COLORADO GEOLOGICAL SURVEY

ROCK TALK

VOLUME TWO, NUMBER TWO APRIL, 1999

WHAT IS ENVIRONMENTAL GEOLOGY?

BY VICKI COWART, STATE GEOLOGIST

Environmental geology is a broad term that can mean different things to different people. One of the Colorado Geological Survey's first publications, Special Publication 1, chronicled the proceedings of "The Governor's Conference on Environmental Geology" in 1969. The conference tackled this question head-on. At the conference, John B. Ivey broadly defined environmental geology as, "The total of all geological conditions, and influences, affecting the life and development of man." This definition includes what many people now recognize as "engineering geology," including landslides, swelling soils, hydrocompactive soils, and other topics. As a well-defined engineering geology discipline has emerged during the last 30 years, a more specific definition for environmental science, and hence, environmental geology has evolved. Society's definition of "environmental" has narrowed to focus on the quality of our surroundings and how impacts to air and water may adversely affect humans, and other life on earth. This narrower definition of environmental geology includes the study of surface- and ground-water quality, ground water movement and interaction with surface water, geologic conditions related to waste containment, environmental effects of resource development, mitigation technologies, and other subjects.

The CGS has recognized this distinction by administratively separating the Environmental Geology Section from the Engineering Geology and Land Use Section. Matt Sares is the chief of the Environmental Geology Section. This distinction has not changed the fact that the two disciplines are very interrelated. The people and projects in these two CGS sections are closely linked.

The Environmental Geology Section identifies, investigates, and assists in solving environmental issues related to geology in Colorado. Cooperative projects with local, state, federal, and academic groups are used to investigate or mitigate problems of joint interest. Much of the section's work is related to how geology affects the process of identifying, investigating, and preventing the spread of contaminants in the environment.

The geology of an area can determine the direction of contaminant movement, accelerate or decrease the rate of movement, diminish contaminant concentration, and in some situations, prevent contaminant movement. Our work is not just related to contamination, but more generally, how geology interacts with the surrounding media of water and air. Applying this kind of information

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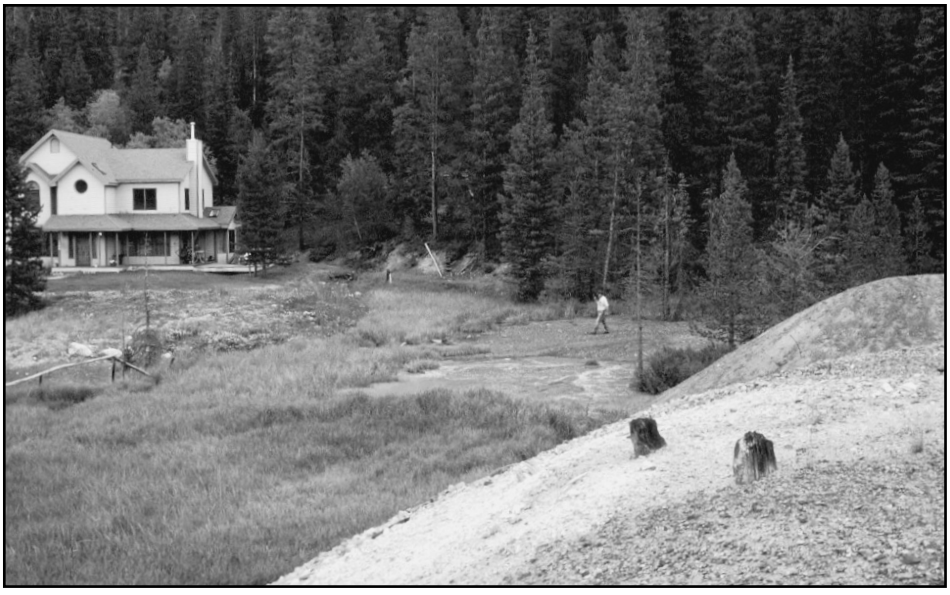

Abandoned mine with dump and acid mine drainage a "stone's throw" from a housing development near Breckenridge PHOTO BY MATTHEW A. SARES

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in the early stages of development projects can result in better planning and decision-making for people and the environment.

The activities of the CGS Environmental Geology Section fall into the following categories:

1) Water Quality Data Program,
2) Uranium Mill Tailings Remedial Actions
3) U.S. Forest Service Abandoned Mine Land Program activities,
4) Wetland Investigations, and
5) Underground Storage Tank Program.

In the following pages you will learn more about each of these activities and the importance of CGS's environmental geology work in Colorado.

CGS WATER QUALITY DATA PROGRAM

Water quality is an important issue in Colorado. With a growing population there is increasing demand for water suitable for drinking water supplies, aquatic life, recreational activities, and industrial uses. Consequently, there is an increasing need for water quality data and information related to these activities. The relatively new Water Quality Data Program at the Colorado Geological Survey (CGS) is addressing these needs by investigating the influence of geology on water quality. A bit of history is needed to understand the current program.

Over the years the CGS has been involved in many projects related to water and water quality. Soon after the CGS was re-established in 1969, the agency started looking at the influence of geology on water quality and availability. As interest in water issues grew during the 1970s, so did the amount of work we were doing in this vital area. In the '70s and early '80s, the CGS water program was involved in the correct placement of landfills to limit ground-water pollution, assessment of hazardous waste sites, planning for the impact of both urban development and resource development on water resources, and basic data collection on water quality throughout the state. Most of this work, including basic data collection, ended in 1983 due to budgetary constraints.

Then, in 1995, the CGS Advisory Committee and Department of Natural Resources Minerals, Energy, and Geology Advisory Board proposed augmenting the CGS budget with a portion of Severance Tax funds. This was not a new tax, but a re-allocation of existing state revenues. In 1996, Senate Bill 170 was crafted and passed by the Colorado General Assembly.

