Satellite and Aerial Imagery
Demonstration Project

Introduction to USGS Topographic Digital Raster Graphics (DRG)

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Section

1

Digital Raster Graphic (DRG) Topographic Images

WHY TOPOGRAPHIC DRGS?

Topographic map themes are a readily obtained and easy to use source of basic spatial and descriptive data of the land surface. Topographic maps are created for a variety of purposes and range from very large scale maps (1 inch = 100 feet or larger) produced by municipalities and transportation departments to very small scale (1:250,000) regional topographic maps produced by the U.S. Geological Survey (USGS). Topographic maps share at least one characteristic: they all depict the spatial variation in elevation of the ground surface. Beyond that, depending on purpose, topographic maps reveal specific features on or related to the ground surface. Features may include land cover type, hydrography (streams and waterbodies), building locations, cultural features, political boundaries, road systems, railroads, pipelines, and transmission lines. Topographic maps almost always have a means to identify the geographic location and size of map features in real world dimensions. Some, such as many USGS topographic maps, display multiple coordinate coordinate grids to enable positioning in geodetic, U.S. customary and metric coordinate systems. Topographic maps are a fundamental source of basic geospatial data and can provide an initial base map coverage for a GIS implementation.

USGS DRGs

Perhaps the most well known topographic maps employed in environmental assessment are the 7.5-minute topographic quadrangle maps produced by the USGS for the United States and its territories. The primary 7.5-minute quadrangle is a precisely printed 1:24,000 scale paper map (or stable polymer media) that measures 22 inches by 27 inches. Each 7.5-minute quadrangle covers an area 7.5 minutes of longitude by 7.5 minutes of latitude. Widespread

adoption of GIS and conversion to computer based terrain analysis has prompted USGS to develop digital versions of the 7.5-minute quadrangles. The digital topographic quadrangles are known as 24K Digital Raster Graphics (DRGs). DRGs purchased directly from USGS are delivered as a Tagged Image File Format (TIFF) 6.0 image file, a format that most image viewing and GIS software packages can read.

Many state agencies and value-added map retailers further process and distribute the USGS DRGs in alternative formats to better suit particular uses. Alternative image formats include Joint Photographers Engineering Group (JPEG) format and proprietary compressed image formats (ie, LizardTech's MrSid™ format). A common modification is to remove the map legend and border textual data included in the original map scan. This border area is called the **collar**. "Clipped" DRGs can be more easily joined in a GIS coverage so as to not obscure topographic detail with non-essential data.

Two files usually accompany the USGS TIFF image files: a **metadata** file that describes the origin and lineage of the DRG, and a **world file** that provides coordinate information for GIS software. Some formats, including the geoTIFF extension of TIFF 6.0, ERDAS imagine IMG, and MrSid embed the coordinate and projection information directly into the image file making the auxiliary world file unnecessary. There are many different image formats with new and modified formats being developed to take advantage of advances in file compression technology. Discussion in this tutorial series will be limited to the most common used in GIS and remote sensing.

DRGs retain the horizontal accuracy of the printed source maps. Most USGS printed maps meet the National Map Accuracy Standards (NMAS). The NMAS states that for maps on publication scales of 1:20,000 or smaller, no more than 10 percent of the points tested shall be in error by more than 1/50 inch measured on the publication scale. Test points must be "well-defined", that is, easily visible or recoverable on the ground. The elevation accuracy depends on the contour spacing of the DRG and is better than one-half the contour interval. Surface features and elevation data depicted on DRGs are identified by photogrammetric analysis and interpretation of aerial photography. The DRG collar usually contains a note indicating the date of the aerial photography used in the latest photorevision (currentness year) of the map information.

USGS established a policy to produce DRGs for every standard and current USGS topographic map. DRGs products are available at the following scales and coverages:

- 7.5-minute map series: Conterminous United States, Hawaii, and limited areas of Alaska at 1:24,000 and 1:25,000 scale

- 7.5- by 15-minute map series: Covers limited areas of the conterminous United States at 1:25,000 scale
- Pacific Island map series at 1:20,000, 1:24,000, and 1:25,000 scale
- Puerto Rico and the Virgin Islands at 1:20,000 scale.
- Culebra, its adjacent islands, and the Island of Vieques at 1:30,000 scale
- Alaska at 1:63,360 scale
- 30- by 60-minute map series: Conterminous United States and Hawaii at 1:100,000 scale
- 1 by 2-degree map series: United States at 1:250,000 scale.

Several points should be recognized about the production and use of the original USGS DRGs :

- The original DRGs were made by scanning an entire paper map, including the map collar, legend, and any overedge or insets.
- Product resolution is between 250 dots per inch (dpi). So printing of a DRG with computer software will not produce a printed copy as good as the original paper map.
- The image inside the boundaries of the map area (neatlines) is usually georeferenced to datum of the source map and projected to the Universal Transverse Mercator projection, regardless of the projection of the source map. DRGs in the Pacific Northwest are referenced to UTM NAD27.
- DRGs preserve the horizontal accuracy of the source map but do not improve it. Manipulation in GIS of geospatial data derived from DRG's may imply higher spatial accuracy than actually exists.
- Colors of the scanned image are reduced to a standard color map of 13 colors and stored as an 8 bit (0-255) image to conform with the TIFF 6.0 standard. This color map models the line drawing nature of the source graphic.
- Users can never be quite certain how current the spatial information is in a DRG. The source aerial photography may be 10 or 20 years old. The photorevision date specified in the DRG collar may give an indication of currency, but it is not a certification of temporal accuracy. Currency is even less apparent with clipped DRGs.

USGS DRGs are public domain data and may be freely copied and redistributed. The widespread use of DRGs, their relatively high resolution of spatial detail and the commitment of USGS to produce and update DRGs make them the single most important source of basic geospatial data for environmental assessment and resource management.

Quick-Look Sources of Information

Many publications address the development and use of topographic maps. USGS gives a brief description of the process of developing a topographic map with emphasis on USGS products at:
http://mac.usgs.gov/isb/pubs/booklets/topo/topo.html .

USGS provides a short tutorial covering the basics of topographic maps and a description of USGS map symbols at:
http://mac.usgs.gov/mac/isb/pubs/booklets/symbols/ .

USGS follows a rigorous procedure to ensure the accuracy of paper topographic maps and DRGS. A description of the DRG production standards are available at: http://rmmcweb.cr.usgs.gov/public/nmpstds/drgstds.html .

Section

2

1:24,000 (24K) USGS DRGs

Projections and Coverage

The largest scale (most detail) topographic map routinely produced by USGS is the 1:24,000 or 24K DRGs. This map series is used as a base for maps of many different types and scales. Most USGS 7.5-minute printed quadrangles are published in either the Lambert or Transverse Mercator projections of the State Plane Coordinate System [Moore, 1997 #9499]. During production of DRGs, USGS re-projects the scanned map image into the Universal Transverse Mercator (UTM) projection coordinate system based on the North American Datum of 1927 (NAD27). The UTM is a Transverse Mercator cylindrical projection defined by local central meridians that afford a reasonable fit to rectangular coordinate system [Snyder, 1987 #6427]. The Earth is divided into 60 UTM zones between latitudes 84° N. and 80° S., each 6° wide in longitude. UTM zones are numbered west to east and are designated as either north or south of the equator. Idaho, Oregon and Washington lie in mostly in UTM zones 10 North and 11 North. Figure 3.1 shows the UTM zones for North America. Agencies and companies that redistribute DRGs may reproject them into other coordinate systems. Map projections will be discussed in greater detail in Tutorial xx.x.

There are over 54,000 7.5-minute DRGs in the national coverage. The State of Idaho alone is covered by 1709 individual DRGs. USGS identify DRGs by map numbers and geographic location names unique to the set of maps comprising a state coverage. Organizations that redistribute 7.5 minute DRG's may use an alternative system to identify and name DRGs according to a local cataloging scheme. This is especially true if the DRGs are reprojected to a local horizontal datum, as is the case with state agencies in Idaho and Oregon. A common secondary designation system assigns DRGs new filenames based on their position within a 1 degree by 1 degree block of longitude and latitude (each block contains 64 DRGs). Figure 3.2 shows the typical row-column position location scheme. Column letters are sequential right to left to agree with the direction of increasing westerly longitude. Similarly, the row numbers increase bottom to top in the direction of increasing latitude.

For example, the 7.5 minute DRG that covers the confluence of the Potlatch and Clearwater Rivers in north central Idaho is named the Lapwai, Idaho DRG and is USGS map number DT00001043956. The southeast corner of the map has geographical coordinates 46°22'30"N, 116°45'00"W. In the row-column naming scheme the file for this quadrangle would be named 46116D7.tif because it is D = 4 (ie, 22.5'/7.5' + 1) columns west of the nominal 116°W longitude and 7 rows (45'/7.5' + 1) rows up from the nominal 46°N latitude. Some of the newer USGS DRGs have the alternate location designation included in the textural information of the map collar. An alphabetic letter may be added to the beginning of the file name to indicate the type of DRG product. For example, O46116D7.tif indicates the Lapwai DRG is a 24K topographic map image.

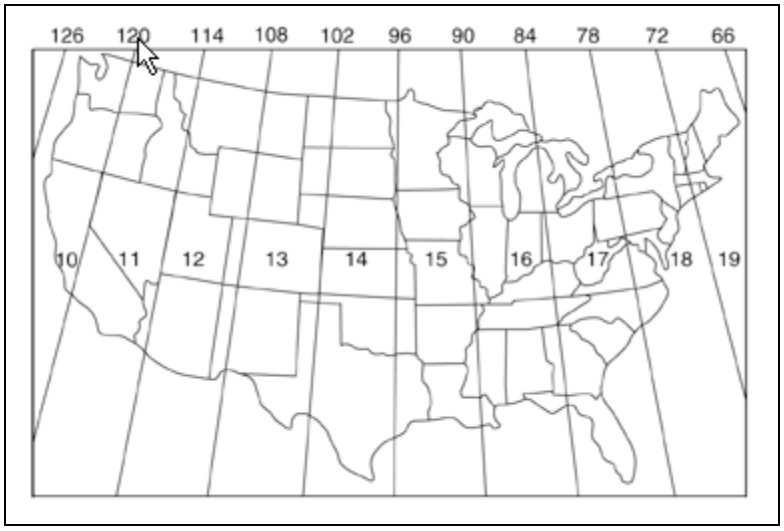


Figure 3.1. UTM Zones for North America.

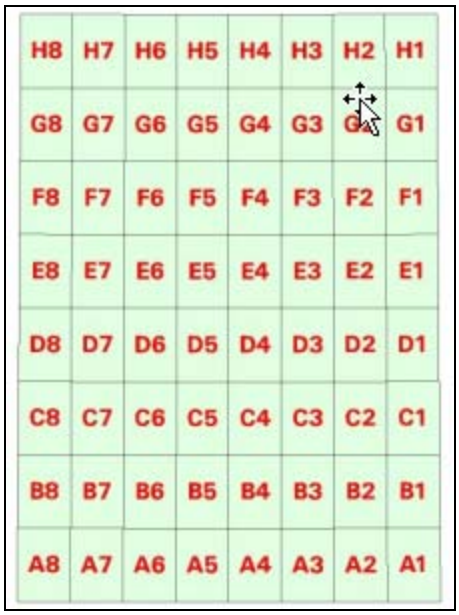


Figure 3.2. USGS 7.5 minute DRG designation convention.

Geospatial Content

The USGS 7.5-minute DRGs contain extensive geospatial information related to surface waterbodies and aquatic resources. This information is shown primarily in the form or lines and symbols developed and depicted using the principles of cartography, topology and graph theory. USGS calls lines that exist as separate attributed entities Digital Line Graphs (DLG). Several categories of DLGs and layered together to form the line vector content of the topographic map or DRG. Surface characteristics that are distributed in nature, such as landcover type, are shown through color tints or shading.

The 7.5-minute series topographic maps are printed using up to six colors (black, blue, green, red, brown, and purple). Each color has a specific use:

- Black: Lettering (culture, margin), projection (State grid ticks), miscellaneous culture, civil boundaries, primary and supplementary bathymetric contours, urban tint, UTM grid lines, roads (classes 1 to 5).
- Blue: Drainage, lettering, open water, marsh/swamp, mangrove, intermittent water, inundated, supplemental and index contour lines (bathymetric).
- Green: Woodland tint, orchard, vineyard, scrub.
- Red: Lettering (road shields), roads (classes 1 and 2), land lines (Public Land Survey System).
- Brown: Lettering (contour line numbers), contour lines, supplemental contour lines, sand, intricate surface details (e.g. landfills, mining).
- Purple: Photorevised data, not field checked, consisting of a variety of added features.

In general, the USGS 7.5-minute DRGs contain nine categories of information. Each type of feature is depicted according to a consistent set of map symbols. Some of the line vector categories, notably hydrography and linear transportation features, are available as separate DLG files. These map symbols have specific meanings and represent the skilled interpretation of aerial imagery and ancillary data of the cartographic analysts who developed the map. Attentive review of the type and spatial arrangement of the topographic map symbols can yield considerable information to guide further data acquisition and field investigations. The general categories of geospatial data contained in the 7.5-minute DRG are:

1. Public Land Survey System, including township, range, and section line information (available as a DLG);

2. Boundaries, including State, county, city, and other national and State lands such as forests and parks (available as a DLG);

3. Transportation systems, including roads and trails, railroads, pipelines, and transmission lines (available as a DLG);

4. Hydrography, including flowing water, standing water, and wetlands (available as a DLG);

5. Hypsography, including contours and supplementary spot elevations (available as a DLG);

6. Nonvegetative features, including lava, sand, and gravel;

7. Survey control and markers, including horizontal and vertical positions (third order or better);

8. Manmade features, including cultural features not collected in other data categories such as buildings;

9. Vegetative surface cover, including woods, scrub, orchards, vineyards, and vegetative features associated with wetlands.

