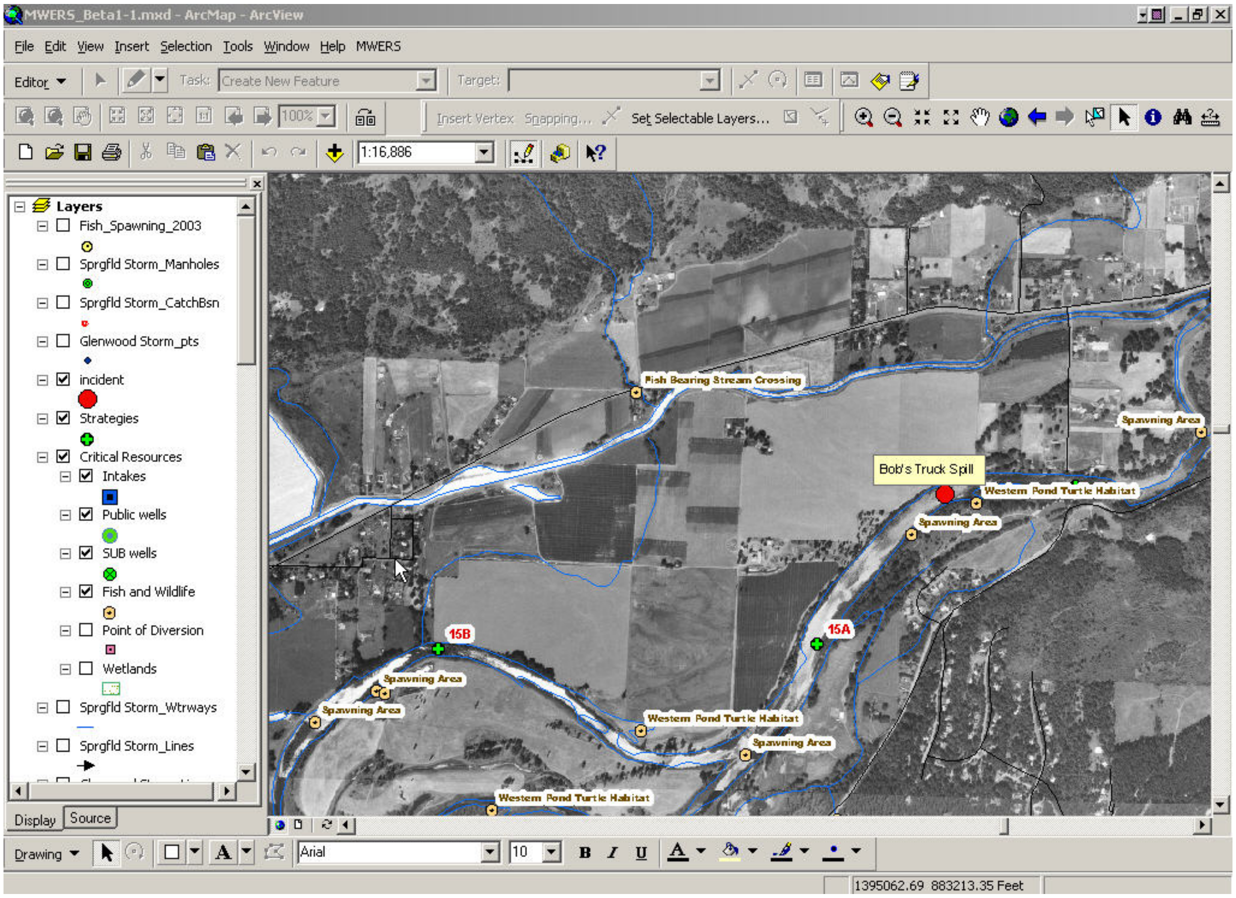

Figure 7b: Automatic zoom to incident area after entering incident in menu screen.

- The responder can then create a critical resource report that shows each resource, spill travel time, and contact information. The responder can notify the appropriate resource manager(s) for downstream critical resources and provide approximate times until spill reaches that resource (Figure 7e). Critical resource managers would then be able to start implementing the specific response strategies designed to protect those resources.
- The responder can establish radius distance rings from the incident to calculate population located within that search radius. This information is critical to establishing an evacuation plan and estimating shelters and other evacuation supplies.

