COLORADO GEOLOGICAL SURVEY

# WAT-2000-01 SCOPING REPORT
# FOR
# GROUND-WATER ATLAS OF COLORADO

**22 September 2000**

**Prepared for: Colorado Geological Survey**
**Prepared by: Pearson, deRidder, and Johnson, Inc.**

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## 4.0 PROPOSED CONTENT FOR THE ATLAS

Although considerable thought has been given as to the content and formatting of the atlas, a final decision cannot be made until data acquisition and synthesis has occurred. Therefore, a suggested table of content is provided below solely to help initiate further thought.

1.0 INTRODUCTION
*purpose and scope of the atlas*
*description of subsequent sections*

2.0 GROUND WATER
*use usgs primer, G&M special report*
*show recharge, movement, discharge concepts*

2.1 Hydrologic Cycle
*provide figure with appropriate text describing*

2.2 Surface/Ground water interaction
*report in lac library other*

3.0 WATER LAW
*general discussion re colo system, use info frm water in west (lac)*

3.1 The Permit Process
*brfly describe types of permits and general criteria for each*
3.2 Well Construction Requirements
*reference state engr office document show typical figures*
3.3 Water Quality Considerations
*reference CWL, State, County regs*

4.0 HYDROGEOLOGY IN COLORADO
*describe aquifer characteristics*

5.0 WATER QUALITY IN COLORADO
*maps with brief narrative*

6.0 POTENTIAL FOR GROUND-WATER DEGRADATION
*introduce various ways, geologic controls*

6.1 Septic-leach field systems
*show figure, describe suitability for various geologic conditions*
6.2 Abandoned Mine Lands
*why may-may not be factor, cause-effect, couple examples, figure*

6.3 Oil & Gas Operations

*discuss with Trish*

6.4 Agricultural Effects

*corrals, feedlots, hog farms, herbicide/pesticide app*

6.5 Industrial/Manufacturing Operations

*npdes permit process, stream/gw interaction*

6.6 Landfills

*ck w/dd, relate love canal etc.*

## 7.0 Division Maps

Because Colorado's water resources are administered on the basis of water divisions, it is recommended that an atlas that depicts ground-water information be based on division boundaries. Within the boundaries, designated basins and management districts could be shown. This would mean seven base maps that would have some or all of the following information:

1. *Base map of division boundaries, designated basins and management districts. Show key cities with infrastructure (on a transparency).*
2. *Topographic map*
3. *Geology-generalized*
4. *Precipitation/evapotranspiration data (contours or color pattern)*
5. *Recharge areas for various aquifers (possibly est, of amt)*
6. *Aquifer delineation (lineation map for hdrx areas). Aquifer thickness*
7. *Potentiometric surface*
8. *Well density for respective aquifers*
9. *Areas of water level change*
10. *Average yield for respective aquifers*
11. *GW quality (naturally occurring)*
12. *Septic-leachfield density*
13. *Nitrogen isoconcentration or color map of average for area*
14. *Areas of naturally occurring arsenic and selenium*
15. *Areas of radon concentration*
16. *Abandoned mines*
17. *Abandoned oil and gas wells*
18. *Vulnerability map (areas susceptible to contamination)*
19. *Wetland areas*
20. *Areas of planned growth dependent on ground water*
21. *Perched water table areas*

## 1.0 INTRODUCTION

In an effort to provide a user-friendly ground-water atlas of the State of Colorado, the Colorado Geological Survey (CGS) commissioned this scoping study to determine the potential level of interest in such a document, and the types of data desired to be portrayed. The primary purpose of the proposed atlas is to provide the lay person, administrators, developers, the general public, and technical personnel with an understandable overview of ground water resources and development in Colorado.

The scoping study consisted of contacting a representation of potential users, and of conducting a cursory literature search to ascertain the availability of the requisite data to be included in the atlas. Administrators or senior planners in seven counties; Jefferson, Arapahoe, Grand, Adams, Park, Clear Creek, and Douglas, were contacted for their input. In addition, eight professionals, consisting of hydrogeologists, engineers, and land developers were contacted for their suggestions. Sources of data were identified on the web, and in the published literature.

## 2.0 CONSTITUENCY SURVEY

As anticipated, professionals working with ground-water issues on a daily basis identified a need for more quantitative data. Water quality, potentiometric surfaces, recharge amounts, and water level change maps were but a few of the requests made. Those individuals in administrative and planning roles identified the need for qualitative data related to the availability and quality of ground water within their respective jurisdictions. These requests consisted of density of wells, size of lots, radon concentrations, and wetland areas. Developers were very interested in the locations of existing wells, depths, yields, and areas where wells have failed. It is likely that most of the needs of all parties can be satisfied with the atlas planned. The limiting factor will be the availability of data related to the various needs. A record of verbal communication with the various constituency groups is provided in Appendix A.

## 3.0 LITERATURE SURVEY

Once the needs of the constituency were identified, a cursory literature search was conducted to determine if data were currently available to prepare the requisite maps. Based on a computer search of the Colorado School of Mines library, and of the USGS web pages, it appears that abundant data sources are available. In addition, the library of PRJ has a considerable amount of applicable data. Some of the data sources within the USGS include: USGS hydrologic atlases, water supply papers, professional papers, and miscellaneous investigation series maps. Publications of the Colorado Geological Survey related to water data for various counties will also be a valuable source. The files of the Colorado State Engineer's office will be relied on to provide data on wells in each of the water divisions. All of these data will require a fairly significant effort to synthesize and prepare for map presentation, but will most likely be of greatest value to potential users. Examples of typical sources are included in this report in Appendix B.

The advantages of presenting maps based on water divisions of the state engineer are:

- Allows for better coordination between users and water rights administrators
- Allows for opportunity to upgrade or add a map without having to change all maps
- Will provide more user friendly map scales
- Will be more user friendly for those living and working in a particular division

Some of the disadvantages are:

- The number of maps to be compiled increases
- If someone is interested in county-wide information, more than one division map may need to be reviewed
- The principal aquifers will occur in more than one division (this should not be a problem for the average user, but anyone interested in a specific aquifer would have to consult more than one map)

