Risk-Based End State Guidance:
Geospatial Mapping Tool

Report Prepared for DOE - HQ

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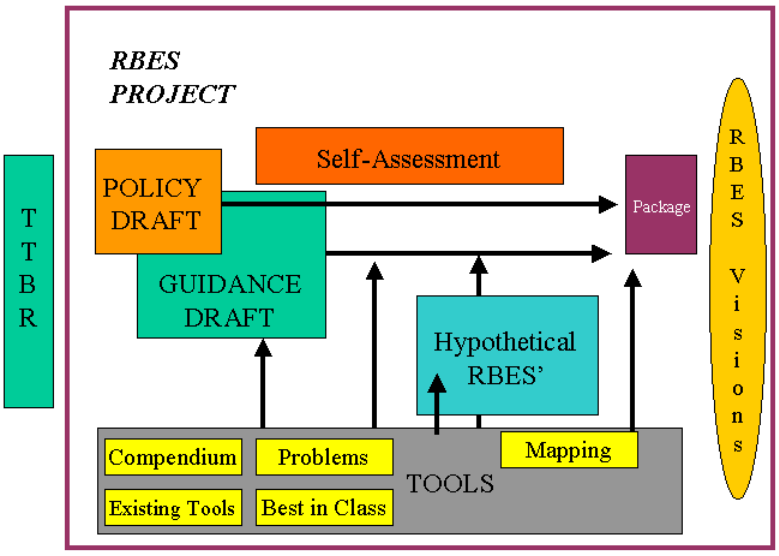
INTRODUCTION

CRESP was asked to design a core set of geospatial maps that can be developed and used by all of the Department of Energy's former nuclear weapons sites. Their purpose would be to effectively communicate the end-state vision for each site that is being developed through the Risk-Based End State (RBES) project, to regulators, DOE-HQ, and other important stakeholders. These core maps would also permit a comparison between that end-state vision and the site's current environmental and physical condition, with a focus on the existing on and off-site risks to human and ecological receptors. Integrating and presenting technical information so that complex current and future site conditions are readily understandable to laypeople, government officials and scientists alike, will be a critical factor in gaining public and regulatory support for this new end-state approach to environmental cleanup decisions. Comparability and consistency across all DOE sites will also improve communication with regulators and others who are responsible for overseeing multiple sites.

The core set maps outlined in this Guidance paper are intended to identify the location of sources of potential risk, and the interfaces and possible pathways that might bring them into contact with at risk human and ecological populations. The ability to reduce or eliminate the contaminant, and/or to control its ability to reach human and ecological receptors would be shown on the maps depicting the site's end-state vision. These maps are a foundation for quantifying, but not a depiction of the actual or relative level of risk represented by each contaminate source. This is an important next step, and is discussed later in this paper.

These geospatial maps are one of the "Tool" components of the RBES Project and specifically of its Guidance document, as graphically depicted below.



The Guidance paper that follows includes six sections:

1. An overview of the geospatial map types and associates attributes recommended, including the purpose of each within the overall context of providing a visual comparison between the site's end-state vision and its current environmental and physical condition;
2. A discussion on the need to use standardized definitions, scales and formats in the collection and display of georeferenced data on these core maps, and a review of the alternative data sources and mapping formats that were considered;
3. A discussion of the recommended definition and associated data and mapping format for the land cover, infrastructure, land use and contaminant attributes, including legends, colors and symbols that would be used to ensure a consistent presentation across all sites;
4. Review of the DOE's GEMS system and the availability of internal GIS and Internet resources at the Grand Junction Office.
5. An overview of the data and meta data structure needed to support a geospatial mapping system; and,
6. A discussion of the next steps required to refine this extensive Guidance paper into an integral part of the RBES Guidance document, and need for pilot testing at several DOE sites.

1.0 MAP TYPES AND ATTRIBUTES

The DOE complex of sites requiring remediation is remarkably heterogeneous. Some sites are small, others are large. Some sites are in arid environments, others in wet ones. Some sites have massive contamination, others do not. Developing a way of depicting what will have been achieved when remediation, mitigation and/or encapsulation have made them risk protective is daunting because of the variety of environmental and institutional conditions. The development of geospatial maps provides a means for integrating diverse databases and creating accurate and broadly understandable visual presentations and descriptions of complex environmental, physical site and human health conditions. However, producing maps that are inconsistent in their terminology and definitions, and in their the portrayal of contaminants and associated risks, can lead to confusion and a possible misunderstanding of what is being presented to the public or regulatory officials. The challenge is to provide consistency in the maps without sacrificing unique site attributes.

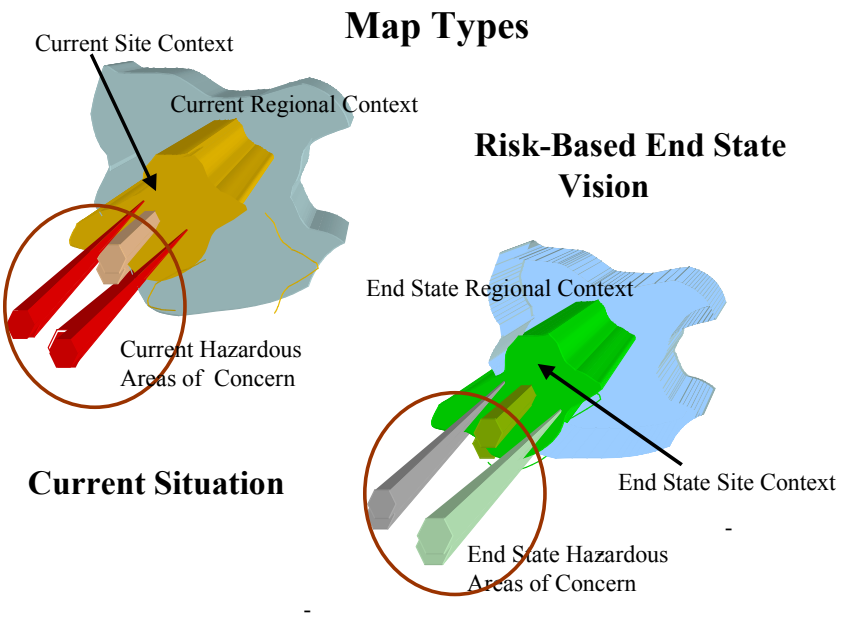
Three types of geospatial maps are needed to help stakeholders visualize current site conditions and those anticipated in the risk-based end-state vision for the site. They are:

- *Regional Context*: A map that places the site within its larger geographic regional area and in relationship to important ecological or human receptors of concern.

- *Site-Wide Context*: Maps that focus on the site and contiguous off-site areas of concern. They show greater amounts of data and detail, including the location of hazardous conditions in relationship to environmentally sensitive areas, or to possible exposure and potential risk pathways and receptors.

- *Hazardous Areas of Concern:* Maps that zoom in and more closely examine each of the hazardous areas identified on the *Site-Wide Context* maps. Greater detail, such as concentration isopleths for soil, sediment and groundwater contamination would be required where appropriate.

The *Hazardous Areas of Concern* maps are a subset of the *Site-Wide Context* maps, which are in turn a subset of the *Regional Context* map. Each provides a greater level of detail on a smaller geographic or subject area of interest. One set of these maps would be prepared to depict current conditions, and a second set would be used to provide a visualization of the site consistent with its risk-based end-state vision.



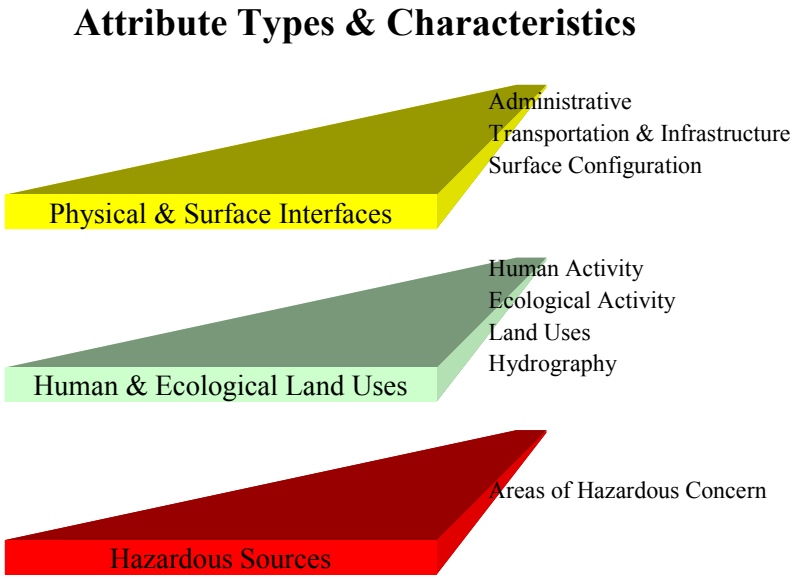
Three types of attribute content would be geospatially displayed on these maps. They correspond to the potential sources of risk, possible interfaces or pathways, and the human and ecological populations that would be considered in any risk assessment process.

- ***Physical and Surface Interfaces***: Attributes of the site and surrounding geographic area that identify **Administrative** characteristics, such as boundaries and building footprints; the location of **Transportation and Infrastructure**, such as roads and utilities; and **Surface Configuration** characteristics, such as topography and land cover.

- ***Risk Sensitive Human and Ecological Land Uses***: Attributes of the site and surrounding area that identify **Human Activity**, such as the location of at risk populations and schools; **Ecological Activity**, such as the location of habitats of concern and critical watersheds; physical **Land Uses**, such as residential and

industrial areas; and, areas of **Hydrography** concern, such as surface and underground drinking water sources.

- ***Hazardous Sources***: Attributes of the site that identify areas of **Hazardous Concern**, such as contaminated buildings, underground plumes and discharge points of air emissions.



The following is a description of each type of core map and the associated attributes that would be geospatially identified and displayed.

1.1 Regional Context Map

The Regional Context map is intended to geospatially place the site within its larger contiguous regional area and in relationship to the possible off-site pathways and ecological or human receptors that are of concern. The size and boundaries of the regional area shown on this map will differ somewhat from site to site because of their differences in land size and complexity, but also because of differences among nearby population centers, habitat and ecology areas, watersheds, and other areas that could be affected by contamination and other hazards on the site. As a guidance, the regional boundaries should not be a fixed number of miles from the site's boundary, but rather they should follow the boundaries of all contiguous local and county governments, and tribal nations that surround the site. They should also encompass all watersheds, habitat and ecology areas, and other off-site areas that could be affected by site contamination. At some of the larger sites, the regional context may be hundreds of square miles and many counties, while at some small sites the regional context may be only a few square miles, made up of the surrounding local government and perhaps a critical watershed.