A map symbol legend is not included in the 7.5 minute DRG, but is readily obtained in printed form from USGS or viewed at the USGS website: http://mac.usgs.gov/mac/isb/pubs/booklets/symbols/ . Symbols for elevation, survey control and hydrologic features found on 24K DRGs for inland (non-coastal) areas are shown in Figures 3.3 through 3.6.

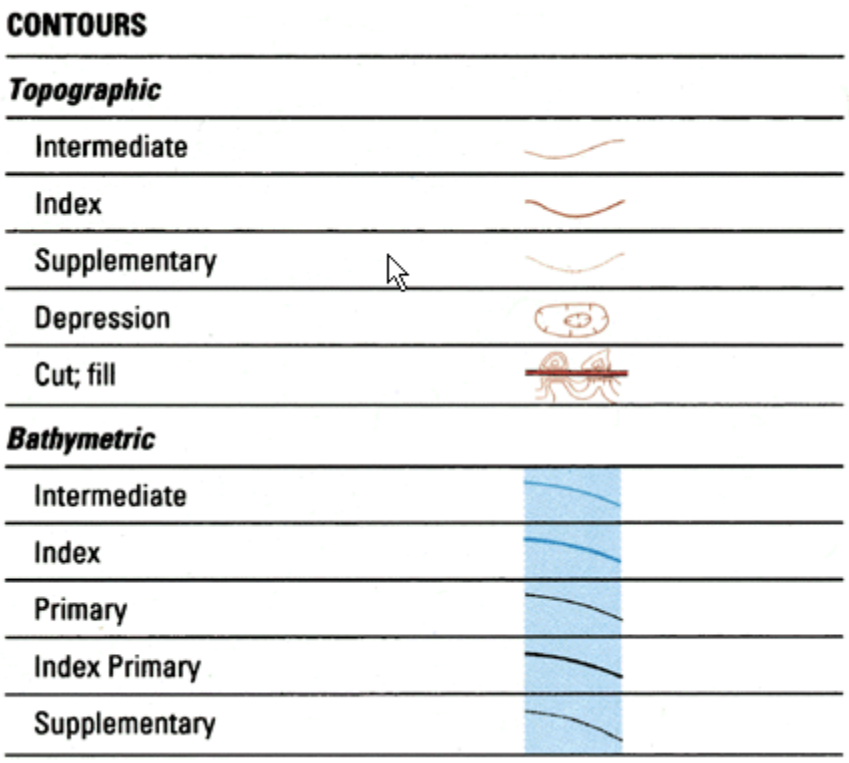


Figure 3.3. USGS 24K DRG Symbols for Elevation Contours.

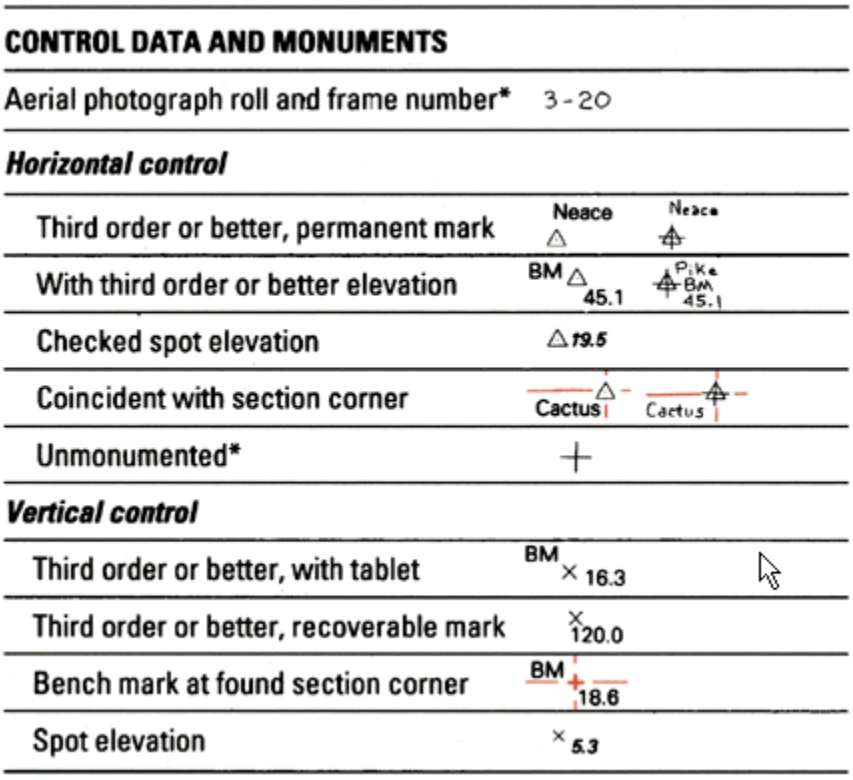


Figure 3.4. USGS 24K DRG Symbols for Horizontal and Vertical Survey Control.

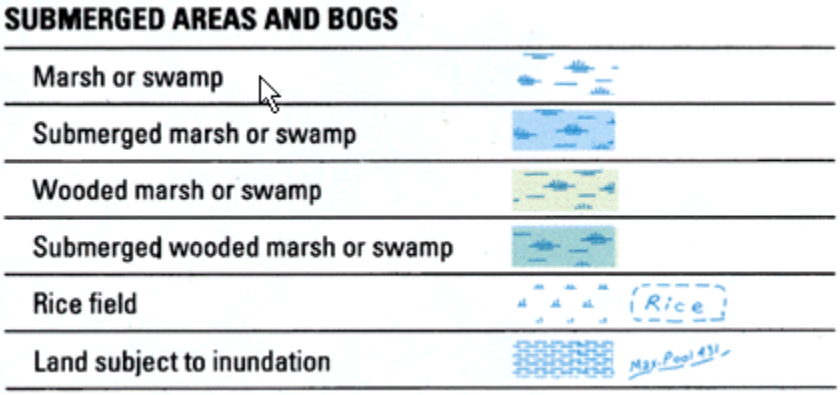


Figure 3.5. USGS 24K DRG Symbols for Submerged Areas and Bogs.

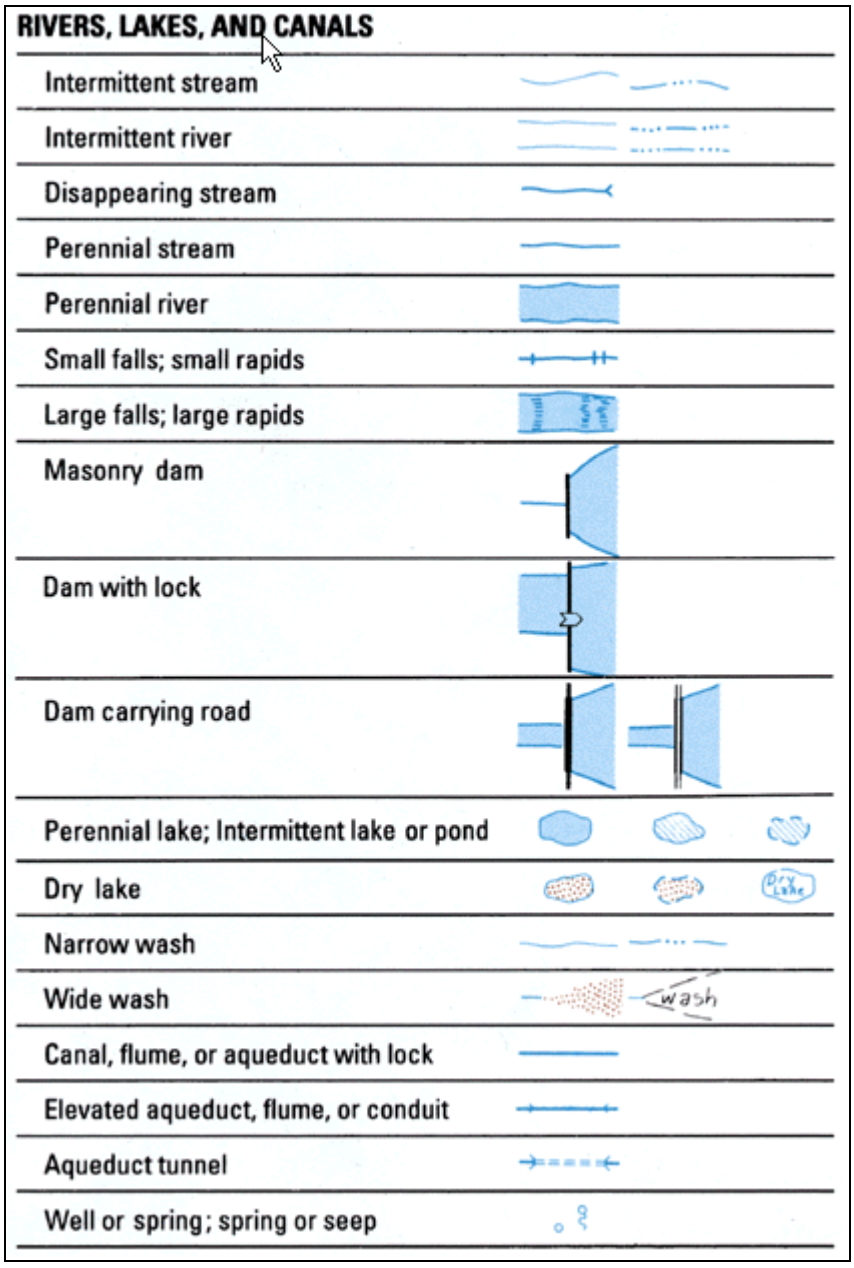


Figure 3.6. USGS 24K DRG Symbols for Rivers, Lakes and Canals.

Standards for USGS 24K DRGs

The USGS established rigorous standards for interpretation and identification of topographic features included on 7.5-minute series topographic maps. Adoption and adherence to these standards helps assure scientific users that the data is properly depicted and reliable within the constraints established in the standards. Detailed standards exist for each of the nine categories listed above, plus a tenth standard for delineation of built-up areas. The standard for delineation of hydrographic features by itself is over 300 pages. The Standards for 1:24,000-Scale Digital Line Graphs and Quadrangle Maps were most recently revised in 2001 and can be viewed at the USGS website:
http://rockyweb.cr.usgs.gov/nmpstds/dlgstds.html .

The hydrography of rivers and streams provides an example of the nature of the standards. The USGS hydrography standard classifies rivers and streams as either intermittent or perennial. These are depicted as the well know solid and dashed blueline streams seen on the 24K quandrangle maps. The standard defines the limit of a perennial stream or river as "the position of the shoreline when the water is at the stage that prevails for the greater part of the year", while the limit of an intermittent stream or river is "the position of the shoreline when the water is at the stage that prevails when the feature is at or near capacity". In other words, the extent of an intermittent stream is shown for the condition when the stream is experiencing high flows. Following these definitions it is clear that it is a misuse of the hydrography data in a 24K DRG to attemp a precise estimate the extent of wetted channel during low flow conditions. USGS affirms this with the statement,

"*The perennial and intermittent classification of hydrographic features in the field is done during a limited time period and relies on observations and information obtained from local residents and, thus, is a subjective process. No scientific measurements are made to determine the classification*" [USGS, 2002 #9502].

All topographic maps by nature represent features as they existed in the past. As discussed in the next section, the original topographic quadrangles from which DRGs are developed may be over 20 years old. It is tempting to use 7.5-minute DRGs as a source of quantitative data for temporal change analysis, particularly when other historic information does not exist. The author's experience with historic aerial photography and hydrographic information shown on 7.5 minute DRGs indicates that reasonable comparisons over time can be made with older quadrangles if the analyst has a good understanding of the conditions and limitations for feature inclusion in the DRGs. The conditions and limitations for feature inclusion are clearly specified in the USGS DRG and topographic map standards.

The USGS includes definitions, delineation criteria and capture conditions for 54 common hydrographic features in the latest revision of the hydrography standard.

An excerpt of these features is given in Table 3.1. A complete listing of the hydrographic features and their definitions is given in Appendix A.1.

Table A.1. Feature Names and Definitions, cont.	
Feature	**Definition**
Lake/Pond	A standing body of water with a predominantly natural shoreline surrounded by land.
Lock Chamber	An enclosure on a waterway used to raise and lower vessels as they pass from one level to another.
Mile Marker	A point on a feature indicating the distance, in miles, measured along the course or path of the feature, from an established origin point on the feature.
Mud Pot	A pool of mud from which gas or vapors issue.
Nonearthen Shore	A structure built of stone, brick, concrete, or other building materials that borders a body of water.
Pipeline	A closed conduit, with pumps, valves and control devices, for conveying fluids, gases, or finely divided solids.
Playa	The flat area at the lowest part of an undrained desert basin, generally devoid of vegetation.

Table 3.1. Excerpt from USGS Hydrograph Features and Definitions (Appendix Table A.1).

Names and definitions given in Table A.1 are mostly familiar. In addition to definitions, the USGS hydrography standard specifiy delineation and capture criteria for each feature. The delineation criteria describe the extent to which the feature will be depicted on the final topographic map or DRG, while the capture criteria specifies the minimum size or occurrence that a feature must be before it is symbolized or delineated on the map. Together the delineation and capture criteria give a technical user a good idea of what the presence and extent of a feature on the map or DRG implies in the real environment at the time of map development. Tables 3.2 and 3.3 give examples of delineation and capture criteria. Delineation and capture criteria for most of the common hydrologic features are compiled in Appendix A.1. Delineation and capture criteria are specified differently for arid regions. Figure 3.7 shows the arid regions defined by USGS for use with the hydrography standards.

Spatial capture conditions are expressed in units of length (inches) at map scale. For example, a pond at average water elevation is 400 feet wide (0.2" at 1:24,000) and 600 feet long (0.3" at 1:24,000). The capture conditions in the standard require the depiction of a lake or pond if it is greater than .025 inches along the shortest axis. Since the smallest dimension of the pond at map scale is 0.2 inches it exceeds the size criteria and is captured for depiction on the topographic map. Once a feature meets the capture criteria it is delineated as accurately as permitted by the source imagery or information.