8.0 APPENDICES

*references, web sites for info, other??*

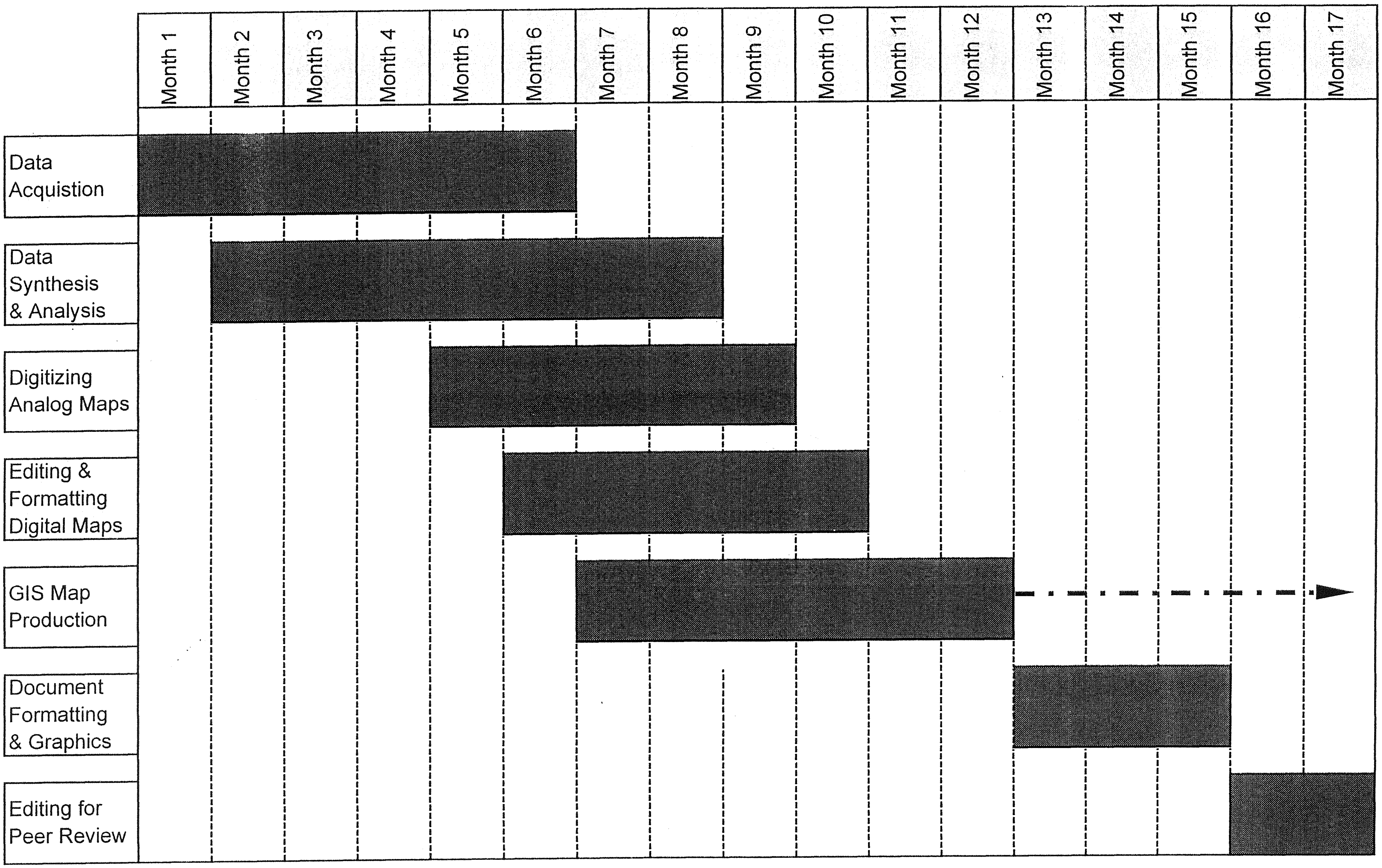
## 7.0 PROPOSED PLAN FOR THE ATLAS

Obviously the preparation of a meaningful atlas useful to a broad range of interests is no small task. The anticipated sequence for preparation will approximate the following:

- Data Acquisition
- Data synthesis and analysis
- Digitizing of analog maps
- Editing and formatting digital maps
- GIS map production
- Document formatting, and graphics production
- Editing for peer review

In an effort to assess the timeframe to prepare such a document, a proposed schedule has been prepared for completing the above tasks, Figure 1. This schedule is definitely tentative, and is provided in an effort to solicit more discussion.

# Ground Water Atlas Development Schedule



# APPENDIX A
# CONSTITUENCY CONTACTS

**County Contacts**

7/7-7/12 **Jefferson** Jean Reince Schwartz Sr. Planner 271-8731

Show types of aquifers, how geology affects movement of gw

7/11-7/12 **Grand** Lorleen Underbrink Cty Mgr. 970-725-3347

Impact of grth on water resources, septic tanks and gw, lot size rqd for well and septic leachfield

7/11 **Adams** Rob Coney Hd. Planning and development 853-7000

Depth to base of aquifer, aquifer quality vs drkg wtr stds, nitrogen concentration map, oil and gas well map, septic leachfield (lf) density map

7/7-7/11 **Park** Tom Eiseman Planning Dept. 719-836-4265

Location of aquifers, depth to water, wetlands map, abandoned mines, water quality

7/11-7/12 **Clear Creek** Lisa leben Land use case Mgr. 679-2362

Well density map, recharge area, mine locations, water quality map, radon concentration

7/7-7/11 **Douglas** Don Moore Sr. Planner 660-7400

Aquifer map, water quality

7/11-7/19 **Boulder** Graham Billingsley Planning Director 441-3131

Depth to water, wetland, recharge areas, basin delineation (looking fwd to such a document)

7/17 **Arapahoe** Sue Conaway County Planning 795-4452

Recharge map, wtr quality

## HYDROGEOLOGISTS, ENGINEERS, DEVELOPERS

7/11 Mike West Phd Geological Engineer 720-529-5300

Structure contour, QW, areas of perched water tables, well density with average depth max-min,

7/11 Fred Marinelli, Phd Hydrogeologist/Engr 970-224-5999

QW-arsenic, selenium, well yield map

7/7 John Helgesen ,MS Hydrogeologist, USGS 913-842-9909

Recharge/discharge areas, areal variation in well yield, QW, areas of water level decline

7/10 Frank Sherman, MS Sr. Hydrogeologist, Idaho Dept. of Water Resources 208-327-7900

Areas susceptible to contamination, water level change map, recharge areas

6/27 Ed Gutentag, MS Hydrogeologist USGS rtd 988-0890

Aquifer map, precipitation, recharge, gnrl geology, areas of known contamination. Check USGS PP 1400B.

7/17 Jim Goecke, MS Research Hydrogeologist, Univ.Nebraska 308-532-3611 x-138

Saturated thk, irrigation well density, WL fluctuation. Will send copy of Nebraska Atlas.

7/17 David Graham W.J. Graham Construction 674-0444

Well yield map, quality, well density

7/13 Bud Simon VP of Development dhm planning 892-5566

Well density/location, ave. depth, yields, failures

# RECORD OF VERBAL COMMUNICATION

DATE: 7/7/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Jefferson County Planning

ADDRESS:

PERSON CONTACTED: Jean Schwartz TELEPHONE: 271-8731

TITLE: Sr. Planner

SUBJECT *(SUMMARY - INCLUDING PURPOSE & RESULT)*:

— Show types of aquifers

— How the geology affects movement of gw

— Quality of gw as related to geology

7/12/00 — Wk. Jonathan Caine – post Doc. physical aspects

full time w/ USGS — inter-disciplinary

[illegible] geophysical – regional

☆ — lineation maps — for Front Rge areas

Have [illegible] [illegible] — State Health — George Moravek (tritium isotopes)

Next 3 wks – will get samples – 25 wells –

319 – Grant – Mt. GW [illegible] ($12,000)

FOLLOW-UP REQUIRED: Radon program (Mike Wireman EPA)

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/7/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Grand County

ADDRESS:

PERSON CONTACTED: Lorleen TELEPHONE: 970-725-3347

TITLE: County Manager → Underbrink-Current

SUBJECT (*SUMMARY - INCLUDING PURPOSE & RESULT*):

Left msge w/ commissioner

7/11/00 Lorleen Underbrink Current – Cty Mgr.