This regional context map should include the following important attributes:

***Physical and Surface Interfaces*:**

Administrative

Legal boundaries of local & county governments, tribal nations, national wildlife and wilderness areas, etc.
DOE Site boundaries
Historical sites
Footprint of important buildings or building complexes

Transportation & Infrastructure

Highways and major roads
Railroads
Important oil, gas, electric, high power, telephone or fiber optic lines
Important infrastructure – dams, water treatment plants and power plants

Surface Configuration

Topography
Land cover – forest, pasture, developed, etc.
Surface water – lake, river, stream
Other Important physical features

Risk Sensitive Human and Ecological Land Uses

Human Activities

Population centers
Open space, parks and recreational areas

Ecological Activity

Conservation and ecological areas
Habitats of concern (especially unique habitats)
Watershed, floodplains, wetlands, marshes

Land Uses

Industrial & Commercial
Residential
Agriculture

Hydrography

Single source aquifers
Drinking water sources

Hazardous Sources

Hazardous areas of concern [each major group of contaminants to be defined separately (e.g. radionuclides, chlorinated solvents, etc.)]:

Surface water - areas of sediment contamination
Groundwater – contaminated area
Soils - contaminated areas
Buildings - contaminated areas

Not all of these attributes will be germane to every site, but every effort should be made to include those attributes that are relevant to the regional area and/or which may be perceived by the public or other stakeholders to be at risk.

1.2 Site-Wide Context Maps

The two *Site-Wide Context* maps that should be developed are subsets of the larger *Regional Context* map. They are intended to show greater amounts of data and detail, including the location of hazardous conditions in relationship to environmentally sensitive areas, or to possible exposure and potential risk pathways and receptors. The boundaries for these maps should extend beyond the site to include all contiguous population and environmentally sensitive areas that might be affected by contamination on the site. Even in instances where the contamination is believed to be totally contained within the site boundaries, we recommend that the *Site-Wide Context* maps show consideration and awareness of human and ecological areas in close proximity to the site.

The first map in this set would show ***Hazardous Sources*** (on and off-site) in relationship to the area's ***Physical & Surface Interfaces***, and include the following important attributes:

Physical & Surface Interfaces

Administrative

Legal boundaries of contiguous local governments, tribal nations, national wildlife and wilderness areas, etc.
DOE Site boundaries
DOE Fence lines
Historical sites
Footprint of buildings – differentiate by type of building; i.e. private, public, abandoned, operational, manufacturing, office, school, hospital

Transportation & Infrastructure

Highways and major roads – primary and secondary
Railroads – passenger, freight
Utilities – oil, gas, electric, high power, telephone, fiber optic lines
Other infrastructure – dams, water and wastewater treatment plants (private, public), power plants (nuclear, coal)

Surface Configuration

Topography
Land cover – forest, pasture, developed, etc.
Soil types
Contours
Surface water – lake, river, stream
Elevation points
Other physical features (including seismic)

Hazardous Sources

Hazardous areas of concern [each major group of contaminants to be defined separately (e.g. radionuclides, chlorinated solvents, etc.)]:

Surface water - areas of sediment contaminations
Groundwater - contaminated areas
Monitoring wells (locations)
Soils - contaminated areas
Buildings & storage areas - contaminated areas

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The second map of this set would focus on showing ***Hazardous Sources*** (on and off-site) in relationship to the area's ***Risk Sensitive Human & Ecological Land Uses***, and include the following important attributes:

Risk Sensitive Human & Ecological Land Uses

Human Activity

Population centers
Identification of vulnerable subpopulations (seniors and children), socio-economic status of different groups, and distribution of minorities in close proximity to site.
Schools, houses, hospitals & other major public buildings in close proximity
Open space, parks – active and passive recreation

Ecological Activity

Conservation and ecological areas
Habitats of concern (especially unique habitats)
Threatened or Endangered Species
Watershed identification
Single source aquifers

Land Uses

Industrial – light, heavy
Commercial, retail
Residential – single family, multi-family
Agriculture

Hydrography

Floodplains, wetlands, marshes
Surface water
    Flow direction
    Discharge locations
Groundwater
    Flow direction
    Groundwater divide
Drinking water sources
Vertical cross-section of geology and aquifers
Rainfall, temperature and wind data

Hazardous Sources

Hazardous areas of concern [each major group of contaminants to be defined separately (e.g. radionuclides, chlorinated solvents, etc.)]:

Surface water - areas of sediment contaminations
Groundwater - contaminated areas
Monitoring wells
Soils - contaminated areas
Buildings - contaminated areas
Storage containers – contaminated – above & below ground
Air emissions (magnitude and type)
Wind rose
Discharge points[1]

Again, not all of the attributes recommended for these two maps will be germane to every site, but an effort should be made to include those attributes that are relevant to the site and local area, or which may be perceived by the public to be of concern. One area that is likely to be germane to all sites is the identification and delineation of watershed areas, as they are critical for determining the transport of contamination to both potable water supplies and ecological systems.

1.3 Hazardous Areas of Concern

The third group of maps would zoom in and more closely examine each of the hazardous areas of concern that were identified on the *Site-Wide Context* maps. Greater detail, such as concentration isopleths for soil, sediment and groundwater contamination, and screening depths and COPC concentrations for monitoring wells, would be required where appropriate. Some sites may be able to, or desire to, augment these map depictions with cross-section diagrams and other graphics that may be needed to more fully explain the geospatial and other unique characteristics of the contaminated area. This might include information on the human and ecological Applicable and Relevant and Appropriate Requirements (ARARs). ARARs are federal and state human health and environmental requirements used to (1) evaluate the appropriate extent of site cleanup; (2) define and formulate remedial action alternatives; and (3) govern implementation and operation of the selected action. These added diagrams and data are optional, very site specific and are not included in the recommended attributes for this core set of maps.

1.4 End-State Vision Maps

The three sets of maps described above should first be developed for the purpose of showing current environmental and physical conditions at the site, with a focus on effectively communicating the types and levels of risk that currently exist to on and off-site human and ecological receptors. A second set of these maps, depicting the risk-based end-state vision for each hazardous area of concern, as well as the vision for the site as a whole, should then be prepared.

[1] It may be that there should be another set of attributes as well: Regulatory Authority Attributes. DOE views on this would be helpful

The first of the *End-State Vision* maps should mirror each of those developed under the *Hazardous Areas of Concern* section above, except that they should show each area of concern after remediation, mitigation and/or implementation of other forms of protection (institutional controls, land use, etc.). The risk-based end state vision for each area would need to be accompanied by a verbal or written explanation of the cleanup approach that is intended to be used, and the planned monitoring and other long-term stewardship requirements, if any. Where the end-state vision for a hazardous area is not expected to be reached in the next 10 years, it would be advisable to develop a series of temporal maps that show the condition of these areas at the end of different points in time into the future.

The second set of maps in this group should follow the structure of the two *Site-Wide Context* maps that were prepared earlier to show the current environmental and physical condition of the site. The first map should show the risk-based end-state vision for the site, in relationship to the area's ***Physical and Surface Interfaces***. As such, it should show all of the attributes displayed on the earlier *Site-Wide Context* map, after adjusting for all proposed changes in roads, buildings, infrastructure, utilities, boundaries and fence lines, land cover, land contours and other physical features contemplated under the end-state vision. The ***Hazardous Sources*** component of the map should also show the same features as the earlier map, after adjusting for the effects of removing or mitigating the various hazardous areas of concern previously identified. It should also show the location of all monitoring wells, pump and treat facilities, permanent storage units, and permanently restricted areas that are part of the end-state vision for the site.

The second map in this set should show the mitigated risk-based end-state vision for the site, in relationship to the area's ***Human & Ecological Land Uses***. This map should show all of the attributes described on pages 7 and 8 of this paper and used earlier to develop the "current condition" *Site-Wide Context* map, after adjusting for any anticipated on and off-site changes in human and ecological activities and land uses. The ***Hazardous Sources*** component of the map should also show the same features of that earlier map, adjusted for the effects of removing or mitigating the various hazardous areas of concern previously identified. It should also show the location of all monitoring wells, pump and treat facilities, permanent storage units, and permanently restricted areas that are part of the end-state vision for the site. This map will be especially important where long-lived radioactive contamination will remain on the site under the proposed end-state vision, such as with Hanford, Rocky Flats and Mound.

The final map in this *End-State Vision* group should mirror the structure of the *Regional Context* map that was prepared earlier to geospatially place the current site within its larger contiguous regional area, and in relationship to the possible off-site pathways and ecological or human receptors that are of concern. As with the previous maps in this group, this map should show the same attributes displayed on the "current condition" *Regional Context* map, after adjusting for any changes in ***Physical & Surface Interfaces, Human & Ecological Land Uses,*** and ***Hazardous Sources*** included in the two site-wide *End-State Vision* maps discussed above.

A Table listing the specific attributes being recommended for each core map is attached to this report as Tables 1 and 2.

1.4 Summary

These two groups of *Regional Context, Site-Wide Context* and *Hazardous Conditions* maps should enable all of the DOE's sites, regardless of their size or complexity, to:

- Accurately capture and depict the current environmental and physical conditions at the site and surrounding area, with a focus on the existing on and off-site risks to human and ecological receptors.

- Effectively communicate the end-state vision for each site that is being developed through the Risk-Based End State (RBES) project; and,

- Permit a comparison between that end-state vision and the site's current environmental and physical conditions.

2.0 DATA SOURCES AND NEED FOR MAPPING STANDARDIZATION

We believe that these core maps can be developed at every DOE site with a minimal cost and a maximal reliance on readily available data. Most of the sites have previously developed maps showing infrastructure, building footprints, contaminant areas, and other on-site attributes listed below. In addition, most, if not all, of the sites already have, or have ready access to, georeferenced data on many of these same attributes. As a first step, we recommend that all of the sites take an inventory of existing in-house data and other relevant information (including that held by outside consultants and contractors), and from that determine what data gaps may exist versus the attributes listed below. In some instances, such as with smaller sites, it may be necessary to use a portable or mobile Global Positioning System (GPS) unit to georeference the exact location of monitoring wells, or to use georeferenced orthophotos of the full site to develop a more accurate data set. We believe, however, that the question that is most likely to be raised, is where can they obtain the off-site data needed for the *Regional* and *Site-Wide Context* maps.