Table A.2. Feature Limits of Delineation, cont.	
Feature	**Limit of Delineation**
Spring/Seep	The limit of SPRING/SEEP is the extent of the place where water issues from the ground.
Stream/River	The limit of a perennial STREAM/RIVER is the position of the shoreline when the water is at the stage that prevails for the greater part of the year. The limit of an intermittent STREAM/RIVER is the position of the shoreline when the water is at the stage that prevails when the feature is at or near capacity. The upper limit of STREAM/RIVER is where the feature first becomes evident as a channel. The limit of STREAM/RIVER where it enters or leaves LAKE/POND is determined by the conformation of the land. The limit of STREAM/RIVER where it enters SEA/OCEAN is where the conformation of the land and water make the division obvious, or, if the land and water do not suggest an obvious limit, the limit is where the stream reaches a width of 1 nautical mile (6076.1 feet or 1.15 statute miles) with no further constrictions. The limit of STREAM/RIVER where it enters ESTUARY is where ESTUARY ends.

Table 3.2. Excerpt from USGS Hydrograph Features Limits of Delineation (Appendix Table A.2).

Table A. 3. Feature Capture Conditions.	
Feature	**Capture condition**
Flume	If FLUME is > 0.12" along the longest axis,
Gaging Station	If GAGING STATION is published in the most recent "USGS Water Resources Data for (State)" report or is a tide station recognized by NOS, and it is permanent, automatic, continuous reading, and housed,
Inundation Area	If INUNDATION AREA is controlled and is > 0.06" along the shortest axis, If INUNDATION AREA is uncontrolled, and is > 0.06" along the shortest axis, and is along SEA/OCEAN or ESTUARY,
Lake/Pond	If LAKE/POND is in an arid area, If LAKE/POND is > 0.025" along the shortest axis and > 0.0025 square inches (10,000 square feet at 1:24,000-scale)

Table 3.2. Excerpt from USGS Hydrograph Features Capture Conditions (Appendix Table A.3).

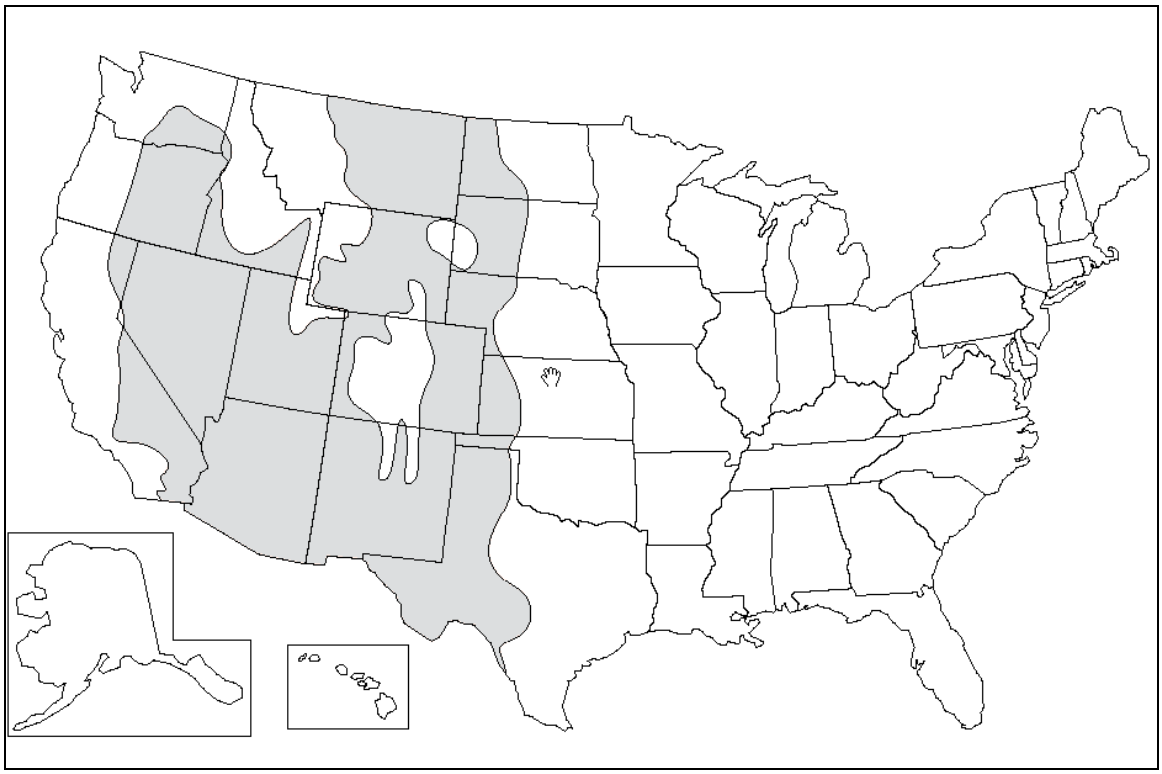


Figure 3.7. Arid Regions as Defined by the USGS Standards for 1:24,000-Scale Digital Line Graphs and Quadrangle Maps

Topograhic maps often contain a general indication of landcover type. The USGS 7.5-minute topographic series and DRGs use a combination of line work, symbolic patterns, color tint, shading, and text to depict general landcover type. Land cover is separated into vegetative and non-vegetative surfaces. Vegetative surface types include cultivated cropland, shrubland, and Trees. Non-vegetative surface types include barren land, beach, dunes and moraine. There are attribute subtypes within some of these categories. Similar to hydrographic features, each land surface category is defined, and has delineation and capture criteria defined in the Standards for 1:24,000-Scale Digital Line Graphs and Quadrangle Maps. A compilation of the definitions, delineation criteria and capture conditions is included in the Appendix. Tables 3.3, 3.4 and 3.5 are excerpts from the full tables in the Appendix. Examination of these tables will give a better feeling for the manner in which land cover is represented on the USGS 24k DRGs.

Table A. 4. Definitions of Vegetative and Non-Vegetative Surfaces.	
Cover Type	**Definition**
Vegetative Surfaces	
Cultivated Cropland	Land that has been plowed or otherwise cultivated for crop production.
Shrubland	Area covered with plants that have persistent woody stems and a relatively low growth habit, and that generally produce several basal shoots instead of a single shoot.
Tree	A woody perennial plant having a self supporting main stem or trunk and a definite crown.
Trees	An extensive area of land covered with woody perennial plants having a self-supporting main stem or trunk, a definite crown and usually reaching a mature height of more than 6 feet.
Non-Vegetative Surfaces	
Barren land	Places composed of bare rock, sand, silt, gravel, or other earthen material with little or no vegetation and having limited ability to support life.
Beach	The gently sloping shore which is washed by waves, usually composed of sand and pebbles.
Dunes	Hills or ridges of sand piled up by the wind.
Moraine	An accumulation of earth and stones carried and deposited by a glacier.

Table 3.3. Excerpt from USGS Vegetative and Non-Vegetative Surface Definitions (Appendix Table A.4).

Table A. 5. Delineation of Vegetative and Non-Vegetative Surfaces.	
Cover Type	**Limit of Delineation**
Vegetative Surfaces	
Cultivated Cropland	The limit of CULTIVATED CROPLAND is the extent of the area under production. When CULTIVATED CROPLAND is a planting of trees, the edge is defined as the center line of the bounding row. When CULTIVATED CROPLAND is a planting of cranberries, the edge is defined by the outermost ditch or embankment surrounding the planting.
Shrubland	The limit of SHRUBLAND is the extent of the area covered with the low growing shrubs.
Tree	The limit of TREE is the extent of the crown.
Trees	The limit of TREES is the extent of the treed area. The limit is the center of the outermost trees, not the edge of their crowns.
Non-Vegetative Surfaces	
Barren land	The limit of BARREN LAND is the extent of the non-vegetated surface.
Beach	he limit of BEACH is the extent of the area identified by the name.
Dunes	The limit of DUNES is the extent of the area of sand hills or ridges.
Moraine	The limit of a MORAINE is the edge of the glacial deposit.

Table 3.4. Excerpt from USGS Vegetative and Non-Vegetative Surface Delineation Criteria (Appendix Table A.5).

Table A. 6. Capture Criteria of Vegetative and Non-Vegetative Surfaces.	
Cover Type	**Capture Conditions**
Vegetative Surfaces	
Cultivated Cropland	If CULTIVATED CROPLAND is > 0.1" along the shortest axis. The minimum size for non-linear clearings within CULTIVATED CROPLAND is 0.1" along the shortest axis. Do not capture CULTIVATED CROPLAND for linear clearings that are > 0.05" along the shortest axis, whether there is another linear feature or not. Do not capture CULTIVATED CROPLAND for linear clearings, if the clearings are > 0.02" along the shortest axis and < 0.05" along the shortest axis and do not coincide with another linear feature that meets capture conditions. Where CULTIVATED CROPLAND has an intricate outline, the outline should be generalized.
Shrubland	If SHRUBLAND is > 0.1" along the shortest axis, and has a crown density 20%. The minimum size for non-linear clearings within SHRUBLAND is 0.1" along the shortest axis. Do not capture SHRUBLAND for linear clearings that are > 0.05" along the shortest axis, whether there is another linear feature or not. Do not capture SHRUBLAND for linear clearings if the clearings are > 0.02" along the shortest axis and < 0.05" along the shortest axis, and do not coincide with another linear feature that meets capture conditions. Where SHRUBLAND has an intricate outline, the outline should be generalized.

Table 3.5. Excerpt from USGS Vegetative and Non-Vegetative Surface Capture Conditions (Appendix Table A.6).

Revisions to USGS 24K DRGs

The median currentness date of the USGS 7.5-minute series is 1979 [Moore, 2000 #9500]. Some of the oldest and newest 7.5-minute topographic quadrangles are in the Pacific Northwest (Figure 3.6). USGS has an ongoing program to update the 7.5-minute series, but progress is heavily dependent on budget. Up to 1,400 7.5-minute quadrangles per year are being revised. Very few revisions include contour updates, new control, or field verification of content. There are four main categories of map revision: minor, basic, complete, and single edition. Minor revision is done on maps that have few changes since the last revision; it includes boundary updates and corrections of previously reported errors. Basic revision updates features from digital orthophoto quadrangles (DOQ) and aerial photographs. Complete revision of all layers is seldom performed because of the high cost. Most single-edition revisions are made by the U.S. Forest Service. Contour update is an optional part of basic and single edition revision but is not often done because of the high cost. These revision programs were not designed to do replacement mapping. Most map revision is based on data from remote sensing and secondary sources including:

- Geometry is controlled and some feature content interpreted from Digital Orthophoto Quadrangles (DOQ).
- Most feature content is interpreted by using stereophotographs from the National Aerial Photography Program.
- Boundary and name information is collected from Federal databases, other maps, and State and local agencies.

The primary sources used to revise quadrangle maps are digital orthophotoquads, aerial photographs, satellite imagery, or other image products. For revision, the vintage of these primary image sources must be no older than 6 years from the date of completion and no more than 3 years from the date of authorization . This will ensure that the content of the revised map is based on relatively current sources.

The USGS originally compiled topographic maps using procedures designed to meet the National Map Accuracy Standards (NMAS). Basic revision procedures were originally designed to retain the accuracy of the existing map but not necessarily to improve it. With increased reliance on DOQ as a source of information, the accuracy objective has been modified to make the horizontal accuracy of the revised map at least as accurate as the previous version and that all features should match the DOQ to within at least 73 feet.

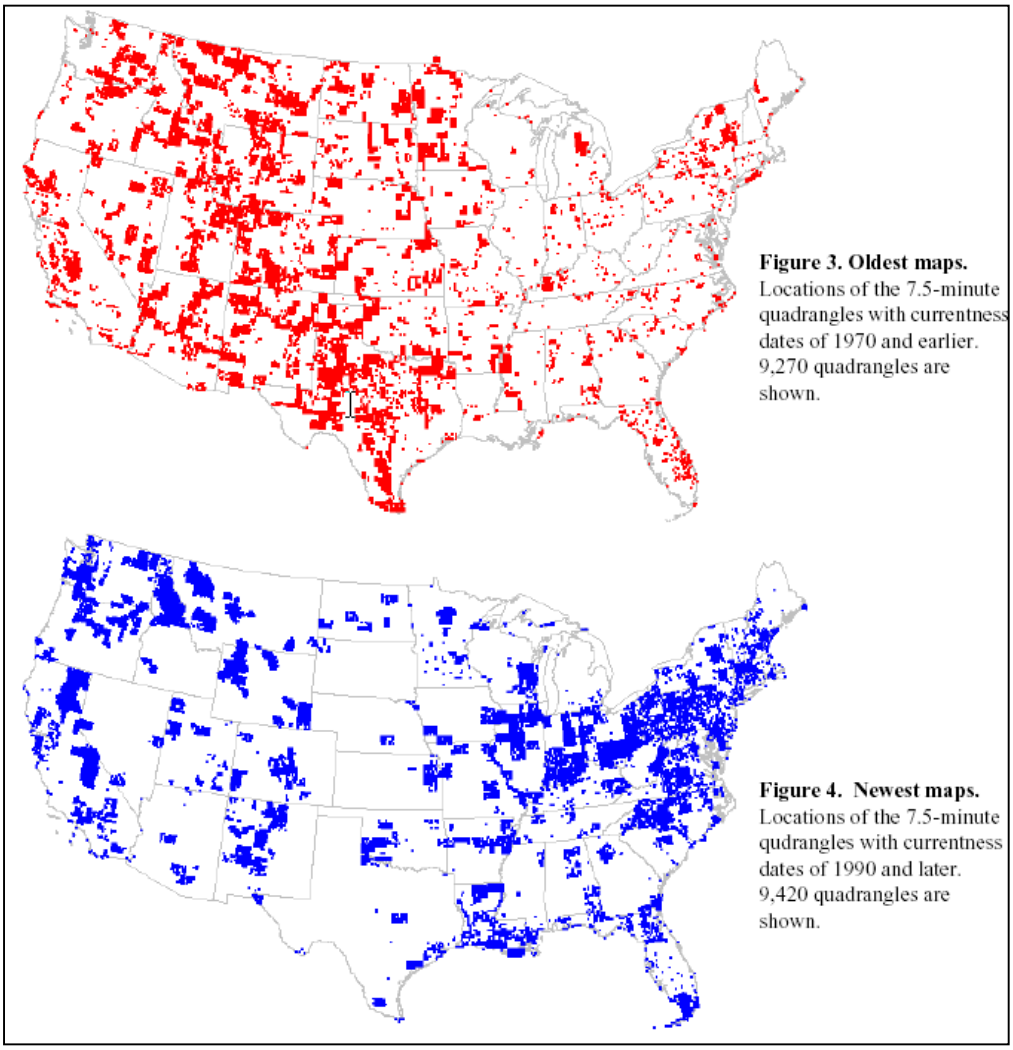


Figure 3.7. Oldest and newest USGS 7.5-minute Topographic Quadrangles.