- proliferation of septic ~~tanks~~ affect S.W.
- How small a lot can put well & septic
- Impact of growth on water sources
- USGS $80,000/yr. Jeff ~~Bayless~~ Bails

Denver – Regional (Fraser Valley Wtr.)

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/11/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Adams County

ADDRESS:

PERSON CONTACTED: Rob Coney TELEPHONE: 303-853-7000

TITLE: Hd of Planning & Devlpmt.

SUBJECT (SUMMARY - INCLUDING PURPOSE & RESULT):

Left msge.

Variable depth to base of aquifer

Water Quality — Lower Arapahoe — High Qual. — Low avail
Low. Fox Hills — Low qual. — high qty

Dr. by Water stds — vs — aquifer quality

Nitrogen distribution map —

Areas where is not aquifer available or improbable

areas —

Oil & gas conservation comm data — with relation to wells

Problem w/ lack of data re - density of septic flds

Reg. Council of govt thinking

FOLLOW-UP REQUIRED:

Propose for local cty

Mapping of systems — concentration vs. gw —

Overlay area of potential svc. extension

non renewable source but within area of potential svc.

Limits of municipal supply —

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/7/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Park County

ADDRESS:

PERSON CONTACTED: ~~[illegible]~~ Scott Bernard (sw ks) TELEPHONE: ~~719-836-4333~~ x201

TITLE: Planning Dept. Tom Eiseman - 836-4265 Gary

SUBJECT (*SUMMARY - INCLUDING PURPOSE & RESULT*):

Left msge Fax - 719-836-4268

7/11/00 He only there . 5

Commissioners . Linda Jones

719-836-4201

Ivan Widom — 719-836-4203

area around Bailey - Alum -

Tom Eiseman

Location of aquifers quantity - resource availabil.

Depth to water Indian Mt. area -

Radon - radioactivity Bailey - Crow Hill

Quality - ~~[illegible]~~ - Guffey area

wetlands map. Abandon mine maps/tailings

FOLLOW-UP REQUIRED: getting from old maps

Maury Rajber ~~[illegible]~~ word of mouth internet Harley Hamilton

303-973-1116 wetlands maps - 719-836-2920

719-836-2421 30+ yrs.

library on mining claims.

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/11/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Clear Creek County

ADDRESS:

PERSON CONTACTED: Lisa Leben TELEPHONE: 303-679-2362

TITLE: Land Use Case Manager

SUBJECT *(SUMMARY - INCLUDING PURPOSE & RESULT)*:

Very interested will call w/ ideas

7/12/00 — Hydrogeologic map Dept Nat. Res. — clear Jan Kraem → 1976

1" = Still using this —

— Density issue — re: no. of wells/section

— Recharge area —

— Mine locations

— Water Quality Map. / Radon Concentrations

RC [illegible]

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/7/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Douglas County

ADDRESS:

PERSON CONTACTED: ~~Peter Holein Director~~ Don Moore Sr. Planner TELEPHONE: 303-660-7400 ~~660-7460~~

TITLE:

SUBJECT *(SUMMARY - INCLUDING PURPOSE & RESULT)*:

~~left msg on voice mail~~

7/14/00 — Don Moore left msg

RCF — Don Moore anything are info compatible

— aquifer information

— 80% dependent on gw —

— aquifer disappear near foothills

— ~~Have regulations based on previous maps~~

— Cannot rely on gw —

— Zoning regulations determine a lot of

— Water quality issues — phosphorus out of system

FOLLOW-UP REQUIRED:

Phase II Stormwater

Protection for Tributary streams

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

# RECORD OF VERBAL COMMUNICATION

DATE: 7/11/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Boulder County

ADDRESS:

PERSON CONTACTED: Graham Billingsley TELEPHONE: 441-3131

TITLE: Planning Director

SUBJECT *(SUMMARY - INCLUDING PURPOSE & RESULT)*:

left msg.

7/19/00 RCF - Graham

He spoke to Health Dept.

DTW

Wetland delineation

Recharge areas

Basin delineation

Everyone he spoke to is looking fwd to such a document

could use in variety of ways

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/17/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Arapahoe County

ADDRESS:

PERSON CONTACTED: Sue Conaway TELEPHONE: 303-795-4452

TITLE: County Planning

SUBJECT *(SUMMARY - INCLUDING PURPOSE & RESULT)*:

Lance Raymond

for eastern portion of Arapahoe Leonard Rice doing for City east of Gun Club -

analyzing amt of water in Denver/ not looking at recharge - would like this

Will do some on quality.

Looking to develop water policy for cty -

Haven't been looking at data except for where new devlpmt.

Most being served by existing water and sewer -

FOLLOW-UP REQUIRED: John Ford w/ Leonard Rice (PE)

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

# HYDROGEOLOGISTS, ENGINEERS, DEVELOPERS

RECORD OF VERBAL COMMUNICATION

DATE: 7/11/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Mike West and Assoc.

ADDRESS:

PERSON CONTACTED: Mike West, Ph.d. TELEPHONE: 720-529-5300

TITLE: Geological Engineer

SUBJECT (SUMMARY - INCLUDING PURPOSE & RESULT):

+ Potentiometric surface - some info inaccurate
+ Structure contours
+ QW data
+ Well data - (State Eng. data of Arapahoe Well (Cormic Map not accurate) see his info   +4x deeper than thought
Ck. records of consultants
Offstream storage gravel pit - fluctuation water level and recharge to - from bedrock   Piney Crk - Post Piney Crk
Depth of weathering in bedrock -
★ Perched water table areas -

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/11/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: RTW Engin.

ADDRESS: Ft Collins [1600 Stout Ste. 1800 Denver - 80202 / 291-8602]

PERSON CONTACTED: Fred Marinelli Ph.D. TELEPHONE: 581-5552

TITLE: Hydrogeologist / Engr. 303-825-5999 / Ft Collins - 970-224-5999

SUBJECT (*SUMMARY - INCLUDING PURPOSE & RESULT*):

RTW - engrg. firm - water district - civil engrg. of water pumping stations tanks - wastewater district

- Map showing distribution of chemicals relevant to [illegible] water
  - arsenic in particular
  - Selenium [illegible] ingestion water

Colo Dept. Public Health Env. database - 22 micrograms/l (Alamosa city)

- Well yields -

Aside { - Biggest cause of premature death is untreated water - need chemicals - or boiling - solar powered disinfection - ultra violet - NaCl & electricity generate chlorine gas w/ salt & electricity -

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

**From:** HELGESENJC@aol.com <HELGESENJC@aol.com> Hydrogeologist, USGS
**To:** cerrillo@rmi.net <cerrillo@rmi.net>
**Date:** Friday, July 07, 2000 6:50 PM
**Subject:** Re: atlas

Hi Larry,

>From "glorified curve plotting" to the Pakistan-India border..... what an evolution!
We just got back from a trip north -- the usual family visits, then drove along the Mississippi from the Twin Cities to St. Louis. Some of that country we had not seen before, so it was nice. Spent the 4th in St. Louis with Karla & hubby, along with Kristin and her boyfriend (they drove over to there from Lawrence).

Well, I could list some things that come to mind for possible ground-water atlas illustrations. Some of them probably would be the usual stuff and are probably on your list already; a lot of it depends on what information is available..........