WATER QUALITY DATA PROGRAM MISSION STATEMENT

- ***To provide readily accessible water quality data and information resources for the public, institutions, and businesses of Colorado, allowing all parties interested in the state's water quality the ability to be well informed.***
- ***To investigate and report on water quality topics related to the geology and hydrogeology of Colorado, based on objective, scientific evaluation.***

Water Quality Data Program Steering Group

Lawrence Cerrillo
John Hardaway
Wendy Harrison
Jeanette Hillery
Holly Huyck
R.L. Jones
John M. Kaufman
Bob McConnell
Jerry Raisch

The Water Quality Data Program became one of four CGS programs supported with the new funds. Continual, long-term, water-quality data collection was again a part of CGS's everyday activities.

A steering group was convened at the start of this new program to ensure that the activities would address real needs for water quality information within the state. With their guidance, a formal mission statement was adopted and a prioritized list of projects was generated. The program is currently focusing on data dissemination and surface water studies. These are the current projects:

1) Water Quality Database Access

A new publication, "Colorado Water Quality Database," is a reformatted database from the Environmental Protection Agency's nationwide database known as STORET. It is now available on CD-ROM (see article on page 4).

2) Colorado Directory of Water Quality Data

A publication that provides information on who has water quality data, what kind of data it is, and how it can be obtained.

3) Roaring Fork River Basin Reconnaissance Salinity Investigation

A reconnaissance-level investigation of surface-water salinity in the lower Roaring Fork River basin. The report is now in press and will be released as Information Series 49.

4) Water Sampling and Analysis

This is an ongoing effort to collect baseline water quality data in areas of the state that have little information on ambient conditions, especially headwaters areas.

5) Wetland Research

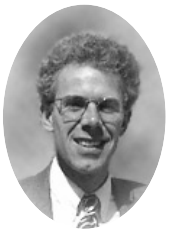
The program is supporting research characterizing western wetlands from a geological viewpoint. Cooperation with local entities is being emphasized. (See article on page 10.)

6) Study of Naturally Occurring Degradation of Water Quality in Hydrothermally Altered Terranes in Colorado

This project is compiling water-quality data and geologic controls on locations in Colorado that exhibit naturally occurring, poor quality water. This is a two-year study.

The Water Quality Data Program provides a variety of useful products for those interested in Colorado's water quality. Some projects will provide important information on how geology influences water quality. Other projects provide increased access to water quality data for all who need it. Working with its Steering Group and partners, the Water Quality Data Program is on course to meet its mission.

New Engineering Geology Section Chief



On January 1, 1999, David C. Noe became the second chief of the Engineering Geology Section. He succeeds William Pat Rogers, who assumed the position in 1971 and retired in 1998. David has been with the CGS for over seven years. His work with expansive soil and heaving bedrock, land-use issues, and outreach are well known to the engineering geology community.

David is a fourth-generation Coloradan who hails from Greeley. He developed an interest in geology as a result of numerous family outings to the Indian teepee rings near Nunn, the family ranch in Douglas County, and the Rocky Mountains. Growing up, he served for eight summers as a volunteer and Park Ranger/Naturalist in Rocky Mountain National Park. He received a BA in Geology from the University of Northern Colorado in 1979 and an MA in Geology from the University of Texas at Austin in 1984. He is currently writing his Ph.D. dissertation for a degree in Geological Engineering at Colorado School of Mines.

In his new position, David will oversee all aspects of the CGS Engineering Geology Section, including project

New Chief continued on page 7

How to Order CGS Publications

HOW TO ORDER PUBLICATIONS

Mail:
Colorado Geological Survey,
1313 Sherman Street,
Room 715, Denver, CO 80203
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Prepayment required.

SHIPPING AND HANDLING
Please contact the CGS for shipping and handling costs.

DISCOUNTS
Available on bulk orders.

Call for a complete publication list

PUBLICATIONS MENTIONED IN THIS ISSUE

Information Series 48
Colorado Water Quality Database $20.00

Special Publication 1
The Governor's First Conference on Environmental Geology, (Proceedings, 1969) $1.00

SELECTED WATER RELATED PUBLICATIONS

Bulletin 36
Geologic Control of Supply and Quality of Water in the Mountainous Part of Jefferson County, Colorado $2.00

Bulletin 42
Water Resources of Boulder County, Colorado $4.00

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COLORADO WATER QUALITY DATABASE

Water quality is important to many people in Colorado. Many industries, consultants, government agencies, environmental organizations, and citizens require accurate water quality data in their work. Often though, water quality data are not easy to obtain. Data must be requested from the agency that performed the original sampling, and then, may only be available in a hardcopy form or a digital form that is not easily used.

Colorado Water Quality Database Facts

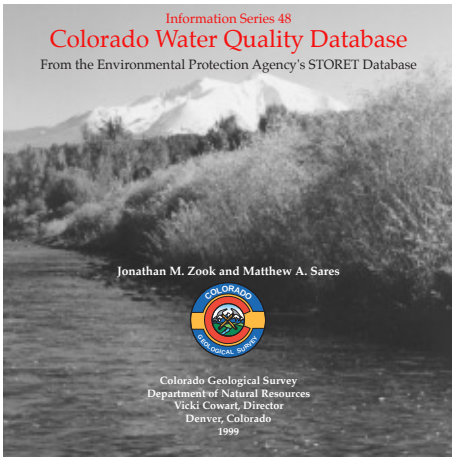
- 400 megabytes of data
- 2,933,375 separate analyses
- Data from all 63 counties
- 12,289 water sample stations

For these reasons, the Colorado Geological Survey's Water Quality Data Program produced a CD-ROM that makes water quality for our state more accessible and easier to use. *Colorado Water Quality Database—from the Environmental Protection Agency's STORET Database* (Information Series 48) contains all the ambient water quality data for Colorado contained in the Environmental Protection Agency's (EPA) Storage and Retrieval (STORET) database through January 1998. The STORET database is a nationwide repository of water quality and biological data collected from a number of state and federal agencies.

