

# **Digital Databases and CD-ROM for the Animas River Watershed**

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Chapter G of

**Integrated Investigations of Environmental Effects of Historical  
Mining in the Animas River Watershed, San Juan County, Colorado**

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# Contents

Abstract.....	1081
Introduction.....	1081
Purpose and Scope .....	1083
Acknowledgments .....	1083
Base Cartographic Data .....	1083
Site Data .....	1084
Sample-Site Data .....	1084
Mine-Related Site Data .....	1087
Geoscientific Data .....	1088
Geologic Data .....	1088
Geochemical Data .....	1088
Biological Data .....	1088
Geophysical Data .....	1088
Relational Database .....	1089
Contents of Database.....	1089
Database Structure .....	1089
Data Viewer Software.....	1095
Animas River Watershed CD-ROM .....	1096

## Figures

1. Map showing geographic extent of Animas River watershed study area.....	1082
2. Map showing distribution of Animas River watershed study sample sites in nine-quadrangle area .....	1085
3–6. Diagrams showing:	
3. Tables in relational database and relationships between tables.....	1087
4. Select query qselFerricreteChem1 in Query Design view.....	1093
5. Crosstab query qctabFerricreteChem2 in Query Design view.....	1094
6. Crosstab query ctabFerricreteChem2 exported as an XLS file.....	1095

## Tables

1. Base cartographic data coverages in the Animas River watershed GIS database .....	1083
2. Elevation and elevation-derived grids in the Animas River watershed GIS database .....	1084
3. File names for Site Data in various formats .....	1086
4. Geoscientific data in the Animas River watershed GIS database .....	1090

# **Chapter G**

## **Digital Databases and CD-ROM for the Animas River Watershed**

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### **Abstract**

During the U.S. Geological Survey Animas River watershed Abandoned Mine Lands Initiative between 1996 and 2001, scientists collected diverse data that describe and characterize the geology, geophysics, geography, biology, mining, and water quality of the Animas River watershed. The environmental effects of more than 100 years of mining along with a complex geologic history in this area have brought to light several fundamental questions regarding the relationships between the products and features left behind from hardrock mining, weathering processes of geologic units, and water quality. Team scientists produced and compiled many layers of spatial digital data to support the multiple objectives of the Animas River watershed project. Base cartographic data covering the project study area were used to provide geographic reference for display of scientific information and results. The accompanying compact disc (CD-ROM) contains these data and provides users with capabilities for viewing these data layers and for utilizing the information for user-defined purposes. The data not only are useful for cartographic displays of scientific results, but also can be used for watershed characterization, investigative analysis, and modeling.

### **Introduction**

This chapter is a summary and description of the digital data that were generated as part of the Animas River watershed study, and which are placed on the CD-ROM that accompanies this volume.

The Animas River watershed study area is located about 40 miles north of Durango, Colo. Our multidisciplinary study has resulted in numerous digital data layers, which have been used to produce maps and images included and cited in other chapters of this volume. Team scientists analyzed rock, sediment, water, and biota. The data of other Federal and State agencies were incorporated where needed, as well as data from

previous USGS studies. Different types of remote-sensing information were gathered from several platforms, including helicopters, fixed-wing aircraft, and satellites.

An integral part of this chapter is a description of the relational database, the geographic information systems (GIS) database, and the map, image, and graphics products created during the Animas River watershed study. The databases and graphics products are contained on the accompanying CD-ROM, and these digital data are described and listed in tables as part of this text chapter. The relational database contains the biologic, hydrologic, geochemical, and geologic sample-site data collected for the Animas River watershed study, and an inventory and description of mine-related sites. These same data are provided as data layers and associated tables in the GIS database, in both vector and raster formats. In addition, the CD-ROM provides data viewing software that allows basic spatial analysis of the digital data layers.

The base cartographic data cover the Telluride, Ironton, Handies Peak, Ophir, Silverton, Howardsville, Engineer Mountain, Snowdon Peak, and Storm King Peak 7.5-minute quadrangles at a level of detail similar to that of U.S. Geological Survey 1:24,000-scale topographic maps. The geoscientific data also exist within these same nine quadrangles. Most of the sample sites fall within the project-defined watershed boundary (wshdbnd), but there are also some sample-site data in other portions of the Animas River watershed, and a few outside the Animas River watershed. Nine sites are outside the nine-quadrangle area.

The data are available on the CD-ROM in native software platform formats, and in several other formats including DOS ASCII text file (TXT), ESRI shapefile, ESRI interchange file (E00), dBASE (DBF) file, Adobe Portable Document format (PDF), and georeferenced tagged image file format image file (GeoTIFF) formats. The *x,y* coordinates of the ArcInfo coverages, ESRI shapefiles, and GeoTIFF image files are in UTM (Universal Transverse Mercator) meters, zone 13, and are projected to the common datum of North American Datum of 1927 (NAD27). The FieldSite table in the relational database also contains the longitude and latitude values of the field site locations in decimal degrees, also in NAD27.

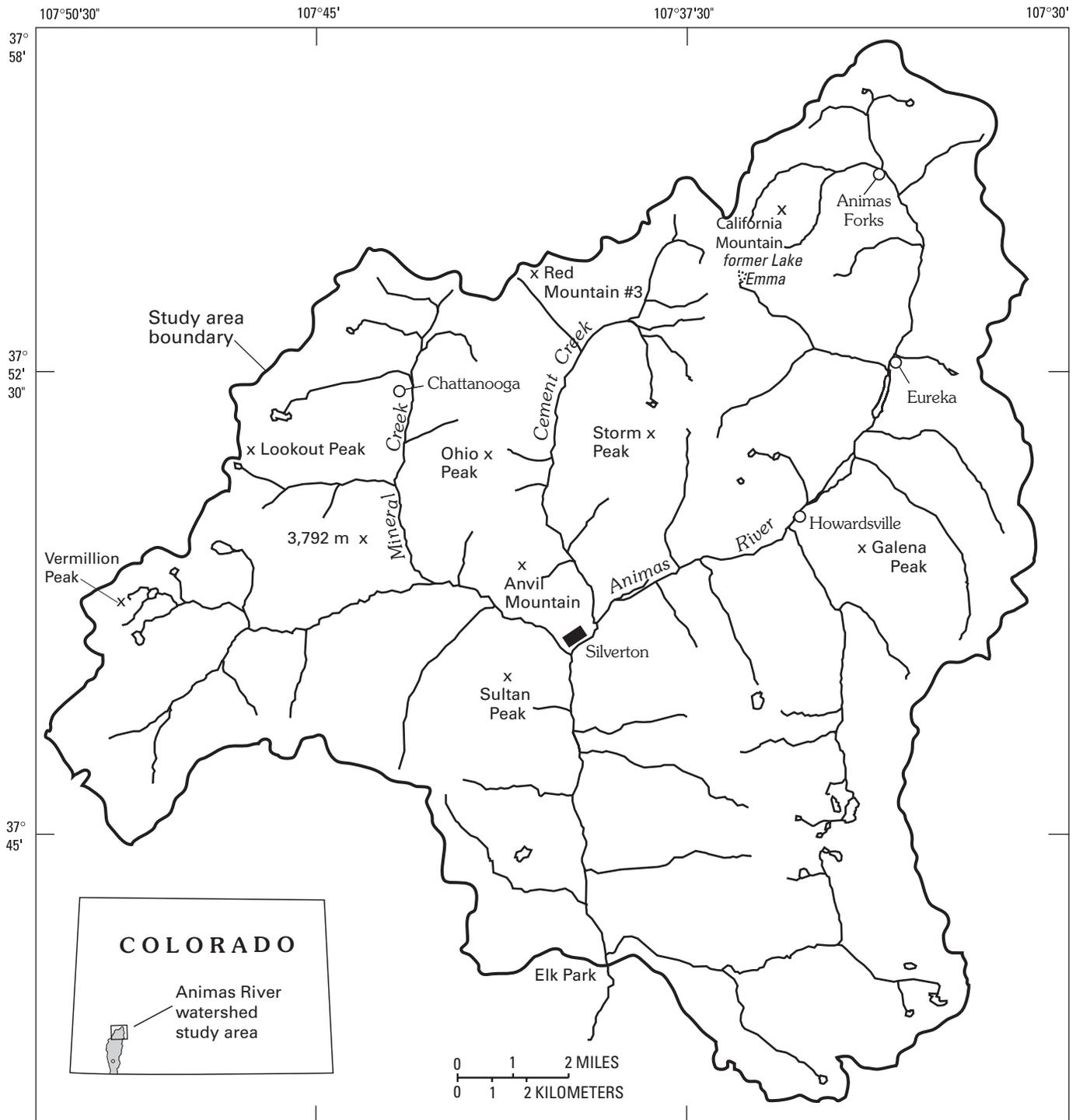


Figure 1. Geographic extent of Animas River watershed study area.

The following sections describe the data in three categories, including (1) base cartographic data, (2) sample-site data and mine-related site data, and (3) data layers pertaining to geologic, geochemical, biologic, and geophysical information. (This third group of data layers is collectively referred to in this chapter as “Geoscientific Data.”) A brief description of the data

is followed by summary tables that provide relevant information about individual data files. This data synopsis is followed by an explanation of the relational database. The chapter concludes with a description of the data viewer software that is provided on the CD-ROM and an explanation of the content and format of the CD-ROM.

## Purpose and Scope

The purpose of this study was to design a relational database and a GIS database to aid scientists in evaluating the effects that mining and weathering processes have on the ecosystem health of the Animas River watershed study area. The relational database was designed and implemented to store sample and analyses information in a format that permits simple to complex queries. The GIS coverages were created to permit data to be viewed, analyzed, and plotted.