Depth to water table
Depth to top or base of aquifer
Saturated thickness
Recharge/discharge areas
Connected surface-water features
Textural variations
Structural trends/variations
Areal variations in expected well yield
Areal variations in water quality
Areas affected by contamination
Areas of water-level decline (developed aquifer)
Zones of contribution (to wells)

I'm drawing a blank right now on any pertinent references. Good luck.

I spent a few days in Ft. Collins last month. It was fun to look at the campus again. The old geology building was flooded several years ago like most other buildings, and was remodeled inside... exterior looked the same but the interior looked nothing like it used to. The area just north of the main part of downtown, called Old Town, is really neat (restaurants, shops, etc.). It is just west of our first apartment -- that building (366 East Mountain) is still there! Some of us drove up to see Horsetooth Reservoir -- considerable housing up there now, whereas in the 60's it was pretty barren around there. Then we kept driving west and got a good look at the Bobcat fire. Glad that other fire kept its distance from Evergreen.

Hi to Ginny, and bon voyage to you. How long will you be gone? We wish you

RECORD OF VERBAL COMMUNICATION

DATE: 7/10/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Idaho Dept of Water Resources

ADDRESS:

PERSON CONTACTED: Frank Sherman TELEPHONE: 208-327-7900

TITLE: SR. Hydrogeologist

SUBJECT (*SUMMARY - INCLUDING PURPOSE & RESULT*):

Re mtrl for Atlas -

— Areas susceptible to contamination

— Changes in SWL comparison of couple years to determine if losing or gaining -

— Recharge areas for various aquifers

Will think of others and send -

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

# RECORD OF VERBAL COMMUNICATION

DATE: 6/27/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY:

ADDRESS:

PERSON CONTACTED: Ed Gutentag TELEPHONE: 988-0880

TITLE: Hydrogeologist USGS Retired

SUBJECT *(SUMMARY - INCLUDING PURPOSE & RESULT)*:

Major aquifers

WL -

Precipitation

Recharge amt - location - generalized

Soil types - infiltration rates

Geology - gen'l.

See Prof Paper 1400B

Areas of known contam. (CERCLIS LIST)

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/17/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: Nebraska Dept. Water Res.

ADDRESS:

PERSON CONTACTED: F. Wm Goeke TELEPHONE: 308-532-3611 x138

TITLE: Research Hydrogeologist + Univ. of Nebraska

SUBJECT (SUMMARY - INCLUDING PURPOSE & RESULT):

Yes, they have done one which has been revised - will send me a copy

Includes:

GW Vulnerability - based on - Drastic Program

Sat thk.

T's

Irrig wells

Rising/Declining wells

Etc - etc

Should have before ) leave

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

RECORD OF VERBAL COMMUNICATION

DATE: 7/17/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: W.J. Graham Construction Co. Inc

ADDRESS: Evergreen. Co

PERSON CONTACTED: David Graham TELEPHONE: 674-0444

TITLE: owner.

SUBJECT *(SUMMARY - INCLUDING PURPOSE & RESULT)*:

7/17/00 mostly yields, production, quality failures, density –

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

# RECORD OF VERBAL COMMUNICATION

DATE: 7/13/00 JOB # OR REFERENCE: 00900

COMPANY/AGENCY: dhm Planning

ADDRESS:

PERSON CONTACTED: Bud Simon, V.P. TELEPHONE: 303-892-5566

TITLE: V.P. of Development

SUBJECT *(SUMMARY - INCLUDING PURPOSE & RESULT)*:

On a daily basis utilize
Location of wells
Depths
Yields
Failures - areas where wells have failed.
Currently - hunt and peck for information
Would definitely be a customer if complete.

FOLLOW-UP REQUIRED:

HOW INITIATED: TELEPHONE___ PERSONAL___ OTHER___

# APPENDIX B
# TYPICAL DATA SOURCES

PRJ Library sources: (these will be provided to CGS for perusal)

Ground Water Basic Data Reports: 1-11,13-16, 18-21 --these reports were then changed to Water Resources Basic Data Reports. The reports available are ; 22-31, and 33-36.

Ground Water Circulars: 5-15—these were changed to Water Resource Circulars. The reports available are 16-19, 23, 30, and 36.

Others:

Geology of Ground Water Resources, Colorado by Richard H. Pearl

Evaluation of Water Resources in Kiowa and Bijou Creek Basins

Geohydrology of High Plains Aquifer, USGS Professional Paper 1400-B

Hydrologic Data for Water Table Aquifers in Greater Denver Area, USGS OF Report79-214

Ground Water in the Julesburg Area, Colorado, Thad McLaughlin, USGS GW Series Circular No. 1 (this is quite old but has some useful info.)

Hydrogeologic Maps of the Sterling, Julesburg, and Brush Reach of the S. Platte River Valley

Colorado Ground-Water Association, 2000, Colorado Ground-Water Atlas. (*This document has numerous references that would be of value for the proposed atlas.)*

Colorado Wetlands—report done in 1997. Do not have exact reference. Ck EPA, COE, U.S. Fish and Wildlife, all participated.

For Denver Basin hydrologic data, USGS hydrologic atlases HA's 643,646,647,650 and miscellaneous field investigation maps, Map-I-791 and 1043 will have considerable but somewhat outdated information.

Hampton, E.R., 1975, Hydrologic Data, Greater Denver Area, Colorado. USGS Miscellaneous Investigation Series Map I- 856-C.

Hillier & Schnieder, 1979, Depth to Water Table, Boulder-Ft. Collins-Greeley. USGS map I-855-I

Kelly, T.E., 1974, Reconnaissance Investigation of Ground Water in the Rio Grande Drainage Basin with special emphasis on saline sources. USGS HA-510.

Nimick, David A., 1998, Abandoned Mine Lands, U.S.G.S. Open File Report 98-297. (May want to check with Dave Bucknam of DMG. They were working on inactive mines.)

Robson, S.G.and Banta, E.R., 1987, Geology and Hydrology of Deep Bedrock in Eastern Colorado. USGS Water Resources Investigation Report-WRIR85-4240.

USGS Hydrologic Atlases—HA-736,730-C, 720-A, C, D, E, F, G and J

Van Slyke, G., et al, 1987, Aquifer Data from Geophysical Logs, Denver Basin, CO. Basic Data Report 1, Office of State Engineer, Division of Water Resources.

Welch, A. H., et al 2000, Arsenic in ground-water resources of the United States: U. S. Geological Survey Fact Sheet 063-00, 4p.