Jonathan Zook, a geologist specializing in computer applications, captured Colorado data contained in the unwieldy 30-year old STORET data management system and reformatted it for use on the personal computer. The resulting Colorado Water Quality Database is very detailed and user-friendly, having been created in the widely-known Microsoft® Access 97 database format. The database consists of three main types of data: grab-sample data (surface- and groundwater), composite-sample data (surface water only), and groundwater data. All sample locations are geographically referenced by latitude and longitude. "Look-up" tables were added for all codes used in the database. A report containing an explanation of the format, fields, and look-up tables in the database is included on the CD-ROM.

The database includes all ambient Colorado water quality data that has been submitted to the EPA STORET database. Other databases exist, but STORET is the largest water-quality database, and CGS is glad to make its information more widely available and more useful for all those interested in water quality in Colorado.

Funding for this project came from state severance taxes, which are derived from the production of natural gas, oil, coal, and minerals in the state of Colorado.



CGS WRAPS UP U.S. FOREST SERVICE ABANDONED MINE LAND INVENTORY PROJECT

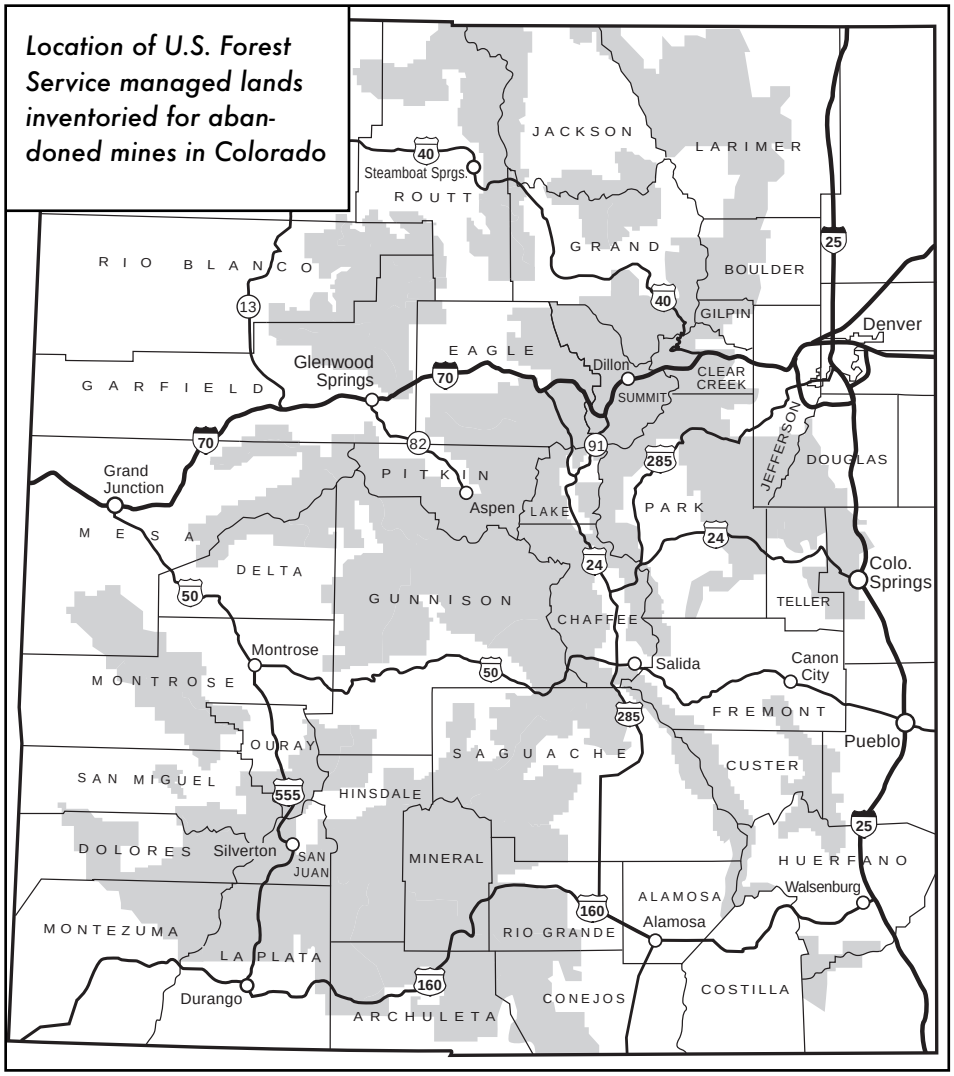
For eight years beginning in 1991, CGS sent forth teams of geologists into the backcountry of Colorado. Their mission was to locate and characterize abandoned mines on land managed by the U.S. Forest Service (USFS). These hardy souls worked 3 to 5 months of the year, living in tents, often not seeing a town for days, in order to reach the remote sites where the mines were found. Some campsites were not as isolated. The City Park in Telluride was home to John Neubert and Tom Harris for a month. The work and the travel must have had its appeal, particularly for geology students who desired the temporary work. Many of the investigators returned summer after summer.

As a result of this effort, the USFS and the CGS have nearly completed a cooperative agreement aimed at identifying all environmental and physical hazards associated with abandoned and inactive mines on Colorado's USFS lands. A total of 11,307 mine openings (adits, shafts, large prospect pits, etc.) and 6,829 mine dumps or tailings piles were documented during the inventory.

The driving force behind the project is the Federal Facilities Compliance Program (FFCP) that is designed to address environmental problems on federal lands. The FFCP will bring facilities of federal agencies into compliance with several laws enacted to protect the public and the environment. These laws include the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund), Resource Conservation and Recovery Act, Clean Water Act, Clean Air Act, and Safe Drinking Water Act.

Environmental problems associated with past mining activity include: generation of acid mine drainage from mine workings and waste rock, metals loading in streams via acid mine drainage, and erosion of mine dumps and mill tailings leading to sediment deposition in streams. Acid rock drainage (includes natural or mine-induced situations) is formed when surface or ground water interacts with sulfide minerals, essentially creating sulfuric acid. Sulfide minerals are abundant in many mineral-rich veins in Colorado. The increased acidity allows metal-containing minerals to dissolve in waters draining from the mine. Relatively low concentrations (tens of parts per billion) of some metals in streams can adversely affect aquatic life and, at higher concentrations, can affect human health if used as drinking water.