The objectives of this study are to:

- Integrate the thousands of rock, water, and biology data items initially stored in flat files into a relational database
- Archive spatial data in a vector GIS database
- Provide metadata for the digital data collected for the Animas River watershed project.

## Acknowledgments

The authors acknowledge the assistance of Paul Martin, Rick Poss, Stewart Wright, Steve Howard, Earl Wilson, Maria McCormick, Steve Methven, Martin Chourre, and Eric Wong in the creation of the base cartographic data for the Animas River watershed GIS database.

## Base Cartographic Data

The base cartographic data were initially collected from the nine 7.5-minute U.S. Geological Survey topographic maps mentioned previously. Data were scanned or digitized from stable-base separates for each pertinent 7.5-minute

topographic map. Digital line graph (DLG) files were created, and then converted to ArcInfo coverages. The coverages were then revised where possible using 1998 one-meter resolution digital orthophoto quadrangles (DOQ).

Base cartographic layers created as just described include hydrography, roads and trails, railroads, miscellaneous transportation, hypsography (vector topographic contours), administrative and political boundaries, and cultural features. The hydrography and roads and trails layers were revised using DOQ files as just described. The remaining layers were not altered, and thus their content reflects the content of the 7.5-minute topographic maps.

Inactive mines and mine-related features were of utmost importance to this study, and are described separately later in this chapter, and in detail in the chapter, "Mine Inventory and Compilation of Mine-Adit Chemistry Data" (Church, Mast, and others, this volume, Chapter E5). The Animas River watershed study area boundary layer was created using the administrative boundaries, hypsography, and hydrography layers.

The base cartographic data vector layers exist on the Animas River watershed CD-ROM as Arc Interchange files in the \animas\_cd\gis\_db\basecart\ directory, and as ESRI shapefiles in the \animas\_cd\gis\_db\basecart\shape directory. A complete list of base cartographic data coverages is in table 1. Due to shapefile naming restrictions, the names of some of the shapefiles are abbreviated versions of their corresponding ArcInfo coverage names. For a complete listing of the shapefile names, see the \animas\_cd\gis\_db\basecart\README.txt file on the CD-ROM which accompanies this volume.

The coverages listed in table 1 contain data that lie entirely within the nine-quadrangle area. The Administrative Boundaries theme contains national forest and wilderness boundaries but does not include private inholding boundaries. The Political Boundaries theme contains county and incorporated boundaries that represent the only political boundaries that exist in the nine-quadrangle area.

**Table 1.** Base cartographic data coverages in the Animas River watershed GIS database.

Coverage name	Theme	File name	Data format
ADMINBND	Administrative Boundaries	adminbnd.e00	ArcInfo vector coverage
HYDRO	Hydrography	hydro.e00	ArcInfo vector coverage
HYP SO	Hypsography	hypso.e00	ArcInfo vector coverage
MINE_TOPO_PTS	Mine-related Point Features from Topographic Maps	mine_topo_pts.e00	ArcInfo vector coverage
MISC_CUL	Miscellaneous Culture Features	misc_cul.e00	ArcInfo vector coverage
MISC_CUL_PTS	Miscellaneous Culture Point Features	misc_cul_pts.e00	ArcInfo vector coverage
MISCTR	Miscellaneous Transportation Features	misctr.e00	ArcInfo vector coverage
PLACE_NAMES	Place Names	place_names.e00	ArcInfo vector coverage
POLBND	Political Boundaries	polbnd.e00	ArcInfo vector coverage
RAILRDS	Railroads	railrds.e00	ArcInfo vector coverage
QUADS	Quadrangle Boundaries	quads.e00	ArcInfo vector coverage
Q9OUTLINE	Outline of nine-Quadrangle Area	q9outline.e00	ArcInfo vector coverage
ROADS	Roads	roads.e00	ArcInfo vector coverage
WSHDBND	Watershed Boundary	wshdbnd.e00	ArcInfo vector coverage
SUBBASINS	Subbasins	subbasins.e00	ArcInfo vector coverage

A typical USGS DLG Miscellaneous Culture Features file would contain the contents of the Miscellaneous Culture Features theme, the Miscellaneous Culture Point Features theme, and the Mine-related Point Features from Topographic Maps theme. Because of the importance of mine-related sites to this study, mine-related sites were separated from the other cultural point features and stored in a separate coverage called MINE\_TOPO\_PTS. This coverage contains all mine-related point features exactly as they are shown on the 7.5-minute topographic maps. A separate coverage, MINE\_SITES, which was created using the digital orthophoto quadrangle files and a wide variety of other sources, is described briefly in this chapter under the SITE DATA section, and in greater detail in Church, Mast, and others (this volume).

Other related base cartographic data in the GIS database include an elevation grid created by converting USGS 10-meter Digital Elevation Model (DEM) files into individual grids and mosaicking them together, and individual Digital Raster Graphic (DRG) files of the topographic maps. Slope grids in percent and degrees, and aspect and shaded-relief grids were also derived from the elevation grid. All of the elevation-related grids are listed in table 2. The elevation and elevation-derived grids exist on the CD-ROM in the \animas\_cd\gis\_db\basecart\lev\grids directory as a compressed tar file (elev.tar.gz), which, when uncompressed, produces an entire ArcInfo workspace containing all of the elevation-related grids. The elevation and elevation-derived data also exist as GeoTIFF and TIFF files on the Animas River watershed CD-ROM in the \animas\_cd\gis\_db\basecart\lev\images directory.

For more detailed information describing the sources, creation and content of the base cartographic data in the Animas River watershed GIS database, see the metadata located on the accompanying CD-ROM, in the \animas\_cd\gis\_db\basecart\meta directory.

## Site Data

Site characterization, analysis, and monitoring were the primary objectives of the research of this project. Rock, sediment, water, and biological samples were collected, measured, and analyzed, and an inventory of mine-related sites and

descriptions was compiled. All data were integrated spatially, using a GIS, and conceptually, using a relational database, to produce a coherent organization of project data.

There are three sets of site data. Two are sample-site data and the third is mine-related site data; they are field sites, analysis sites, and mine sites. Field sites are all the sites that were sampled by project scientists; they number 2,014. Analysis sites are groupings of field sites. These are field sampling sites that are considered by project scientists to be co-located for analysis purposes; there are 1,648 analysis sites. Mine sites represent both inactive mines and other mine-related features; they number 374.

The conceptual structure of the implementation of the site data differs from the GIS data files to the relational database. The three data sets are provided as ArcInfo export files of coverages as well as ESRI shapefiles and DBF files. In the Access database the Field Sites and Mine Sites all are contained in a single table (Site). Associations between the GIS data files Field Sites (field\_sites) and Mine Sites (mine\_sites) were defined and represented in the relational database as relationships, rather than as individual Access tables.