2.1 Major Sources of Information

State and federal governments and their agencies have developed a huge amount of geospatial data that can be readily accessed by the sites to meet these needs. Major contributors include USGS, the Bureau of Land Management, Department of Agriculture, Department of Housing and Urban Development, U.S. Census Bureau, the Environmental Protection Agency, and U.S. Park Service. Many states, such as South Carolina, provide web access to more localized data, and others will make information available on CDs for a fee. Much of the data has also been converted into georeferenced maps, which are available for viewing and download over the Internet using GIS software packages already owned by many DOE sites or through the use of free shareware, such as ESRI's free ArcExplorer software package for viewing.

There are many web sites from which the GIS practitioner can obtain on and off-site regional data, including the *National Geospatial Data Clearinghouse* which is operated by the Federal Geographic Data Committee. We believe that the *Center for Advanced Spatial Technologies (CAST)* facility at the University of Arkansas maintains one of the most comprehensive and easy to use web sites. It is titled *Starting the Hunt: Guide to Mostly On-Line and Mostly Free U.S. Geospatial and Attribute Data.* CAST has organized several hundred web-based data sources into two broad classifications: National Aggregations and State and Local Aggregations. The vast majority of these web sites require ArcView or other GIS software systems to view and download the data, but many provide data in Adobe Acrobat (pdf) or picture (jpeg) formats. As an example, the *South Carolina Department of Natural Resources GIS Data Clearinghouse* site includes digital orthophotos (aerial photos taken in 1999); data from USGS on hydrography, topography, elevation, pipe/transmission lines, roads and railroads; wetlands data from the U.S. Fish & Wildlife Service; and, soils data from the National Cooperative Survey. All are in standard 7.5 Quad map format, with the exception of the orthophotos, which are available in quarter quads.

The State of Ohio's *OhioLINK Media Center* provides access to Landsat 7 Satellite Images. A variety of dates can be chosen if the image that appears is not sharp enough because of clouds, smoke or other interference. Using the site's Navigation Tool the user can zoom in on a specific geographic areas of interest, and access topographic maps of that and even smaller geographic areas produced by TopoZone.com. As an example, the user can develop and download a topographical map at 1:25,000 scale of Miamisburg that shows the location of the DOE's Mound facility relative to a golf course, local sewage disposal facility and various residential areas.

A more detailed review of available geospatial data and map sources is attached as Appendix B.

2.2 Need for Data and Mapping Standardization

During remedial investigations, a significant amount of data of varying quality and formats are collected and compiled in a multitude of database structures. Other data, such as the site's topography, location of roads, streams and buildings, and land uses are similarly collected and stored in various databases and formats, including paper documents. Additional data such as satellite images, and information on land uses and populations outside the site boundaries may be downloaded from local, state and federal governments sites. Much of this data is georeferenced, or linked to specific geographic coordinates on the site, but some is not. The degree and consistency of the maps that would be developed from this data would therefore vary in accuracy, resolution, projection and scale.

A content standard for digital geospatial metadata was promulgated in 1994 through an executive order (Executive Order 12906). The purpose was to standardize procedures so the prospective user could determine the availability of a set of geospatial data, determine the fitness of the set of geospatial data for an intended use, determine the means of accessing the set of geospatial data, and successfully to transfer the set of geospatial data.

In 1990 the federal government formed the interagency Federal Geographic Data Committee (FGDC) which not only developed the standards in the Executive Order, but under OMB Circular A-16, FGDC continues to promote the coordinated use, sharing, and dissemination of geospatial data on a national basis. One of its most important contributions to this effort is the development of the National Spatial Data Infrastructure (NSDI), in cooperation with organizations from State, local and tribal governments, the academic community, and the private sector. The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. DOE Headquarters has been an active member of FGDC since its inception, with Guy Caruso and Karen Evans currently serving as Steering Committee members and John Stewart and three other DOE staff participating on the Coordination Group

2.3 Alternative Geospatial Mapping Standards

While these efforts are critical to the development and maintenance of geospatial data on a consistent basis across the DOE, they do not address the need to develop and implement standardized definitions and classifications of the descriptive elements in the spatial data set. As we noted earlier, the development of geospatial maps provide a means for integrating diverse databases and creating accurate visual presentations and descriptions of complex environmental, physical site and human health conditions. However, producing maps that are inconsistent in their terminology and definitions, and in their the portrayal of contaminants and associated risks, can lead to confusion and a possible misunderstanding of what is being presented to the public and/or regulatory officials. For example, a land classified and geocoded as agricultural at SRS should have the same, or as close to as possible, criteria as agricultural land at Hanford, Oak Ridge or Mound. Similarly, care must be taken to ensure that maps and diagrams of surface or underground contaminant plumes, which have been developed using a variety of statistical and graphical software packages, are based on accurate and minimal number of data readings, and depicted on maps using a consistent set of colors, legends and symbols.

There are many different protocols or formats at the DOE sites for collecting and managing data, and for developing and displaying maps of the nature that we have been discussing. Although one or more of these in-house protocols might be a good model for certain aspects of the Department's overall mapping needs, a broader study was undertaken to determine whether more dynamic and universally applicable systems were available from government and private sector organizations. The objective was to identify data and mapping protocols for land cover, infrastructure, land use and contaminants that were broad, deep and easily transferable to the DOE sites. They also needed to be integrated structures that included clear definitions and codes for each of these attributes and data elements, and associated map legends, colors and symbols that could be used to produce consistent maps across all sites.

Appendix C contains a short review of the DOE's LandTrek and FIMS systems that were considered within this study.

3.0 RECOMMENDED DATA AND MAPPING STANDARDS

No one organization was found to have the breadth and depth of information and tools needed to develop and maintain the core set of geospatial maps proposed. As a result, we chose three organizations that excel in areas that do not greatly overlap, and that when combined create the strongest data and mapping tools available for the land cover, soil type, infrastructure, land use and contaminant attributes being sought. They were chosen because they provide widely used definitions of each attribute cataloged, a data code system that can be easily downloaded, and associated legends, colors and symbols for use in preparing consistent maps across all DOE sites.

3.1 Land Cover Attribute

We recommend that the DOE follow the format developed by the U.S. Geological Survey (USGS) for data characterization and mapping of Land Cover attributes. The USGS National Land Cover Characterization project was created in 1995 to support the original Multi-Resolution Land Characterization (MRLC) initiative and fulfill the requirement to develop a nationally consistent land cover data set from MRLC data called National Land Cover Data 1992 (NLCD 1992). This culminated in the September 2000 completion of land-cover mapping using a modified Anderson level II classification for the conterminous United States. In addition to satellite data, scientists used a variety of supporting information including topography, census, agricultural statistics, soil characteristics, other land cover maps, and wetlands data to determine and label the land cover type at 30 meter resolution. Twenty-one classes of land cover were mapped, using consistent procedures for the entire U.S. and a subsequent accuracy assessment was performed. The resulting land cover dataset is being used for a wide variety of national and regional applications, including watershed management, environmental inventories, transportation modeling, fire risk assessment, and land management. The land cover classes, codes and associated definitions are:

10. Water - All areas of open water or permanent ice/snow cover.

11. *Open Water* - all areas of open water, generally with less than 25% cover of vegetation/land cover.
12. *Perennial Ice/Snow* - all areas characterized by year-long surface cover of ice and/or snow.

20. Developed Areas characterized by a high percentage (30 percent or greater) of constructed materials (e.g. asphalt, concrete, buildings, etc).

21. *Low Intensity Residential* - Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
22. *High Intensity Residential* - Includes highly developed areas where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials

account for 80 to100 percent of the cover.
23. *Commercial/Industrial/Transportation* - Includes infrastructure (e.g. roads, railroads, etc.) and all highly developed areas not classified as High Intensity Residential.

These categories of land cover overlap with the APA land use classification system discussed later in this paper.

30. Barren - Areas characterized by bare rock, gravel, sand, silt, clay, or other earthen material, with little or no "green" vegetation present regardless of its inherent ability to support life. Vegetation, if present, is more widely spaced and scrubby than that in the "green" vegetated categories; lichen cover may be extensive.

31. *Bare Rock/Sand/Clay* - Perennially barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, beaches, and other accumulations of earthen material.
32. *Quarries/Strip Mines/Gravel Pits* - Areas of extractive mining activities with significant surface expression.
33. *Transitional* - Areas of sparse vegetative cover (less than 25 percent of cover) that are dynamically changing from one land cover to another, often because of land use activities. Examples include forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.).

40. Forested Upland - Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25-100 percent of the cover.

41. *Deciduous Forest* - Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
42. *Evergreen Forest* - Areas dominated by trees where 75 percent or more of the tree species `maintain their leaves all year. Canopy is never without green foliage.
43. *Mixed Forest* - Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

50. Shrubland - Areas characterized by natural or semi-natural woody vegetation with aerial stems, generally less than 6 meters tall, with individuals or clumps not touching to interlocking. Both evergreen and deciduous species of true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions are included.

51. *Shrubland* - Areas dominated by shrubs; shrub canopy accounts for 25-100 percent of the cover. Shrub cover is generally greater than 25 percent when tree cover is less than 25 percent. Shrub cover may be less than 25 percent in cases

when the cover of other life forms (e.g. herbaceous or tree) is less than 25 percent and shrubs cover exceeds the cover of the other life forms

60. Non-Natural Woody - Areas dominated by non-natural woody vegetation; non-natural woody vegetative canopy accounts for 25-100 percent of the cover. The non-natural woody classification is subject to the availability of sufficient ancillary data to differentiate non-natural woody vegetation from natural woody vegetation.

61. Orchards/Vineyards/Other - Orchards, vineyards, and other areas planted or maintained for the production of fruits, nuts, berries, or ornamentals.

70. Herbaceous Upland - Upland areas characterized by natural or semi-natural herbaceous vegetation; herbaceous vegetation accounts for 75-100 percent of the cover.

71. *Grasslands/Herbaceous* - Areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is less than 25 percent, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.

80. Planted/Cultivated - Areas characterized by herbaceous vegetation that has been planted or is intensively managed for the production of food, feed, or fiber; or is maintained in developed settings for specific purposes. Herbaceous vegetation accounts for 75-100 percent of the cover.

81. *Pasture/Hay* - Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
82. *Row Crops* - Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
83. S*mall Grains* - Areas used for the production of graminoid crops such as wheat, barley, oats, and rice.
84. *Fallow* - Areas used for the production of crops that do not exhibit visable vegetation as a result of being tilled in a management practice that incorporates prescribed alternation between cropping and tillage.
85. *Urban/Recreational Grasses* - Vegetation (primarily grasses) planted in developed settings for recreation, erosion control, or aesthetic purposes. Examples include parks, lawns, golf courses, airport grasses, and industrial site grasses.