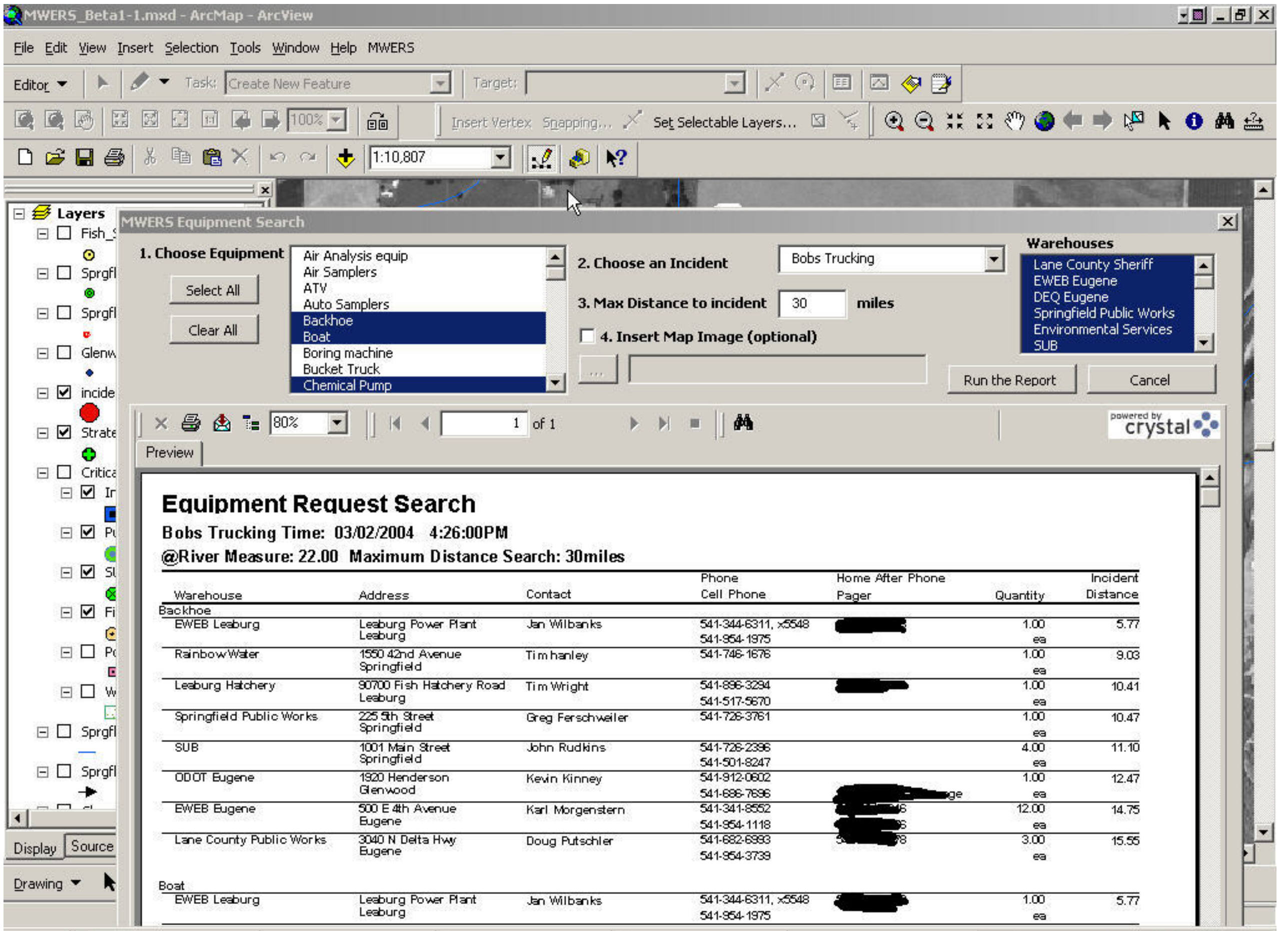

Figure 7c: Equipment search menu and report sample.

- If the incident material is known, the responder can quickly access CAMEO and enter the CAS number or product name and retrieve chemical and physical characteristics for the material in question.
- If the responder needs more equipment not identified in the strategy report, they can perform a search for the equipment, and retrieve a listing of warehouses and contacts to acquire the additional equipment.
- The responder can save and name the incident location, and enter new spill locations in order to track the progress of the spill over time.