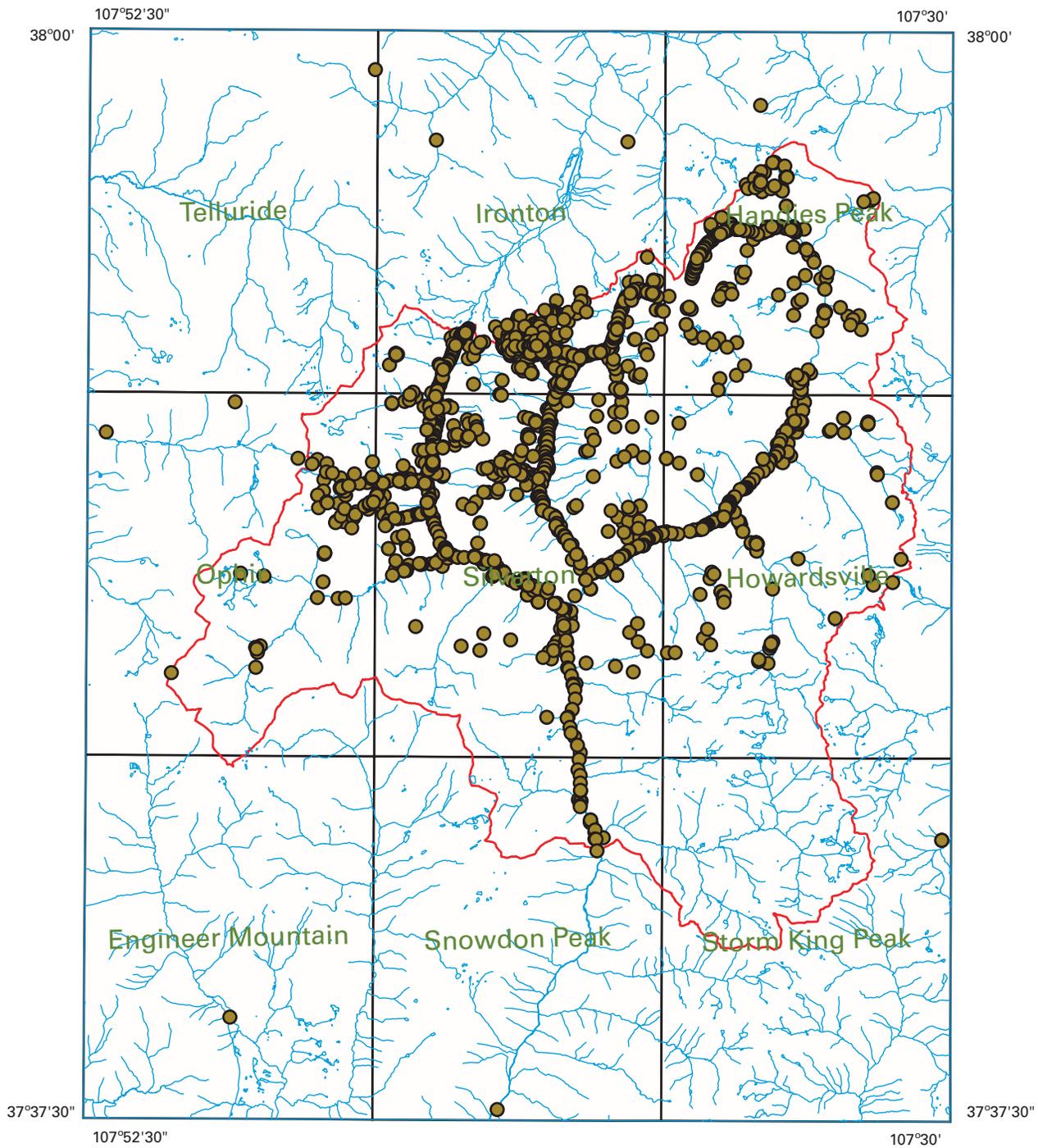
## Sample-Site Data

Figure 2 shows the distribution of the sample sites for the Animas River watershed study which lie within the nine-quadrangle area. Most sites are in the Animas River watershed; a few are outside of the Animas River watershed, and nine sites are outside the nine-quadrangle area. For detailed locations of specific sample sites, see the appropriate chapter of this volume or extract the FIELD\_SITES data from the accompanying CD-ROM.

The sample-site data and mine-related site data exist in a number of different formats on the accompanying CD-ROM. The site data file names and associated formats are shown in table 3. Because of the differences in the allowed lengths of file names and attribute names, some of the ArcInfo, ESRI shapefile, and DBF file names and attribute names are abbreviated versions of those that exist in the analogous relational (Access) database tables. These differences are delineated in the README.txt file on the Animas River watershed CD-ROM in the \animas\_cd\gis\_db\sitedata directory.

**Table 2.** Elevation and elevation-derived grids in the Animas River watershed GIS database.

Grid name	Theme	File name	Data format
ELEVATION	Elevation	elev.tar.gz	ArcInfo grid
ELEV_60MINT	Reclassified Elevation	elev.tar.gz	ArcInfo grid
HILSHD	Shaded Relief	elev.tar.gz	ArcInfo grid
SLOPE_DEGREE	Slope in Degrees	elev.tar.gz	ArcInfo grid
SLOPEDEG_CLS	Reclassified Slope	elev.tar.gz	ArcInfo grid
SLOPE_PERCENT	Percent Slope	elev.tar.gz	ArcInfo grid
SLOPEPCT_CLS	Reclassified Slope	elev.tar.gz	ArcInfo grid
ASPECT	Slope Aspect	elev.tar.gz	ArcInfo grid
ASP_CLASS2	Reclassified Aspect	elev.tar.gz	ArcInfo grid



**Figure 2.** Distribution of Animas River watershed study sample sites in nine-quadrangle area.

The coverage, file, and attribute names used in the remainder of this section are from the ArcInfo GIS database. Access relational database table and attribute names are used in the “Relational Database” section later in this chapter.

The sample data exist in the GIS database as two point feature data layers (FIELD\_SITES and ANALYSIS\_SITE) and 15 associated tables. The FIELD\_SITES data layer contains one point feature for each sample site. Attributes for

each site include a unique identifier called SITENUMBER, various information provided by the person who collected the sample(s) at the site, and location information. A table called FSLOC\_MASTER contains the attributes ELEVATION, UNIT (stratigraphic unit), LITH (lithology), and AGE (geologic age), for each sample site. Values for these attributes were assigned by using the GIS to perform spatial overlays with the FIELD\_SITES coverage and the appropriate base cartographic and geologic coverages.

**Table 3.** File names for Site Data in various formats.

Export files for ArcInfo coverages or Info files	Shapefiles or dBASE files	Access tables	ASCII tables
analysis_site.e00 (coverage)	anlysite.shp	SpatialAnalysisSites	SpatialAnalysisSites.txt
analytic_meth.e00 (Info file)	an_meth.dbf	AnalyticMethod	AnalyticMethod.txt
field_sites.e00 (coverage)	fldsitem.shp	Site	Site.txt
fs_ms_assocs.e00 (Info file)	fmsassoc.dbf	FieldSiteMineSiteAssocs	FieldSiteMineSiteAssocs.txt
fsloc_master.e00 (Info file)	fslocmst.dbf	FieldSiteLocationMaster	FieldSiteLocMaster.txt
lab_name.e00 (Info file)	labname.dbf	LabName	LabName.txt
msloc_master.e00 (Info file)	mslocmst.dbf	MineSiteLocationMaster	MineSiteLocMaster.txt
mine_sites.e00 (coverage)	minesite.shp	Site	Site.txt
parameter.e00 (Info file)	parametr.dbf	Parameter	Parameter.txt
project.e00 (Info file)	project.dbf	Project	Project.txt
qual_result.e00 (Info file)	qualres.dbf	QualitativeResult	QualitativeResult.txt
result1.e00 (Info file)	result1.dbf	Result	Result.txt
result2.e00 (Info file)	result2.dbf	Result	Result.txt
result3.e00 (Info file)	result3.dbf	Result	Result.txt
sample.e00 (Info file)	sample.dbf	Sample	Sample.txt
sample_media.e00 (Info file)	sampmed.dbf	SampleMedia	SampleMedia.txt

Sample sites that are considered co-located for purposes of spatial analysis are assigned the same value for an identifier called AMLI\_ANALYSIS\_ID. Because the location chosen to represent the “analysis site” is not always exactly the same as that of the sample sites that are logically considered to be co-located there, a second point feature data layer, ANALYSIS\_SITE, is used to contain the locations of the analysis sites. The same attributes that were added to the FIELD\_SITES data layer using spatial overlay were also added to the ANALYSIS\_SITE data layer.

Because the AMLI\_ANALYSIS\_ID exists in the attribute tables for both the FIELD\_SITES and ANALYSIS\_SITE data layers, the two can be related to each other and to other data tables containing actual sample data and results. The relationship between the two point feature data layers is one-to-many, since more than one field site can have the same AMLI\_ANALYSIS\_ID. In order to aid GIS users not familiar with techniques for dealing with one-to-many relationships, the attribute table for the ANALYSIS\_SITE data layer also contains the SITENUMBERS of the field sites associated with each analysis site.

A table called FS\_MS ASSOCS contains a list of field sites that are associated with specific mine-related sites. For a complete description of the inventory of mining-related sites created for this study, see Church, Mast, and others (this volume).

The other tables contain the actual sample data and results, as well as various characteristics of the samples and results. These tables were initially created using Microsoft Access and then converted to INFO files and DBF files for inclusion in the GIS database. These tables are described in the “Relational Database” section of this chapter. Effective use of the data in many of these tables requires dealing with one-to-many relationships. The relationships between the tables are shown in figure 3, and are explained in the “Relational Database” section of this chapter. An Adobe Portable Document format document (relationship.pdf) containing a complete diagram of the relationships of all the files in the Animas River watershed relational database exists on the accompanying CD-ROM in the \animas\_cd\rel\_db directory. Because effective use of the sample-site data requires an understanding of these relationships, this diagram is important for users of the GIS database, as well as for users of the relational database.

