Information Series 47

GEOLOGIC HAZARDS AVOIDANCE OR MITIGATION

A Comprehensive Guide to State Statutes, Land Use Issues, and Professional Practice in Colorado

By Erin J. Johnson, J.D., AICP
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Colorado Geological Survey
Department of Natural Resources
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About the cover: In the early 1980's a landslide undermined the support for this house in the Rockrimmon area of Colorado Springs. The geologic formation underlying this area is known for its highly expansive soils and bedrock, and is also prone to landslides. The exposure resulting from the landslide indicates the house rests on a shallow foundation, obviously inadequate under the circumstances. On the right side of the exposed foundation wall, the foundation perimeter drainpipe drapes down on top of the landslide bench below, once at the same level as the front yard. Below the lower end of the drainpipe, a small pile remains of what was the fence and other landscaping. With proper identification, investigation, and mitigation, these problems can be avoided. This guide provides information and seeks to increase awareness of issues related to this and other geologic hazards. Photo by John Himmelreich.

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FOREWORD

The Colorado Geological Survey is pleased to offer *Geologic Hazards Avoidance or Mitigation* to our constituents. The document's authors are Erin J. Johnson, an Attorney at Law from Cortez, and John W. Himmelreich, a Professional Geologist from Colorado Springs. They have assembled a comprehensive guide that describes state statutes, land use issues, and professional practice for geologists and engineers with regard to geologic hazards in Colorado. This guide contains a wealth of information that should be indispensable to geologists, engineers, attorneys, planners, and any other practitioner who deals with geologic hazards in the State.

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Vicki J. Cowart, Director
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Erin J. Johnson, J.D., AICP[1]
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INTRODUCTION

The 1990's has brought about an era of renewed interest in land-use planning and development issues that in many ways mirrors events that occurred in Colorado during the 1960's and 1970's. The efforts made during previous decades resulted in many statutes that address growth and development and remain in effect today. However, there are many differences between the original intent of the citizens and legislature and what has actually occurred regarding one of the most important areas of land-use regulation: the avoidance or mitigation of geologic hazards in the land development process. The differences have resulted in a scattered and incoherent legal structure that is difficult to understand, discuss, and practice.

It is time to revisit the issues and address what has been accomplished and what falls short of the earlier and present expectations. The 1990's rerun of growth and development issues has the same players as the 1970's version: 1) individuals, groups, and local governments that are scrambling to control the growth machine, and 2) those fueling the growth machine in response to various economic and other factors.

On the control side of the argument, many excellent regulatory tools have been developed since the 1970's that directly address specific concerns. These tools, properly implemented, in addition to well-designed growth management strategies, conservation plans, and other efforts, have kept the machine somewhat under control. On the fuel side of the argument, all of the factors that support development have gained a certain momentum that makes it harder and harder to keep growth within reasonable parameters. Additionally, the development community has recently made several legislative attempts to enact a Colorado "takings" bill that seeks to strengthen private property rights and limit governmental interference with land development.

How are these arguments to be reconciled? Do the citizens of Colorado, practicing professionals, and the major stakeholders in the development industry have to muck through the issues as if they are all new, or can we build on the foundation that has been established over the past three decades?

The answers to these questions are elusive, but the sharing of information, experiences, successes, and failures can lead us all in the right direction. This publication is a reference guide to

provide history, information, and perspectives relative to the foundation that has already been established. It is intended to inspire new thought regarding old topics, and to raise more questions than it answers as a challenge to each individual to broaden their own perspectives.

Specific guidance is intentionally lacking: the reader is urged to use the information presented here to better understand the practical implications of existing regulations within their area of expertise, identify areas that need improvement, and formulate workable solutions to unsolved problems. This guide does provide valuable general guidance. For example, engineers and geologists can use this guide to help fulfill their professional obligation to become familiar with professional practice issues and land use regulations. This guide can also be used by a wide range of other practicing professionals to collectively address today's issues in a way that will establish a sustainable quality of life in Colorado.

To lead this discussion, we begin with a "reality check" that identifies current issues regarding land use, geologic hazard, and professional practice issues. This is followed in Section II with a summary of Colorado land use and planning regulations that gives an overview of the law and also provides a historical perspective of the development of the land-use regulations during the 1960's, 1970's, and 1980's.

The state constitution and statutes define the authority of local governments in Colorado and place requirements on certain governmental functions. Master plans, zoning, subdivision, and other parameters are discussed in Section III.

Colorado has enacted specific consumer protection legislation regarding soil and geologic hazards. The strengths and weaknesses of this statute are presented in Section IV. Because natural and geologic hazard issues are addressed in many Colorado statutes, Section V lists and summarizes some important statutory requirements that may be overlooked.

State statutes also define some of the professional responsibilities related to practice in areas of land use and natural hazards. Section VI presents this information and also includes a discussion of professional organizations and their requirements for professional performance as prerequisites for membership.

The Colorado Geological Survey plays a central role in guiding land-use decisions related to geologic hazard issues. The CGS conducts research, reviews land-use applications, and provides a wealth of information to practicing professionals and the public. The major functions and activities of the CGS are summarized in Section VII.

Finally, a few goals and perspectives are provided in Section VIII to help set the stage for change. The use of this publication as a discussion of important issues and as a guide will help each individual work toward solutions that will benefit everyone in Colorado.