Prior to field work, information on historic mining activity in an area was collected and compiled onto "work maps" for use in the field. Once this extensive preliminary work was completed, geologists began the field inventory. The inventory included



Location of U.S. Forest Service managed lands inventoried for abandoned mines in Colorado

Publications continued from page 4

Information Series 6
Hydrogeochemical Data of Thermal Wells in Colorado $8.00

Information Series 14
Hazardous Wastes in Colorado: A Preliminary Evaluation of Generation and Geologic Criteria for Disposal $15.00

Information Series 37
Water Resources Beneath State Lands in Part of T. 16 S., R. 63 W., Black Squirrel Creek Basin, El Paso County, Colorado $10.00

Special Publication 38
Proceedings: Summitville Forum '95 $95.00

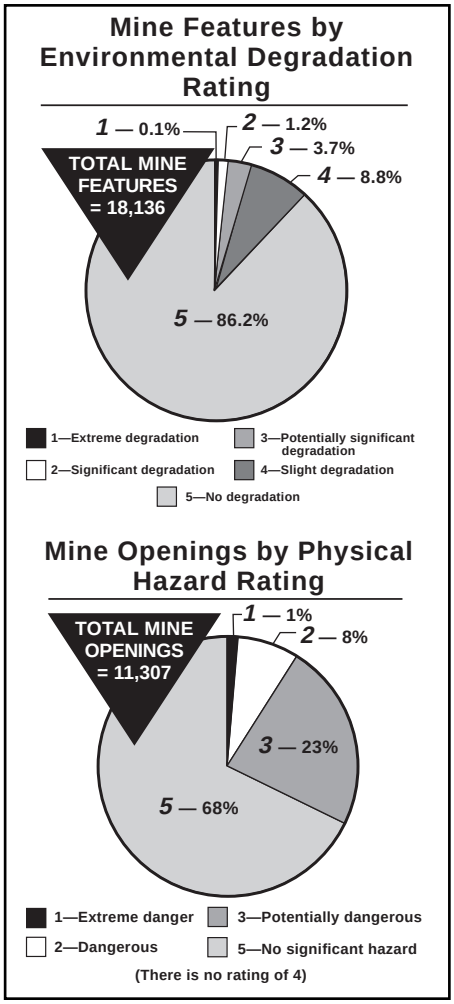
Map Series 16
Atlas of Ground Water Quality in Colorado $12.00

general information about the location, geography, and surrounding environment of the site. Specific data about the mine opening, waste rock, tailings, and water quality were also recorded. Water quality was determined initially by field tests of acidity (pH) and conductivity on the mine effluent. If these tests indicated poor quality water, a sample was collected for laboratory analysis to identify the type and degree of contamination. The environmental degradation and physical hazards associated with the mine features were rated on a scale of one to five, one being an extreme problem and five being no problem.

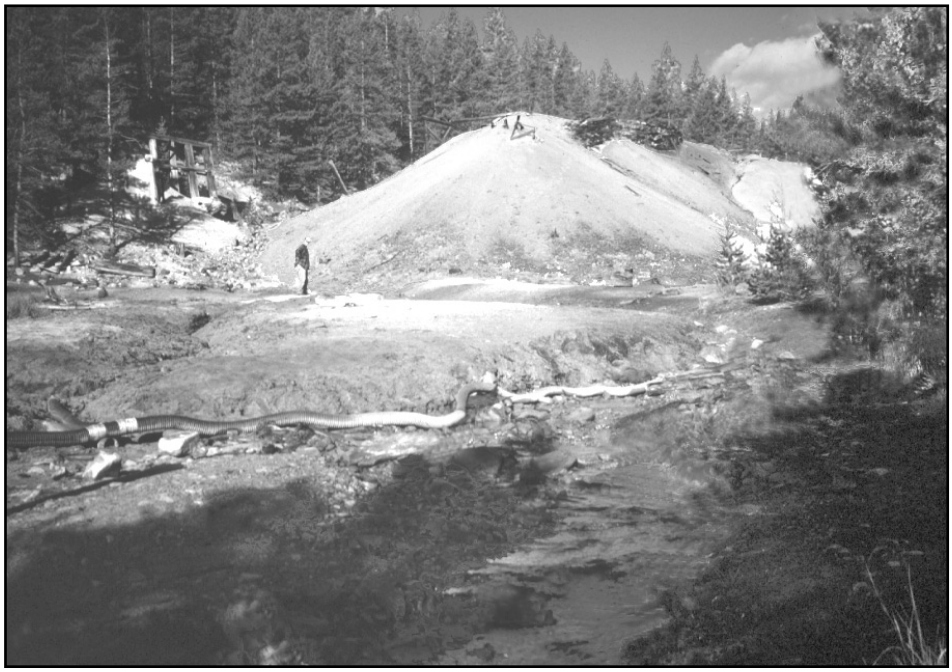
Tabulation of the inventory results is revealing (see pie graphs). Over 86 percent of the mine features (mine openings and waste piles) cause no environmental degradation. Just fewer than 14 percent, or 2,504, exhibit some impact on the environment, varying from slight to extreme degradation. It should be noted that the unpatented mines on USFS-managed lands are generally smaller than those on patented (private) lands. Therefore, these percentages should not be extrapolated to represent land areas outside USFS management.

The danger of people falling into a mine or being hurt exploring a mine is very real in Colorado. Nearly every year there are incidents of this type in the news. The CGS inventory identified that 32 percent, or 3,623, of the mines on USFS-managed land are potentially to extremely dangerous physical hazards. This highlights the need for caution when recreating in mining areas. The Division of Minerals and Geology has been actively safeguarding the worst of these hazards, but there is a long way to go. ***Please stay out of abandoned mines and stay alive!***

The inventory data from the field forms are being keyed into a computer database developed by Randy Phillips of the CGS. This database will provide quick access to information about any individual mine feature located on USFS managed land. The database will be compiled in XBase format and a geographic information system (in ARCView® compatible shape files). The project is scheduled for completion at the end of April 1999.