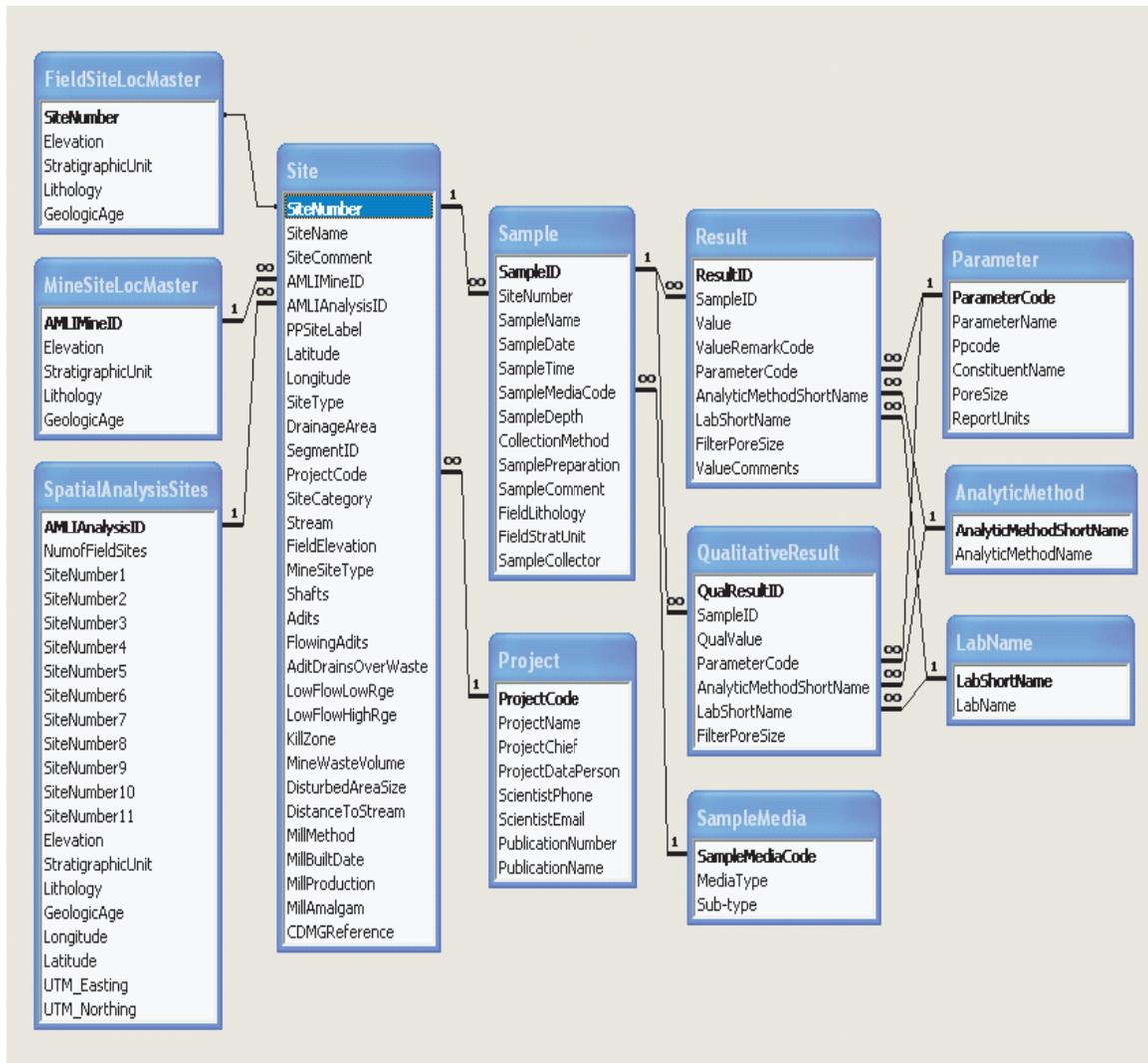


Figure 3. Tables in relational database and relationships between tables.

The FIELD\_SITES and ANALYSIS\_SITE coverages exist on the Animas River watershed CD-ROM as export files in the \animas\_cd\gis\_db\sitedata\00 directory. These coverages and tables also exist as ESRI shapefiles and DBF files, respectively, in the \animas\_cd\gis\_db\sitedata\shape and \animas\_cd\gis\_db\sitedata\dbf directories.

### Mine-Related Site Data

An inventory of inactive mines and mine-related sites in the Animas River watershed study area was compiled from existing State and Federal sources. The data include significant mines, mills, and mill tailings sites. This inventory of mine-related data provides detailed site characterization, including flowing adits, as well as the size and distribution of mine and mill waste.

In some cases, multiple shafts, adits, prospects, and mined areas of disturbance were located at a given site, but in each case a single point location was chosen to best

represent the entire site. Several points were used, however, to represent some mine sites that are composed of multiple levels. The location of each mine-related site was verified where possible with digital orthophoto quadrangle (DOQ) images, and by persons with local knowledge of the area.

Three hundred and seventy-four mine-related sites are stored in an ArcInfo coverage called MINE\_SITES, which exists on the Animas River watershed CD-ROM as an Arc Interchange export file in the \animas\_cd\gis\_db\sitedata\00 directory. A detailed description of the mine inventory data is in Church, Mast, and others (this volume).

In addition, the MINE\_SITES coverage and related tables are also available on the Animas River watershed CD-ROM as an ESRI shapefile and DBF files, respectively, in the \animas\_cd\gis\_db\sitedata\shape and \animas\_cd\gis\_db\sitedata\dbf directories. The mine-related site data are also part of the Animas River watershed relational database, which is described later in this chapter.

## Geoscientific Data

### Geologic Data

The geology of the Animas River watershed study area is described in Yager and Bove (this volume, Chapter E1). These data overlap the areas of the Ironton, Handies Peak, Ophir, Silverton, and Howardsville 1:24,000-scale topographic maps. The combined data files produce a generalized geologic map of the study area. All of the data are provided in both Arc Interchange format and ESRI Shapefile format.

These data consist of the following:

1. A geology coverage (geo.e00, geop.shp, and geol.shp). This file is provided with both polygon and line attributes.
2. A faults coverage (faults.e00 and faults.shp). Included in this fault coverage are combined fault and vein structures.
3. A veins and fissures coverage (veins.e00 and veins.shp). This coverage shows mineralized and nonmineralized or altered veins and fissures in the geologic map area.
4. An andesitic dikes coverage (a\_dike.e00 and a\_dike.shp). The a\_dike file shows dikes of andesitic (52–68 percent SiO<sub>2</sub>) composition.
5. A rhyolitic dikes coverage (r\_dike.e00 and r\_dike.shp). The r\_dike file shows dikes of rhyolitic (>68 percent SiO<sub>2</sub>) composition.
6. A caldera coverage (sjcald.e00 and sjcald.shp). This coverage defines the boundary of the San Juan caldera.

These data files are provided in Arc Interchange format in the \animas\_cd\gis\_db\geosci\geology\ directory, as well as in ESRI shapefile format in the \animas\_cd\gis\_db\geosci\geology\shape directory.

In addition, the CD-ROM contains six oversize map products, presented as PDF (portable document format), that were generated from data pertinent to the Animas River watershed study. These maps are provided in the \animas\_cd\gis\_db\geosci\plates directory. Each is listed in the contents of, and described in, a specific chapter, but most are referenced in several chapters throughout the volume. Plate 1, called pl\_1.pdf in the \geosci\plates directory, is an integrated, generalized geologic map; it is described in Yager and Bove (this volume). Plate 2 is also from Yager and Bove (this volume); it is a map showing ferricrete, manganocrete, and bog iron occurrences and related bogs and springs in the study area region; its image is called pl\_2.pdf. Plates 3 and 4 are a total-field magnetic map and apparent conductivity map, respectively, of the watershed study area, and are associated with Smith and others (this volume, Chapter E4). They are called pl\_3.pdf and pl\_4.pdf. Plate 5, pl\_5.pdf, is a map of surficial geologic deposits along Cement Creek and is from Vincent and others (this volume, Chapter E16). Plate 6, pl\_6.pdf, presents the stratigraphy

of channel and flood-plain deposits in a trench near the Eureka townsite; it is from Vincent and Elliott (this volume, Chapter E22).

Two oversize data tables, too large to be included in the printed book, are also included in the \animas\_cd\gis\_db\geosci\ directory on the CD-ROM, in a folder called \animas\_cd\gis\_db\geosci\tables. One is an expanded version of table 1 in Jones, Chapter C, giving cumulative production history of mining by year in San Juan County, Colo. The second is an appendix to Anderson, Chapter E20, and is a large table of effects of mining on benthic macro-invertebrate communities in the study area; it includes strategies for monitoring. These items are included as both .xls and .pdf files.

### Geochemical Data

In addition to the streambed and water geochemistry site data, which are provided in the Access database, both generalized and detailed hydrothermal alteration assemblages have been developed as the result of integration of the geologic data described previously with the results of the aqueous geochemical data (alt\_gen.e00, alt\_genl.shp, alt\_genp.shp, and alt\_det.e00, alt\_detl.shp, alt\_detp.shp). These data highlight the contrasting types of mineralization and hydrothermal alteration in the Animas River watershed study area. The files are provided in both Arc Interchange format in the \animas\_cd\gis\_db\geosci\geochem\ directory as well as ESRI shape file format in the \animas\_cd\gis\_db\geosci\geochem\shape directory.

A detailed description of the hydrothermal alteration data is in Bove and others (this volume, Chapter E3).

### Biological Data

Fish survey studies resulted in a data set that shows locations of species survival in the tributaries of the Animas River (ani\_fish.e00 and ani\_fish.shp). The fish sampling was conducted in 1992 by the Colorado Department of Health and Environment Water Quality Control Division (WQCD) with additional help and information provided by Mike Japhet of the Colorado Division of Wildlife in Durango, Colo. This file is provided in Arc Interchange export format in the \animas\_cd\gis\_db\geosci\biologic\ directory and in ESRI shapefile format in the \animas\_cd\gis\_db\geosci\biologic\shape directory.

### Geophysical Data

Electromagnetic and magnetic anomaly geophysical data were collected over the Animas River watershed study area. The primary goal of the geophysical data is to aid the mapping of surface and subsurface lithology and structure in the study area.

The electromagnetic and magnetic anomaly data are described in Smith and others (this volume, Chapter E4). The chapter by McDougal and others (this volume, Chapter E13), provides a description of geophysical signatures of mapped geologic structures and identifies possible unmapped structures based on these geophysical signatures. Images of these data are available in the \animas\_cd\gis\_db\geosci\geophys\geotiff directory.

Vector files that define the extent of the airborne geophysical surveys are available in ArcInfo export format (gp\_poly.e00) in the \animas\_cd\gis\_db\geosci\geophys\e00 directory, and in ESRI shapefile format (gp\_poly.shp) in the \animas\_cd\gis\_db\geosci\geophys\shape directory.

The images provided on the CD-ROM were derived from grids of data collected along closely spaced (200 m and 400 m) flightlines as part of a high-resolution airborne geophysical survey over the Animas River watershed area. The 200 m flight spacing is in the western section of the geophysical study area. The closer spacing was chosen to highlight features of the Cement and Mineral Creek drainages.

Images relating to the magnetic anomaly data include a reduced-to-pole magnetic anomaly map (rtp\_mag.tif), a high-pass magnetic anomaly map (rtp\_mag\_hipass.tif), a low-pass magnetic anomaly map (rtp\_mag\_lowpass.tif), a high-pass horizontal magnetic gradient map (HGM\_hipass.tif), and a low-pass horizontal magnetic gradient map (HGM\_lowpass.tif). The high-pass and low-pass images emphasize magnetic anomalies caused by lateral variations in magnetic properties of rocks from surface elevations to approximate depths of 200 m. They are the result of a filter that was applied to the reduced-to-pole data. From these data, a predictive model of geologic structures was calculated (HGM\_hipass\_model.tif).