Going…..… Going…..…

REALITY CHECK

Gone!!!!!!! Photos by John Himmelreich.

SECTION I: REALITY CHECK

A. Overview of Current Issues.

Risks of damages to residential, commercial, and industrial development and infrastructure due to geologic hazards has progressively increased in Colorado over the past 30 years due to growth and development trends. In previous decades significant growth in Colorado was generally driven by events and economic cycles such as energy booms, increased tourism and recreational interests, and regional population expansions based on employment or other factors[3] [see Appendix 1]. In areas affected by these situations, many local communities or regions addressed specific growth-related problems through regulatory efforts.

Currently almost all areas of Colorado are experiencing some growth, and much of it does not follow traditional development patterns. Growth is occurring in remote areas, in and near towns and cities of all sizes, in rural and agricultural areas, and in environmentally sensitive areas. Additionally, growth is now occurring on many platted parcels that were previously avoided due to adverse site conditions and in unregulated areas in and around municipalities. This is generally referred to as "infill" growth, and in many cases local governments encourage this type of development without a thorough analysis of actual site or area conditions.

The recent non-traditional growth trends in Colorado are generally not tied to any single event or economic factor. In some cases the result is more compact and concentrated development patterns and in others the development is dispersed. Both situations have the potential of significantly increasing natural hazard risks. Examples of non-traditional development include 1) large "second" homes and remote recreational facilities, 2) rapid growth in RV/motor home parks and recreational homes, 3) heavy influxes of part-year residents, 4) conversion of seasonal uses to year-round uses, 5) 35-acre "developments" that are not subject to subdivision regulations, design standards, or public review processes, and 6) construction in riparian areas, on steep slopes, and in other environmentally sensitive areas.

In some cases this non-traditional development results in greater natural hazard risks to the landowner, neighboring landowners, the public, and local governments. Importantly, the less populated areas where these trends are occurring may not have land use regulations or development review procedures that adequately address growth and natural hazard issues. Also, the affected local government entities may not have the financial ability to meet increased demands on governmental services caused by the new development.

Lack of proper knowledge about natural and geologic hazards at a very early stage in the development process leads to improper development approvals and potential liability for damages. Unless properly identified and avoided or mitigated at the site analysis, design, planning, zoning, subdivision, or construction phases, some geologic hazards are not apparent until the site is disturbed,

infrastructure is installed, or a structure is built. In some instances, such as in steeply-dipping bedrock areas, problems may not become apparent until runoff and infiltration patterns are changed by grading or watering of the landscaping around newly-built structures. If a geologic hazard is not appropriately identified or avoided, remedial efforts after development and construction may be costly, and the underlying geologic problem may not be resolved. Additionally, the affected properties or developments may drop in value.[4]

In light of the increased development in Colorado and the critical nature of situations where geologic hazard problems do occur, local government entities and practicing professionals need to ensure the proper early assessment of geologic hazard risks. Potential problems need to be identified and addressed at an early stage in the development process instead of after damages, economic losses, and environmental losses have occurred. Reduction of risks can be accomplished through: 1) regulatory or other efforts that require qualified professional analysis and technical review, 2) preventive actions to solve the problem before it arises, 3) mitigative actions, 4) avoidance of the hazard area from development activity if not mitigatable, and 5) follow through by local regulatory authorities to assure the risks have been appropriately addressed.

There is a lot of room to improve on methods currently used to address geologic hazard issues in Colorado. As a short-term measure, understanding linkages between existing laws can improve both professional and development practices. This will lead to more proactive and interdisciplinary involvement by all players in the land use and development process. In the long term, the concerns presented here should be included in local government regulatory activities and any comprehensive statewide approach to planning and development issues. Governor Romer's Smart Growth Initiative[5] that began in 1994 and the proposed Colorado Planned Growth Act[6] are two efforts that are addressing these issues.

The proposed Planned Growth Act is a statewide effort that applies to local governments and seeks to strike a balance between "No Growth" and "Uncontrolled Growth" policies. This proposed act would require comprehensive plans for counties with over 25,000 people or that have grown by more than 10% over 10 years, and towns with over 2,500 people, or that have expanded their boundaries over 20% over the past five years. The requirements are specifically directed at establishing coordination between local government entities and the management of future growth within urban growth boundaries. "Natural hazards" is one of six topics that is required to be included in the comprehensive plans. The bill provides for the withholding of state funds for non-compliance. While this bill may or may not pass in its current form, some form of a statewide planning policy is likely to be passed in the next few years. The more that practicing professionals from many disciplines get involved in the process, especially at the legislative stage, the better the results will be for both the public and private sectors.

Recognizing that bringing attention to these issues is not likely to precipitate an immediate landslide of activity, we suggest here many ways to increase public and professional awareness of geologic hazard risks and establish a rational platform for discussion of the issues. Addressing geologic hazard risks requires an interdisciplinary approach, encompassing professions of geology and engineering, public officials and representatives, practitioners in land-use planning, law, the construction industry, and many others. This guide outlines the foundation of basic information that should be understood by practitioners in all of the involved professions, and advocates increased cooperation between practitioners. Because every participant in the land use process may ultimately incur liability related to the occurrence of geologic hazard problems, each one has an obligation to develop a better understanding of the issues both inside and outside of their own specialties. Practitioners should also make serious efforts within their area of expertise to help develop preventive and mitigative solutions rather than reactive solutions.