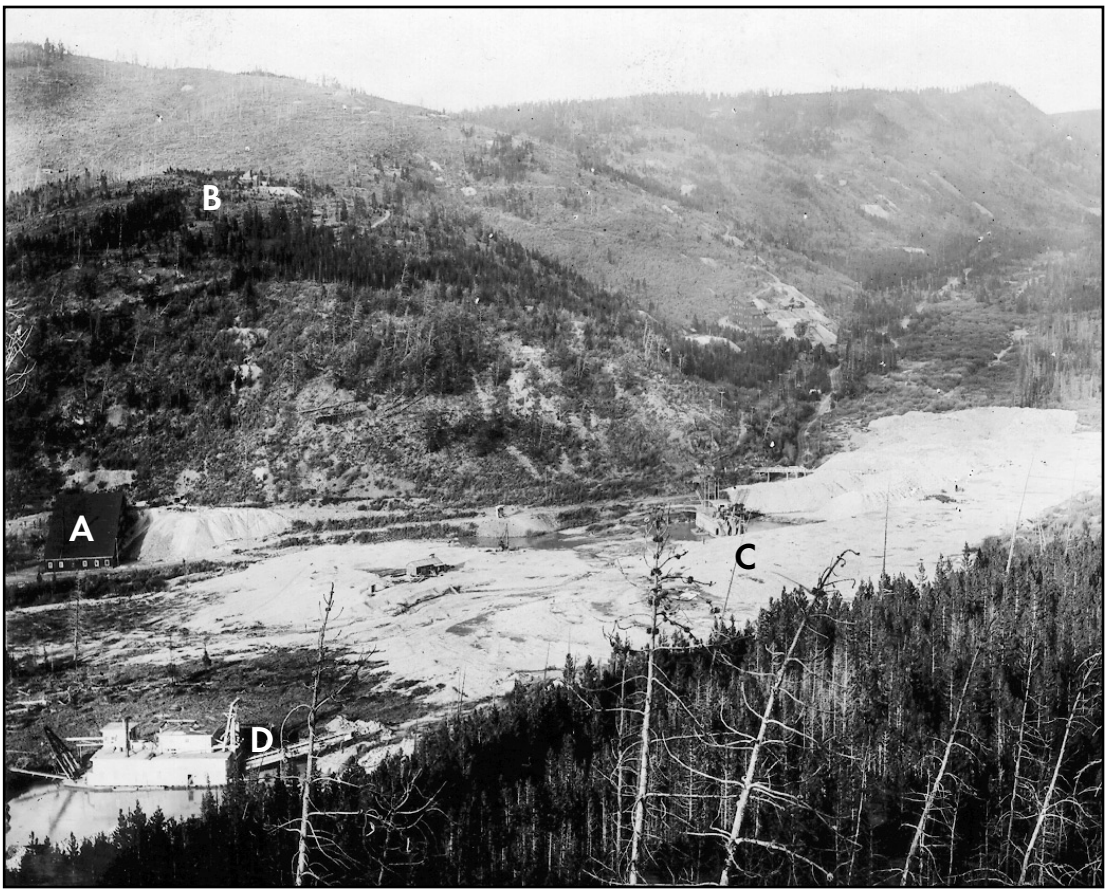


Pie graphs showing breakdown of environmental degradation and physical hazards by ranking



Abandoned mine on St. Kevin Gulch north of Leadville PHOTO BY ROBERT WOOD III

NEW PROJECT DIGS INTO COLORADO'S MINING PAST



*Union Mine and Mill in French Gulch, Summit County, 1909; **A)** Union mill and adit; **B)** Union shafts; **C)** Reliance dredge; and **D)** Reiling dredge* PHOTO FROM USGS DDS-12

In the summer of 1998, the U.S. Forest Service entered a cooperative agreement with the Colorado Geological Survey to prepare site history reports for selected abandoned mines on Forest Service-administered lands in Colorado.

The mine site history project falls on the heels of a nearly completed CGS project that cataloged abandoned mines on Forest Service lands in Colorado (see previous USFS-AMLIP article). The Forest Service has selected several sites from the abandoned mine inventory to examine in closer detail. These sites exhibit a range of environmental degradation, from extreme to potentially significant. Many of these sites fall within watersheds of special interest to the Forest Service, specifically, the Arkansas River and Rio Grande drainage basins.

In November 1998, a report on the Union Mill site near Breckenridge was completed. The Union Mine produced silver and lead with some associated gold and zinc. A report describing nine sites near Creede, in the Rio Grande National Forest, is in the draft stages. Research has been initiated on various sites in the upper Arkansas River Basin, within the Pike/San Isabel National Forest.

Mine site history reports contain sections describing the regional geology, site-specific geology, mineralogy and ore deposit type, operation and production history of the mine, and environmental information. The history of each mine is summarized on a timeline. The report may include surface maps of the sites; water, waste rock, and tailings sample analyses; field water test results; and past and present photographs. Field investigations are conducted to fill gaps in existing knowledge.

Researchers use a variety of information sources during the project. All of the sources are available to the public through libraries or government agencies. No confidential information is compiled.