Images that portray apparent conductivity of rocks as measured from the airborne geophysical survey are provided on the CD-ROM. The images represent conductivity of rocks at three frequencies resulting in different depths of penetration. They illustrate the electrical structure of the Earth. The image produced using the highest frequency (34,960 Hz) shows conductivities of rock at depths from the topographic surface of a few to 10 m (cond\_34960csr\_100k.tif). The mid-frequency (4,310 Hz) images (cond\_4310\_48k.tif and cond\_4310csr\_100k.tif) map conductivities of rock from the surface to depths of approximately 30 m. The lowest frequency (984 Hz) image (cond\_984csr\_100k.tif) maps conductivities of rock at depths to approximately 60 m.

In addition, two images of predictive models are provided. The first image uses the electrical resistivity at 4,310 Hz to model geologic structures (res4310\_model.tif). The second image is a profile convexity predictive model of geologic structures (profile\_convex\_model.tif). A detailed description of these images is found in McDougal and others (this volume).

The geologic, geophysical, and geomorphological maps and the geochemical, biological, geophysical, and remote sensing data are listed in table 4, and are available on the CD-ROM accompanying this paper in the \animas\_cd\gis\_db\geosci directory.

## Relational Database

The Abandoned Mine Lands Initiative (AMLI) Animas River relational database was constructed as a tool to be used for data synthesis and analysis, and as an archive of data collected during the AMLI project. It includes data collected by USGS biologists, geologists, and hydrologists within or adjacent to the Animas River watershed during the period 1995 to 2000<sup>1</sup>. It also includes data collected by the Colorado Division of Minerals and Geology during the period 1995 to 1998. It is a relational database containing field measurements made at point locations, and laboratory analyses of samples collected at point locations. Quality-assurance data are not included; information on field and laboratory quality-assurance practices is located in individual chapters in this report or in previously published reports.

## Contents of Database

The AMLI Animas River relational database contains 19 data sets contributed by USGS scientists and teams from the Geologic Discipline, Water Resources Discipline, and Biological Resources Discipline. These data sets comprise all the available data collected as part of the project, and all the data discussed in this volume, amassed at 2,389 sites. Samples, taken from a total of 66 defined media types, included 1,898 water, 1,885 earth material, and 190 biotic material. Water media sampled included surface water (for example, streams) and ground water (for example, well water). Earth media sampled included sediment, soil, bedrock, and mine-waste material. Biotic media sampled include biofilm, fish tissue, invertebrate tissue, and vegetation. The database contains 144,522 results, divided among quantitative, qualitative, and descriptive measurements. Data definition is provided through the establishment of 1,231 unique parameters (measurement types).

## Database Structure

Because of the scope and complexity of data collected as part of the AMLI project, a relational database structure was designed for data storage. Data are grouped into logical units (tables), and relationships are defined to link the tables. This structure provides efficient storage of information (information need not be repeated), and also provides for built-in data verification checks. For example, a result cannot exist without corresponding site, sample, and parameter information. The relational database structure is also a powerful and efficient tool for retrieving subsets of data to meet user requirements. The AMLI relational database contains 12 tables that have been populated and linked to one another, providing the necessary functionality that the project requires.

<sup>1</sup>Analyses of 110 bedrock samples collected during previous studies (1982–1993) are also included in the AMLI database.

**Table 4.** Geoscientific data in the Animas River watershed GIS database.

[On the CD-ROM, the six PDF maps are in a separate sub-directory called \geosci\plates\; the two tables (mine production information and invertebrate community information) are in a separate sub-directory called \geosci\tables\]

Subject	Description	File name	File format(s)	Chapter
<b>Geology</b>				
Geology		geo.e00, geop.shp (polys), geol.shp (lines)	ArcInfo vector coverage	Yager and Bove (E1)
Structure		faults.e00, faults.shp	ArcInfo vector coverage	Yager and Bove (E1)
Veins		veins.e00, veins.shp	ArcInfo vector coverage	Yager and Bove (E1)
Dikes-andesitic		a_dike.e00, a_dike.shp	ArcInfo vector coverage	Yager and Bove (E1)
Dikes-dacitic		d_dike.e00, d_dike.shp	ArcInfo vector coverage	Yager and Bove (E1)
Dikes-rhyolitic		r_dike.e00, r_dike.shp	ArcInfo vector coverage	Yager and Bove (E1)
Topographic base		topobase_nad27_4bit.tif	GeoTiff	Yager and Bove (E1)
San Juan caldera		sjcald.e00, sjcald.shp	ArcInfo vector coverage	Yager and Bove (E1)
Geologic Map Plate		pl_1.pdf	PDF Map	Yager and Bove (E1)
Ferricrete, Manganocrete, Bog Iron Occurrences, and Related Bogs and Springs Map Plate		pl_2.pdf	PDF Map	Yager and Bove (E1)
Cumulative production history of mining by year in San Juan County		ChCTable1_orig.xls .pdf	XLS Table PDF Table	Jones (C)
<b>Geochemistry</b>				
Generalized hydrothermal alteration assemblages		alt_gen.e00, alt_genl.shp, alt_genp.shp	ArcInfo vector coverage	Bove and others (E3)
Detailed hydrothermal alteration assemblages		alt_det.e00, alt_detl.shp, alt_detp.shp	ArcInfo vector coverage	Bove and others (E3)
<b>Biological Data</b>				
Fish species survival location map		ani_fish.e00, ani_fish.shp	ArcInfo vector coverage	Besser and Brumbaugh (E18) Besser and others (D)
Effects of mining on benthic macroinvertebrate communities in the study area, with strategies for monitoring		ChE20Appendix.xls .pdf	XLS Table PDF Table	Anderson (E20)
<b>Geophysics</b>				
984 Hz. conductivity		cond_984csr_100k.tif	GeoTiff	Smith and others (E4)
4310 Hz. conductivity (1:48k)		cond_4310_48k.tif	GeoTiff	Smith and others (E4)
4310 Hz. conductivity (1:100k)		cond_4310csr_100k.tif	GeoTiff	Smith and others (E4)
34960 Hz. conductivity		cond_34960csr_100k.tif	GeoTiff	Smith and others (E4)
4310 Hz. resistivity predictive model		res4310_model.tif	GeoTiff	McDougal and others (E13)
Reduced-to-the-pole magnetic anomaly		rtp_mag.tif	GeoTiff	McDougal and others (E13)
Reduced-to-the-pole high pass magnetic anomaly		rtp_mag_hipass.tif	GeoTiff	McDougal and others (E13)
Reduced-to-the-pole low pass magnetic anomaly		rtp_mag_lowpass.tif	GeoTiff	McDougal and others (E13)
Reduced-to-the-pole high pass horizontal magnetic gradient		HGM_hipass.tif	GeoTiff	McDougal and others (E13)
Reduced-to-the-pole low pass horizontal magnetic gradient		HGM_lowpass.tif	GeoTiff	McDougal and others (E13)

**Table 4.** Geoscientific data in the Animas River watershed GIS database.—Continued

Subject	Description	File name	File format(s)	Chapter
<b>Geophysics—Continued</b>				
	Profile convexity predictive model of geologic structures	profile_convex_model.tif	GeoTiff	McDougal and others (E13)
	High-pass horizontal gradient magnitude magnetics predictive model of geologic structures	HGM_hipass_model.tif	GeoTiff	McDougal and others (E13)
	Outline of the geophysical study area boundary	gp_poly.e00, gp_poly.shp	ArcInfo vector coverage	McDougal and others (E13)
	Outline of extent of structural mapping	struct.e00, struct.shp	ArcInfo vector coverage	McDougal and others (E13)
	Total-Field Magnetic Map Plate	pl_3.pdf	PDF Map	Smith and others (E4)
	Apparent Conductivity Map Plate	pl_4.pdf	PDF Map	Smith and others (E4)
<b>Geomorphology</b>				
	Surficial Geologic Deposits Map Plate	pl_5.pdf	PDF Map	Vincent and others (E16)
	Stratigraphy of Channel and Flood-Plain Deposits Map Plate	pl_6.pdf	PDF Map	Vincent and Elliott (E22)

The principal tables in the AMLI relational database are the **Site**, **Sample**, **Result**, **QualitativeResult**, and **Parameter** tables (fig. 3). The **Site** table contains information about each of the 2,389 sites in the database. A SiteNumber uniquely identifies each site, which may be further described with data entered in the SiteName and SiteComment fields. The SiteNumber field also provides the link between data in the **Site**, **FieldSiteLocMaster**, and **Sample** tables. Sites that are considered co-located for purposes of spatial analysis are assigned the same AMLIAnalysisID, which creates the link needed to access data in the **SpatialAnalysisSites** table. The **Site** table also contains all of the project data that describes mining activity in the Animas River watershed study area. All sites that are located at mine sites have been assigned AMLIMineID numbers, providing the link to data stored in the **MineSiteLocMaster** table. A project code for each site (ProjectCode) indicates what project and scientist established the site. ProjectCode links **Site** to the data in the **Project** table. Additional characteristics in the **Site** table include geographic coordinates (Latitude and Longitude) and a Stream designation that indicates the name of the stream on which the site is located. Relationships between the **Site** table and other tables in the database are shown in figure 3.