While Colorado citizens tend to ferociously protect their Western heritage and ethics, there is no reason why practitioners should "shoot from the hip" when it comes to identifying and avoiding or mitigating geologic hazards associated with land development. In fact, proper attention to these issues enhances the preservation of the valuable resources of Colorado, including our Western heritage. It also reduces potential economic losses by managing growth based on tangible planning and environmental considerations as guiding principles in development activities.

B. The Nature of the Beast.

A primary issue that complicates this discussion is the interchanging of the terms "natural hazard" and "geologic hazard" by practitioners of different disciplines. This guide generally addresses geologic hazards based on the statutory definitions contained in HB 1041, C.R.S. §24-65.1-101, that defines "natural hazards" to include geologic hazards, flood hazards, and wildfire hazards. Under HB 1041, soils hazards are considered a subcategory of geologic hazards. Dealing with flood hazards and wildfire hazards is not a specific emphasis of the subject matter of this guide, but these hazards are not excluded from the intended scope or content of this guide.

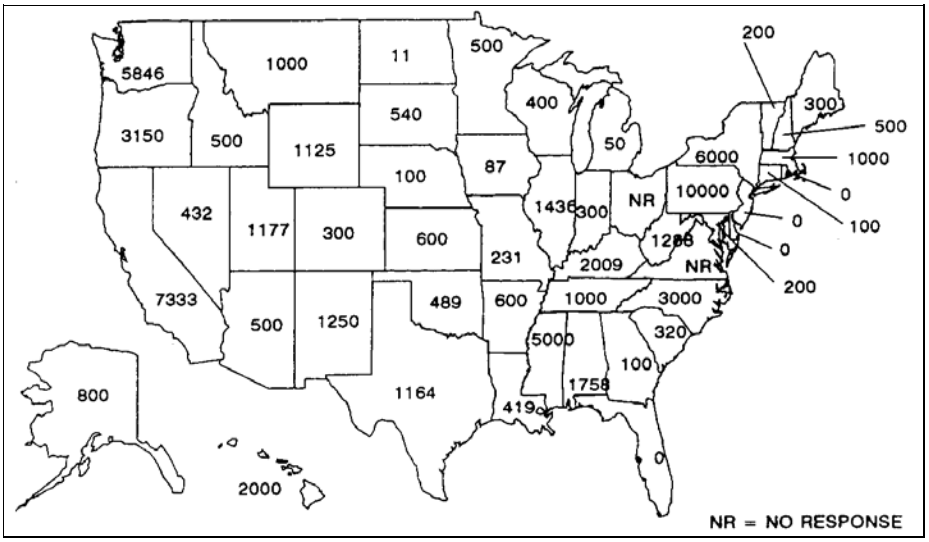
Although the practice of both engineering and geology encourages as much precision as possible, the difference between natural and geologic hazards is really not as complicated as it may seem. The specific types of natural or geologic hazards included in either term are dependent on how they are defined in the context in which they are applied. The statutory definitions that were developed in HB 1041 are discussed in Section II.D. [see also Appendix 2.a.]. Geologic hazards are more thoroughly defined in Colorado Geological Survey (CGS) Special Publication 6[7] [see Appendix 3]. The important thing to remember is to specifically define these terms to indicate their intent and scope in any application.

Presenting a discussion of geologic hazards and land use issues is a difficult task. Geologists and engineers might tend to get pretty excited about natural hazards, but the subject is generally bad news to many others.[8] The identification of a geologic hazard is virtually never a benefit to a landowner or developer, and the mitigation of risk always costs money that would not otherwise be spent. For a developer, acreage is reduced, the per lot infrastructure investment is increased, expenses necessary to address specific problems are driven up, and profit margins are reduced. Local governments have to design and administer special regulations to deal with known and unknown problems. Lenders and insurance agencies may have to turn down applications where the risks are too high. The landowner or end user pays the bill and may still have the liability of the risks.

As a result, real economic pressures exist to ignore or downplay hazards and reduce or eliminate risk management. These pressures may be passed on to the engineers and geologists working on development projects, especially where the risks appear to be low and the mitigation costs appear to be high. Regardless of the economic pressures, all professionals in the land development industry have certain standards of care that must be followed and respected by other practitioners. After all, land development usually occurs only once in a great period of time, unless it is done improperly. Every practitioner needs to remember that they are being paid to disclose their knowledge and expertise, not to conceal it.

Slump encroaches on roadway and jeopardizes bike path (left). Photo by John Himmelreich. Landslide closes two lanes on Interstate 25 (right). Photo courtesy of the Pikes Peak Library District.

COLORADO LAND USE AND PLANNING REGULATIONS



Average annual costs (in thousands of dollars) of contracted highway repairs due to landslides on U.S. state highway systems for 1986-1990. (From Schuster, 1996).