90. Wetlands - Areas where the soil or substrate is periodically saturated with or covered with water as defined by Cowardin et al.

91. *Woody Wetlands* - Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
92. *Emergent Herbaceous Wetlands* - Areas where perennial herbaceous

vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.

The color legends for each of these land covers are shown in the following Table, and can be found at http://edcwww.cr.usgs.gov/pub/data/landcover/states/NLCD_legend.jpg

National Land Cover Dataset Classification System Legend

Color Key	RGB Value	Class Number and Name
	102, 140, 190	11 - Open Water
	255,255,255	12 - Perennial Ice/Snow
	253, 229, 228	21 - Low Intensity Residential
	247, 178, 159	22 - High Intensity Residential
	231, 86, 78	23 - Commerical/Industrial/Transportation
	210, 205, 192	31 - Bare Rock/Sand/Clay
	175, 175, 177	32 - Quarries/Strip Mines, Gravel Pits
	83, 62, 118	33 - Transitional
	134, 200, 127	41 - Deciduous Forest
	26, 129, 78	42 - Evergreen Forest
	212, 231, 177	43 - Mixed Forest
	220, 202, 143	51 - Shrubland
	187, 174, 118	61 - Orchards/Vineyards
	253, 233, 170	71 - Grasslands/Herbaceous
	252, 246, 93	81 - Pasture/Hay
	202, 145, 71	82 - Row Crops
	121, 108, 75	83 - Small Grains
	244, 238, 203	84 - Fallow
	240, 156, 054	85 - Urban/Recreational Grasses
	201, 230, 249	91 - Woody Wetlands
	144, 192, 217	92 - Emergent Herbaceous Wetlands

4.2 Infrastructure and Hazardous Attributes

We recommend that the DOE follow the format developed by the U.S. Department of Defense's CADD/GIS Technology Center for Facilities, Infrastructure, and Environment for data characterization and mapping of Infrastructure and Hazardous attributes. The "Center" is located at the U.S. Army Engineer Research and Development Center, Information Technology Laboratory in Vicksburg, Mississippi. One of the major initiatives assigned to the Center has been the development of the Spatial Data Standard for Facilities, Infrastructure, and Environment (SDSFIE), which is focused on the development of graphic and nongraphic standards for GIS implementations at Air Force, Army, Navy, and Marine Corps installations, U.S. Army Corps of Engineers Civil Works activities, and other Government organizations.

The SDSFIE data model consists of five basic levels of hierarchy: *Entity Sets, Entity Classes, Entity Types, Attribute Tables,* and *Domain Tables.* The SDSFIE Release 2.10 structure contains the following twenty-six Entity Sets:

Auditory	Boundary	Buildings
Cadastre	Climate	Common
Communications	Cultural	Demographics
Environmental Hazards	Ecology	Fauna
Flora	Future Projects	Geodetic
Geology	Hydrography	Improvements
Landform	Land Status	Military Operations
Olfactory	Soil	Transportation
Utilities	Visual.	

Of these, seven appear to best meet the standardization needs of our core mapping project in the areas of infrastructure and hazardous attributes. They are:

Buildings	Communications
Cultural	Evironmental Hazards
Improvement	Transportation
Utilities	

The appropriate *Entity Set* name is reflected in the first two characters of each attribute table name code. Example: The first two characters of each attribute table name code in the *Transportation Entity Set* is always represented by "tr".

Entity Classes comprise the next level of the hierarchical SDSFIE data model structure. Each *Entity Class* is equivalent to a separate map or drawing file. The name of *Entity Class* is represented by a three-character code that makes up a part of the attribute table name codes (and design/drawing files name codes for CADD and CADD-based GIS). For example: Each attribute table name in the ***transportation-vehicle*** *Entity Class* begins with "***trveh"***, where ***"tr"*** represents the *Entity Set* name (transportation) and ***"veh"*** represents the *Entity Class* name (vehicle).

Each *Entity Class* contains one or more *Entity Types.* An *Entity Type* roughly corresponds to a set of features, which attach to the same table and can be differentiated through the use of an attribute. For example: ***road centerline*** is an *Entity Type* associated with the *Entity Class* ***transportation-vehicle.*** The *Attributes* correspond to the data or information, which is retained regarding each *Entity Type*. In the SDSFIE structure, these are organized into relational groupings called *Attribute Tables.*

A complete description of the SDSFIE data structure and dictionary can be found in the Appendices of the *SDSFIE Data Model and White Paper* (Update June 2002) located at http://tsc.wes.army.mil/products/tssds-tsfms/tssds/html/sdsdocin.asp.

For purposes of our core map project, the *Entity Set* Environmental Hazards contains 31 *Entity Classes* and the following relevant *Entity Types*:

Construction stormwater	Ordinance/explosive waste
Radioactive waste	Petroleum waste
Mixed waste	Medical Waste
Chemical Waste	Hazardous Waste
Non-Point Source Pollution	Biological Warfare
Chemical Warfare	Munitions Waste

These *Entity Types* have a unique Symbology developed using the SDS RGB (red, green, blue) Color standard, Line Standard, and cell or symbol when appropriate. The following environmental media, building type or site condition have a defined symbology:

Groundwater	Air Pollution/Emissions
Building Environmental Concerns	Biological
Sediment	Soil
Solid Waste	Surface Water

Hazardous Sites (such as brownfield, superfund and environmental restoration)
Above ground, underground and Storage Tanks

As an example, the mapping data file for a radioactive groundwater plume would be:

Entity Set – Environmental Hazards
Entity Class - env_haz_groundwater_pollution
Entity Type – radioactive_waste_polluted_groundwater_area
Attribute Table – ehgwtrad
Definition: Area where radioactive waste residues are present in the groundwater at concentrations considered to be detrimental to the environment.
Symbology:
Object Type G/GT Polygon
SDS Color 3
R 255
G 0
B 0
ArcInfo/ArcView Line Style 9
SDS FIE Line 8
Width 2
Chain double dashed

Colors, legends and symbols are available for each *Entity Class* and *Entity Type*, and can be extracted from the *tssdssym_90500.pdf* file in the *Symbology* section of the SDSFIE web site. A list of those associated with *Entity Types* and *Classes* that are of greatest relevance to the DOE sites are shown in the Table below.

TABLE TO BE PROVIDED

In addition, SDSFIE has over 1,000 Attribute Tables, with 27,000 Attribute Fields, many of which could be used to identify and code environmental project types (compliance, cleanup, conservation, etc.), RCRA waste categories, and site remediation types (Fence or other site access control measures, treatment of an alternate water supply, capping insitu contaminated material with a nonpermeable membrane or nonporous soil material, drainage control measures, excavate contaminated material and treat in a separate prepared area by bioremediation, etc.). These Tables and Fields have unique definitions and codes, but do not have specific colors, symbols or other mapping legends associated with them. They are meant to serve as supporting data files that are part of the DOD's Relational Database Management System (RDBMS) supporting the SDSFIE, and roll-up into the higher level Entity Types and Classes.

4.3 Land Use Attributes

For the purposes of defining and mapping land use we recommend adopting the Land Based Classification Standards (LBCS) developed by the American Planning Association (APA). The LBCS is an update of the 1965 Standard Land Use Coding Model, and provides a consistent model for classifying land uses based on their characteristics. The LBCS model extends the notion of classifying land uses by refining traditional categories into five multiple dimensions - activities, functions, building types, site development character, and ownership constraints. Each dimension has its own set of categories and subcategories.

Activity refers to the actual use of land based on its observable characteristics. It describes what actually takes place in physical or observable terms (e.g., farming, shopping, manufacturing, vehicular movement, etc.). An office activity, for example, refers only to the physical activity on the premises, which could apply equally to a law firm, a nonprofit institution, a court house, a corporate office, or any other office use. Similarly, residential uses in single-family dwellings, multi-family structures, manufactured houses, or any other type of building, would all be classified as residential activity.

Function refers to the economic function or type of establishment using the land. Every land use can be characterized by the type of establishment it serves. Land-use terms, such as agricultural, commercial, industrial, relate to enterprises. The type of economic function served by the land use gets classified in this dimension; it is independent of actual activity on the land. Establishments can have a variety of activities on their premises, yet serve a single function. For example, two parcels are said to be in the same functional category if they belong to the same establishment, even if one is an office building and the other is a factory.

Structure refers to the type of structure or building on the land. Land-use terms embody a structural or building characteristic, which suggests the utility of the space (in a building) or land (when there is no building). Land-use terms, such as single-family house, office building, warehouse, hospital building, or highway, also describe structural characteristic. Although many activities and functions are closely associated with certain structures, it is not always so. Many buildings are often adapted for uses other than its original use. For instance, a single-family residential structure may be used as an office.

Site development character refers to the overall physical development character of the land. It describes "what is on the land" in general physical terms. For most land uses, it is simply expressed in terms of whether the site is developed or not. But not all sites without observable development can be treated as undeveloped. Land uses, such as parks and open spaces, which often have a complex mix of activities, functions, and structures on them, need categories independent of other dimensions. This dimension uses categories that describe the overall site development characteristics.

Ownership refers to the relationship between the use and its land rights. Since the function of most land uses is either public or private and not both, distinguishing ownership characteristics seems obvious. However, relying solely on the functional character may obscure such uses as private parks, public theaters, private stadiums, private prisons, and mixed public and private ownership. Moreover, easements and similar legal devices also limit or constrain land-use activities and functions. This dimension allows classifying such ownership characteristics more accurately.

Of the five dimensions to choose from, we believe that the DOE should classify it land uses by their ***Function***. This system would use the following nine major land uses categories and APA definitions:

1000 Residence or accommodation functions
This top-level category comprises all establishments offering residence or accommodation, such as homes, apartments, housing for the elderly, and hotels. Note that leased service departments (e.g. a grocery store in an apartment building) are usually considered separate establishments and should be classified separately in your database. See the detailed function dimension description for information on classifying leased service departments.

2000 General sales or services
The general sales and services category comprises the vast majority of establishments typically associated with commercial land use. Since this category covers such a wide range of establishments, the subcategories provide the best definition. These are: retail sales and service; automobile sales or service; finance and insurance; business, professional, scientific, and technical services; food services; and personal services. For most applications, the general sales and services category is not specific enough for classifying the economic function of

land. However, in cases where specific information is not available, this category may be used as a default for commercial land uses.