The **Sample** table contains information about the sample material collected at each site. Each analyzed sample has a unique SampleID, as well as a SampleName provided by the sample collector. SampleID is the key field that links the sample to its chemical and physical data found in the **Result** and **QualitativeResult** tables. The time and date of sample collection are noted in the SampleTime and SampleDate fields. The SampleMediaCode defines the sample material type, a definition that is clearly described in the **SampleMedia** look-up table to which it is linked. Media type should be carefully

noted in analysis of data so that data from different sample types are not mistakenly equated. For example, the database contains analyses for arsenic found in streambed sediment and in mill tailings sediment—two types of sample material that have different potential for the concentration of metals. Information regarding the collection and preparation of the sample may be found in the optional fields CollectionMethod, and SamplePreparation. Any other pertinent sample information available may be found in the SampleComment field. Relationships between the **Sample** table and other tables in the database are shown in figure 3.

The **Result** table contains measurements made in analytical laboratories as well as at sampling sites, expressed as numeric values, whereas the **QualitativeResult** table (fig. 3) contains qualitative measurements that are expressed as text values. For the most part, the two tables function in the same way, although 97 percent of the project result data is found in the **Result** table. The characteristic measured is identified using a ParameterCode, a succinct 20-character-length field that can be used as a column name in a data report or spreadsheet. The ParameterCode links both result tables to the **Parameter** look-up table, which is further detailed in the next paragraph. In the **Result** table, measurements consist of a numeric Value and an optional ValueRemarkCode, which is used to qualify results such as non-detections or estimates based on limits of instrumental detection. Data describing water filters, where used in the sampling procedure, may be found in the FilterPoreSize field. Information regarding the method of analysis or measurement used to obtain data is found in the AnalyticMethodShortName field, which is an abbreviated label linked to the **AnalyticMethod** look-up table. Likewise, LabShortName is an abbreviated label linked to the **LabName** look-up table, which provides information

regarding the laboratory or work group responsible for the analysis. Any further remarks regarding the Value or the analytic process will be found in the ValueComments field. Relationships between the **Result** and **QualitativeResult** tables and other tables in the database are shown in figure 3.

The **Parameter** table is a look-up table that contains a complete description of each characteristic measured. Whereas the **Result** table contains a short description of the characteristic measured (ParameterCode), the highly specific nature of laboratory measurements requires a lengthier description. For example, the ParameterCode "Ag\_st\_sl" is shorthand for "Silver, sediment, mine waste/tailings/dump material, dry sieved, finer than 0.18 millimeters, leachate from 1% H<sub>2</sub>O<sub>2</sub>-HCl leach digestion, laboratory, micrograms per gram." The **Parameter** table also includes a ConstituentName field that groups results according to the element or compound type (zinc, for example), and a Ppcode field that lists the corresponding measurement code (where available) in the U.S. Geological Survey's National Water Information System (NWIS) and the U.S. Environmental Protection Agency's STORET database. Lastly, the **Parameter** table contains fields that show the units in which values are reported, as well as the pore size of the filtered or sieved sample in question.

Relationships between these tables are depicted as lines in figure 3. The **Site** table is linked to the **Sample** table by including a common field (SiteNumber) in both tables. Therefore, a sample cannot exist without having a site in the **Site** table. The symbols "1" and "∞" at the ends of the relationship line indicate a one-to-many relationship, that is, a site may have many samples. Similarly, a sample may have many results, and a parameter may also have many results.

As for the remaining seven tables, the **SpatialAnalysis-Sites** table provides site groupings so that data may be extracted from sites in the same locale, stream basin, or mine area. The **FieldSiteLocMaster** and **MineSiteLocMaster** tables contain characteristics for each field site and mine site. These characteristics were derived from overlays using a GIS database. The **AnalyticMethod** table provides additional information on field and laboratory techniques used for sample analysis. The **LabName** table provides additional information about analytical laboratories or work groups that produced chemical results or physical measurements. The **Project** table provides additional information about the projects or work groups that provided data to the AMLI relational database. This table provides contacts for these projects, as well as information regarding other publications where the project's data have been previously published. The **SampleMedia** table not only provides additional information about the media types sampled but also is a media classification scheme created for the purpose of concise data retrieval.

Relational databases can be used by a variety of proprietary or nonproprietary software packages. The AMLI relational database is provided in the CD-ROM attached to

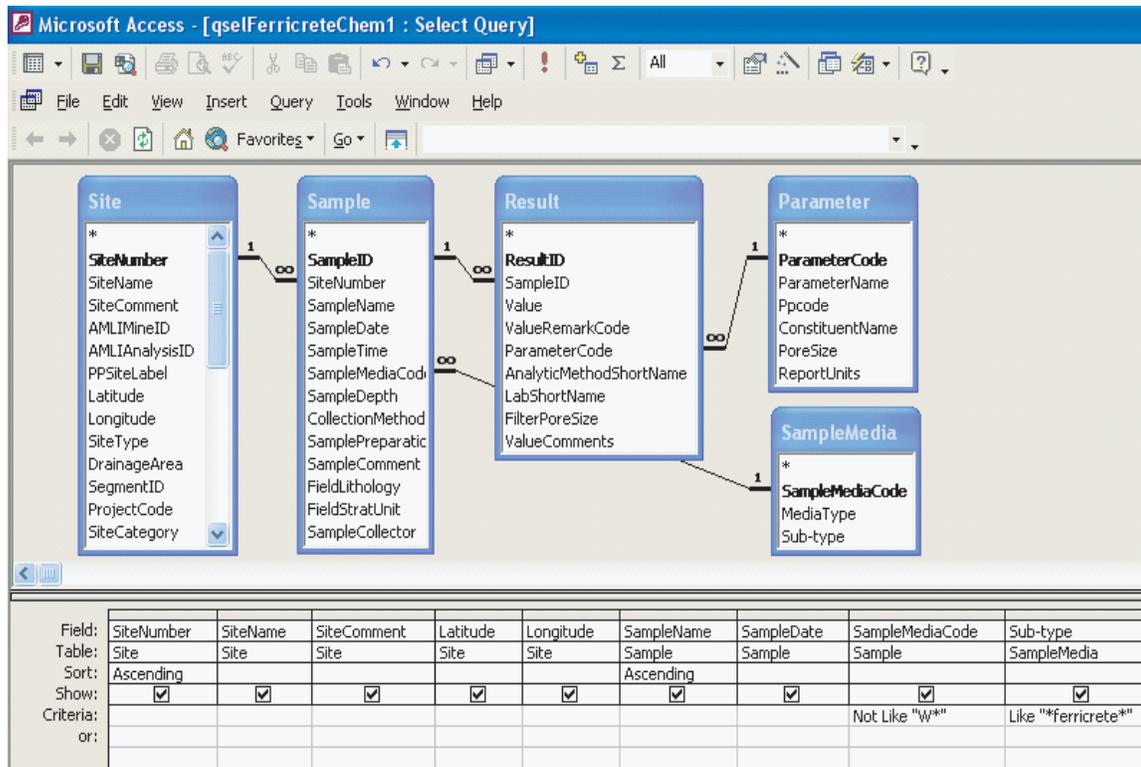
this report in a proprietary, write-protected, read-only format (Microsoft Access 2003) and it is also provided in a nonproprietary format. A README file on the CD-ROM provides technical details about how to use the database in these two formats. A more complete discussion of the creation and content of the database is included on the CD-ROM in a Federal Geographic Data Committee-compliant metadata file.

Data may be extracted from the AMLI relational database to meet specific user needs. Within relational database software packages, queries may be constructed and saved to retrieve data using user-defined criteria. The Microsoft Access version of the AMLI relational database on the CD-ROM contains several example queries. For example, a series of linked queries were constructed to extract data yielded from ferricrete samples collected in the Animas River watershed study area. To formulate this query, the user needs to list the database fields of interest and the conditions to be placed on extracting this information. The construction of more complex queries requires the user to browse the various tables to get an idea of their contents. For the ferricrete data, the table includes the site name, site location, sample name, sample media information, sample date, elemental concentrations, analytic method used for detection, and a detailed description of the analytic parameter. The query 'qselFerricreteChem1' selects these fields of interest (fig. 4).

This query combines data from five tables: the **Site** table (containing the SiteNumber, SiteName, and coordinates), the **Sample** table (containing the sample name and date), the **SampleMedia** table, the **Result** table (containing result information and parameter codes), and the **Parameter** table (containing the detailed parameter names). Data will be sorted first by SiteNumber and then by SampleName. Conditions are placed on this query so that only ferricrete solid sample media data are selected. This is done by specifying the criteria "Not like 'W\*'" for SampleMediaCode, and "Like '\*ferricrete\*'" for the Sub-type of SampleMedia. Ferricrete rock and sediment are now queried. This query also constructs the Result value as a new field called "adjvalue" so that all results that are less than the detection limit (have "<" in the ValueRemarkCode accompanying the Value) are divided by two. The script used to define this field is:

```
“adjvalue: IIf(Result!ValueRemarkCode='<',0.5*Result!Value,[Value])
```

This procedure renders all result data as numerical results. Also included in the query is the creation of a new field "LongParam" that combines the ParameterCode and AnalyticMethodShortName from the **Result** table and ReportUnits from the **Parameter** table so that the resulting data can be clearly qualified. The new LongParam "As\_r\_sl\_\_ug/g\_\_ICP-AES" is a shortened equivalent of the ParameterName "Arsenic, rock/"fossil" ferricrete/mineral, outcrop, dry sieved, finer than 0.149 millimeters, leachate from 2M HCl-1% H<sub>2</sub>O<sub>2</sub> leach digestion, laboratory, micrograms per gram". The script used to define this new field is:



Field:	adjvalue: IIf(Result!ValueRemarkCode='<','0.5*Result!Value,[Value]	LongParam: (Result!ParameterCode &" " & Parameter!ReportUnits &" " & Result!AnalyticMethodShortName)	ParameterName
Table:			Parameter
Sort:			
Show:	<input checked="checked" type="checkbox"/>	<input checked="checked" type="checkbox"/>	<input checked="checked" type="checkbox"/>
Criteria:			
or:			

Figure 4. Select query qselFerricreteChem1 in Query Design view.