CARLweb

## TITLE LIST

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**Database** Colo School of Mines
**Search type:** Browse by Title
**Search was:** ground-water atlases Colorado

Previous Next

| | | |
|---|---|---|
| ☐ | Hopkins, herbert t.,<br>Ground water availability along the blue ridge p | I 19.42/4:84-4168<br>1985 |
| ☐ | Kues, georgianna.<br>Ground water availability and quality in eastern | I 19.42/4:89-4127<br>1990 |
| ☐ | Mazzaferro, david l.<br>Ground water availability and water quality at s | I 19.42/4:84-4221<br>1986 |
| ☐ | Mazzaferro, david l.<br>Ground water availability and water quality in f | I 19.76:80-751<br>1980 |
| ☐ | Jones, m. a. 1952-<br>Ground water availability from a dune sand aquif | I 19.76:90-563<br>1992 |
| ☐ | Underwood, mark r.<br>Ground water availability from the hawi aquifer | I 19.42/4:95-4113<br>1995 |
| ☐ | Geological survey (u<br>Ground water availability from the unconsolidate | I 19.42/4:87-4133<br>1987 |
| ☐ | Hansen, bruce p.<br>Ground water availability in acadia national par | I 19.76:80-1050<br>1980 |
| ☐ | Hollyday, e. f.<br>Ground water availability in carbonate rocks of | I 19.76:79-1263<br>1980 |
| ☐ | Geological survey (u<br>Ground water availability in the black river bas | I 19.42/4:86-4040<br>1986 |

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**Search type:** Keyword
**Search was:** hydrologic atlas Colorado

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| 4 | Geological survey (u<br>Hydrogeology of the point lookout sandstone in t | G3701.C3 svar .U5 HA-720-G<br>1990 |
| 5 | Dam, william l.<br>Hydrogeology of the pictured cliffs sandstone in | G3701.C3 svar .U5 HA-720-D<br>1990 |
| 6 | Geological survey (u<br>Ground water atlas of the united states | 1990 |
| 7 | Kernodle, john micha<br>Hydrogeology of the kirtland shale and fruitland | G3701.C3 svar .U5 HA-720-C<br>1990 |
| 8 | Thorn, conde r. | G3701.C3 svar .U5 HA-720-E |

Hydrogeology of the cliff house sandstone in the | 1990

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| 9 | Geological survey (u<br>Hydrogeology of the morrison formation in the sa | G3701.C3 svar .U5 HA-720-J<br>1990 |
| 10 | Levings, gary w.<br>Hydrogeology of the san jose, nacimiento, and an | G3701.C3 svar .U5 HA-720-A<br>1990 |

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**Title** Hydrogeology of the Morrison Formation in the San Juan structural basin, New Mexico, Colorado, Arizona, and Utah / Department of the Interior, U.S. Geological Survey ; by William L. Dam ... [et al.].
**Corporate Author** Geological Survey (U.S.)
**Scale** Scale 1:1,000,000 (W 109□p0□s30'--W 106□p0□s30'/N 37□p0□s45'--N 34□p0□s45').
**Publisher** Reston, Va. : Denver, CO : The Survey ; For sale by Map Distribution, 1990.
**Description** 12 maps on 2 sheets : col. ; sheets 100 x 141 cm. and 96 x 133 cm., folded in envelope 30 x 24 cm.
**Series Title** Hydrologic investigations atlas ; HA-720-J
**Notes** "A contribution of the Regional Aquifer-System Analysis Program"--Envelope.
Includes text, bibliography, 3 tables, location map, ancillary map, and hydrographs.
**Subject(s)** Groundwater Maps. San Juan Basin (N.M. and Colo.)
Hydrogeology Maps. San Juan Basin (N.M. and Colo.)
Morrison Formation Maps.
**Other Entries** Dam, William L.
National Regional Aquifer Systems Analysis Program (U.S.)
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| 4 Planert, michael. Ground water atlas of the united states. segment | G3701.C3 svar .U5 HA-730-B | 1995 |
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USGS

National Water-Quality Assessment
**National Analysis of Trace Elements**

# Arsenic in ground water of the United States

## Publications

**Fact sheet--**
Arsenic in ground-water resources of the United States

**Detailed report--**
WRIR 99-4279: A retrospective analysis on the occurrence of arsenic in ground-water resources of the US and limitations in drinking-water-supply characterizations

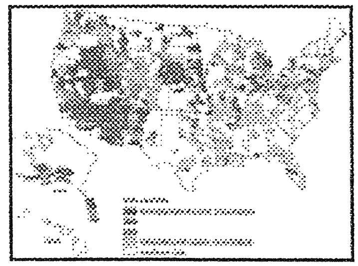
**1998 conference paper--**
Arsenic in ground water supplies of the United States

**More....**

Arsenic is a naturally occurring element in the environment. Arsenic in ground water is largely the result of minerals dissolving naturally from weathered rocks and soils. Several types of cancer have been linked to arsenic in water. The US Environmental Protection Agency is currently reviewing the maximum contaminant level of arsenic permitted in drinking water, and will likely lower it, as recommended last year by the National Research Council.

The USGS has developed a map that shows where and to what extent arsenic occurs in ground water across the country. Highest concentrations were found throughout the West and in parts of the Midwest and Northeast.

See the news release, 8 May 2000, and frequently asked questions.

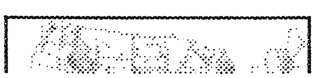


Counties in which at least 10% of ground-water samples exceed possible new maximum contaminant levels *(23 Kb, GIF)*

Map is also available as a PostScript file--
Color (3,279Kb)
Grey-scale (3,250Kb)

## Data

Arsenic concentrations for 18,850 ground-water samples collected in 1973-97



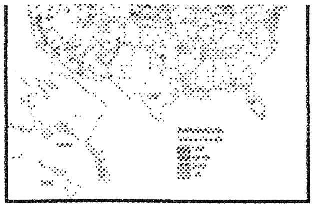
## Other arsenic links

World Health Organization -- Arsenic in drinking water

U.S. Environmental Protection Agency--Proposed revision to arsenic drinking water standard and Q & A's: Occurrence

## Other organizations with drinking-water interests

American Water Works Association



*(23 Kb, GIF)*

Map is also available as a PostScript file-- Color (4,729Kb)

Arsenic data available as-- Tab-delimited text file (1,130 Kb)

U.S. Agency for Toxic Substances and Disease Registry-- ToxFAQs: Arsenic

National Research Council-- Arsenic in drinking water

Congressional Research Service report-- Safe Drinking Water Act Amendments of 1996

Natural Resources Defense Council-- FAQs: Arsenic in drinking water

West Bengal and Bangladesh Arsenic Crisis Information Centre

Association of State Drinking Water Administrators

National Ground Water Association

National Rural Water Association

U.S. Environmental Protection Agency Office of Water

## Local arsenic information

USGS-- Arsenic, nitrate, and chloride in groundwater, Oakland County, Michigan

USGS-- Relation of arsenic concentrations in ground water to bedrock lithology in eastern New England

4th International Conference on Arsenic Exposure and Health Effects (San Diego, June 2000)

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**National Analysis of Trace Elements**
National Water-Quality Assessment
Water Resources of the United States
U.S. Geological Survey

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USGS

National Water-Quality Assessment
**National Analysis of Trace Elements** - Publications

# Figure 3

from Fact Sheet 063-00, **Arsenic in Ground-Water Resources of the United States**