3000 Manufacturing and wholesale trade
Differentiating manufacturing from retail or service establishments can be confusing. The distinctions used in this category closely follow the NAICS definitions. Manufacturing establishments are located in plants, factories, or mills and employ power-driven machines and materials-handling equipment. They may also employ workers who create new products by hand, without the characteristic machinery-intensive enterprise. Many manufacturing establishments process products of agriculture, forestry, fishing, mining, or quarrying as well as products of other manufacturing establishments. The subcategories reflect sectors with distinct production processes related to material inputs, production equipment, and employee skills. Most manufacturing establishments have some form of captive services (e.g., research and development, and administrative operations, such as accounting, payroll, or management). These must be functionally coded the same as the establishment. However, when such services are provided by separate establishments, they are classified in the appropriate function code, and not in manufacturing. Use the activity dimension to differentiate between an office activity and a factory activity for such establishments.

4000 Transportation, communication, information, and utilities
This is a catch-all category comprising transportation, communication, and utilities for essential facilities. In this category, an establishment cannot be distinguished by a single physical location as it can in most other categories. To classify land in this category, other factors are needed for deciding which land serves a particular establishment. In most cases, the type of establishment in this category is easily deduced from the type of structures and actives on the land. The remaining difficulty is deciding how significant a structure or activity is necessary for the land to be associated with an establishment type. For example, it would not be realistic to classify all land with telephone lines under telephone communications; however, land with more important telephone communication facilities may be classified here.

5000 Arts, entertainment, and recreation
These establishments operate facilities or provide services for a variety of cultural, entertainment, and recreational functions. Establishments include those that produce, promote, or participate in live performances, events, or exhibits intended for public viewing; those that preserve and exhibit objects and sites of historical, cultural, or educational interest; and those that operate facilities or provide services to serve activities associated with amusement, hobby, and leisure time interests. Use the other dimensions, especially ownership and site development character, to further differentiate the precise nature of land use associated with these establishments.

6000 Education, public admin., health care, and other inst.
This is a catch-all category for grouping a variety of functions, which planning applications normally aggregate.

7000 Construction-related businesses
These establishments either build buildings or structures, or perform additions, alterations, reconstruction, installation, and repairs. They may also provide building demolition or wrecking services. Establishments engaged in blasting, test drilling, landfill, leveling, earthmoving, excavating, land drainage, and other land preparation are included as well. This category reflects the unique processes employed by the establishments. Coding should reflect the location of the establishment and not where it is performing its services (which often happens on other sites). Construction sites must get the appropriate function code for the enterprise for which the construction (or demolition) is being undertaken. However, in the activity dimension, such sites may be categorized under construction activity.

8000 Mining and extraction establishments
These establishments extract natural mineral solids (coal and ores), liquid minerals (crude petroleum), and gases (natural gas). Mining includes quarrying, well operations, beneficiating (e.g., crushing, screening, washing, and flotation), and other preparations customarily performed at the mine site, or as a part of mining activity.

9000 Agriculture, forestry, fishing and hunting
These establishments grow crops, raise animals, harvest timber, and harvest fish and other animals from a farm, ranch, or their natural habitats. They may be described as farms, ranches, dairies, greenhouses, nurseries, orchards, or hatcheries. A farm, as an establishment, may be one or more tracts of land, which may be owned, leased, or rented by the farm operator. Farms may hire employees for a variety of tasks in the production process. Subcategories in this dimension differentiate establishments involved in production versus those that support agricultural production. For agricultural research establishments administering programs for regulating and conserving land, mineral, wildlife, and forest use, apply the relevant institutional or research and development categories.

The Land Based Classification Standards color codes follow a standard convention for top-level land use categories only, for maps, GIS, and other rendering and presentation media. The color and codes for the Function based land use definitions described above are shown in the Table below and can be found at
http://www.planning.org/lbcs/standards/colorcodes.htm

Function 1000-1999 color codes


RGB Value:(251, 248, 60)
RGB Hexadecimal Value: FBF83C

Function 2000-2999 color codes

RGB Value:(233, 51, 51)
RGB Hexadecimal Value: E93333

Function 3000-3999 color codes

RGB Value:(172, 89, 202)
RGB Hexadecimal Value: AC59CA

Function 4000-4999 color codes

RGB Value:(210, 210, 210)
RGB Hexadecimal Value: D2D2D2

Function 5000-5999 color codes

RGB Value:(166, 255, 165)
RGB Hexadecimal Value: A6FFA5

Function 6000-6999 color codes

RGB Value:(45, 107, 254)
RGB Hexadecimal Value: 2D6BFE

Function 7000-7999 color codes

RGB Value:(73, 139, 142)
RGB Hexadecimal Value: 498B8E

Function 8000-8999 color codes

RGB Value:(124, 66, 145)
RGB Hexadecimal Value: 7C4291

Function 9000-9999 color codes

RGB Value:(69, 127, 65)
RGB Hexadecimal Value: 457F41

5.0 GEMS AND INTERNAL DOE RESOURCES

The Geospatial Environmental Mapping System (GEMS) was designed to provide dynamic mapping and environmental monitoring data display for sites under stewardship by the DOE Grand Junction Office (DOE-GJO) Long-Term Surveillance and Maintenance (LTSM) Program. GEMS is the result of a pilot project in 2002 to develop a web-based GIS for the LTSM program that could be used by all stakeholders, including DOE, regulatory agencies, LTSM program staff and local community members. The first phase consisted of assessing the information needs and developing web application specifications. Based on these requirements, a prototype was developed and demonstrated. This was followed by final development and deployment of basic mapping data layers and environmental monitoring information at 28 LTSM sites .

Unlike the LandTrek web site, GEMS was integrated into the existing LTSM Program web. The Grand Junction Office retains responsibility for maintaining and updating the environmental monitoring data and mapping data layers for the existing LTSM sites. A

similar function will be performed as more sites are transitioned into the LTSM Program. With GEMS, the user can start with a map of the US and then click on a state with sites listed or use the drop-down site menu and select a specific LTSM site. GEMS employs simple user-friendly navigational tools which includes the ability to zoom in and out, to pan, to print etc. The data layers presented include monitoring wells, fences, roads, streams, water bodies, disposal cell boundaries, and site boundaries. USGS 1:24000 guadrangle maps and georeferenced orthophotography photography (if available) can also be displayed to provide a more regional context view of the site.

The GEMS format differs from our core maps in two ways. The first is that, at least in its current configuration, GEMS does not intend to show many of the human and ecological activity attributes that we are recommending. In fact, they were not listed in the Pilot Project survey document that was used to determine needs and priorities. The second difference is that much more extensive contaminant data has been collected and made available for easy access through the web-based interactive maps. The user is able to click on any monitoring well displayed, and obtain a wealth of current and historical information about multiple contaminants, some even in graphic form. Photos from the annual site inspection are also available on most of the sites.

These mapping differences result from differences in the status of these DOE sites versus those that we are addressing in this report, and not from any inconsistency or differences in geospatial data collection or mapping philosophy. The LTSM sites are not undergoing active remediation and restoration and thus are not in need of developing a risk-based end-state vision. They are largely inactive sites, except for ongoing monitoring, surveillance and other long-term stewardship requirements. As such, their priority is to provide regulators and the public with data and other information that shows that any remaining contaminants are being effectively monitored and controlled.

GEMS, and more specifically the Grand Junction Office, represent a valuable resource that should be used to help implement this core map program at DOE sites across the country. Grand Junction has, through the lessons learned in converting 30 sites, developed a deep understanding of the problems, issues and challenges of building a geospatial database and mapping system for sites with little or no understanding of the subject. It has been learned effort required is in proportion with the quality and availability of the data. In response, Grand Junction has developed a process or protocol for working with new sites, even before cleanup is completed and they are transferred to the LTSM Program. This seasoned approach and the availability of DOE staff experienced in developing web-based GIS systems for a variety of sites should be factored into any proposed core map implementation program.

A more descriptive discussion of the GEMS system and its possible application to the RBES Project has been prepared by John Stewart (DOE-HQ) and Dan Collette DOE-GJO), and is included as Appendix D.

6.0 DATA MANAGEMENT AND QUALITY

In a very broad sense, working with geospatial data involves three tasks: data generation, data management, and data dissemination. Data generation involves data collection and QA/QC practices; Data management involves archival of data into databases and generation of metadata; and Data dissemination involves production of maps and/or reports for conveying the substance of the data to the intended target audience.
If the focus is on obtaining new geospatial data that are hitherto unavailable, then data generation becomes a consideration. However, for this project the greater focus is on collecting, organizing, and disseminating available data, and efforts should concentrate on the latter two tasks. It should be noted that robust data dissemination practices simply cannot be implemented unless good data management practices are in place.

Good geospatial data management practices are no different from good general information management practices, except for the additional stress on the spatial (and possibly spatiotemporal) dimensions of data being managed. There are several dimensions to data management, such as choice of relational database management software, the architecture of the database, formatting standards, security and access control criteria, documentation and cataloguing of data, and so on. This Guidance paper does not intend to cover all different areas of data management in detail. The focus will be on cataloguing and documentation of data, with emphasis on generation and maintenance of metadata.

5.1 What are metadata?

Metadata have been widely defined as "data about data", or in other words, detailed descriptions about the content of a particular data set. Metadata are intended to provide the user a detailed characterization of the content, quality, conditions and other attributes of the data, without having to access the actual data (FGDC, 2000). A completed 1040 Tax form is, in a sense, metadata regarding an individual's financial information.

As noted earlier, a content standard for digital geospatial metadata was promulgated in 1994 through an executive order (Executive Order 12906). The purpose was to standardize procedures so the prospective user could determine the availability of a set of geospatial data, determine the fitness of the set of geospatial data for an intended use, determine the means of accessing the set of geospatial data, and successfully to transfer the set of geospatial data.

5.2 How are metadata generated and maintained?

Metadata are generated and maintained by individuals in charge of developing and maintaining GIS coverages. Metadata generation should ideally begin with collection of data; however, metadata can also later be generated for legacy datasets. Essentially, metadata generation entails production of standardized data description forms. For someone knowledgeable about the data coverage being described, generating metadata is no different from filling out a tax form. No specialized technical skills beyond an intimate knowledge of the data being described are required. And, as in filling tax forms, software packages are readily available to ease the process of metadata generation and maintenance.

While generating and maintaining metadata is not a time consuming, complicated, or expensive exercise in itself, there can be significant administrative blocks in the process of developing metadata. Metadata are often developed as an afterthought, and the task of generating and maintaining them is regarded as trivial or a time-consuming chore. Generating data descriptions is also incorrectly regarded as being a non-essential or bureaucratic requirement that can compromise confidentiality of data.