LongParam: (Result!ParameterCode&" "&Parameter!Report Units&" "& Result!AnalyticMethodShortName)

The graphical view of the query shown in figure 4 is translated into a Structured Query Language (SQL) statement as follows:

```

SELECT Site.SiteNumber, Site.SiteName,
Site.SiteComment, Site.Latitude, Site.Longitude,
Sample.SampleName, Sample.SampleDate,
Sample.SampleMediaCode, SampleMedia.[Sub-type],
IIf(Result!ValueRemarkCode='<','0.5*Result!Value,
[Value]) AS adjvalue, (Result!ParameterCode&" "&
Parameter!ReportUnits&" "&Result!AnalyticMethod
ShortName) AS LongParam, Parameter.ParameterName
FROM (SampleMedia INNER JOIN (Site INNER JOIN
Sample ON Site.SiteNumber = Sample.SiteNumber) ON
SampleMedia.SampleMediaCode = Sample.Sample
MediaCode) INNER JOIN (Parameter INNER JOIN
    
```

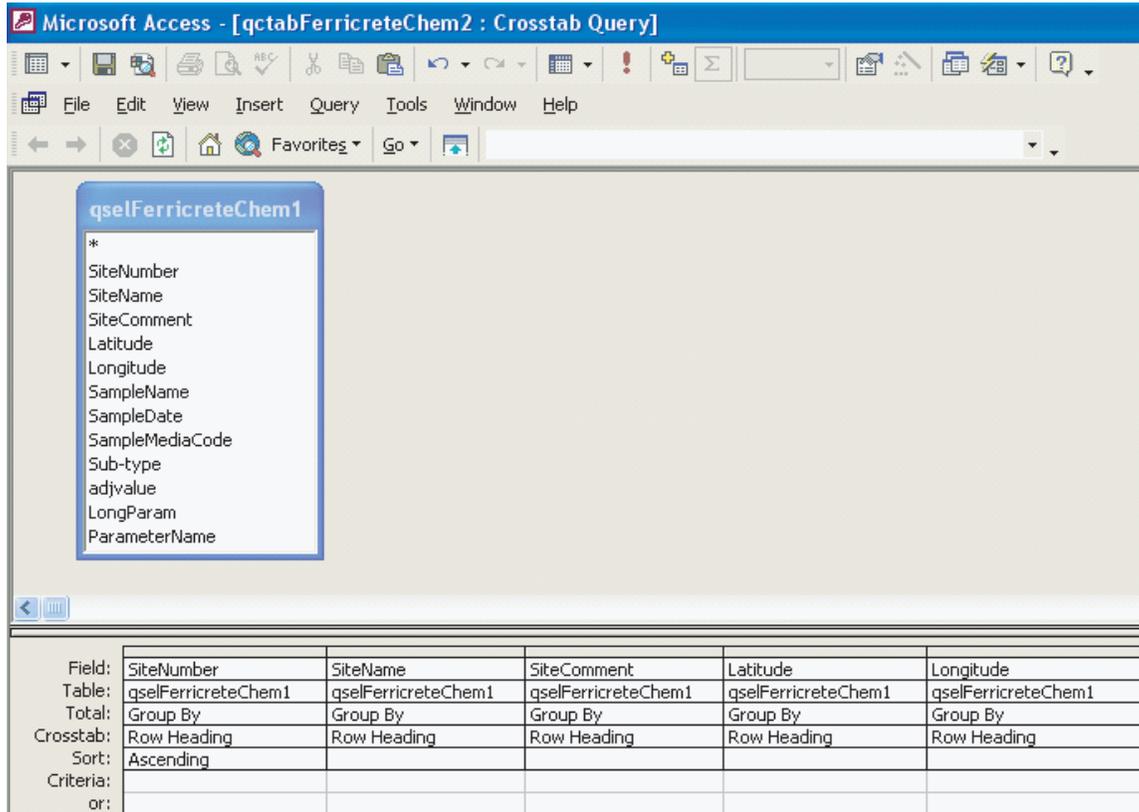
```

Result ON Parameter.ParameterCode = Result.
ParameterCode) ON Sample.SampleID = Result.SampleID
WHERE (((Sample.SampleMediaCode) Not Like "W*")
AND ((SampleMedia.[Sub-type]) Like "**ferricrete*"))
ORDER BY Site.SiteNumber, Sample.SampleName;
    
```

In addition, the query “qselFerricreteMin1” has been constructed to gather mineralogical data for these same samples.

Running select query qselFerricreteChem1 produces a display containing 1,571 rows, each one containing one chemical value. The second query in this example is a crosstab query “qctabFerricreteChem2” that pivots the results of interest gathered by the first query so that they appear as columns rather than rows (fig. 5).

This crosstab query was constructed using our first query so that SampleNames are row headings and ParameterCodes are the column headings. In this case, the query is seeking all arsenic results for ferricrete solids (see Criteria row,



(continued from right side)

Field:	SampleName	SampleDate	SampleMediaCode	Sub-type	LongParam	adjvalue	LongParam
Table:	qselFerricreteChem1						
Total:	Group By	First	Where				
Crosstab:	Row Heading	Row Heading	Row Heading	Row Heading	Column Heading	Value	
Sort:	Ascending						
Criteria:							Like "As_*")
or:							

Figure 5. Crosstab query qctabFerricreteChem2 in Query Design view.

LongParam column in fig. 5). SampleMedia subtypes and associated Site table data are listed to further describe the samples. The graphical view of the query shown in figure 5 is translated into a Structured Query Language (SQL) statement as follows:

```

TRANSFORM First(qselFerricreteChem1.adjvalue)
AS FirstOfadjvalue
SELECT qselFerricreteChem1.SiteNumber,
qselFerricreteChem1.SiteName,
qselFerricreteChem1.SiteComment,
qselFerricreteChem1.Latitude, qselFerricreteChem1.
Longitude, qselFerricreteChem1.SampleName,
qselFerricreteChem1.SampleDate, qselFerricreteChem1.
SampleMediaCode, qselFerricreteChem1.[Sub-type]
FROM qselFerricreteChem1
WHERE (((qselFerricreteChem1.LongParam)
Like "As_*"))
    
```

```

GROUP BY qselFerricreteChem1.SiteNumber,
qselFerricreteChem1.SiteName, qselFerricreteChem1.
SiteComment, qselFerricreteChem1.Latitude,
qselFerricreteChem1.Longitude, qselFerricreteChem1.
SampleName, qselFerricreteChem1. SampleDate,
qselFerricreteChem1.SampleMediaCode,
qselFerricreteChem1.[Sub-type]
ORDER BY qselFerricreteChem1.SiteNumber,
qselFerricreteChem1.SampleName
PIVOT qselFerricreteChem1.LongParam
    
```

This query can be exported as a spreadsheet or as a text file (fig. 6).

In addition, the query “qctabFerricreteMin2” has been constructed to display the mineralogical data for these same samples in the same manner.