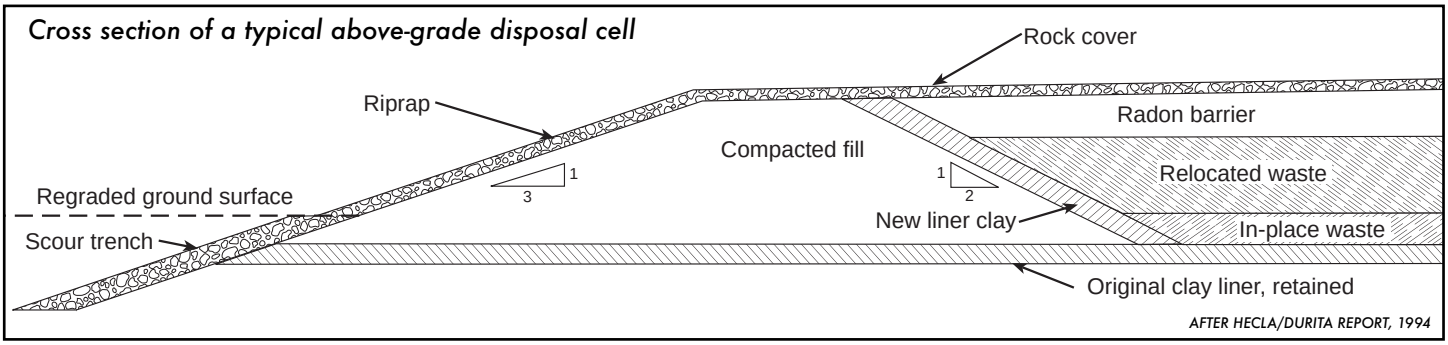
This project continues the long-term relationship of the CGS with mining, mining history, and mineral resources, and is a logical continuation of the abandoned mine inventory. The non-regulatory nature of the Survey allows us to examine these sites in an objective and scientific manner, and provide the Forest Service with the information necessary to remediate environmental problems effectively and economically.

New Chief continued from page 3

budgeting, implementation, and tracking, and land-use review, research, and outreach activities. In addition, he will represent the CGS as chairman of the Geologic Hazards Committee of the Colorado Natural Hazard Mitigation Council.

The CGS welcomes David C. Noe as the newest member of our management team.

CGS SUPPORTS RADIOACTIVE CLEANUP/REMEDIATION ACTIVITIES



The exploration, mining and milling of radioactive materials represents a significant chapter in Colorado's rich and varied mining history. Radium, vanadium, and uranium have been produced in large quantities in support of the Nation's defense programs, the private nuclear power industry, and metallurgical research. The radium on which Madame Curie performed her breakthrough experiments came from the Uravan Mineral Belt in southwestern Colorado.

As a result of such mining and milling, dating back to the turn of the century, large quantities of waste materials have been left behind. This has caused significant environmental problems that were not anticipated at the time. Adverse impacts of these past operations are related to surface- and groundwater contamination. Human health risks may be associated with the use of these waters or direct exposure to the waste's residual radioactivity.

A national remediation program, conducted under the joint aegis of the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), and the Environmental Protection Agency (EPA) is addressing these issues through a comprehensive site evaluation and corrective action program. The Colorado Department of Public Health and Environment (CDPHE) is the lead regulatory agency at non-federal facilities.

The Colorado Geological Survey provides technical support to CDPHE for activities related to geology, hydrogeology, and construction at several state-regulated sites. These sites include those with both active permits and old, "orphan" facilities that need some

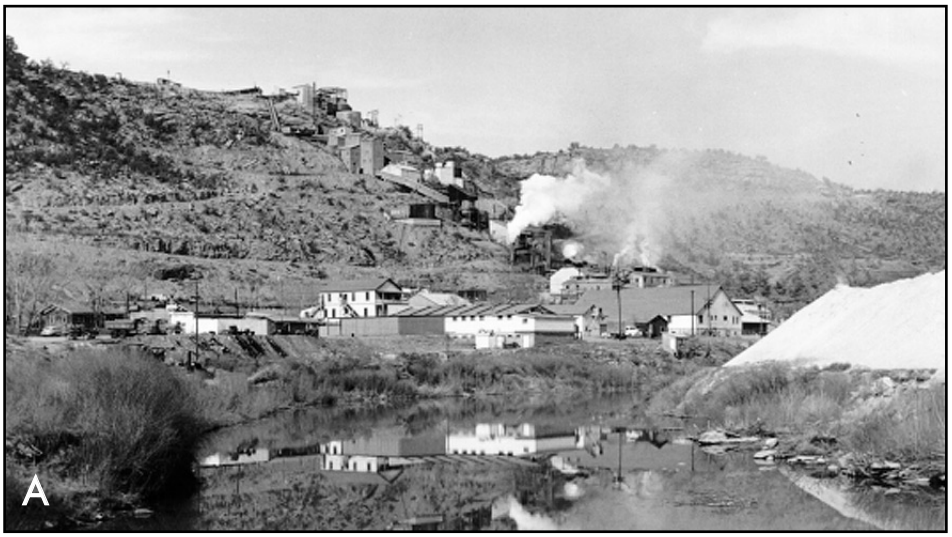
*Cotter Corporation's Canon City Mill site, 1998, looking north; **1)** Existing mill capable of either alkaline or acidic operation modes. **2)** Old, partially reclaimed disposal pond area. **3)** New, lined disposal cell: **a)** primarily accepting current waste stream; **b)** relocated wastes from area 2. **4)** Hogback forming one limb of the structural basin in which the site sits* PHOTO COURTESY OF COTTER CORP.

form of cleanup or remedial action to minimize potentially adverse environmental consequences and possible health risks.

CGS involvement is currently focused on four active sites. Two sites are owned and operated by Cotter Corporation—the Schwartzwalder Mine and the Canon City Uranium Mill. The other two sites are owned and operated by Umetco Minerals Corporation—the Maybell and Uravan remediation sites.

The Cotter facilities represent the only mine-and-mill combination capable of operation at this time in the country. The Schwartzwalder Mine is located about 7 miles north of Golden in the canyon of Ralston Creek. It has been in operation on an intermittent basis since the early '50s, producing uranium ore from vein deposits in the metamorphic complex of the Front Range. CGS is evaluating the slope stability and erosion susceptibility of processing wastes placed as cover material on top of mine waste-rock. Long-term isolation from the environment is also being evaluated for that part of the site closure plan.

The Canon City Uranium Mill is one of only two functional milling facilities in the U.S. at this time. It is currently undergoing modifications to the processing and disposal phases of the operation and CGS has been involved in this process for the last several years. The site is 2 miles south of Canon City, in a closed structural basin formed in the Cretaceous sedimentary sequence of the area. Waste disposal activities conducted before 1978 and as far back as the late 1950s have resulted in ground water and surface soil contamination both on and off site.