SECTION II: COLORADO LAND USE AND PLANNING REGULATIONS

An interdisciplinary approach to geologic hazard issues requires an understanding of existing Colorado land use regulations. With knowledge of the broad authority already available to establish local land-use regulations, practitioners can learn to contribute their expertise to the development of appropriate and meaningful standards and regulations. A brief summary of the major statutes is included here to provide an overview and a historical perspective of the development of the state regulations and as a reference guide. This section begins with Colorado statutes enacted in 1968, the beginning of an era of increased statewide involvement in land use and planning issues that followed the advent of federal environmental regulation in the 1960's.[9]

A. 1968: Administrative Organization Act -- C.R.S. § 24-1-101.

One early cornerstone of change in Colorado was the *Administrative Organization Act of 1968,* that "reinvented" state government by grouping agencies into principal departments according to function and "eliminating overlapping and duplication of effort."[10] The intent of this act was, "...to create a structure of state government which will be responsive to the needs of the people of this state and sufficiently flexible to meet changing conditions."[11] The act also strengthened the powers of the governor and the role of the general assembly, and encouraged greater participation by the public in state government.

B. 1970: Colorado Land Use Act -- C.R.S. § 24-65-101.

Shortly following the Organization Act, the first major land use effort of the state was adopted, the *Colorado Land Use Act of 1970.* The Land Use Act acknowledged that "the rapid growth and development of the state and the resulting demands on its land resources make new and innovative measures necessary to encourage planned and orderly land use development."[12] The Colorado Land Use Commission, a nine-member board, was appointed and set on a three-year mission to address defined issues and to achieve several goals.[13] One goal was to create a total land use planning program for the state of Colorado, including model regulations and other implementation techniques, by December 1, 1973.[14]

An important aspect of the mandated planning program was to recognize that the decision-making authority as to the character and use of land was to be at the lowest level of government possible consistent with the purposes of the statutory directives.[15] The program was to specifically define the roles, responsibilities, and authority of the various levels and agencies of government, and to establish criteria to classify land use management conflicts regarding matters of state, local, or mixed concerns to reduce problems associated with home rule authority.[16]

During this same time period, Governor John A. Love sponsored a conference on Environmental Geology. The conference proceedings were published as the Colorado Geological Survey's first Special Publication.[17]

C. 1972: SB 35, County Subdivision Regulations: C.R.S. § 30-28-133.[18]

Prior to 1972, counties in Colorado were not required to have subdivision regulations. Under the Land Use Act, the land use commission was directed to develop model subdivision regulations to be used as guidelines for local governments.[19] If a county did not adopt its own regulations, the state could require adoption of the model regulations. The model subdivision regulations reflect the statutory requirements imposed on counties by SB 35 to ensure the provision of adequate domestic water and septic systems, mitigation of soil and geologic problems, dedication of land or money for future park and school sites, and bonding for public improvements. A companion bill in 1972 that was intended to place similar requirements on existing subdivisions was not approved in the legislative process.[20]

These subdivision requirements have been generally effective in reducing the number of substandard lots produced and slowing sprawl development, especially around urban fringes. Other contributing factors to "smarter growth" have been health laws controlling well and septic systems, legislated constraints on the formation of special districts, slow economic growth in the mid-1970's, and state financial assistance to local governments for planning purposes. Changing development patterns and trends also present a constant challenge to the effectiveness of subdivision regulations. Therefore, local governments need to keep abreast of changing conditions and regularly review their regulations.

D. 1974: HB 1041, Areas and Activities of State Interest, C.R.S. § 24-65.1-101.[21]

Once the land use commission completed its directives to the extent that funding allowed, the Land Use Act was amended by the adoption of House Bill 1041, *Areas and Activities of State Interest.* This is very important legislation that is extremely effective if implemented by local governments. However, its application has been limited because it is not mandatory and because it provides detailed statutory guidance that has been met with resistance by many local governments in Colorado.

Although the statewide land use planning program did not fully materialize as originally envisioned,[22] the commission's work resulted in the establishment of a comprehensive yet flexible state-wide system and model regulations that provide detailed land-use regulatory guidance. Under HB 1041, local governments may adopt specific development restrictions regarding state-defined areas or activities of state interest. Where adopted by local governments, these regulations have been proven to effectively address some very difficult development issues in Colorado.

Protection of natural hazard areas from inappropriate development is an obvious and important focus of House Bill 1041. These statutes establish "natural hazard areas" as one of the four state-identified "areas of statewide interest" and encourage local government entities to designate certain areas within their jurisdiction for specific regulatory controls. If a local government chooses to regulate activities in identified natural hazard areas, it must follow specific statutory procedures to accomplish the designation and establish regulations that can be no less stringent than the statutory provisions. Model regulations were developed by various state agencies to assist local governments in effectively implementing the enabling authority: the Colorado Water Conservation Board established model floodplain regulations; the State Forest Service established model wildfire hazard area control regulations; and the Colorado Geological Survey created model geologic hazard area control regulations.[23] The model geologic hazard regulations include guidelines and criteria for identification and land-use controls for geologic hazard areas.

There are 44 statutorily-defined terms in HB 1041, and 24 of these are in a separate section that pertains to natural hazards. Under the statutes, the term "natural hazard" includes geologic hazards, wildfire hazards, and floods.[24] The specific statutory definitions of these three terms include a broad spectrum of natural hazards.