The National Map Concept

The USGS recognizes that continued production of individual quadrangle based topographic maps is somewhat at odds with the national need for consistent and current GIS based topographic information [Moore, 2000 #9500]. Recently the USGS has emphasized the development of an internet based National Map of topographic [USGS, 2002 #9501]. Topographic data is intended to be seamless and consistently classified, enabling users to extract information for irregular geographic areas, such as counties or drainage basins, and to spatially analyze the information. Data resolution and completeness will vary depending on geographic area and need. Perhaps most important for assessment of aquatic resources, the National Map will contain higher resolution elevation data near waterbodies to support hydrologic modeling. Positional accuracy will be sufficient to vertically and logically align features from different data themes.

The National Map will be accessible through the Internet. The data will be in the public domain and data procured from commercial sources will include unlimited distribution and use rights. Users will be able to combine data from The National Map with geographic information available from other organizations, such as cadastral information from the Bureau of Land Management and socioeconomic data from the Bureau of the Census. USGS intends the National Map to be a common geospatial base to which all organizations can reference their information.

The main elements of the National Map coverage include:

- High-resolution digital orthorectified imagery that will provide some of the feature information content now symbolized on topographic maps (Figure 3.7).

- High-resolution surface elevation data, including bathymetry, to derive contours for primary series topographic maps and to support production of accurate orthorectified imagery (Figure 3.8).

- Vector feature data for hydrography, transportation (roads, railways, and waterways), structures, government unit boundaries, and publicly owned lands boundaries (Figure 3.9).

- Geographic names for physical and cultural features to support the U.S. Board on Geographic Names and other names, such as those for highways and streets (Figure 3.10).

- Land cover data that classify the land surface into categories such as open water and high-density residential (Figure 3.11).

Vector hydrography data will be based on the National Hydrography Dataset (NHD). It includes information about naturally and constructed waterbodies, flow paths and riparian features. Attributes are attached to the vector features to convey classification (for example, perennial and intermittent), geographic name, position, length, area, and water flow direction. A reach code assigned to each feature uniquely identifies that feature and is a link through which other information can be related to the NHD. In addition to this geographic information, the dataset contains metadata and information that supports future updates and improvements to the data.

Figure 3.8. National Map High-resolution digital orthorectified imagery.

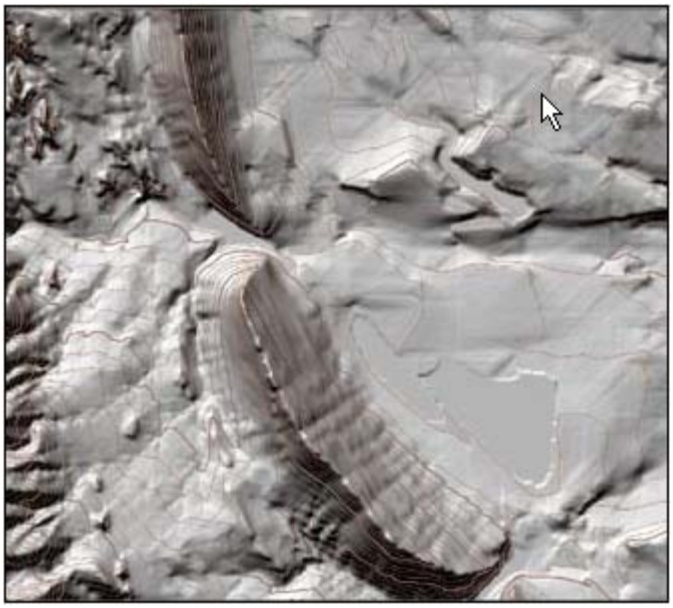


Figure 3.9. National Map High-resolution digital surface elevation data.

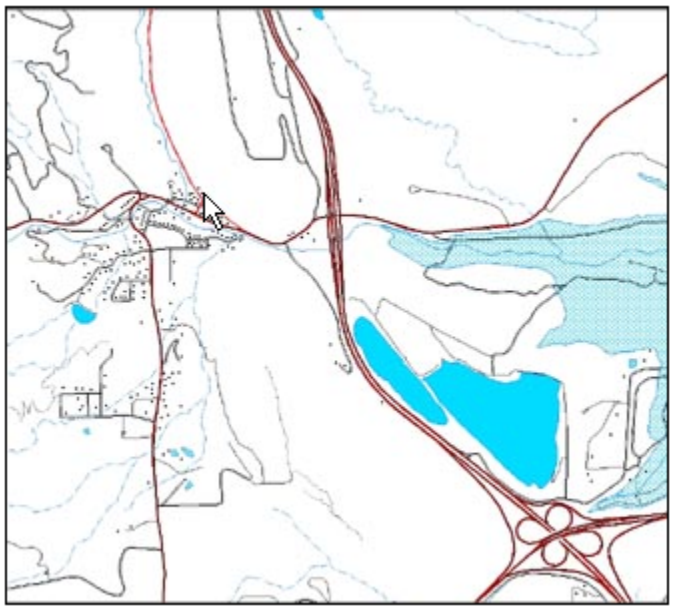


Figure 3.10. National Map Vector features and hydrography.

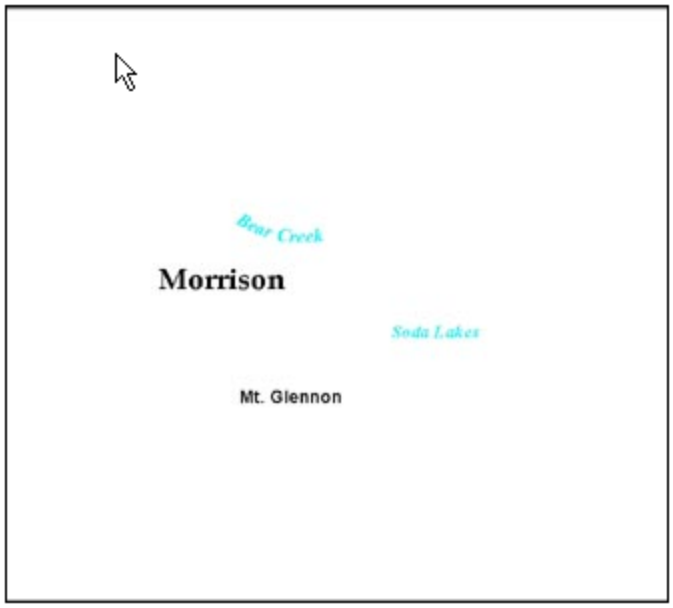


Figure 3.11. National Map Independent Theme of Geographic names.

Figure 3.12. National Map Classified Land Cover Data.

Elevation data for the National Map will be based on the National Elevation Dataset (NED). This NED provides a nation wide digital elevation dataset that has a consistent datum, elevation unit, and projection. The original implementation of the NED was based on a data point spacing of 1 arc-second (approximately 30 meters) for the conterminous United States, Hawaii, and Puerto Rico, and a data point spacing of 2 arc-seconds for Alaska. The NED data are projected in geographic coordinates, using NAD 83 as the horizontal datum and NAVD 88 as the vertical datum. The NED is a multiresolution dataset that is updated and improved, bimonthly, with higher resolution or higher quality elevation data. The 1-arc-second layer of the NED was built from 30-meter (~1 arc-second) data and has been updated over large areas by integrating 10-meter source data, resampled to 1 arc-second.

High resolution digital orthorectified imagery for the National Map will be developed from digital aerial photographs and satellite images that have ground pixel resolutions of one-meter or better. Orthoimagery will be periodically updated through the The National Digital Orthophoto Program (NDOP) and National Aerial Photography Program (NAPP) in cooperation with States and other federal agencies.

Introduction and use of the National Map internet interface is explored in Tutorial 3.2.

Guidance Summary

The content of the USGS 7.5-minute topographical maps and DRGs are necessarily a compromise between development expense, content priorities and a desire for nation wide consistency. Each feature or attributed characteristic on a USGS 7.5-minute DRG is depicted as a result of careful judgment governed by fairly specific criteria. The rigorous nature USGS's mapping criteria allow technical users of DRG and 7.5-minute topographic maps to extract reliable and meaningful information about the natural land surface and constructed features. Careful consideration of the limitations defined by mapping standards should help environmental scientists employ DRG and topographic maps as dependable source of historic data, especially when supported by other archived sources such as the original or concurrent aerial photography.

If needed, the most important line vector data shown on the 7.5-minute DRG is available as a separate Digital Line Graph (DLG) file and can be obtained from the USGS website at: http://edc.usgs.gov/geodata/. The DLG data is in Spatial Data Transfer Standard (SDTS) so it requires conversion to more common GIS formats before use.

The USGS is transitioning to an internet based *National Map* system of distributing seamless and consistent topographic data with the objective of increasing currency and accessibility of its products. This may foreshadow the demise of the printed 7.5-minute quadrangle topographic map in its current form. The current current web application (see Tutorial 3.2) allows users to access a limited number of moderate resolution datasets. USGS plans to enhance the National Map system to provide more detailed data for advanced users and geographic information system (GIS) specialists. The National Map system promises to be an important, possibly the most significant, source of national and regional hydrographic geospatial data.