***A.** Uravan Uranium Mill complex, circa 1952. The large light colored wastepile in the right portion of the photo is from the Manhattan Project.*
***B.** Photo taken in early 1999 from the same vantage point showing the extent of the cleanup. Note the two remaining buildings for reference. These are being restored and preserved for their historical value.*

PHOTOS COURTESY OF UMETCO MINERALS CORP.

Did you know?

One pound of uranium has the equivalent heat energy of 1,500 tons of coal!

The CGS reviews and recommends design modifications to the ground-water monitoring and remediation activities, in response to new operational criteria established for the continued use of the tailings impoundment. Additionally, CGS is a partner in designing and implementing cleanup of contaminated soil carried off-site by past flooding and airborne transport.

In Moffat County, reclamation and closure of the Maybell Heap Leach Facility by Umetco Corporation is almost complete. The CGS has been involved with this site for more than a dozen years. CGS's primary emphasis is on the design, construction, and long-term stability of the closure cell and groundwater monitoring and protection. The latter is complicated by the fact that the site overlies remaining uranium ore bodies. These produce high levels of dissolved, naturally occurring radioactive constituents in the aquifer. Final closure activities at this site are scheduled for 1999 and 2000.

The Umetco facility at Uravan has been the site of radioactive materials processing since the turn

of the century. Uranium and vanadium ores were mined from sandstones of the Jurrasic Morrison Formation. Once a thriving "west end" community in Montrose County dedicated to the adjacent mining and milling industries, the entire town has been removed and reclaimed.

Current remedial activities in which the CGS is involved are related to demolition and removal of the old mill structures, groundwater remediation and characterization, identification, and evaluation of ancillary sites for post-closure radiological impacts.

The CGS is also reviewing design and construction associated with placement of contaminated soil and demolition debris on the top of an old tailings disposal cell and in a new waste repository for additional wastes identified through ongoing investigations. The new repository may also accept certain types of off-site waste. This should minimize the proliferation of disposal sites with their attendant requirements for long-term care and surveillance. Final closure of this facility is scheduled for some time after 2003.

CGS's involvement in these remedial programs throughout Colorado will help ensure the long-term isolation of radioactive mine and mill wastes.

Upcoming Events Involving CGS

April 22

Earth Day, "Soil and Society", CGS, 1313 Sherman St., Rm. 318, Denver, Katie Kellerlynn, (303) 866-3330

May 15

Women in Mining Annual Meeting, Glenwood Springs, Hotel Colorado, Jackie Beasley Dorr, (303) 235-4476

WETLAND PROGRAM

Wetlands are a hot topic in many circles these days, both in Colorado and nationwide. On one hand, wetlands are recognized as a valuable resource. They harbor a vast assemblage of plants and animals. They also provide temporary runoff and flood storage and remove pollutants from the water.

Yet, despite these known values, wetlands are a threatened resource. They often occupy areas that are in demand for highways, subdivisions, and mining projects. This is especially true in mountainous areas, where wetlands occupy a large portion of available and undeveloped flat land.

Since 1994, the Colorado Geological Survey has been involved in wetland research under the State Wetland Grant Program, administered by the Colorado Department of Natural Resources (DNR) and the U.S. Environmental Protection Agency (EPA). These grants are awarded annually, on a competitive basis, under the provisions of Section 104(B)(3) of the Clean Water Act.

The CGS has produced three reports from EPA-funded projects:

- Regulation of Water Quality at Colorado Metal Mining Sites and Associated Wetlands (1995), by A.E. Barry, J.D. Arnow, and D.C. Noe. This report provides an overview of the regulation of water quality for metal mining operations in Colorado, with special emphasis on mining-associated wetlands.
- A Comparison of Natural Acid Rock Drainage Occurrences in Colorado (1996), by W.A. Meyer, R.K. Streufert, and M.A. Williamson. This report characterizes the aqueous geochemistry of naturally occurring acid rock drainage (ARD) for three historic mining districts of Colorado. It considers the magnitude of the initial impact of ARD sources as well as natural amelioration processes.
- Characterization and Functional Assessment of Reference Wetlands in Colorado (1998), by A.E. Barry, M.C. Pavlik, and D.C. Noe (CGS), D.J. Cooper, C. Arp, and R. Chimner (Colorado State University), and K.E. Kolm, R.M. Harper-Arabie, and J.C. Emerick (Colorado School of Mines). This report contains responses from 84 counties and municipalities across Colorado to a wetland-management questionnaire that asked such questions as, "Do you manage wetlands?" The report also makes an initial classification of Colorado wetlands according to the Hydrogeomorphic (HGM) Method, based on a statistical analysis of biotic and abiotic data from 3,625 sample sites. HGM is a classification and wetland functional assessment method based on hydrology and geomorphology. The results of scientific studies of hydrological, carbon storage and export functions at five reference wetland sites in Colorado are documented in the report.

The purpose of these CGS studies is to advance the knowledge of wetland regulatory requirements, as well as to investigate the important connection between geology and wetlands (see the accompanying article, "Geology and Wetlands"). These