A "geologic hazard" is defined as "...a geologic phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property."[25] This term includes but is not limited to avalanches, landslides, rock falls, mudflows, unstable or potentially unstable slopes, seismic effects, radioactivity, and ground subsidence.[26] Most of the individually-listed hazards and several other natural and geologic hazards terms are also more specifically defined in this statute. Statutory and descriptive definitions are contained in Colorado Geologic Survey Special Publication 6[27] [see Appendix 3.]. Some geologic hazards found in Colorado are not statutorily defined, including the steeply-dipping bedrock found generally along the Front Range. This geologic phenomenon has recently gained recognition as a significant geologic hazard in Colorado.[28]

A "wildfire hazard" is defined as a "wildfire phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property."[29] The term includes but is not limited to slope and aspect, wildfire behavior characteristics, and existing vegetation types.

The term "flood" is not statutorily defined, but "floodplain" is defined as "an area adjacent to a stream, which area is subject to flooding as the result of the occurrence of an intermediate regional flood and which area thus is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property."[30] This term includes but is not limited to mainstream floodplains, debris-fan floodplains, dry wash channels, and dry wash floodplains.[31]

Under the act, if a local government chooses to establish regulations for any of the four identified topical "areas" or nine identified "activities" of state interest, the local government is given the responsibility to make the designations, hold hearings on applications for permits, and grant or deny applications for permits.[32] Local governments may also receive recommendations from state agencies, send recommendations to other local governments, and act if requested by the land use commission with regard to specific matters of state interest.[33] State agencies are to send recommendations to local governments relating to the designation of matters of state interest and to provide technical assistance to local governments based on the agency's particular expertise.[34]

The designation process must take into consideration the intensity of the current and foreseeable development pressures and the applicable guidelines for designation. A designation must include: 1) the boundaries of the proposed area, 2) the reasons development in the area constitutes a matter of state interest, 3) dangers that would result from uncontrolled development, and 4) advantages of a coordinated approach to the intended land use.[35] The local government must hold public hearings regarding the proposed designation in accordance with specific statutory requirements. The regulations adopted by local governments for the administration of designated matters must be consistent with and at least as stringent as the statutory criteria.[36]

Several reported Colorado cases presented significant challenges to the state statutes and local government regulations adopted pursuant to HB 1041. The general effect of the court decisions has been to support and strengthen the state's original intent to protect valuable resources. These Colorado Supreme Court and the Colorado Court of Appeals decisions reflect: 1) the constitutionality of the HB 1041 regulations, 2) the latitude of authority granted to local governments, 3) appropriateness of moratorium on development activity while a local government develops regulations, 4) defeat of challenges regarding local governments exceeding statutory authority and uncontrolled exercise of discretionary power, and 5) that the application of HB 1041 authority did not impermissibly infringe on the exercise of home rule powers.[37]

E. 1974: HB 1034, Local Government Land Use Control Enabling Act: C.R.S. § 29-20-101.

The final general area of statutory authority for local governments to control land use issues is found in the *Local Government Land Use Control Enabling Act.* This act was developed in response to concerns that the existing power of local governments to control development was inadequate to deal with land use conflicts.[38] In addition to several other specifically-listed issues, the legislative declaration states:

> .. that in order to provide for planned and orderly development within Colorado and a balancing of basic human needs of a changing population with legitimate environmental concerns, the policy of this state is to clarify and provide broad

authority to local governments to plan for and regulate the use of land within their respective jurisdictions.[39]

This statute further provides that, "...without limiting or superseding any power or authority presently exercised or previously granted, each local government within its respective jurisdiction has the authority to plan for and regulate the use of land by... regulating development and activities in hazardous areas,..." [40]

This statute expands the police powers of county and municipal governments into discretionary areas that were previously not included in local government enabling statutes.[41] However, there are limitations to the authority due to constitutional provisions and compliance with other statutory requirements. Additionally, the statute is limited in applicability because of its broad terms and lack of criteria, standards, and specific guidance.

Landslide toe damages roadway (left) while the scarp damages bike path (right) in Colorado Springs. Photos by John Himmelreich.