U.S. standards for metadata generation are currently set by the Federal Geographic Data Committee (FDGC) in FDGC-STD-001-1998 (FDGC, 1998). The document gives the document structure, content and semantic convention criteria for metadata documents. Detailed guidelines for metadata generation and maintenance are given in the accompanying workbook (FDGC, 2000).

It is not enough to merely generate metadata once. Since databases are living, evolving entities, metadata maintenance is a continuous process that is an integral part of a sound data management policy. Every time a database is modified or expanded, the changes should be noted in the metadata document. Equally importantly, contact information should always remain current to enable users to contact the right person for accessing the data or for seeking further details about the data.

The administrative blocks preventing metadata management can be overcome through DOE-HQ policy decisions. The actual task of generating and maintaining metadata falls to relatively junior staff, so there is a danger that metadata quality may be variable, maintenance and updating of metadata may be neglected, and metadata formats may be inconsistent across different departments in the same organization. These pitfalls can be avoided through level policy directives about metadata generation and maintenance practices. Standardized metadata forms conforming to FDGC or ISO standards are readily available and are already being implemented by several federal, state and local agencies. Procuring standardized forms is trivial and free, and a clearly enunciated policy goes a long way in overcoming institutional inertia in managing metadata.

6.0 DISCUSSION AND NEXT STEPS

These different mapping standards have never been combined with the core maps that are recommended, or with each other into a single integrated set of mapping standards. There may be overlaps in the colors or legends that each use, and several unique physical and environmental attributes of the DOE sites may not be fully addressed. Discussions are continuing with USGS regarding its evolving National Map project, and whether that will provide a more comprehensive and integrated land cover and land use system of definitions, colors and legends.

It is also important that several pilot projects, at sites of varying size and complexity, be undertaken jointly by CRESP and DOE staff over the next few months. We have already initiated such discussions with the DOE Ashtabula site and expect to prepare a set of core maps with these attributes, standards, and a combination of existing and public geospatial

data sources, during the week of April 28th. The Brookhaven site would appear to be good test to determine the time required to convert a comprehensive data and mapping set to these recommended formats. Involving the Grand Junction Office in some or all of these pilot projects might be a further way of refining the formats and implementation process.

As noted at the beginning of the paper, this core set of geospatial maps are intended to identify the location of sources of potential risk, and the interfaces and possible pathways that might bring them into contact with at risk human and ecological populations. The ability to reduce or eliminate the contaminant, and/or to control its ability to reach human and ecological receptors would be shown on the maps depicting the site's end-state vision. These maps are a foundation for quantifying, but not a depiction of the actual or relative level of risk represented by each contaminate source. We believe that a fourth type of map may be required to show the different types of risk present on the site, now and in the future, but before that can happen there must be an agreement on how risk should be measured, and whether ranking of risk is an absolute or relative measurement. We recommend that a small team of DOE and CRESP personnel meet in the next few weeks to address and resolve this issue.

Appendix A

Map Attribute Types and Categories

PHYSICAL AND SURFACE INTERFACES

1. **Administrative**

   Legal boundaries of local & county governments, tribal nations, military sites, national wildlife and wilderness areas, etc.
   DOE Site boundaries
   DOE Fence lines
   Historical sites
   Footprint of buildings – differentiate by type of building; i.e. private, public, abandoned, operational, manufacturing, office, school, hospital
   Ownership – surface and sub-surface

2. **Transportation & Infrastructure**

   Highways and major roads – primary, secondary, tertiary, divided, 2 lane, paved, unpaved, dirt
   Railroads – passenger, freight
   Utilities – oil, gas, electric, high power, telephone, fiber optic lines
   Other infrastructure – dams, water and wastewater treatment plants (private, public), power plants (nuclear, coal)

3. **Surface Configuration**

   Topography
   Land cover – follow USGS classifications
   Soil types
   Contours
   Surface water – lake, river, stream
   Elevation points
   Other Physical Features (including seismic)

RISK SENSITIVE HUMAN AND ECOLOGICAL LAND USES

4. **Community**

   Population centers – cities
   Population densities, information on vulnerable subpopulations (seniors and children), socio-economic status of different groups, and distribution of minorities in close proximity to site.
   Schools, houses, hospitals & other major buildings in close proximity

5. **Land Uses (follow APA classifications)**

   Industrial – light, heavy
   Commercial, retail
   Residential – single family, multi-family
   Open space, parks
   Agriculture

6. **Environmentally Sensitive Areas**
   Conservation and ecological areas
   Open space – active and passive recreation
   Habitats of concern (especially unique habitats)
   Threatened or Endangered Species
   Single source aquifers

7. **Hydrography**
   Watershed identification
   Floodplains, wetlands, marshes
   Surface water
   Flow direction
      Discharge locations
   Groundwater
      Flow direction
      Groundwater divide
   Drinking water sources
   Vertical cross-section of geology and aquifers
   Rainfall, temperature and wind data

HAZARDOUS SOURCES

8. **Hazardous areas of concern [each major group of contaminants to be defined separately (e.g. radionuclides, chlorinated solvents, etc.)]:**
   Surface water - areas of sediment contaminations (including concentration isopleths)
   Groundwater - contaminated areas (including concentration isopleths)
   Monitoring wells (locations, screening depths, COPC concentrations)
   Soils - contaminated areas (including concentration isopleths)
   Buildings - contaminated areas
   Storage containers – contaminated – above & below ground
   Air emissions (magnitude and type)
      Wind rose
      Discharge points[2]

[2] It may be that there should be another set of attributes as well: Regulatory Authority Attributes. DOE views on this would be helpful

Appendix B

Geospatial Data and Mapping Sources

We have recommended a set of geospatial core maps, which in our best judgment can be developed at every DOE site with a minimal cost and a maximal reliance on readily available data. We believe that most, if not all, of the sites already have or have ready access to, geospatial or paper data on most of the on-site attributes needed to prepare the *Site-Wide Context* and *Hazardous Area of Concern* maps. Most of the sites have previously developed maps showing infrastructure, building footprints, contaminant areas, and other on-site attributes, and as a first step we recommend that they do an inventory of existing in-house (DOE and contractor) spatial data. The question that is most likely to be raised is where can they obtain the off-site data needed for the *Regional Context* maps.

This Appendix has been prepared to provide the reader with a small glimpse of the huge amount of geospatial data that has been developed by state and federal governments and their agencies. Most of the maps are available for viewing and download over the Internet using GIS software packages already owned by many DOE sites. Smaller sites that do not have GIS capability can download and use ESRI's free ArcExplorer software package – see http://www.esri.com/software/arcexplorer/index.html

There are many web sites from which the researcher or GIS practitioner can begin to search for on and off-site regional data, including the ***National Geospatial Data Clearinghouse*** which is operated by the Federal Geographic Data Committee. We believe that the ***Center for Advanced Spatial Technologies (CAST)*** facility at the University of Arkansas maintains one of the most comprehensive and easy to use web sites. It is titled ***Starting the Hunt: Guide to Mostly On-Line and Mostly Free U.S. Geospatial and Attribute Data.*** Please go to http://www.cast.uark.edu/local/hunt/index.html and click on **Second Edition.**

As you will see, the Center has organized several hundred web-based data sources into two broad classifications: **National Aggregations** and **State and Local Aggregations**. The vast majority of these web sites require ArcView or other GIS software systems to view the data, which severally limits our ability to show the reader of this Addendum the depth and quality of the maps and data available, but a sufficient number of these sites are accessible without using ArcView to demonstrate the value and flexibility of this large web-based geospatial data source.

One example that permits us to show the depth of some of the information available is under the State of South Carolina. Please scroll down to *South Carolina*, click on the *South Carolina Department of Natural Resources GIS Data Clearinghouse* site. When you reach that site, click on *Download Data* from the menu on the left. You can either register and obtain your own ID number, or if you like you can type in Henry in the box for *First Name* and the number 17515 for *Reference ID*. When you reach the Main Menu, click on the *County Map Query* on the left, and when the map of the state appears,

click on *Aiken County* (home of the Savannah River Site). On the next map click on either the *Aiken, New Ellenton,* or *Hollow Creek* boxes. Assuming everything worked correctly you should be at a table showing the various types of data available for that Quad and when it was last updated, along with web links to the related geospatial maps and metadata. For Aiken this page is located at:
http://www.dnr.state.sc.us/pls/gisdata/quad.qselect?ptilename=AIKEN&pcounty=aiken

Among the databases available for viewing and download are digital orthophotos (aerial photos taken in 1999); data from USGS on hydrography, topography, elevation, pipe/transmission lines, roads and railroads; wetlands data from the U.S. Fish & Wildlife Service; and, soils data from the National Cooperative Survey. All are in standard 7.5 Quad map format, with the exception of the orthophotos, which are available in quarter quads.

Another example of the depth and type of geospatial data available through the ***CAST*** site is under the State of Ohio. Returning to the ***CAST*** main menu page http://libinfo.uark.edu/GIS/us.asp scroll down to *Ohio*, and then click on the *OhioLINK Media Center* and its Landsat 7 Satellite Images site. Then click on the *Path 20 Row 32* area of the state map that appears, and choose the High Resolution Monochrome option. This produces a satellite image of the entire central western area of the state. A variety of dates can be chosen if the image that appears is not sharp enough because of clouds, smoke or other interference. Using the Navigation Tool on the right, the user can zoom in on a smaller geographic area of interest. In addition, the user can click on the *Topographic Map Area of this Region* tool and *1:100,000 scale* to generate a topographical map of an even smaller area. And with a few further adjustments we can generate a map of Miamisburg that shows the location of the DOE's Mound facility, produced by TopoZone.com. Please go to:
http://www.topozone.com/map.asp?lat=39.6223318006107&lon=-84.2788917130149&s=100&sizes=s

Zooming to *1:25,000* scale on the Mound site produces an even finer topographical map, which when blown up to the map's *Medium* and *Large* versions shows the site's location relative to a golf course, local sewage disposal facility, and various residential areas. See – http://www.topozone.com/map.asp?z=16&n=4389427&e=732881&s=25&size=m

What we also learn in the process of this exercise is that TopoZone.com has worked with USGS to produce interactive topographical maps for the entire United States. Thus, we can quickly access similar information on virtually any area of the country. As an example, the following is a large map at 1:50,000 scale of the DOE's Rocky Flats (Rocky Mountain Arsenal) site. See -
http://www.topozone.com/map.asp?z=13&n=4407530&e=513913&s=50&size=l

Summary
These several examples provide a small glimpse into the huge number of geospatial and other databases that are readily available through the ***Center for Advanced Spatial***

Technologies (CAST) web site. There are a large number of federal government and agency web sites with valuable geospatial data that can be accessed via ***CAST*** or reached directly, such as USGS, the Bureau of Land Management, Department of Agriculture, Department of Housing and Urban Development, the Environmental Protection Agency, and U.S. Park Service. Many states, such as South Carolina, provide web access to more localized data, and others will make information available on CDs for a fee.