Section

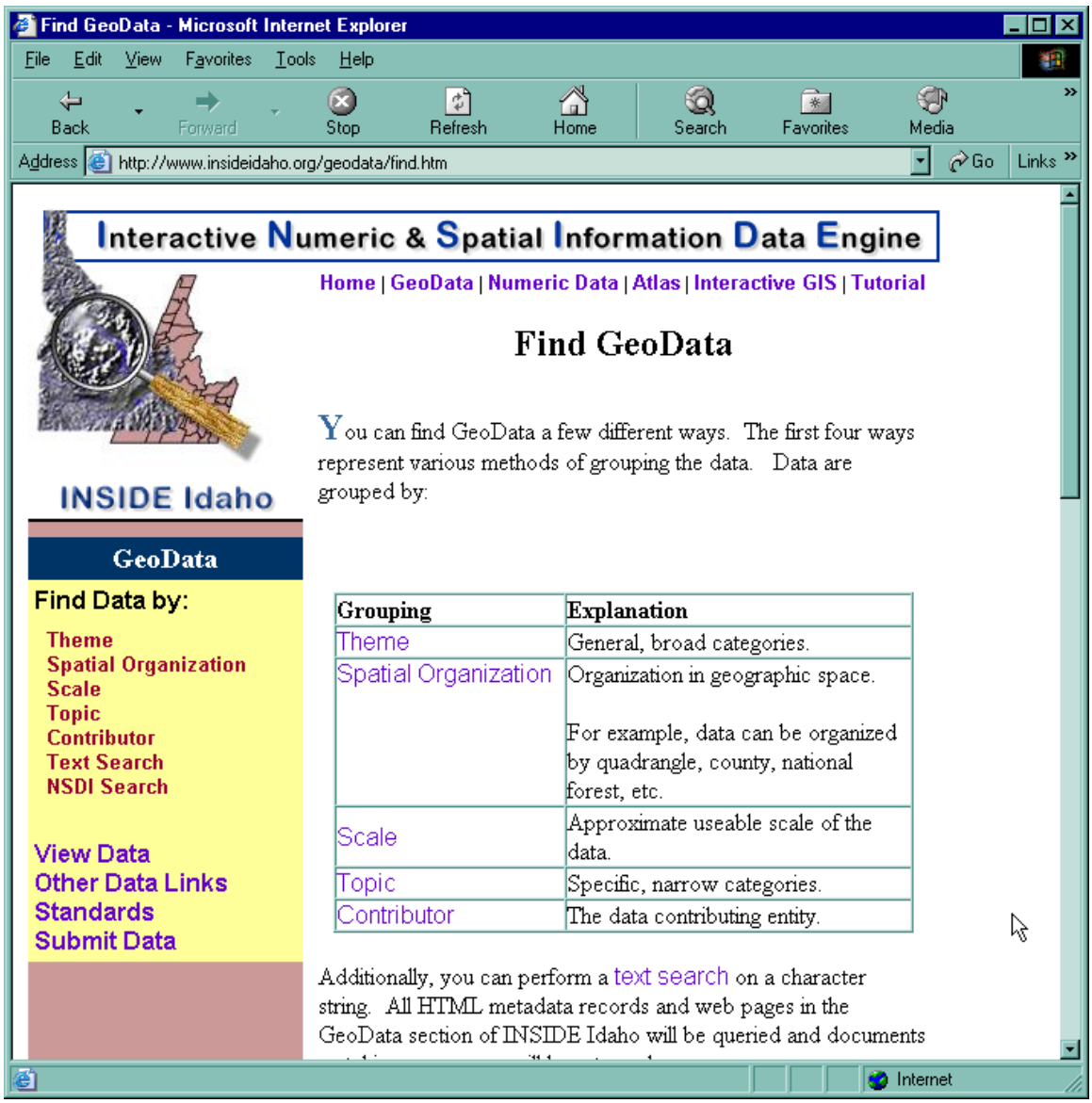
3

24K Topographic DRG Exercises

TUTORIAL 3.1.1 LOCATE AND DOWNLOAD A 24K DRG

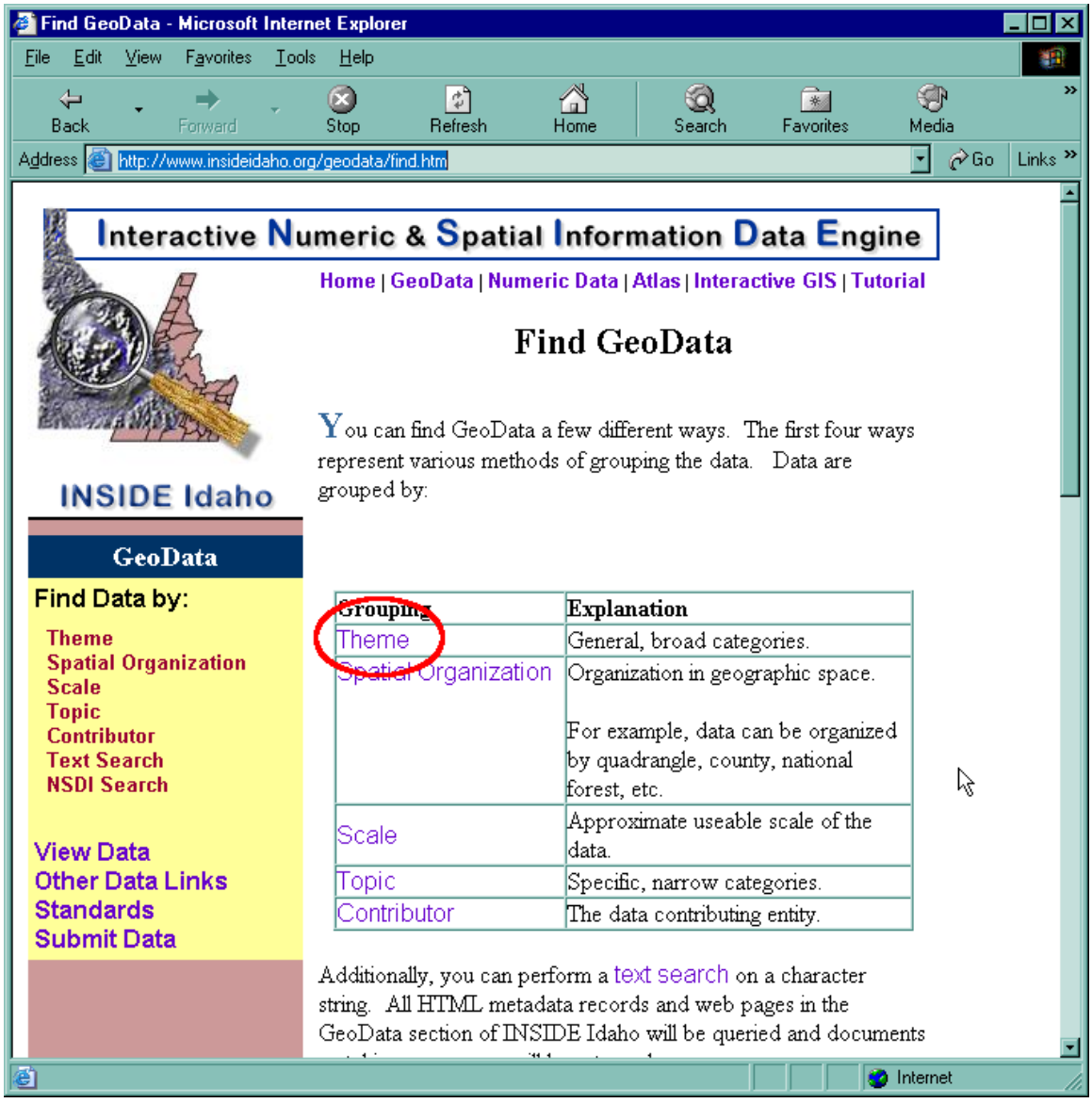
The objective this task is to locate and download a 7.5-minute DRG for Corral Creek in the Potlatch River Basin of north Central Idaho. USGS Topographic DRGs for Idaho are available at the ***Inside Idaho*** website hosted by the University of Idaho Library. This site provides easy access to a wide variety of geospatial data for Idaho including DRGs, digital orthophoto quadrangles, Landsat 5 and Landsat 7 imagery, and many GIS vector themes.

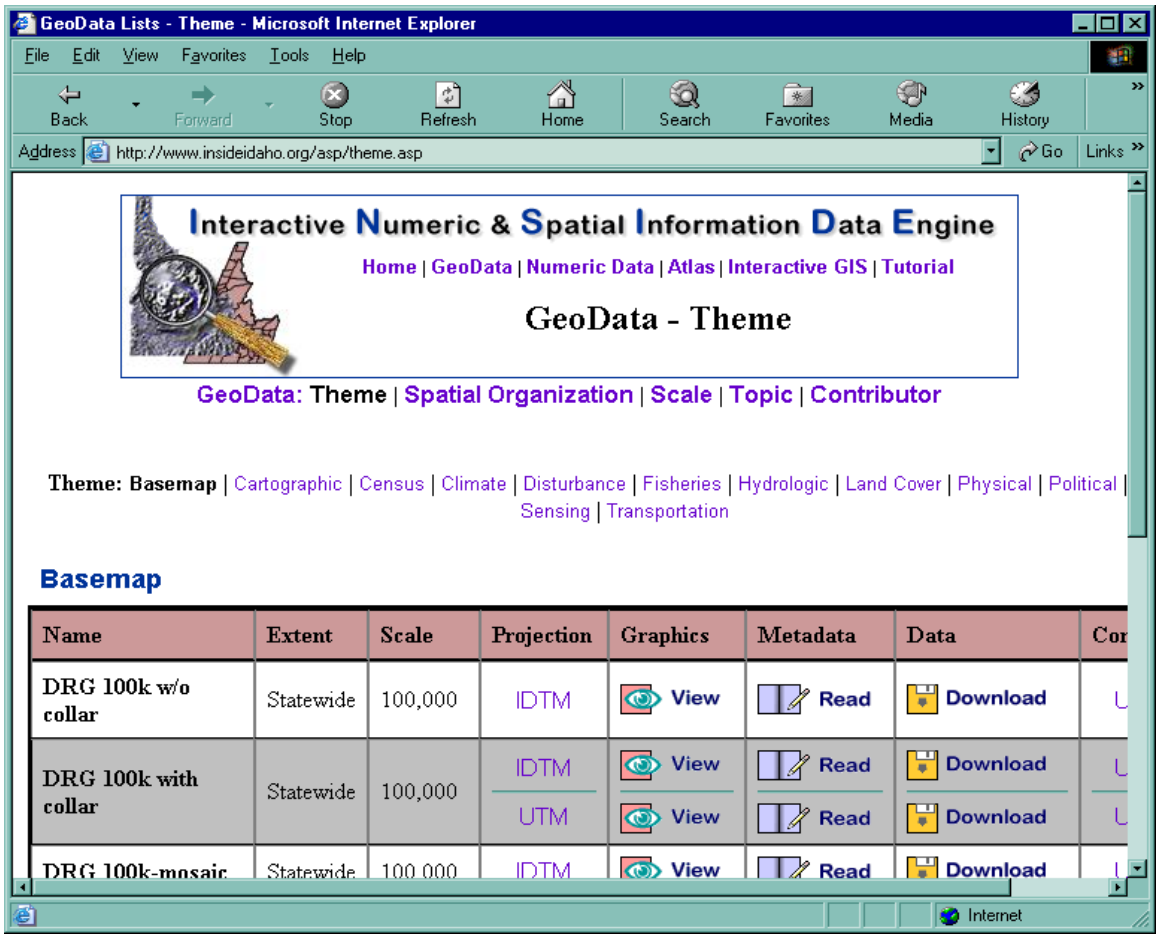
Step 1: Start your internet browser and navigate to the ***Inside Idaho*** website at: http://www.insideidaho.org/geodata/find.htm Screen captures and download steps for this tutorial were developed using Microsoft Internet Explorer 6.0. Procedures with other web browsers will be similar.



Inside Idaho is a clearinghouse and web archive for many kinds of geospatial data. You can access downloadable data from other sources by navigating links to this page. This tutorial will focus on the search and download of only a 24K USGS DRG. It is very much worthwhile to explore other offerings at this site.

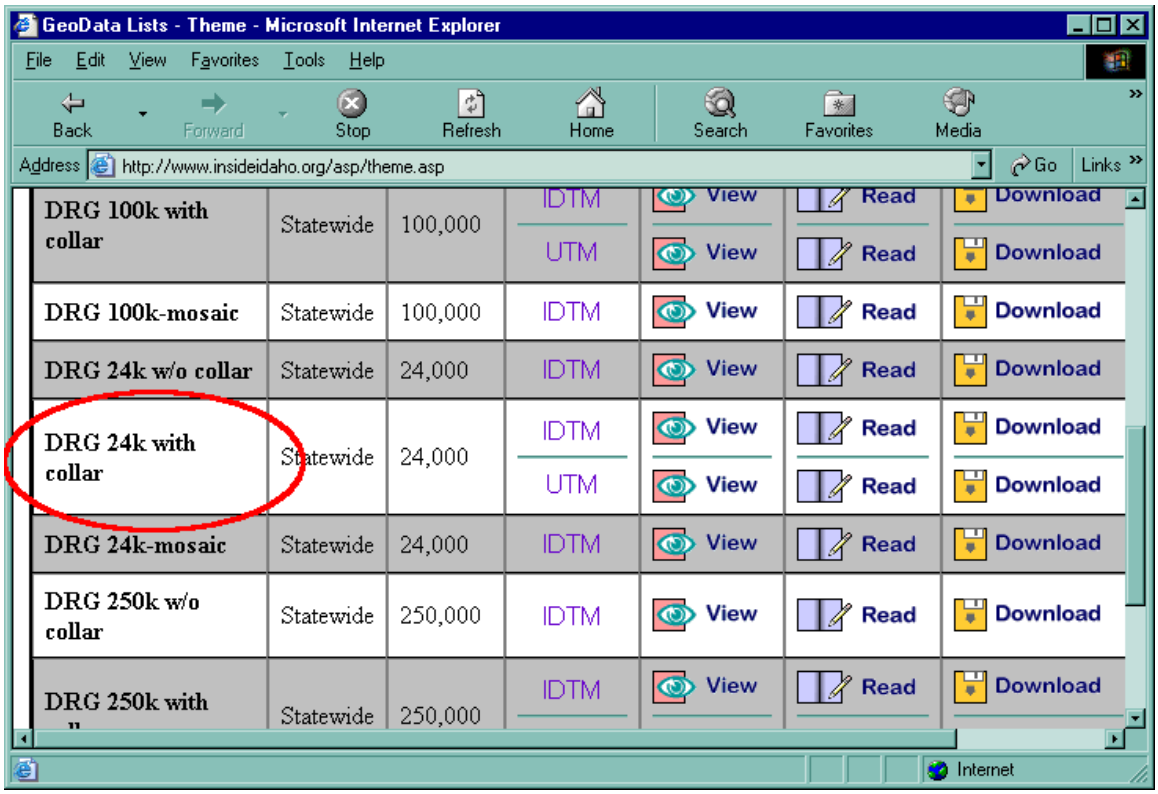
Step 2. Click the Theme grouping to access the page that enables searching and browsing of DRGs and other data directly from the ***Inside Idaho*** website.





This screen is the point of entry for searching and downloading various types of imagery (raster) and GIS vector data. General categories of information include cartographic, census, climate, ecological disturbance, fisheries, hydrologic, land cover, physical, political, remote sensing, and transportation. This tutorial exercise only look at the 24 K DRG under the Base Map category. The *Inside Idaho* contains a wealth of geospatial data. Later tutorials will explore other data sources available at the *Inside Idaho* website.

Step 3. Scroll down to the entry for the Basemap type **DRG 24K with Collar**.