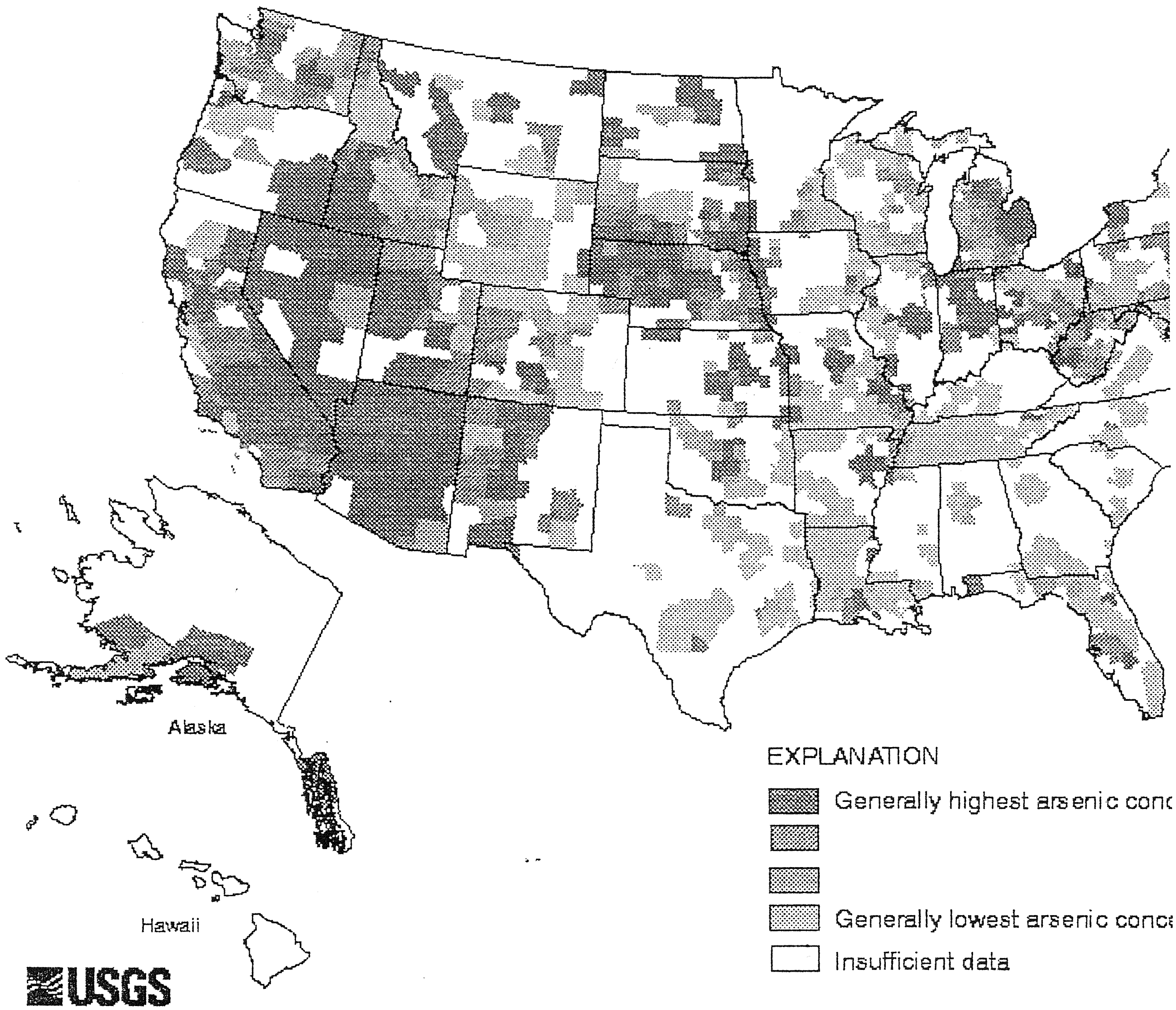


**Figure 3.** Counties with arsenic concentrations exceeding possible new MCLs in 10 percent or more of ground-water samples.

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| Counties with arsenic concentrations exceeding 10 µg/L in 10 percent or more of samples.<br>Counties with arsenic concentrations exceeding 5 µg/L in 10 percent or more of samples.<br>Counties with arsenic concentrations exceeding 3 µg/L in 10 percent or more of samples.<br>Counties with fewer than 10 percent of samples exceeding 3 µg/L, representing areas of lowest concentration.<br>Counties with insufficient data in the USGS data base to make estimates. |

*Citation:*

Welch, A.H., Watkins, S.A., Helsel, D.R., and Focazio, M.F., 2000, Arsenic in ground-water resources of the United States: U.S. Geological Survey Fact Sheet 063-00, 4p.

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## New report details value and status of Colorado wetlands

**May 1997**

*U.S. Water News Online*

**DENVER** -- About 1.5 percent of the State of Colorado is covered by wetlands, which are not only a source of habitat for waterfowl but also are of significant benefit to the state's water resources by providing flood and erosion control and helping to naturally clean up and filter out contaminants, according to the most recent National Water Summary report by the U.S. Geological Survey.

The report, the eighth and final in a series, provides a state-by-state overview of wetland resources that shows the type and distribution of wetlands, trends on wetland losses and gains, and conservation efforts in each state. "The 103 million acres of wetlands remaining in the United States are not only a source of critical habitat for waterfowl, but they also reduce the severity of floods and erosion by modifying the flow of water and improve water quality by filtering out contaminants," said Bruce Babbitt, Secretary of the Interior, in releasing the report.

The USGS wetlands report provides overviews of wetland protection legislation, research by Federal agencies related to wetlands, a discussion of the functions and values of wetlands, as well as an historic look at gains and losses of wetlands across the Nation since the time of European settlement.

The report, was prepared in cooperation with the U.S. Environmental Protection Agency, the U.S. Army Corps of Engineers, the U.S. Fish and Wildlife Service, a sister bureau in the Interior Department, and the former National Biological Service, which became the Biological Resources Division of the USGS on October 1, 1996.

Wetlands occupy about 1 million acres of Colorado. Types of wetlands in the state include forested, scrub-shrub, bottomland shrublands, marshes, fens, and alpine snow glades, among others.

Over the last two centuries, wetland acreage in Colorado has been reduced by about one-half. Major causes of wetland loss or alteration are conversion to cropland, dewatering for irrigation purposes, overgrazing by livestock, encroachment by residential and commercial development, channelization, dewatering for municipal and industrial purposes, and contamination from inadequately treated sewage and industrial waste. Other causes are ski resort development, transmountain water diversions, drainage, burning, clear cutting, mining and related activities, erosion and sedimentation, and construction of dams, reservoirs, roads, and railroads.

Even as wetland area continues to decrease in Colorado, some new wetland areas have resulted from irrigation and changes in land-use practices, principally in the San Luis Valley and near Boulder.

Agencies that have responsibility for wetlands in Colorado include the U.S. Army Corps of Engineers, agencies of the Department of the Interior, State agencies such as the Department of Natural Resources and the Division of Wildlife, some county and local government entities, and various private organizations such as Ducks Unlimited and The Nature Conservancy. The USGS National Water Summary report on Wetland Resources provides a table in each State section on the activities and responsibilities of various government agencies and private organizations related to wetlands.

Highlights from the Colorado wetland resources summary include descriptions of the value of wetlands to the State. Wetlands provide important wildlife habitat. One of the best-known functions of wetlands is to provide habitat for birds. Many species of birds depend on wetlands almost totally for breeding, nesting, feeding, or shelter during breeding cycles and are therefore called "wetland dependent." Wetlands also provide for flood attenuation, bank stabilization, and water-quality improvement. Colorado's tourist industry benefits from the scenic beauty of wetlands and from the recreational opportunities they afford residents and out-of-state visitors, according to the USGS.