Appendix C

DOE Geospatial Mapping Systems

LandTrek

"The LandTrek web site is an interactive web-based tool designed to encourage collaborative decision-making among federal facility project managers, federal and state regulators, and other stakeholders associated with federal facility restoration projects and activities, from site identification through closure, reuse or land transfer" (LandTrek 2003). It was developed and is maintained by the Oakland, CA office of the Department of Energy in cooperation with the Air Force Center for Environmental Excellence (AFCEE) in San Francisco, CA. This web site is best described as an Internet Portal, which is a site that provides public access to data that is presented in multiple formats developed by organizations or units independent of the web site operator.

LandTrek provides varying types and amounts of information about the DOE facilities at INEEL, Brookhaven (BNL), Mound, Grand Junction, and Oakland and the AFCEE Vandenberg site. The vast majority of the information provided is a textual description of regulations, project status, and other information relevant to that site. The BNL section, which requires a separate password, however, provides state-of-the-art interactive GIS maps that show current and historical areas of contamination, both on and off the site. Beginning with a map of Long Island, the user is able to see the site and contaminated areas in relationship to the larger region and important physical attributes, such as rivers, roads and towns. Through interactive web-based tools, the user is able to zoom down to smaller areas of concern, and even view cross-sectional diagrams of the underground contaminant plumes relative to local streets and monitoring wells. BNL incorporates the full range of maps that we are recommending for all DOE sites, and display virtually all of the attributes we are recommending. The missing attributes are those associated with potentially sensitive population areas in close proximity to the site. Ideally we would like to see all DOE sites develop similar GIS and web-based mapping capabilities in the near future, but it may be more than is currently required to satisfy most regulators and other stakeholders. More importantly, many DOE sites may not have the data or GIS capabilities to produce maps of this quality and flexibility at the present time.

However, we feel that regulators, the public and DOE itself are seeking to obtain more and more data and other information over web-based systems, whether that be the Internet (open to public) or Intranet (closed network within DOE). These systems have the capability of putting a large amount of data and other information at the user's fingertips, and permit them to quickly look at a variety of maps using different configurations of that data. We are hoping to have an opportunity to work with BNL over the next few months to explore how other DOE sites can develop this capability. We also would like to explore how LandTrek and GEMS might be integrated into a universal DOE web-based site for displaying these and other of our proposed core maps.

Facilities Information Management System (FIMS)

"The Department of Energy is using the Facilities Information Management System (FIMS) as a tool that assists us in managing our corporate physical assets. FIMS is the Department's corporate real property database for real property as required by Life Cycle Asset Management Order 430.1. Real property includes land and anything permanently affixed to it, such as buildings, fences, and building fixtures (lights, plumbing, heating and air conditioning, etc). Complete and accurate information on real property holdings is critical to the Department for managing facilities and reporting to the General Services Administration (GSA), Office of Management and Budget (OMB), Congress, and the taxpayers."

"FIMS contains information on DOE real property holdings which include:

- over 2.5 million acres of Land with a cost of over $480 million dollars
- over 10,500 Buildings with over 127 million square feet of space
- Building cost over $11 billion dollars
- over 6000 Other Structure and Facilities with a cost over $7 billion dollars
- Nearly 4500 Trailers with cost totaling more than $147 million dollars"

"The data elements within FIMS are sponsored by various Headquarters program offices. As a data element sponsor, the program offices are responsible for defining the data element, providing guidance, and justifying the need to collect the data within FIMS. Information is tracked on an individual asset basis. The data is organized by ownership which includes DOE Owned, DOE Leased, Contractor Leased, Permit, GSA Owned and GSA Leased" (FIMS 2003).

The FIMS User Guide contains an extensive list of building types that are defined by their usage. Their classification and coding system for buildings is built on the two digit format established by Government Services Administration (GSA) for identifying federal facilities, with a third digit added to provided more finite uses within each code. As an example, the GSA code for Hospitals is 21. FIMS breaks the category into hospital (210), medical clinic (211), examination and testing facilities (212), veterinary clinics (213) and other medical facilities (214). Among the data collected and stored for each building is its geographic location on the site. But this location does not have to be georeferenced in terms of standard longitude and latitude coordinates required to support a GIS system. Nor are legends, colors, symbols or other mapping references suggested. FIMS is, as described above, a tool for inventorying and managing physical assets, and not the geospatial database or mapping system we are seeking for this project. However, needless to say, FIMS data would be useful as part of a database mapping system.

Appendix D

ANAYLSIS OF THE POSSIBLE APPLICATION OF GEMS IN MEETING THE MAPPING GUDIANCE NEEDS FOR PROJECT 7

By
John Stewart (DOE-EM) and Dan Collette (DOE-GJO)

The Geospatial Environmental Mapping System (GEMS) was designed to provide dynamic mapping and environmental monitoring data display for sites under stewardship by the DOE Grand Junction Office Long-Term Surveillance and Maintenance (LTSM) Program. The information made available and the environmental data display tools developed for GEMS were done based on input from various stakeholders including regulatory agencies, the public and DOE. Although GEMS was specifically developed for the LTSM program at the Grand Junction Office (GJO), the mapping aspect of the system could have direct applications to the Risk Based End State (Project 7) study currently in progress.

MORE ABOUT GEMS: GEMS was initially developed as a pilot project to provide stakeholders access to basic monitoring well information, groundwater quality information, water level information, and annual site inspection photographs for approximately 30 sites currently under stewardship at the GJO. One of the biggest challenges facing DOE today is being able to properly georeference the location and extent of disposal cells and monitoring wells for future tracking and regulatory compliance needs. Too often this critical information has been lost for future generations (often within only a few years) despite the tremendous cost for cleanup and monitoring and the commitments made to regulators and the public. The GJO has successfully geo-referenced data from a number of smaller sites and continue to perform the ongoing environmental data management functions required for stewardship. GEMS provides a method for displaying this information in a uniform manner for all LTSM sites.

Currently with GEMS, the user can start with a map of the US and then click on a state with sites listed or use the drop-down site menu and select a specific LTS site. GEMS employs simple user-friendly click on navigational tools including the ability to zoom in and out, to pan, to print etc. The data layers include groundwater monitoring wells, fences, roads, site boundaries, aerial photography, USGS quad sheets, etc. GEMS can be accessed from the LTSM Program home page http://www.gjo.doe.gov/programs/ltsm or directly at http://gems.gjo.doe.gov. More information including the LTS GIS Pilot Project Needs Assessment Report, the LTS GIS Pilot Project Final Report, and the GEMS Users Guide is available on the GEMS web site.

LESSONS LEARN AND HOW GEMS WAS DEVELOPED

One of the lessons learned by the GJO pertained to mapping data layer management. This, in conjunction with the lessons learned in the development of the GEMS system,

could be especially helpful for developing the data management and mapping needs of smaller sites that currently have no geographic information systems (GIS) or adequate collection of georeferenced source maps. Many of the LTSM sites had very limited map sources which often included only paper maps that were not georeferenced to any standard grid such as the State coordinates, Lat-Long, or UTM. To geospatially locate a site for GEMS, it was sometimes necessary to convert site drawings to a geographic or a projected coordinate system.

In order to properly geo-rectify the location of needed data such as the disposal cells and monitoring wells, it was often necessary to field verify or even re-survey the site using conventional ground survey or aerial survey techniques. The time that is required and the additional costs that were incurred for conducting such field ground truthing or re-surveying varied greatly based upon the availability of the "trusted" geo-referenced data. This points to the urgent need for data standards, namely data layers requirements, data layer naming and attributing standards, and electronic format standards to meet the needs for DOE. (Reference the GJO Lessons Learned document for more information as the how these non-georeferenced maps were translated into a global coordinate system.[3])

POSSIBLE APPLICATION OF GEMS TO PROJECT 7

GEMS has proven itself to be an excellent tool for displaying LTS environmental monitoring data in a mapped format with very easy public access via the Internet. Although it was developed primarily as a LTS tool, it may have a direct application to addressing the mapping needs for displaying risk-based end state information as needed in Project 7. All the displayed GEMS data, such as the location of wells, fences, roads, site boundaries, surface water, disposal cells, etc. should also be included in any risk-based analysis. In addition, while not currently displayed with GEMS, the system could display other data layers such as the location and extent of contamination plumes for both on site and off site locations in either 2D or 3D. Institutional control (IC) boundaries and the data associated with them could also be a data layer available on GEMS. Additional risk-based information can be added to the system as needed from various sources, depending on availability.

Another good quality of GEMS is that it is was not just site specific but can include site-specific data layers on as needed bases. For example, GEMS displays information on the location and data for the numerous wells offsite in the Monticello community. Other risk-based, IC and environmental data can easily be displayed since the site inventories includes aerial photos and UGSG 1:24,000 (large scale) coverage for both onsite and offsite.

MAPPING STANDARDS AND THE NEED FOR UNIFORM SYMBOLOGY

To maintain uniformity and to be able to compare information between the various sites, it is important to maintain both mapping and symbology standards. If property

[3] GJO Lessons Learned Working with Long Term Stewardship Sites from a Data Management/ GIS perspective

georeferenced, this allows for the aggregation of spatial information (such as the size and extent of risk based information) for the DOE complex. Aggregate risk based information allows for good summarization of the risk-based process, and to display the progress of risk-based cleanup efforts to Congress and the public

There is universal 1:24,000 USGS map coverage for the nation. Also, this mapping information is available from the USGS at reasonable cost in a raster digital format (DRG) and digital line graph format (DLG). Orders for DRGs can be made to Sioux Falls, S.D. at 605-594-6151 or through a USGS business partner. These maps have basically eight layers on information: transportation, hydrology, hypsography (topographic contours), man-made structures, survey contour layers (bench marks, etc.), vegetative cover, non-vegetative cover (open fields, etc.) and boundaries (state, county, etc.)

The DRGs are excellent backdrop maps for providing background information for the sites and surrounding areas since they are universally available with consistent scale and consistent symbology. However, since it is a raster product, individual layers cannot be turned on and off. This can make the map "very busy" and as additional layers are added, such as monitoring wells, legibility becomes a problem. Another option is to take the DRG maps and remove layer by layer the data that is not needed for the base maps. Assistance for this mapping process can also be provided by the USGS.