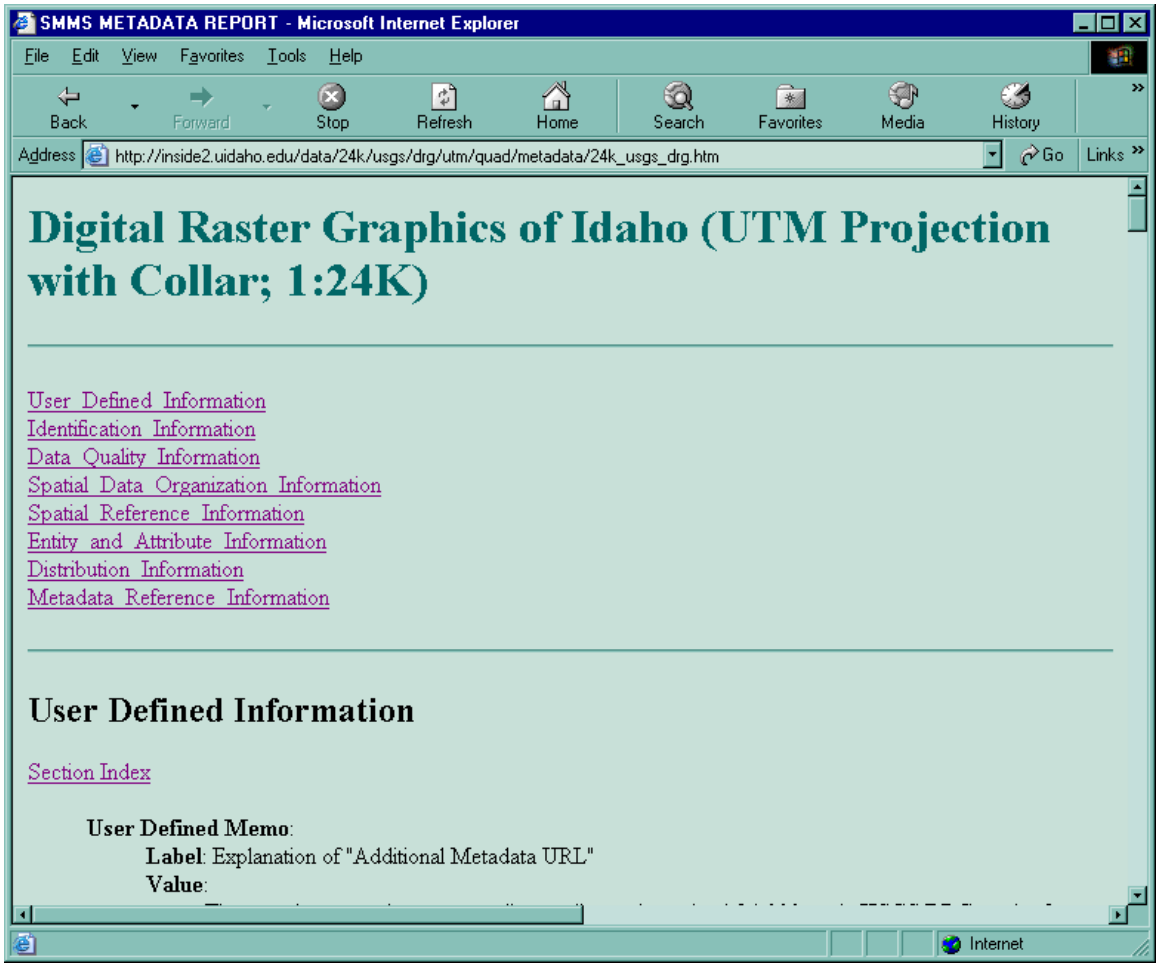


Both DRGs in the UTM and the Idaho Transverse Mercator projections (IDTM) may be downloaded from this site. Either can be with or without collars. DRGs are commonly available with or without the border text and map legend information found on paper topographic maps. All portions of the paper topographic map outside the actual map coverage is called the **collar**. The collar is often removed (clipped) or turned off by redistributors to allow apparently seamless display of adjacent DRG's in a continuous GIS image theme. The map collar contains useful information about the currency of the map and its original projection. Even if the goal is to create a DRG mosaic in GIS, it may be useful to download both versions of a DRG to be able to refer to the collar information.

Clicking the View icon brings up a reduced resolution example of a DRG image. The Read icon shows a html listing of the general metadata for 24K DRGs in Idaho. This metadata is gives background information about the origin and lineage of the 24K DRG.

Step 4. Click the 

metadata icon for the 24K DRG UTM projection.

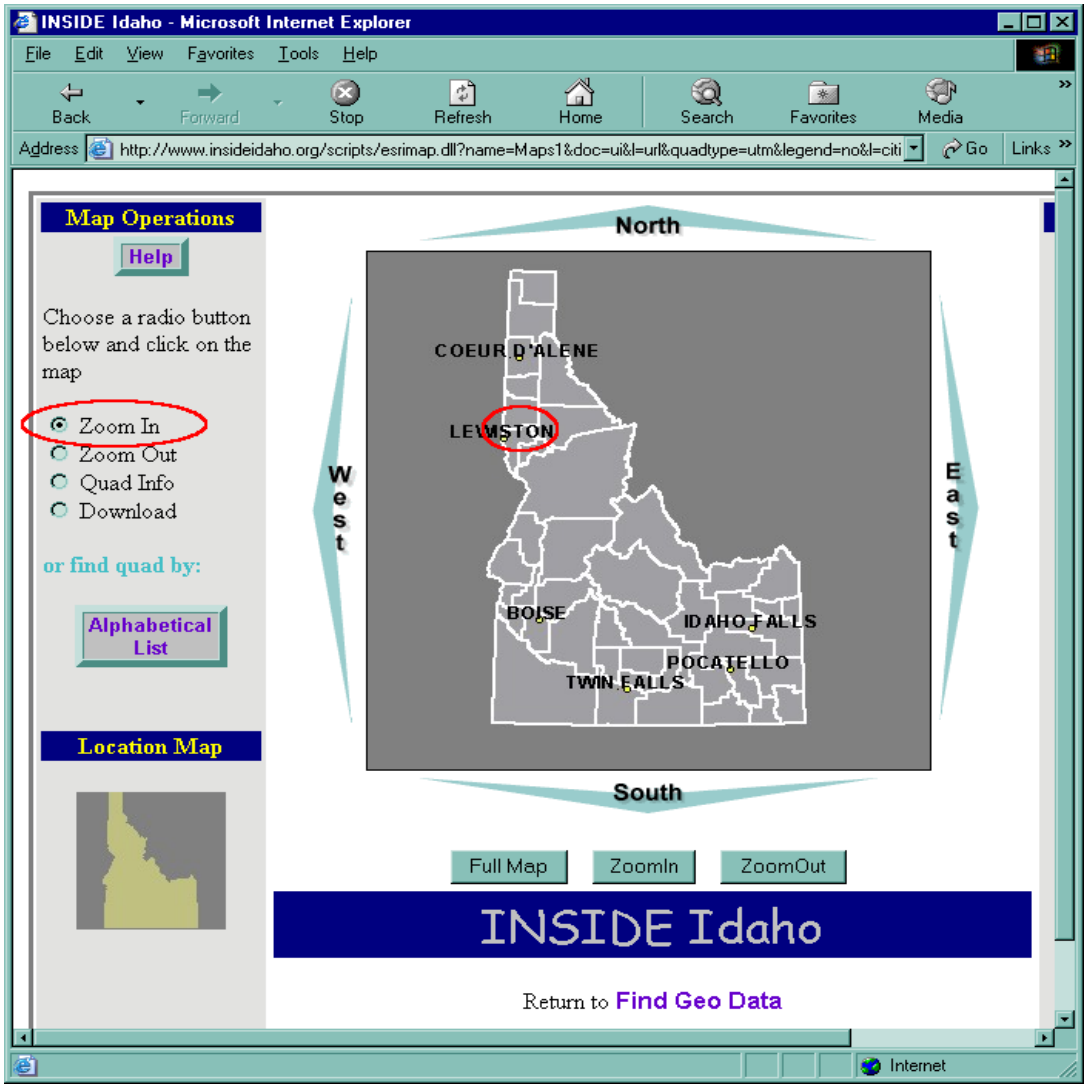


Metadata is a textual description about the source, processing, intended use, accuracy, and distribution of geospatial data in non-textural formats. Imagery and GIS vector themes would be difficult to use properly without the knowing about the way the themes were developed and how to position them in the real-world coordinate systems used by GIS software. Metadata provides this information. Having dependable metadata is a major concern to managers and scientists that must rely on the accuracy of geospatial data when evaluating environmental conditions and trends. Understanding metadata associated with an imagery or GIS theme is as important, or more so, than knowing how to manipulate and extract information from the theme. Understanding metadata will help avoid misuse of imagery and GIS themes.

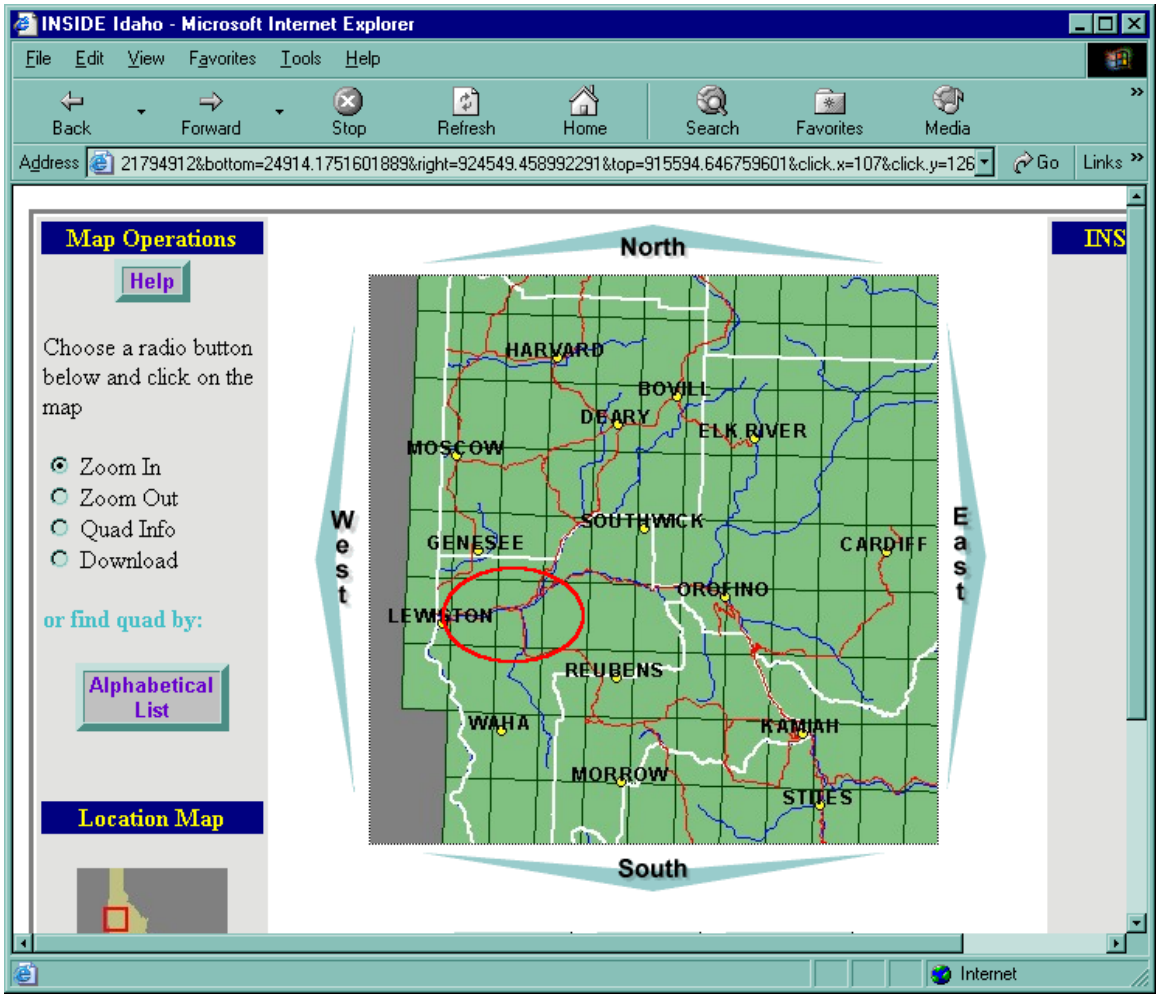
Scroll down through the metadata file to see the kind of information present in the file. This metadata format closely follows the standard set by the Federal Geographic Data Committee (FGDC) for geospatial data produced by the U.S. federal government. To learn more about the FGCD standards visit the website at:

http://www.fgdc.gov/metadata/metadata.html .

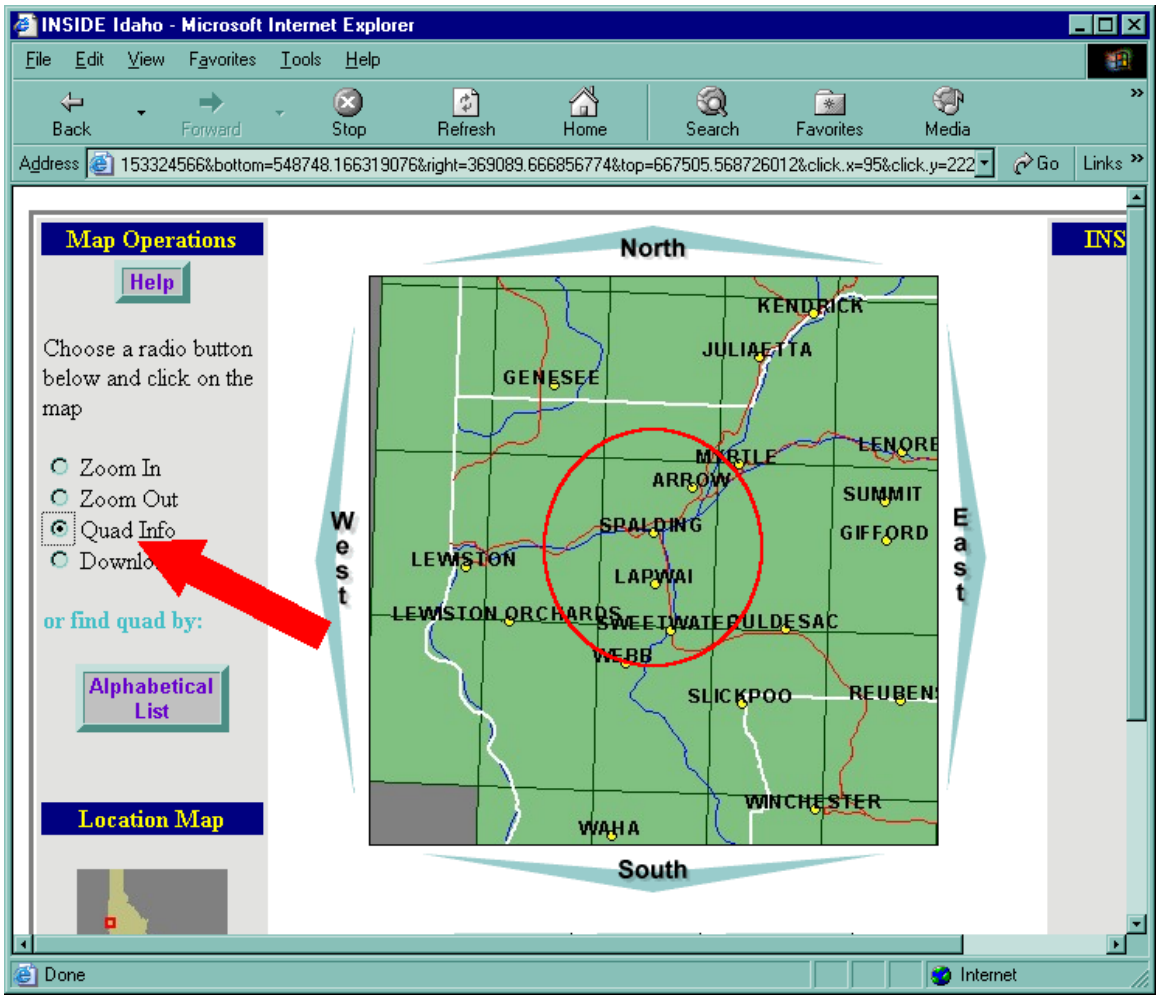
Step 5. Click the Download icon for the UTM 24K DRG. This starts a map server application that can navigate to a specific DRG within the State of Idaho. Click the Zoom In button, then click on the map near Lewiston.