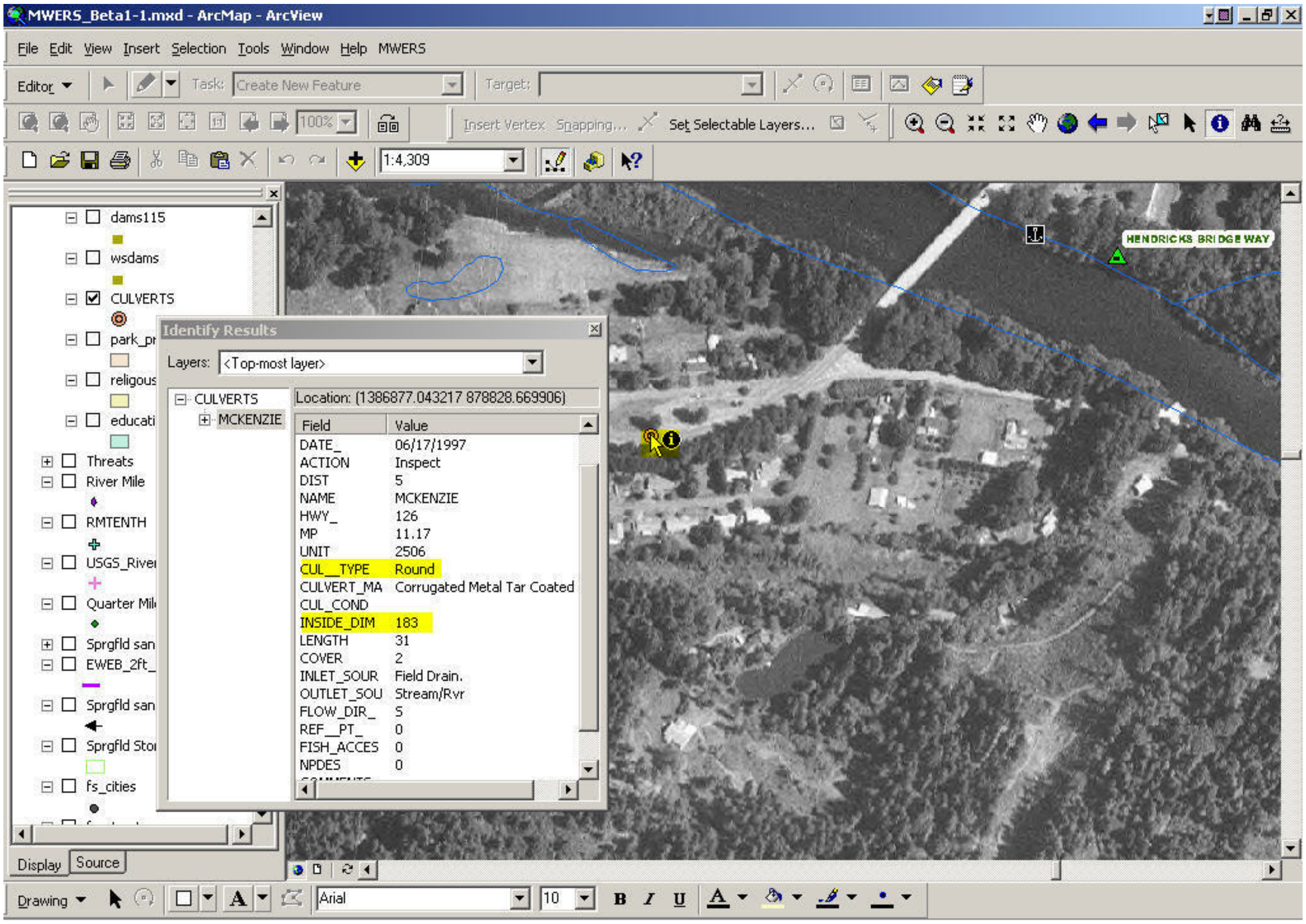

Figure 7d: Sample of how responder can access highway culvert data to determine plug size.

- If the incident hazardous material is known, but the source is not identified, the responder can search the threats data layers and identify upstream facilities that use or store that hazardous material and use this information to identify the source of the material.
- On larger incidents the MWERS can be plugged into the incident command system in the planning section to provide situation maps, aerial photos, and support response planning and design of operations.
- If the responder needs to gain access to property along the river, he can identify the tax lot in question and have access to property owner contact information.