LOCAL GOVERNMENT AUTHORITY AND REQUIREMENTS

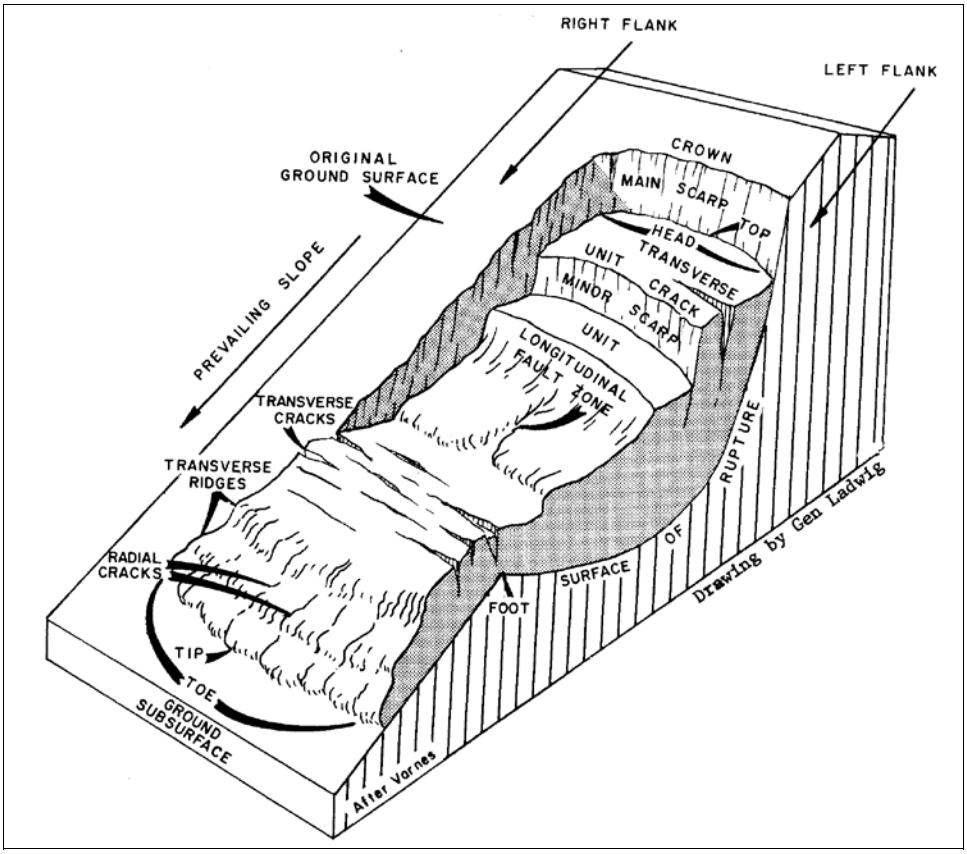


Diagram of landslide. (From Rogers and others, 1974).

SECTION III: LOCAL GOVERNMENT AUTHORITY AND REQUIREMENTS

Local governments in Colorado have different sources of enabling authority and statutory mandates that establish the fundamental structures of local government entities. State statutes address a broad range of requirements for local governments, such as the composition and function of the governing boards and many other topics. As an introduction and overview of regulatory tools that might be applied in preventing natural hazard damages, three important stages of the land use planning and review processes addressed by the state statutes are briefly summarized here: 1) master or comprehensive planning, 2) zoning, and 3) subdividing. This section also includes a summary of three other tools and sources of authority for local governments: planned unit developments, vested rights, and home rule authority.

A. Master Plans.

Municipal and county governments are authorized to establish a planning commission, and the commission has a statutory duty to adopt a master plan.[42] Regional multi-jurisdictional planning commissions are similarly authorized and governed.[43] Generally, a municipal, county, or regional master plan is an advisory policy document that illustrates the recommendations of the commission for the development of the territory covered by the plan. It may include text, maps, plans, charts, and other tools. In preparing a municipal, county, or regional master plan, the planning commission is directed to make careful and comprehensive surveys and studies of existing conditions and probable future growth of the covered territory. The commission must then formulate a plan to guide the development of the area in a manner that will best promote health, safety, morals, order, convenience, prosperity or general welfare of its inhabitants.[44] The master plan process should be used to determine whether H.B. 1041 or other regulations may be needed to address natural hazard risks or other special circumstances that occur within the jurisdiction.

B. Zoning.

The second general opportunity for local governments to identify and address natural hazard issues is through zoning regulations. Both municipalities and counties are statutorily authorized to establish zoning regulations to direct the uniform treatment of development within each zoning district based on established criteria. The enabling authority specifically provides for measures "to secure safety from floodwaters" and for regulating uses along storm and floodwater runoff channels.[45]

Although traditional zoning techniques apply controls to limit elements such as the height, bulk, and lot coverage of structures, contemporary zoning parameters and related tools such as "overlay" zones are increasingly being applied to other sensitive environmental elements such as riparian corridors, steep slopes, and natural hazards. Douglas County is currently working on

regulations addressing specific geologic hazard problems in defined areas. Jefferson County has adopted effective regulations that include general standards for soils and geological issues, and specific criteria that applies to designated Dipping Bedrock Areas.[46]

The City of Colorado Springs Zoning Code includes a chapter on geologic hazard study and mitigation that includes detailed standards. Steep slope areas are regulated under a Hillside Overlay Zone. Subdivision plats in Colorado Springs must include a disclosure statement that a geologic hazard report is on file at the city planning offices.[47] These and other local government regulations addressing geologic hazard problems could be used as reference documents or as a starting point for local governments that desire to implement specific geologic controls.[48] Any regulations actually adopted should be tailored to the specific circumstances of the adopting jurisdiction.

C. Subdivision.

The third and most detailed area in which local governments control land use issues including geologic hazards is subdivision regulations. If geologic hazards have not been identified or addressed at an earlier stage or through tools such as HB 1041 regulations, the subdivision review process is a critical element in identifying potential hazard problems prior to development approval or vesting of development rights. Another important factor is that subdivision review by counties is mandatory unless exempted by the local government. Also, the statutory requirements for subdivision review apply even in the absence of master planning or zoning.

Subdivision regulations for counties require applicants at the sketch plan stage to submit data, surveys, analyses, and plans indicating relevant site characteristics and "reports concerning geologic characteristics of the area significantly affecting the land use and determining the impact of such characteristics on the proposed subdivision."[49] Additional required submittal information includes soil suitability, on-lot sewage disposal systems, and storm drainage facilities.