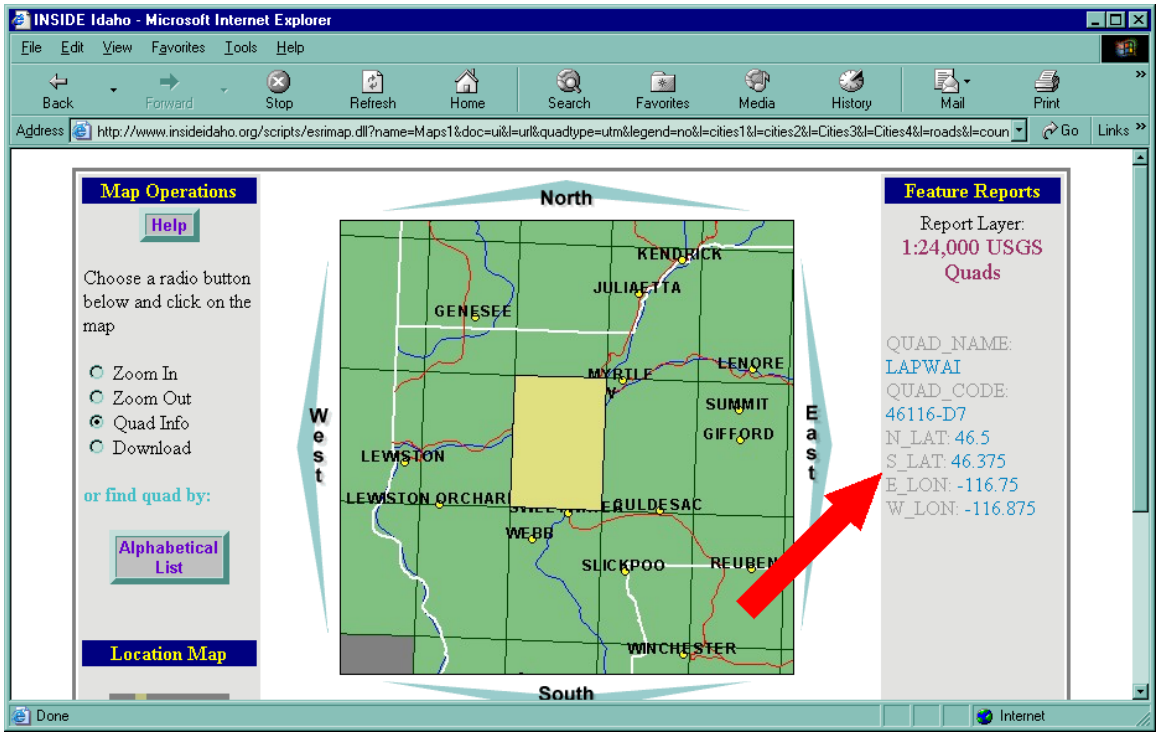
Step 6. Quadrangle boundaries are now shown on the map. Click the quadrangle just east of Lewiston to get a closer view of the Lapwai, ID quadrangle.



Step 7. Click the Quad Info button, then click on the Lapwai quadrangle.



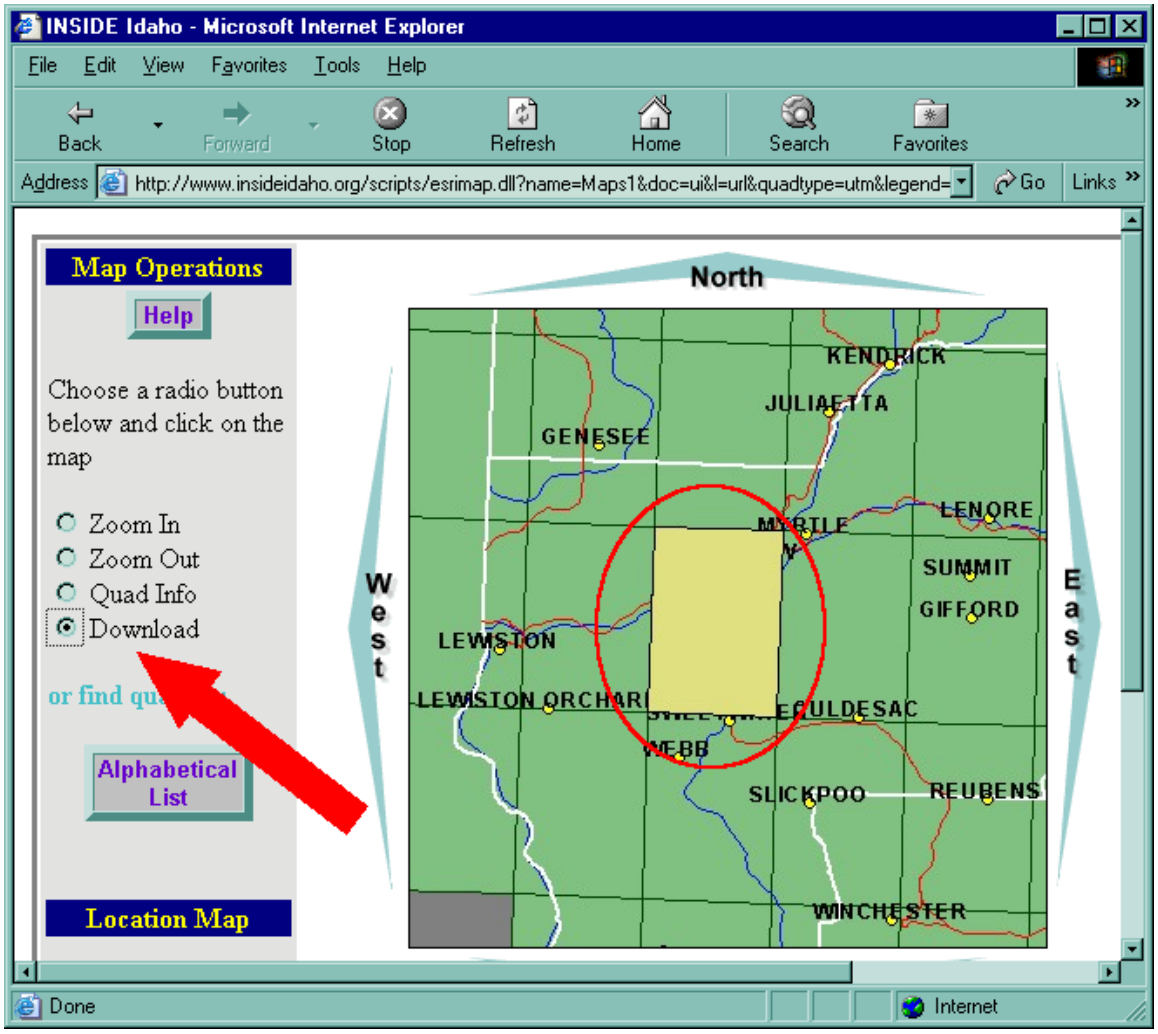
Step 8. Basic information about the selected quadrangle is shown along the right side of the map area.



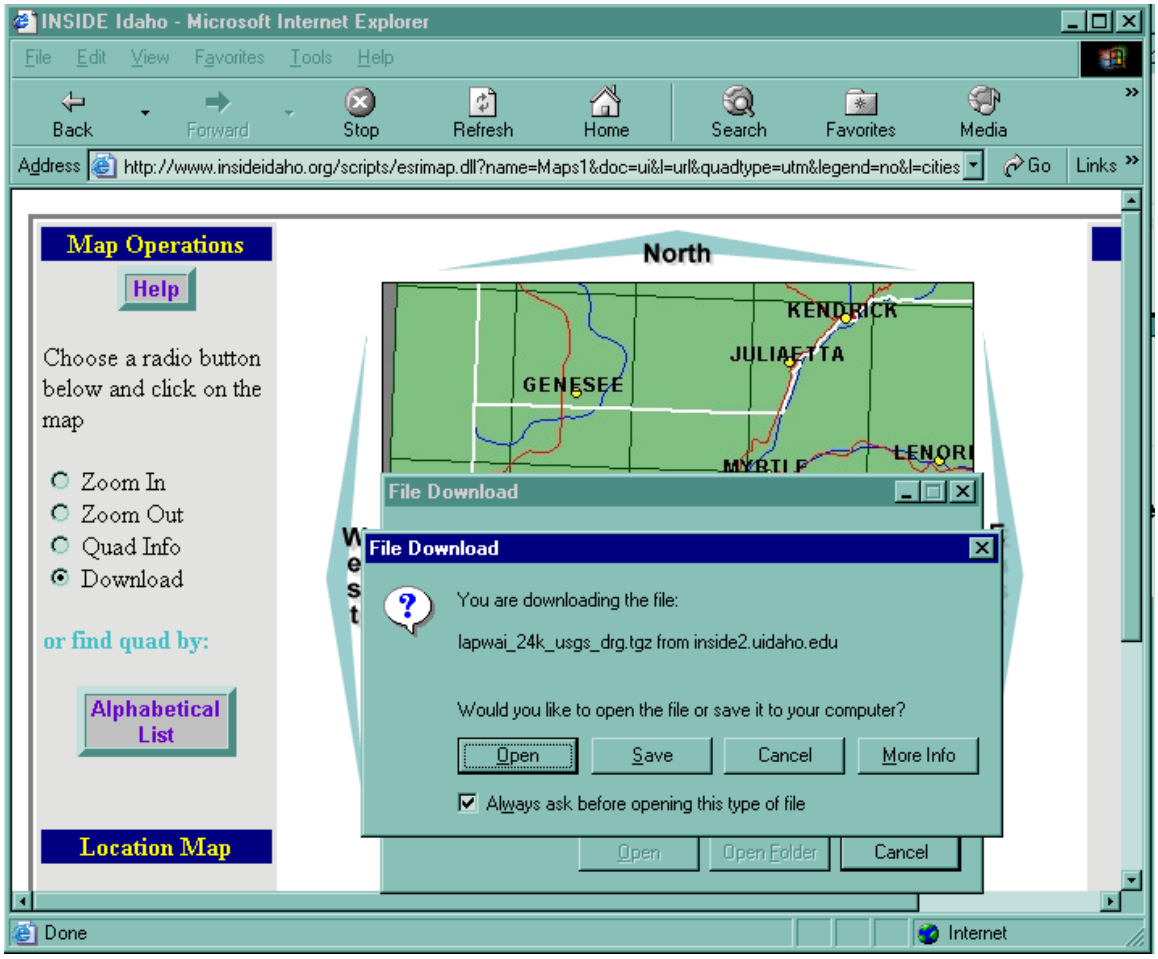
The QUAD_CODE is the alternate file naming convention discussed in the introductory materials. It tells us that the quadrangle belongs to a 1° by 1° block whose southeastern corner is at longitude 116°W and 46°N. The alphanumeric identifier is D7 so the quadrangle is located 4 rows up and 7 columns left from the southeast corner of the block.

The values given for N_LAT, S_LAT, E_LON, W_LON are the geographic extent of the neatline boundary of the map area. The values are in decimal degrees and employ the usual convention of expressing western longitudes as negative numbers.