DLGs, on the other hand, is vector data for each of the eight data sets that can be turned on and off as desired. The USGS has addressed the need for producing vector maps for displaying various layers for the USGS quads.[2] They have worked with the states in the past to produce digitized vector quad maps. A list of quads already in a vector format can be obtained from the USGS or one of their business partners. Also, the UGSG can produce additional vector quad maps at cost depending on the complexity of the quad maps and coverage, etc. Other layers, , such as end state land use for Project 7, can then be added to the base map as an additional overlay.

It is important that uniform symbology and colors be used for maps developed in support of Project 7. Perhaps the most universally accepted symbology for map legends are those used by the USGS on their quad maps (see http://mac.usgs.gov/mac/isb/pubs/booklets/symbols/ for more information). It is suggested that we seriously consider using these symbols for maps in support of Project 7. ArcView (ESRI product) uses the UGSG symbols to display this symbology in their mapping software programs. This is important because most DOE sites already use ESRI projects.

RECOMMENDATIONS: It is suggested that consideration be given to use the GEMS program as a model for web-based maps that display risk-based information in support of Project 7. This is a working DOE system that is readily accessible for review by the public via the Internet and is user friendly. Consideration should be given to using the

[2] Based upon conversations with Bruce Wallace, UGSG, 703-648-5526, April 3, 2003

1:24,000 USGS quads in DRG and/or DLG form as base maps if the site currently does not have georeferenced base maps. It should be recognized that the quad map is only as current as it's last update. .

While the GEMS model may be a good model to use, consideration should be given to incorporating LandTrek elements and suitable elements from other GIS programs that have applications in meet this mapping need. As mentioned by CRESP, we need to also check into various GIS inventory systems throughout the nation (especially at universities and at the Federal Geographic Data Committee One-Stop program) to see what georeference environmental data may already be readily available. In addition, the new LandView 5 develop jointly by USGS, Census, and EPA has universal coverage for social-economic data (including race, income, etc.) and risk-based information (including location of NPL sites and other sources of contamination). LandView 5 has been updated to include nation-wide 2000 census data.

Table 1 – Recommended Attributes for Each Core Map Showing Current Site Conditions

Regional Context Map		
Type of Attributes	**Attribute Categories**	**Recommended Attributes**
Physical & Surface Interfaces	Administrative	Boundaries of local and county government, Tribal Nations, national wildlife and wilderness areas
		DOE Site boundaries
		Historic sites
		Footprint of important buildings or building complexes
	Transportation & Infrastructure	Highways and major roads
		Railroads
		Important oil, gas, high power, telephone, fiber optic lines
		Important infrastructure – dams, water treatment plants and power plants
	Surface Configuration	Topography
		Land cover – follow USGS
		Surface waters
		Other important physical features
Human & Ecological Land Uses	Human Activities	Population centers
		Open space, parks and recreational areas
	Ecological Activities	Conservation and ecological areas
		Areas with habitats of concern, including threatened or endangered species
		Watershed delineation, floodplains, wetlands, marshes
	Land Uses	Major land use delineations – follow APA
	Hydrography	Single source aquifers
		Drinking water sources

Regional Context Map- Continued		
Type of Attributes	**Attribute Categories**	**Recommended Attributes**
Hazardous Sources	Areas of Concern	Surface water and sediments - plumes
		Groundwater - plumes
		Soils - plumes
		Buildings & Storage facilities – above and below ground
		Air emissions – discharge points
Site-Wide Context Map #1		
Type of Attributes	**Attribute Categories**	**Recommended Attributes**
Physical & Surface Interfaces	Administrative	Boundaries of local and county government, Tribal Nations, national wildlife and wilderness areas that are contiguous to site
		DOE Site boundaries
		DOE Fence lines
		Historic sites
		Footprint of all major buildings – differentiate by type of building
		Ownership – surface and sub-surface
	Transportation & Infrastructure	Highways and major roads – differentiate by primary, secondary, divided, paved etc.
		Railroads – passenger & freight
		Utilities – below ground (oil, gas, fiber optic), above ground (electric, high power, telephone, fiber optic)
		Other infrastructure – dams, water & wastewater treatment plants, power plants (nuclear, coal)
	Surface Configuration	Topography
		Land cover – follow USGS
		Soil types
		Contours

Site-Wide Context Map #1- Continued		
Type of Attributes	**Attribute Categories**	**Recommended Attributes**
	Surface Configuration	Surface waters – lake, river, stream
		Elevation points
		Other important physical features
Hazardous Sources	Areas of Concern	Surface water and sediments - plumes
		Groundwater - plumes
		Soils - plumes
		Buildings
		Storage facilities – above and below ground
		Monitoring wells - locations
Site-Wide Context Map #2		
Type of Attributes	**Attribute Categories**	**Recommended Attributes**
Human & Ecological Land Uses	Human Activities	Population areas, vulnerable subpopulations (seniors and children), minorities – by potentially impacted census tract
		Schools, hospitals, other major buildings in proximity
		Open space, parks and recreational areas
	Ecological Activities	Conservation and ecological areas
		Areas with habitats of concern, including threatened or endangered species
		Watershed delineation
		Single source aquifers
	Land Uses	Major land use delineations – follow APA
	Hydrography	Floodplains, wetlands, marshes
		Surface water – flow direction, discharge locations
		Groundwater – flow direction, groundwater divide

Site-Wide Context Map #2- Continued		
Type of Attributes	**Attribute Categories**	**Recommended Attributes**
	Hydrography	Drinking water sources
		Vertical cross-section of geology and aquifers
		Rainfall, temperature and wind data
Hazardous Sources	Areas of Concern	Surface water and sediments - plumes
		Groundwater - plumes
		Soils - plumes
		Buildings
		Storage facilities – above and below ground
		Monitoring wells - locations
		Air emissions (magnitude & type) – wind rose and discharge points
Hazardous Areas of Concern Maps		
Type of Attributes	**Attribute Categories**	**Recommended Attributes**
Hazardous Sources	Areas of Concern	Separate map for each hazardous area of concern – show greater detail such as concentration isopleths, screening depths, COPC concentrations.
		Optional: cross-sectional diagrams of modeled plumes
		Optional: human and ecological ARARs

Table 2 – Recommended Attributes for Each Core Map Showing Risk-Based End-State Conditions

Regional Context Map		
Type of Attributes	**Attribute Categories**	**Recommended Attributes – *Show End State Condition***
Physical & Surface Interfaces	Administrative	Boundaries of local and county government, Tribal Nations, national wildlife and wilderness areas
		DOE Site boundaries
		Historic sites
		Footprint of important buildings or building complexes
	Transportation & Infrastructure	Highways and major roads
		Railroads
		Important oil, gas, high power, telephone, fiber optic lines
		Important infrastructure – dams, water treatment plants and power plants
	Surface Configuration	Topography
		Land cover – follow USGS
		Surface waters
		Other important physical features
Human & Ecological Land Uses	Human Activities	Population centers
		Open space, parks and recreational areas
	Ecological Activities	Conservation and ecological areas
		Areas with habitats of concern, including threatened or endangered species
		Watershed delineation, floodplains, wetlands, marshes
	Land Uses	Major land use delineations – follow APA
	Hydrography	Single source aquifers
		Drinking water sources

Regional Context Map- Continued		
Type of Attributes	**Attribute Categories**	**Recommended Attributes– *Show End State Condition***
Hazardous Sources	Areas of Concern	Surface water and sediments - plumes
		Groundwater - plumes
		Soils - plumes
		Buildings & Storage facilities – above and below ground
		Air emissions – discharge points
Site-Wide Context Map #1		
Type of Attributes	**Attribute Categories**	**Recommended Attributes– *Show End State Condition***
Physical & Surface Interfaces	Administrative	Boundaries of local and county government, Tribal Nations, national wildlife and wilderness areas that are contiguous to site
		DOE Site boundaries
		DOE Fence lines
		Historic sites
		Footprint of all major buildings – differentiate by type of building
		Ownership – surface and sub-surface
	Transportation & Infrastructure	Highways and major roads – differentiate by primary, secondary, divided, paved etc.
		Railroads – passenger & freight
		Utilities – below ground (oil, gas, fiber optic), above ground (electric, high power, telephone, fiber optic)
		Other infrastructure – dams, water & wastewater treatment plants, power plants (nuclear, coal)
	Surface Configuration	Topography
		Land cover – follow USGS
		Soil types
		Contours

Site-Wide Context Map #1- Continued		
Type of Attributes	**Attribute Categories**	**Recommended Attributes– *Show End State Condition***
	Surface Configuration	Surface waters – lake, river, stream
		Elevation points
		Other important physical features
Hazardous Sources	Areas of Concern	Surface water and sediments - plumes
		Groundwater - plumes
		Soils - plumes
		Buildings
		Storage facilities – above and below ground
		Monitoring wells - locations
Site-Wide Context Map #2		
Type of Attributes	**Attribute Categories**	**Recommended Attributes– *Show End State Condition***
Human & Ecological Land Uses	Human Activities	Population areas, vulnerable subpopulations (seniors and children), minorities – by potentially impacted census tract
		Schools, hospitals, other major buildings in proximity
		Open space, parks and recreational areas
	Ecological Activities	Conservation and ecological areas
		Areas with habitats of concern, including threatened or endangered species
		Watershed delineation
		Single source aquifers
	Land Uses	Major land use delineations – follow APA
	Hydrography	Floodplains, wetlands, marshes
		Surface water – flow direction, discharge locations
		Groundwater – flow direction, groundwater divide

Site-Wide Context Map #2- Continued		
Type of Attributes	**Attribute Categories**	**Recommended Attributes– *Show End State Condition***
	Hydrography	Drinking water sources
		Vertical cross-section of geology and aquifers
		Rainfall, temperature and wind data
Hazardous Sources	Areas of Concern	Surface water and sediments - plumes
		Groundwater - plumes
		Soils - plumes
		Buildings
		Storage facilities – above and below ground
		Monitoring wells - locations
		Air emissions (magnitude & type) – wind rose and discharge points
Hazardous Areas of Concern Maps		
Type of Attributes	**Attribute Categories**	**Recommended Attributes– *Show End State Condition***
Hazardous Sources	Areas of Concern	Separate map for each hazardous area of concern – show greater detail such as concentration isopleths, screening depths, COPC concentrations.
		Optional: cross-sectional diagrams of modeled plumes
		Optional: human and ecological ARARs