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Abandoned Mine Lands Reports

## Science for Watershed Decisions on Abandoned Mine Lands: Review of Preliminary Results, Denver, Colorado, February 4-5, 1998

**Edited by David A. Nimick and Paul von Guerard**

**U.S. Geological Survey Open File Report 98-297**

- Impacts of abandoned mine lands on stream ecosystems of the upper Animas River watershed, Colorado by John M. Besser, Del Wayne R. Nimmo, Robert Milhous, and Bill Simon
- Seasonal fluctuations of dissolved-zinc concentrations and loads in the mainstem streams of the upper Animas River watershed, Colorado by Kenneth J. Leib, M. Alisa Mast, and Winfield G. Wright
- Colloid formation and transport of aluminum and iron in the Animas River near Silverton, Colorado by L.E. Schemel, B.A. Kimball, and K.E. Bencala
- Recurrence intervals, probability, and annual duration of dissolved-zinc concentrations using flood analysis techniques in the upper Animas River watershed, Colorado by Kenneth J. Leib, M. Alisa Mast, and Winfield G. Wright
- A toxicological reconnaissance of the upper Animas River watershed near Silverton, Colorado by Del Wayne R. Nimmo, Carla J. Castle, and John M. Besser
- Metal uptake, transfer, and hazards in the stream food web of the upper Animas River watershed, Colorado by John M.Besser, William Brumbaugh, S.E. Church, and B.A. Kimball
- Rare earth element geochemistry of acid waters: Preliminary results identifying source signatures and instream processes by Philip L. Verplanck, D. Kirk Nordstrom, Winfield G. Wright, and Howard E. Taylor
- Comparison of filtration procedures and analytical procedures on iron (II/III): Results from upper Animas, Summitville, and Iron Mountain by James W. Ball, D. Kirk Nordstrom, and Charles N. Alpers
- Characterization of aquatic health in mine-impacted streams: A case history from the Clark Fork River, Montana, and the Coeur díAlene River, Idaho by Dan F. Woodward, Aida M. Farag, and William Brumbaugh

- **Watershed Characterization**
  - Geologic framework of volcano-plutonic igneous complexes as it relates to the upper Animas River and Boulder River abandoned mine lands studies by K. Lund, M.J. O'Neill, D.B. Yager, R.G. Luedke, and D.J. Bove
  - Digital geologic compilations of the upper Animas River and

Boulder River watersheds: Geographic information systems technology used as a scientific interpretation tool by D.B. Yager, K. Lund, R.G. Luedke, D.J. Bove, M.J. O'Neill, and T.C. Sole

- Progress report on surficial deposits and geomorphology of major drainages of the upper Animas River watershed, Colorado by Rob Blair

- Watershed characterization from the air: Application of geophysical techniques to watershed characterization in the Boulder River watershed, Montana by A.E. McCafferty and B.D. Smith

- Mapping of acid-generating and acid-buffering minerals in the Animas watershed by AVIRIS spectroscopy by B. Dalton, T. King, D.J. Bove, R. Kokaly, R. Clark, S. Vance, and G.A. Swayze

- Digital data for watershed characterization of abandoned mine land by E. Paul Martin

- **Source of Metal Loading**
  - Integration of mine-drainage effects in watersheds using tracer injections and synoptic sampling by B.A. Kimball, R.L. Runkel, Katherine Walton-Day, and K.E. Bencala

  - Ground-water input of zinc to a watershed affected by acidic-mine drainage: simulation results and implications for remediationóCement Creek, upper Animas River watershed, Colorado by Katherine Walton-Day, R.L. Runkel, B.A. Kimball, and K.E. Bencala

  - Quantification of metal loading by tracer-injection methods in Cataract Creek, Boulder River watershed, Montana: Study design by Tom E. Cleasby, David A. Nimick, and B.A. Kimball

  - Natural contributions of acidity and metals to surface waters of the upper Animas River watershed, Colorado by Dana J. Bove, Winfield G. Wright, M. Alisa Mast, and Douglas B. Yager

  - Comparison of surface-water chemistry in undisturbed and mining-impacted areas of the Cement Creek watershed, Colorado by M. Alisa Mast, Winfield G. Wright, and Kenneth J. Leib

  - Oxygen isotopes of dissolved sulfate as a tool to distinguish natural and mining-related dissolved constituents in the upper Animas River watershed, Colorado by Winfield G. Wright, M. Alisa Mast, and Kenneth J. Leib

  - Determination of pre-mining background using sediment cores from old terraces in the upper Animas River watershed, Colorado by S.E. Church, D.L. Fey, and E.M. Brouwers

- **Mine-Site Characterization**
  - Acid-neutralizing potential of igneous bedrock in Basin and Cataract Creeks, Boulder River watershed, Montana by G.A. Desborough and P.H. Briggs
  - Effects of selected mine dump piles on dissolved-constituent loads in the Cement Creek basin, upper Animas River watershed, Colorado--A preliminary assessment by Winfield G. Wright, Kenneth J. Leib, and M. Alisa Mast
  - Geochemical and mineralogical characterization of mine dumps on BLM lands, upper Animas River watershed, Colorado: Plans and preliminary results by J.T. Nash, G.A. Desborough, and D.L. Fey
  - Spectral induced polarization studies of mine dumps near Silverton, Colorado by David L. Campbell, David V. Fitterman, and Robert J. Horton
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  - An overview of the U.S. Geological Survey mine waste characterization project by Kathleen S. Smith, James G. Crock, G.A. Desborough, David V. Fitterman, Reinhard W. Leinz, Maria R. Montour, Mark R. Stanton, Gregg A. Swayze, and Robert B. Vaughn
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  - Use of ecological indicators as endpoints for remediation by Terence P. Boyle and Bob Bukantis
- **Presenting Abandoned Mine Lands Information**
  - The Boulder Geoenvironmental Explorer: A GIS tool to communicate science to land managers and the public by A.E. McCafferty, D.B. Yager, and T.C. Sole
- **Perspective on the Watershed Approach**
  - Science and regulatory practice: The search for certainty by D. Kirk Nordstrom
  - A synopsis of presentations and discussions in the Thursday,

February 5th session: Perspectives on implementing the watershed approach to remediate abandoned mine lands by Margot Smit and Gary Broetzman

- **References**
- **Appendix**

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*U.S. Department of the Interior*
*U.S. Geological Survey*
*Rocky Mountain Mapping Center*
*URL: http://amli.usgs.gov/amli/reports/ofr98_297/index.html*
*Maintainer: rtpelltier@usgs.gov*
*Last modified: 05 Dec 1999*

WILDLIFE REPORT For Immediate Release
NEWS FROM THE COLORADO DIVISION OF WILDLIFE

**Release Date:** 04/21/2000

## COLORADO IS HOME TO FOUR TYPES OF WETLANDS

Colorado's mountain valleys, plains and lowlands are home to four types of wetlands, with examples of each type now being protected by the Colorado Wetlands Initiative.

While wetlands make up a small percentage of Colorado's land mass, covering only about 2 percent of the landscape, they are critical to many species in the state, and serve as filters for runoff, as well as acting like giant storage tanks for flood waters.

But over the past century, Colorado has lost many of its wetlands, and it is estimated that only about one million acres remain.