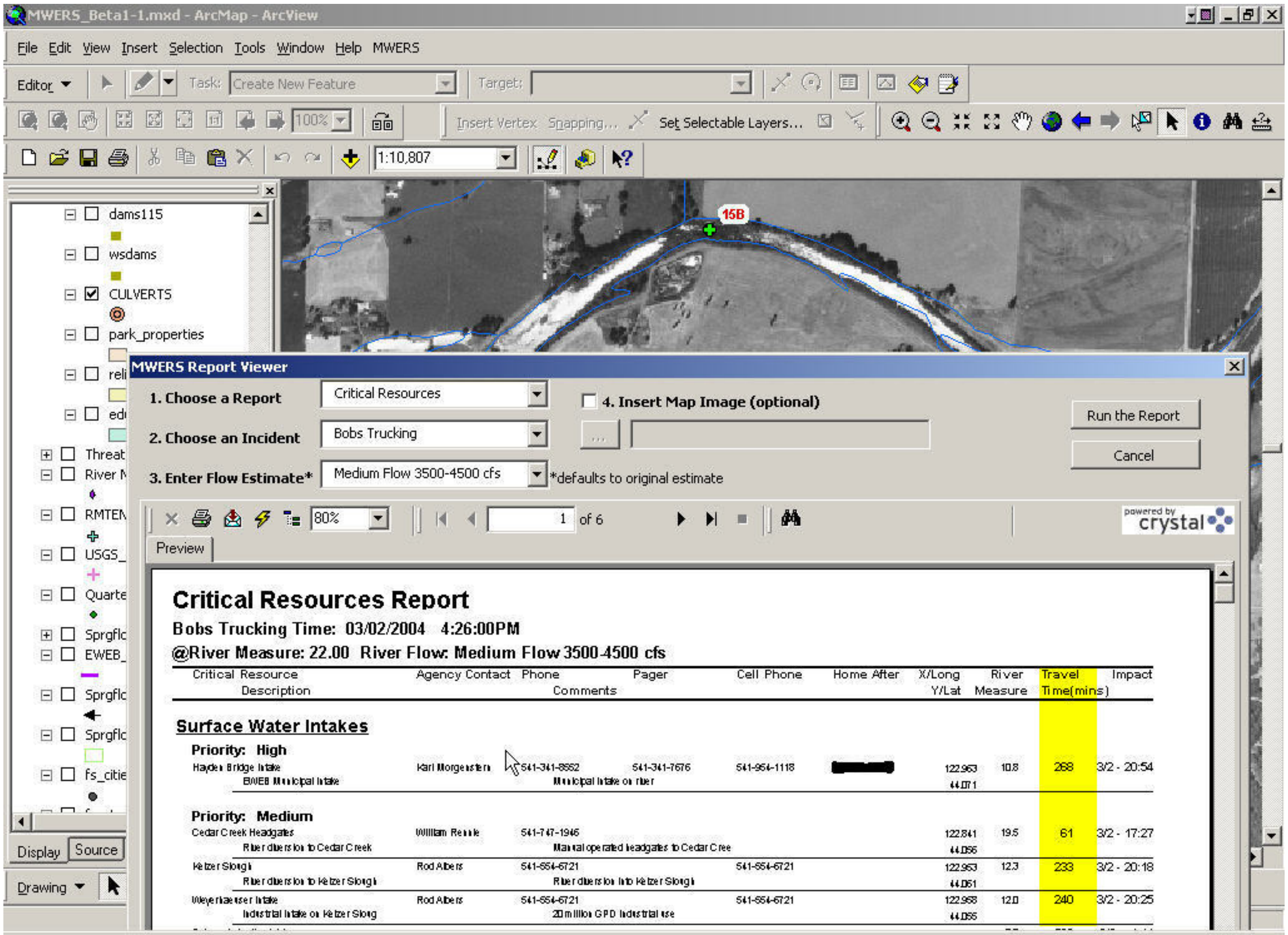

Figure 7e: Sample report of critical resources downriver of spill (travel time to impact highlighted).

Conclusions

The McKenzie Watershed Emergency Response Plan is an integral part of EWEB's drinking water source protection program. It has been identified as a high priority for implementation due to the threat of chemical spills or releases and the need for heightened security of drinking water systems serving large populations. EWEB and its federal, state, and local partners have a strong commitment to the implementation and maintenance of the McKenzie watershed emergency response system. One reason for this commitment is because those who are using it were the ones who developed the watershed emergency response plan.

A number of future modifications and additions are planned for the MWERS. These future efforts include:

- The development and distribution of the MWERS on other platforms such as a handheld Pocket PC with a customized ArcPad application;
- The development of the MWERS on the web using ArcIMS and ArcSDE technology;
- The development and integration of a river flow model to refine the travel time function;
- The development of probability impacts to critical resources that are based on contaminant transport models using different spill locations, river flow regimes, and various hazardous materials; and,
- The continual development of tools based on results of drills and exercises, responder feedback, and changing response needs.

In addition, various "modules" will be developed that focus on weapons of mass destruction (WMD) incident response, forest fire assessment and response, and natural disaster response. The terrorism incident response module is anticipated to be completed by fall 2004 and will include the development of specific response strategies for terrorist activities aimed at high priority targets in the watershed (i.e., chemical facilities, drinking water intakes and treatment plants, hydroelectric plants, dams, sewage treatment plants, and other targets).

This project has and will continue to make a difference in the Eugene/Springfield regional emergency response community by:

- Sharing resources and expertise among 27 different agencies and organizations;

- Prioritizing areas in the watershed with a concentration of high priority critical resources for conducting drills and exercises to test use of the watershed emergency response plan;
- Being better prepared to address large scale incidents;
- Access to equipment inventories from 27 different agencies;
- Assessing response equipment locations in the watershed and identify equipment staging areas;
- Fostering communication among participating agencies and increasing the level of knowledge and training among all participating agencies (not just the first responders);
- Having a comprehensive response plan that can be easily used and accessed; and,
- Transferring this approach and GIS application to other watersheds in the area.

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