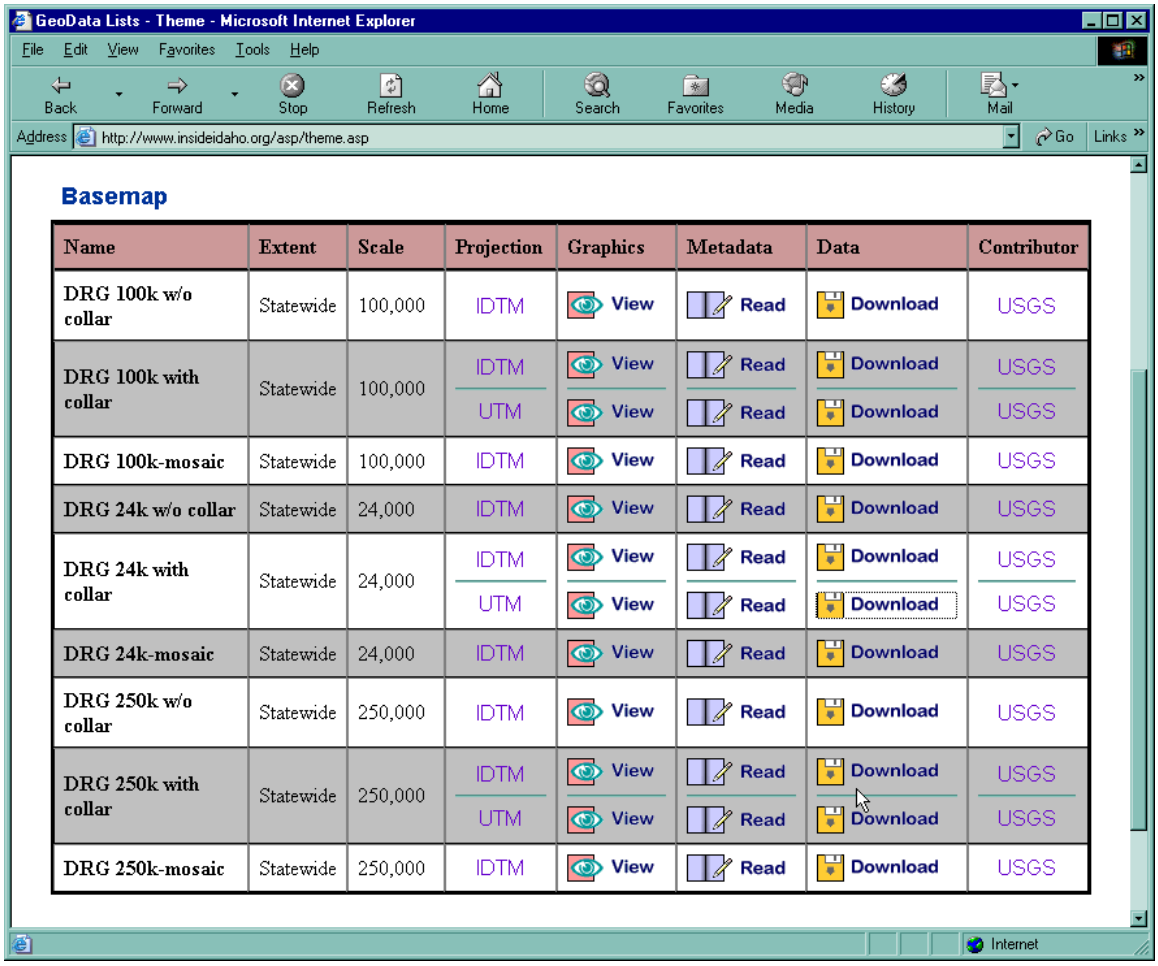
Step 9. Click the Download button, then click the Lapwai quadrangle.



Step 10. Save the Lapwai DRG file to a convenient directory. The file is compressed with the Gzip utility. It can be uncompressed with Gunzip or the WinZip™ compression software.

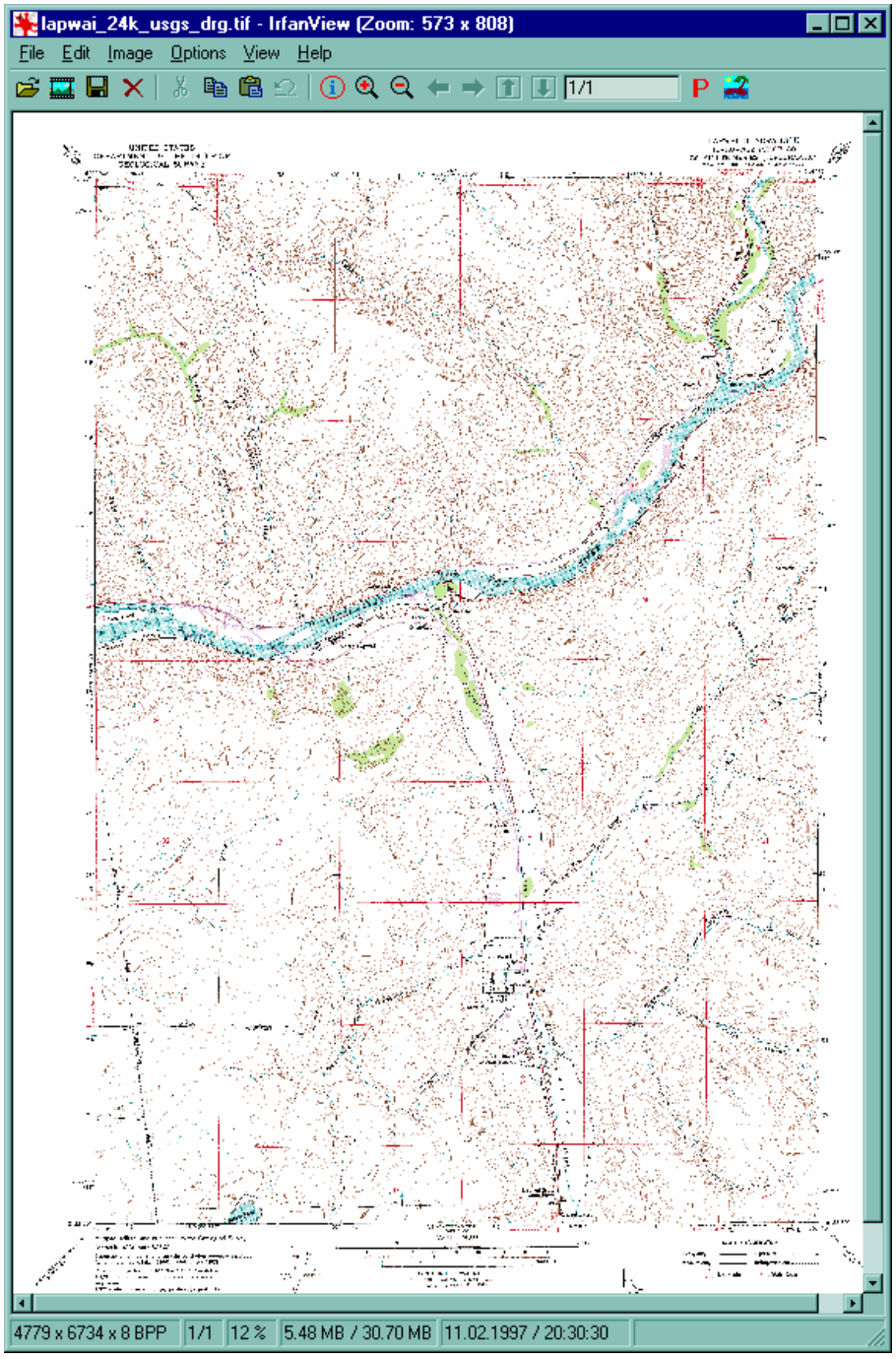


Step 11. Close out of the map server application by repeatedly clicking the Back button. Stop at the opening screen for the Basemap data and examine the other offerings for DRGs. The ***Inside Idaho*** website provides easily searchable and downloadable DRGs for Idaho at the 1:100,000 (100K) and 1:250,000 (250K) scale. These smaller scale DRGs can be useful when studying larger watersheds or to help orient users to the smaller coverage 24K DRGs. ***Inside Idaho*** is a very useful GIS data archive for project sites within Idaho and one of the best State GIS data clearinghouses to be found on the internet.

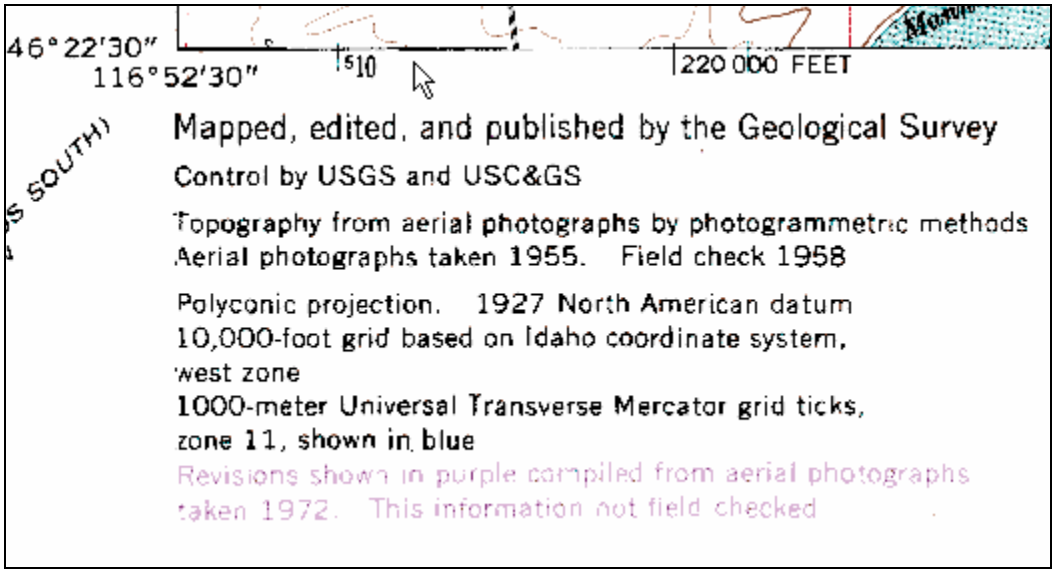


Name	Extent	Scale	Projection	Graphics	Metadata	Data	Contributor
DRG 100k w/o collar	Statewide	100,000	IDTM	View	Read	Download	USGS
DRG 100k with collar	Statewide	100,000	IDTM	View	Read	Download	USGS
			UTM	View	Read	Download	USGS
DRG 100k-mosaic	Statewide	100,000	IDTM	View	Read	Download	USGS
DRG 24k w/o collar	Statewide	24,000	IDTM	View	Read	Download	USGS
DRG 24k with collar	Statewide	24,000	IDTM	View	Read	Download	USGS
			UTM	View	Read	Download	USGS
DRG 24k-mosaic	Statewide	24,000	IDTM	View	Read	Download	USGS
DRG 250k w/o collar	Statewide	250,000	IDTM	View	Read	Download	USGS
DRG 250k with collar	Statewide	250,000	IDTM	View	Read	Download	USGS
			UTM	View	Read	Download	USGS
DRG 250k-mosaic	Statewide	250,000	IDTM	View	Read	Download	USGS

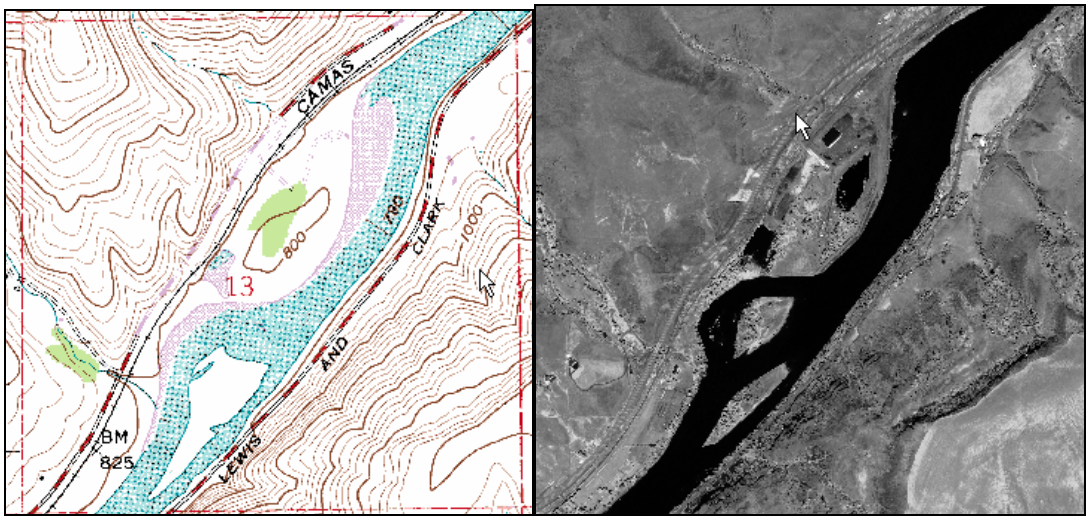
Step 12. Close the internet browser and unzip the Lapwai DRG file. Display the TIFF image file, **lapwai_24k_usgs_drg.tif** with a convenient image viewer. A popular, fast and multifunction viewer is the shareware program Irfanview available from: http://www.irfanview.com/.



Step 13. Zoom to the lower left corner and examine the photorevision date. This DRG was developed from aerial photography almost 50 years ago.



A minor photorevision was made with aerial photography acquired in 1972 but not field checked. Photorevised areas are colored purple such as that shown for the expansion of the lateral bar on the Clearwater River. Compare this to the recent SpaceImaging IKONOS Satellite Imagery acquired June 13, 2002 to see changes in at the lateral bar and mid-channel island.



Lapwai 24K DRG IKONOS June 13, 2002

Final Comments

It is possible to download USGS 24K DRGs for the entire Columbia River Basin free-of-charge by visiting several websites that act as GIS data distribution and clearing houses. Reliable public organization websites that have downloadable DRGs and other geospatial data for Idaho, Oregon and Washington include:

Idaho

The Inside Idaho website:
http://www.insideidaho.org/default.htm.

The Idaho Department of Lands GIS/Cartography website:
http://gis.idl.state.id.us/GIShtm/static/GisProgram.htm.

Oregon

The Regional Ecosystem Office (Federal Interagency) website:
http://www.reo.gov/reo/data/reodata.htm.

Washington

The Washington State Geospatial Data Archive website:
http://wagda.lib.washington.edu/data/washdata.html.

National

The USDA Natural Resources Conservation Service Geospatial Data Gateway website:
http://lighthouse.nrcs.usda.gov/gateway/.

This last website is highly recommended for medium sized projects anywhere in the United States and territories. The author downloaded the entire set of DRGs for Puerto Rico in one evening in a single compressed file amounting to more than 400 mb. The website performed flawlessly. Users may even request that data be sent on compact disc.

There are numerous commercial vendors online that process and redistribute DRGs in convenient formats and custom blocks. While it may seem least expensive to download the DRGs individually from the public access websites, it is good advice to seriously consider using the services of a commercial vendor for GIS projects involving 10's or 100's of individual DRGs. An honest appraisal of time spent manually downloading and mosaicking DRGs will likely reveal that commercial vendors save time and expense.