At the preliminary plan stage of the subdivision process, county governments are required to distribute copies of the proposed development to various state agencies. The local department of health is required to review the proposal to determine the adequacy of on-lot sewage disposal systems, or existing or proposed sewage treatment works. During the review process, the health department may require the subdivider to submit additional engineering or geological reports or data or to conduct a study of the economic feasibility of a sewage treatment works prior to the health department making its recommendations.[50]

The statutes applying to counties further provide that a planning commission may not approve a subdivision including dedications of land for public uses until the data, surveys, and other information that may be required by the regulations or by the county have been submitted, reviewed, and found by the planning commission to "meet all sound planning and engineering requirements of the county."[51] The board of county commissioners may not approve a preliminary plan or final plat

of a subdivision unless the subdivider has provided "evidence to show that all areas of the proposed subdivision which may involve soil or topographical conditions presenting hazards or requiring special precautions have been identified by the subdivider and that the proposed uses of these areas are compatible with such conditions."[52]

A county is also required to refer the submitted application to the Colorado Geological Survey for "an evaluation of those geologic factors which would have a significant impact on the proposed use of the land."[53] The application is referred to the department of health regarding on-lot sewage disposal systems, which may entail the requirement of additional engineering or geologic reports.[54] The local soil conservation district reviews the applications and may make recommendations regarding "soil suitability, floodwater problems, and watershed protection."[55]

One shortcoming of the state statutes for counties is that the board of county commissioners may exempt from the statutory county planning regulations any division of land that the board determines to be outside of the purposes of the statutes.[56] Heavy reliance on this authority in some areas of Colorado contributes to many land use problems, including unchecked natural hazard risks.

Subdivision regulation requirements for municipalities are much less detailed than for counties, and do not include any specific submittal or referral requirements regarding natural hazards.[57] Municipalities that have not already addressed natural hazard problems in their land use code could uses state statutes and other existing regulations as models.

One statute that specifically applies to municipalities that could be useful in identifying natural hazards is C.R.S. § 31-23-225. This statute requires that when a subdivision or commercial or industrial activity is proposed that will cover five or more acres of land, the governing body of the municipality in which the activity is proposed shall provide notice of the proposal prior to approval of any zoning change, subdivision, or building permit application associated with such a proposed activity. Notice is sent to the Colorado Land Use Commission, the State Geologist, and the board of county commissioners of the county in which the improvement is located.

D. 1972: Planned Unit Development -- C.R.S. § 24-67-101.

The Planned Unit Development (PUD) statutes enable all local government entities in Colorado to approve land use plans under planned unit development regulations that encourage innovations and more efficient use of land and public services, as long as the design does not distort the objectives of the zoning laws.[58]

PUD regulations can be adopted to "provide a procedure which can relate the type, design, and layout of residential, commercial, and industrial development to the particular site, thereby encouraging preservation of the site's natural characteristics."[59] Subdivision regulations applicable to planned unit developments may differ from the regulations otherwise applicable, but the PUD authority does not waive the requirements for substantial compliance by counties and municipalities

with the statutory subdivision requirements.[60] PUDs are generally good tools to address natural hazard issues. PUD planning practices typically begin with an analysis of site characteristics and result in the identification of environmental and other limiting factors on the site before the proposed development of the parcel is designed.

E. 1987: Vested Property Rights -- C.R.S. § 24-68-101.

Colorado's Vested Property Rights statute provides landowners with assurance that after obtaining a local government approval for a site-specific development plan, the right to develop the property according to the plan is protected for a certain period of time, usually three years. The statute also authorizes local governments to enter into development agreements to grant longer periods of vesting and to address other long-term or phased development issues.[61] Local governments must provide for the implementation of this state statute by defining what development approvals constitute a site-specific development plan, and determining the appropriate notice procedures for the vested right to be valid.

Once vested, the rights granted can only be terminated: 1) by the landowner's consent, 2) by compensation for damages, or 3) "..upon the discovery of natural or man-made hazards on or in the immediate vicinity of the subject property, which hazards could not reasonably have been discovered at the time of site specific development plan approval, and which hazards, if uncorrected, would pose a serious threat to the public health, safety, and welfare."[62] A vested property right does not preclude the application of ordinances or regulations which are general in nature and are applicable to all property subject to land use regulation by a local government, including, but not limited to, building, fire, plumbing, electrical, and mechanical codes.[63]

F. Home Rule Authority.[64]

Most of the Colorado land use and planning statutes apply to statutory and home rule local government entities, but it is important to understand the fundamental differences between state governmental charter entities and home rule authority entities. Any local government may elect to become a home-rule government, and many municipal governments and some counties in Colorado are home rule. Non-home rule or statutory governments have only one source of their governing power: the state enabling statute. Home rule governments have powers authorized by the state constitution, state statutes, and their own governing charter.