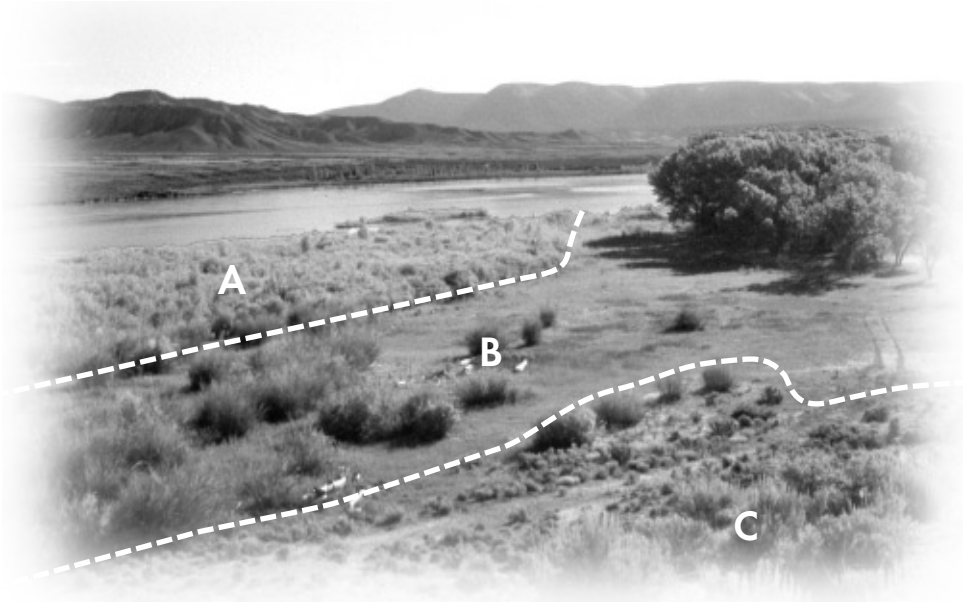
GEOLOGY AND WETLANDS

What do you see in your mind when you think of a wetland? Most people envision lush, green plants, and many types of birds, mammals, and amphibians. Some see beaver ponds or abundant watercourses, while others may think of rich, dark, saturated soils with a rotten-egg smell.

Few people think of geology in connection with wetlands. Yet, the geology beneath the wetland and its surrounding landscape controls the very lifeline of a wetland, its supply of ground and surface water. Also, a wetland's topography is influenced to a great degree by the underlying geology, and by active geological processes such as overbank flooding.

The Deerlodge Park reference wetland (see photo), in northwestern Colorado, provides an excellent example of geological controls on a wetland. The wetland consists of several terraces on a meander bend of the Yampa River. The lowest terrace **(A)** is flooded annually and has a shallow ground water table. It supports a dense stand of willows and young cottonwood trees; these plants depend on the annual floods to deposit a wet, mud drape into which the seedlings can sprout. The middle terrace **(B)** is flooded during most, but not all spring floods, and it has a deeper ground water table. This terrace supports mature cottonwood trees and tamarisk bushes, which have deep taproot systems that reach the ground water table, along with non-wetland grasses. The third terrace (on which the photographer is standing) **(C)** is unaffected by the river, and the ground water is quite deep. Accordingly, this terrace contains only upland plants such as yucca, cheatgrass, and sagebrush.

The geology of the area determines hydrological controls. The wetland receives ground water from two sources in addition to the river. One source is sulfate-rich ground water that emanates from upland arroyo systems (behind the photographer). Another is from a regional aquifer in bedrock that discharges from a hogback system (to the left of the photo) where the Yampa River enters its canyon in Dinosaur National Monument.

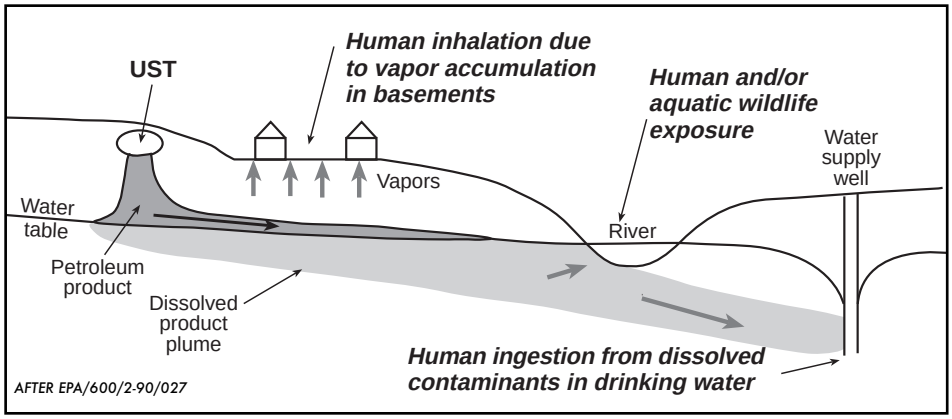


Deerlodge Park wetland, near Dinosaur National Monument PHOTO BY DAVID C. NOE

reports are available through CGS, for the cost of copying.

Besides primary research, the CGS is participating in some local wetland-management initiatives in Colorado. With staff time supported by Severance Tax funds, Monica Pavlik and David Noe served on a technical committee in Summit County in 1998. This summer, CGS will enter into a partnership with the Colorado Division of Wildlife in their Colorado Wetland Initiative Legacy Program. The Wetland Initiative is a cooperative approach between the State of Colorado, local citizens, and various federal, conservation, and agriculture groups to protect wetlands in Colorado. The CGS would provide technical expertise to the program under an EPA grant and possibly other funding, beginning with the San Luis Valley Legacy Project.

(R)UST NEVER SLEEPS



Potential exposure pathways due to a petroleum product release

About twenty years ago a hidden problem with underground storage tanks (USTs) came to light. They can rust and leak. Since then, the removal and replacement of USTs because of actual or potential leakage has been an ongoing activity throughout the nation. The CGS has offered extended technical expertise in removal, monitoring, and characterization of UST sites to other State of Colorado government agencies. To date the CGS has conducted investigations for the removal of over 700 USTs at State agency owned facilities.

Removal of underground storage tank at a state facility PHOTO BY TY ORTIZ

Petroleum products from leaking USTs may contaminate shallow ground water, possibly moving into surface water, and can pose a direct threat to water supplies. Vapors from released petroleum products may also seep into building structures causing a health hazard, and possibly, an explosion hazard. Where contamination has occurred, the CGS has conducted additional investigation to determine the threat to human health and environment. At sites where this threat is significant, the CGS recommends that the responsible agency retain an environmental contractor to perform remedial cleanup.

Most of the current CGS activity in this field consists of report writing and ground-water monitoring. CGS reports compile years of data collection to document that environmental concerns have been addressed and closure of a site is warranted. Monitoring of contaminated ground-water plumes at selected sites is underway to determine whether the plumes are migrating or to document whether contaminants are naturally diminishing to safe concentrations. Agencies working with CGS estimate that contamination at UST sites will be delineated by the year 2000.

ROCK TALK

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