There are many types of wetlands, but they generally have the same characteristics. "The term 'wetlands' refers to areas where the water table is usually at or near the surface of the ground," said Alex Chappell, the Wetlands Program coordinator for the Colorado Division of Wildlife. "Sometimes you can see the water in wetlands and other times it lies just below the surface of the soil where the plant roots grow." In general terms, wetlands are areas that are wet enough for long enough periods during the growing season to have developed specific characteristics which are unique to them, including certain types of plants that survive with little or no oxygen.

Wetlands also perform many valuable functions for society, like cleaning water by retaining and storing harmful chemicals and sediments as water filters through. Wetland plants, soils and bacteria act as natural filters improving water quality and providing a valuable service to the public, according to Denise Culver, the wetland ecology coordinator for the Colorado Natural Heritage Program.

"Wetlands also are valued as energy and water absorbers by spreading out fast-flowing floodwaters from heavy rainfall or snow melt, thus preventing flooding downstream," Culver said.

Colorado supports four broad categories of wetlands – peatlands, marshes, wet meadows and riparian. And the Colorado Wetlands Initiative has funded projects that are representative of each Colorado wetland type.

Peatland is a generic term for any wetland that accumulates decayed plant material, and in Colorado the only known peatland is a fen. Fens are located at high elevations (above 8,000 ft.) and form at low points in the landscape or near slopes where groundwater intercepts the soil surface, maintaining a constant water level.

"They look like meadows," said Gary Skiba, a habitat biologist with the Division. "But they are much more than that. They provide important benefits for a watershed, including preventing or reducing the risk of floods and improving the water quality," he said. "Boreal toads, which are endangered, and chorus frogs are two species that live in peatlands."

High Creek Fen in South Park County, a Wetland Initiative project, is one of the most biologically diverse fens found in the southern Rocky Mountains. It supports more rare plant species than any other wetland known in Colorado. The fen provides habitat for birds such as the spotted sandpiper and Wilson's phalarope.

Another type of wetland found in Colorado is the marsh. Marshes are found next to bodies of water that don't flow, such as lakes or ponds, or by slow-flowing streams or rivers. Such areas have fluctuating levels of water, higher in the early spring and summer, and lower in late summer.

Marshes are generally home to the greatest biodiversity of the four types of wetland found in Colorado. Cattails, bulrush, and many species of waterfowl, insects, mollusks, crustaceans and algae are all found in marshes. The Wetlands Initiative has funded several marsh projects including the Alamosa and Monte Vista National Wildlife Refuges, Russell Lakes State Wildlife Area and Blanca Wetlands. These projects provide habitat for the greater sandhill crane, snowy egret and other waterbirds.

The most common type of wetland found in Colorado is the wet meadow.

"These wetlands are basically grasslands with waterlogged soil near the surface but without standing water for most of the year," Skiba said. Wet meadows depend on precipitation or ground water for a water source, but can be maintained by irrigation. They provide many important benefits to a watershed, including improved water quality.

"Many species of wildlife thrive in this habitat, including deer, elk and sandhill cranes," Skiba said.

The Wetlands Initiative funded many wet meadow projects including the Arickaree Ranch, Phelps Upper Meadow and the L Cross Ranch.

The Arickaree Ranch, located in northeast Colorado, encompasses more than eight miles of the Arickaree River, a stretch of the river believed to be the last intact example of a relatively free-flowing plains river in Colorado. Greater prairie chickens perform their elaborate mating rituals on the ranch and several bird species whose population numbers are declining, including curve-billed thrasers and Cassin's sparrows, make their homes on the ranch.

The last type of wetland found in the state is the riparian wetland. These are associated with moving water and are seasonally flooded. Riparian wetlands are particularly productive ecosystems because they receive large inputs of water and nutrients from upstream sources during flooding. Riparian wetlands and their associated aquatic habitat are important for nutrient cycling and food chain support, providing litter and nesting habitat, fish habitat and forage for wildlife including waterbirds.

The Delta Heron Rookery Project, another Wetlands Initiative project, protects riparian habitat along the Gunnison River. The area is home to dozens of great blue herons, which make their homes in the cottonwood stands. River otters and Colorado pikeminnow, a federally endangered species, also live in the area.

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# Water Resources

Home

WATER RESOURCES are important to construction and maintenance of the Nation's infrastructure. The availability of ground water, for example, can limit man's use of the land in areas of shallow water tables, or can preclude mining of aggregate if water rights issues associated with a gravel pit cannot be resolved. The study area has numerous urban, suburban, and rural areas, and is underlain by a complex network of water-bearing sediments (aquifers). These aquifers are less than 20 feet deep in much of the area and are easily tapped by numerous domestic, commercial, and irrigation wells. The shallow depth makes these aquifers easily polluted by spills of hazardous materials, or leaks from underground storage tanks and oil wells. Knowledge of the thickness, extent, and nature of the shallow aquifers is vital to development of natural resources and planning for increasingly urban land use.

To meet the needs for information on shallow ground-water resources the study includes detailed mapping of 1) the location and thickness of the aquifers, 2) the altitude of the water table and direction of ground-water movement, 3) depth to the water table, 4) saturated thickness of the aquifers, 5) altitude of the buried bedrock surface under the aquifers, and 6) the general water-quality characteristics of the aquifers, and 7) the outcrop and subcrop of bedrock aquifers underlying the shallow aquifers.

## Water Research and Support Activities

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# *Structure, Outcrop, and Subcrop of the Bedrock Aquifers along the Western Margin of the Denver Basin, Colorado*

S.G. Robson, George Van Slyke, and Glenn Graham

This page provides access to maps of the structure, outcrop, and subcrop of the bedrock aquifers along the western margin of the Denver Basin, Colorado, contained in Hydrologic Atlas 742. The 5 maps are in PDF format. To view or print documents in PDF format, download and install the free *Adobe Acrobat Reader* if it is not already available to you. Use your browser BACK button to return here to view another map.

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| *Map 1* | Structure, outcrop, and subcrop of the Laramie-Fox Hills aquifer in the Greeley area. |
| *Map 2* | Structure, outcrop, and subcrop of the Laramie-Fox Hills aquifer in the Platteville area. |
| *Map 3* | Structure, outcrop, and subcrop of the Laramie-Fox Hills aquifer in the Boulder area. |
| *Map 4* | Structure, outcrop, and subcrop of the Arapahoe aquifer in the Golden area. |
| *Map 5* | Structure, outcrop, and subcrop of the Arapahoe aquifer in the Castle Rock area. |

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# National Hydrography Dataset

The National Hydrography Dataset (NHD) is a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. Within the NHD, surface water features are combined to form "reaches," which provide the framework for linking water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data in upstream and downstream order.

The NHD is based upon the content of USGS Digital Line Graph (DLG) hydrography data integrated with reach-related information from the EPA Reach File Version 3 (RF3). The NHD supersedes DLG and RF3 by incorporating them, not by replacing them. Users of DLG or RF3 will find the National Hydrography Dataset both familiar and greatly expanded and refined.

While initially based on 1:100,000-scale data, the NHD is designed to incorporate and encourage the development of higher resolution data required by many users.

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U.S. Department of the Interior
U.S. Geological Survey
URL: *http://nhd.usgs.gov/index.html*
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