SiteNumber	SiteName	SiteComment	Latitude	Longitude	SampleName	SampleDate	SampleMediaCode	Sub-type	As_r_s_ug/g	As_r_sl_ug/g	As_sb_scl_PL
95ABS119			37.89703	-107.64543	95ABS119	10/17/1995	R06	ferricrete, bog iron	15	15	
99ABFC102			37.88935	-107.65677	99ABFC102B	09/01/1999	R07	ferricrete, spring d	31		
99ABFC110			37.88866	-107.6572	99ABFC110	09/01/1999	R04	ferricrete, alluvial	29		
99ABFC111			37.88839	-107.65825	99ABFC111	09/01/1999	R04	ferricrete, alluvial	20		
99ABFC115			37.8864	-107.66288	99ABFC115	09/01/1999	R04	ferricrete, alluvial	25		
99ABFC118			37.88307	-107.66569	99ABFC118B	09/01/1999	R04	ferricrete, alluvial	25		
99ABFC119			37.88258	-107.66605	99ABFC119	09/01/1999	R04	ferricrete, alluvial	24		
99ABFC120			37.88224	-107.66628	99ABFC120	09/01/1999	R04	ferricrete, alluvial	67		
99ABFC126			37.86564	-107.67539	99ABFC126	09/01/1999	R06	ferricrete, bog iron	120		
99ABFC128			37.85641	-107.67532	99ABFC128A	09/01/1999	R04	ferricrete, alluvial	36		
99ABFC131			37.85162	-107.67574	99ABFC131	09/01/1999	R04	ferricrete, alluvial	300		
99ABFC133			37.85075	-107.676	99ABFC133	09/01/1999	R04	ferricrete, alluvial	44		
99ABFC134			37.84563	-107.6776	99ABFC134	09/01/1999	R04	ferricrete, alluvial	73		
99ABFC136			37.8353	-107.67763	99ABFC136A	09/01/1999	R04	ferricrete, alluvial	45		
99ABFC138			37.83316	-107.67255	99ABFC138	09/01/1999	R04	ferricrete, alluvial	46		
99ABFC139			37.83155	-107.67113	99ABFC139	09/01/1999	R07	ferricrete, spring d	5		
99ABFC141			37.82323	-107.66472	99ABFC141B	09/01/1999	R06	ferricrete, bog iron	5		
99ABFC141			37.82323	-107.66472	99ABFC141C	09/01/1999	R04	ferricrete, alluvial	5		
99ABFC151			37.85933	-107.67643	99ABFC151	09/01/1999	R04	ferricrete, alluvial	50		
99ABFC153			37.87382	-107.67277	99ABFC153	09/01/1999	R04	ferricrete, alluvial	21		
99ABFC159			37.88723	-107.64901	99ABFC159A	09/01/1999	R07	ferricrete, spring d	5		
99ABFC161			37.88324	-107.64522	99ABFC161	09/01/1999	R06	ferricrete, bog iron	5		
99ABFC162			37.86965	-107.64429	99ABFC162A	09/01/1999	R06	ferricrete, bog iron	2100		
99ABFC170			37.90989	-107.6377	99ABFC170	09/01/1999	R05	ferricrete, colluvial	13		
99ABFC173			37.90466	-107.64375	99ABFC173	09/01/1999	R06	ferricrete, bog iron	5		
99ABFC176			37.89586	-107.64629	99ABFC176A	09/01/1999	R04	ferricrete, alluvial	18		
99ABFC176			37.89586	-107.64629	99ABFC176B	09/01/1999	R06	ferricrete, bog iron	5		
99ABFC185			37.86409	-107.6791	99ABFC185C	09/01/1999	R04	ferricrete, alluvial	30		
99VM09			37.82361	-107.70566	99VMS09	09/01/1999	R05	ferricrete, colluvial	38		
99VM13	Mineral Creek		37.86833	-107.72583	99VMS13A2	09/01/1999	R04	ferricrete, alluvial	5		
99VM29			37.86016	-107.7108	99VMS29	09/01/1999	R04	ferricrete, alluvial	100		
99VM33			37.84492	-107.731	99VMS33	09/01/1999	R04	ferricrete, alluvial	23		
99VM65			37.86528	-107.72667	99VMS65A	09/01/1999	R07	ferricrete, spring d	120		
99VM65			37.86528	-107.72667	99VMS65B	09/01/1999	R07	ferricrete, spring d	5		
IDY00-14			37.89445	-107.64603	IDY00-14	09/01/2000	R06	ferricrete, bog iron	5		
IDY00-29			37.8829	-107.66888	IDY00-29A	09/01/2000	R06	ferricrete, bog iron	480		
IDY00-29			37.8829	-107.66888	IDY00-29B	09/01/2000	R06	ferricrete, bog iron	400		
NAR205	Rusty alluvi	Rusty alluvium	37.89331	-107.66067	NAR205	08/16/1997	SD08	active ferricrete, al			0.1
ODY99-09			37.84419	-107.75362	ODY99-09	09/01/1999	R04	ferricrete, alluvial	5		
SDY00-17A			37.8494	-107.6895	SDY00-17A1	09/01/2000	R06	ferricrete, bog iron	150		
SDY00-17A			37.8494	-107.6895	SDY00-17A2	09/01/2000	R05	ferricrete, colluvial	5		
SDY00-2			37.84035	-107.6887	SDY00-2	09/01/2000	R05	ferricrete, colluvial	160		
SDY00-28			37.83453	-107.72729	SDY00-28	09/01/2000	R05	ferricrete, colluvial	35		
SDY99-14			37.84111	-107.74883	SDY99-14	09/01/1999	R05	ferricrete, colluvial	5		

Figure 6. Crosstab query ctabFerricreteChem2 exported as an XLS file.

## Data Viewer Software

Two freeware GIS data viewer software packages are provided on the CD-ROM with this volume. These products are GIS data explorers. The purpose of the data viewer software is to give the user the capability to display and perform elementary GIS analysis on the digital data. The vector coverages and raster images provided on the CD-ROM are useful for illustrating the processes and dynamics, in terms of mine drainage, that occur in the watershed.

The two data viewer software packages are ArcExplorer 2.0 and MapSheets Express 1.3. ArcExplorer 2.0 was written by Environmental Systems Research Institute, Inc. MapSheets Express was written by ERDAS, Inc.

Using these two products, the spatial data can be displayed, queried, and overlaid to produce map output. MapSheets Express enables the user to generate maps that

can be imported into PowerPoint presentations. In addition, Word and WordPerfect documents can be output from MapSheets Express.

The two software packages have some important differences. ArcExplorer is better at handling vector files than raster files. Raster images can be displayed in ArcExplorer, but one cannot query the images. The raster images can only be displayed one at a time as a background for vector files. Basically, this image is a static backdrop with no inherent analysis properties.

In contrast, MapSheets Express has more functionality for raster images than ArcExplorer provides. The user is able to query pixels of the raster images. The attributes of these pixels are accessible in the data tables for user output. In addition, MapSheets Express allows the user to control the transparency of the images, which allows several raster images to be overlaid. In summary, for vector data work, ArcExplorer is a more effective tool, and for raster data work, MapSheets Express is better.

The two packages have similar platform requirements. ArcExplorer 2.0 requires a PC with Windows 98/2000/NT/XP operating systems. It requires Internet Explorer 4.0 for the internet capabilities of the software. MapSheets Express 1.3 requires Windows 95 or Windows NT version 4.0 operating system or later. Both ArcExplorer 2.0 and MapSheets Express 1.3 need 16 MB RAM and an IBM/PC or compatible system with 486-class processor or better.

## Animas River Watershed CD-ROM

The `rel_db` directory contains the relational database version of the sample-site data collected for the study, and the mine-related site inventory compiled for the study. The directory contains a `README.txt` file which describes the contents of the directory, and an Adobe Portable Document Format file (`relationship.pdf`) which is a diagram of all the tables in the relational database, and the relationships between them (fig. 3 of this chapter). The `mdb` subdirectory contains the Microsoft Access version of the relational database (`AnimasAMLI.mdb`), the `ascii` subdirectory contains relational database tables in the form of flat ASCII files, and the `meta` subdirectory contains metadata for the relational database.

The `gis_db` directory contains three subdirectories (`basecart`, `sitedata`, and `geosci`), each of which contains different types of data in formats suitable for use in Geographic Information Systems. The `basecart` subdirectory contains base cartographic data used as reference for the other data. The `basecart` subdirectory itself contains a `README.txt` file describing the base cartographic data. Below the `basecart` subdirectory, the `e00` subdirectory contains ArcInfo export files of base cartographic data stored as ArcInfo coverages. The `shape` subdirectory contains ESRI shapefiles and DBF files of the data contained in the ArcInfo coverages. The `elev` subdirectory contains a compressed tar file, which when uncompressed creates an ArcInfo workspace containing an elevation grid, and slope, aspect, and shaded relief grids derived from the elevation grid. The `elev` subdirectory also includes GeoTIFF image file representations of the elevation data, and TIFF images of legends for the elevation data image files. The `meta` subdirectory contains metadata for the data in the `e00`, `shape`, and `elev` subdirectories. The `drg` subdirectory contains U.S. Geological Survey Digital Raster Graphic (DRG) image files for the nine 7.5-minute quadrangles which contain the majority of the data in the Animas River watershed study.

The second subdirectory under the `gis_db` directory, the `sitedata` subdirectory, contains the sample-site and mine-related site data from the relational database, but in formats directly compatible with Geographic Information Systems. A `README.txt` file at the `sitedata` level provides descriptive information about the data stored beneath it. The `e00` subdirectory contains the site data as ArcInfo export files of coverages and ArcInfo export files of INFO files. The `shape` subdirectory contains ESRI shapefiles of the layers field sites, analysis sites, and mine-related sites. The `dbf` subdirectory contains tables in dbf format that provide information about the sites, and data collected at the sites. The `meta` subdirectory contains metadata about the data in the `e00`, `shape`, and `dbf` subdirectories.

The third subdirectory under the `gis_db` directory, the `geosci` subdirectory, contains geoscientific and hydrologic data sets, as well as a sample ArcExplorer project file. A `README.txt` file in the `geosci` subdirectory lists the contents of the directory. There are eight subdirectories: `geology`, `geochem` (geochemistry), `geophys` (geophysics), `biologic`, `meta` (metadata), `aep_project` (ArcExplorer project file), and `plates` (PDF maps) and `tables` (oversize tables). The `meta` subdirectory contains metadata about all of the interpretive geoscientific data. In each of the data subdirectories, an `e00` subdirectory contains data as Arc Interchange export files of coverages, a `shape` subdirectory contains data as shape files, and a `geotiff` subdirectory (if one exists) contains data in the GeoTIFF format. The `viewer` directory contains two data viewer software packages. The directory contains a `README.txt` file which summarizes the directory's contents. There are two subdirectories: `ArcExplorer` and `MapSheets_Express`. The `ArcExplorer` subdirectory contains an executable file (`ae2setup.exe`) that allows one to install the ArcExplorer 2.0 data viewer software. The `ArcExplorer.pdf` file, created when the `ae2setup.exe` file is run, is a User Guide for ArcExplorer which includes a tutorial. Similarly, the `MapSheets_Express` subdirectory contains an executable file (`mxsetup.exe`) that allows one to install the MapSheets Express 1.3 data viewer software. The `README.txt` file, created when the `mxsetup.exe` file is run, provides various types of information about the MapSheets Express program.

An ArcExplorer project file (`animas_aml.AEP`, located in the `\animas_cd\gis_db\geosci\ae2project` directory on the CD-ROM) is available as an example of how to use the ArcExplorer software to display and use the data on the CD-ROM. The data files have been organized, and their attributes have been displayed, in the explanation defined in the project file.