Home rule governments in Colorado are based on the original or "imperio" legal foundation, which grants the strongest powers to local governments. Home rule powers are authorized under the Colorado Constitution, Article XX, Sections 1 and 6. Home rule authority in Colorado provides that local governments have superior powers regarding matters of local concern, and that the state government has superior powers regarding matters of state concern. If a local government has

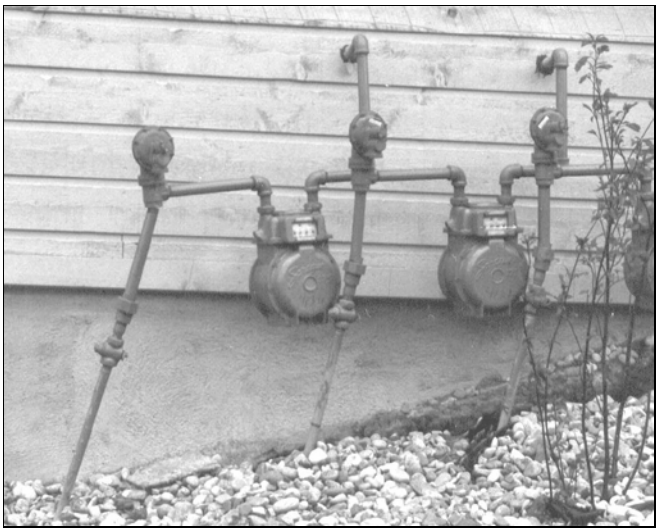
adopted a home rule charter, the state may preempt a matter of mixed concern if warranted but not a matter of exclusively local concern.

In matters of mixed state and local concern, the dominant authority may be determined by courts through an analysis of several factors: 1) the need for uniform governmental treatment, 2) the impact outside the jurisdictional boundaries, 3) a balance of state and local interests, and 4) history and tradition of the treatment of the matter.[65] Because home rule issues concern the balance of power between the state government and local government entities, many difficult legal questions, especially concerning land use issues, arise due to the exercise of home rule powers.

It is also unclear whether a home rule entity may rely on its home rule powers as an alternative to statutory authority. This could result in a home rule question being determined based on the scope of authority contained in its home rule charter. Disputes concerning state authority versus home rule powers are extremely complex legal matters and are difficult to understand, but can be navigated if the basics are kept in mind.

Landslide resulted in severe structural damage of two houses in Colorado Springs in 1995. Photos by John Himmelreich.

CONSUMER PROTECTION LEGISLATION



Landslide jeopardizes residence (left). Gas services broken by landslide at apartment complex. Photos by John Himmelreich.

SECTION IV: CONSUMER PROTECTION LEGISLATION

A. 1984: SB 13, Soil and Hazard Analyses of Residential Construction -- C.R.S. § 6-6.5-101.

The *Soil and Hazard Analyses of Residential Construction* statute was adopted in 1984 to attempt to address the growing problems of natural hazards occurring in residential development. Even with SB 35 and HB 1041 firmly in place and in practice at this time, in many cases significant natural hazard problems were discovered only after the sale of property. The *Soil and Hazard Analyses of Residential Construction* statute has value as the most direct legislative response in Colorado to natural hazard problems. Interestingly, it is not found in statutes addressing land use issues, but rather in Title 6, Consumer and Commercial Affairs, a section generally addressing fair trade and restraint of trade. The statute generally requires disclosure of a geologic and other natural hazard risks or problems prior to a transfer of ownership of new residences. [see Appendix 2.b.]

The justification of the prior legislation, including Senate Bill 35 and House Bill 1041, was based largely on the need to address natural hazard and development issues. While the intent of SB 13 is to further these needs by requiring that the right hazard studies, prepared by the right professionals, are provided to the actual land "users," it has failed to be very effective.

Both the measure as written and its common interpretation are grossly inadequate when compared to the nature and magnitude of geologic and other natural hazard problems in Colorado. First, the statute applies only to new residential construction. Second, if expansive soils are found, the law only requires a publication describing potential problems with expansive soils to be presented to the prospective new owner. Third, although the title of the article includes "soil and hazard analyses," neither "soil" or "hazard" are defined or restated in the text of the statute as the subject of the regulation. Fourth, while the statute text does require that specific information be provided to the consumer, it has largely been interpreted to apply only to expansive soils and not to the broader geologic and other natural hazard analyses context that was originally intended.

Finally, another significant problem with this statute is that it does not actually protect the consumer. The statute only requires that certain information be provided to the consumer at least 14 days prior to closing. To provide adequate consumer protection, the consumer should be apprised of any natural hazard potential prior to any decision to build or even to invest in that particular property.

To gain the appropriate and timely information, a buyer has a right to rely on a certain sequence of events based on the existing state statutes: 1) that the local government has a comprehensive plan that addresses environmental limitations on development, 2) that if significant natural hazards were present in a particular area, the local government would have adopted regulations under HB 1041 or other authority to ensure that the hazards are addressed prior to development activities, 3) that zoning or other land use regulations would address natural hazard

issues, 4) that the subdivider performed the appropriate studies of the land, 5) that the professionals performing the studies are qualified and competent, 6) that the local government reviewed those studies and found them to meet accepted standards, 7) that the developers, builders, and others in the development process had knowledge of previously established information, performed additional analyses as necessary, and took preventive or mitigating actions in constructing improvements on the lot, and 8) that the local government verified that the appropriate mitigative measures were implemented. Today's reality is that under the consumer protection statute, there is no guarantee that any of the required events have actually occurred, which places the entire burden of "trusting the system" on the buyer (beware!).

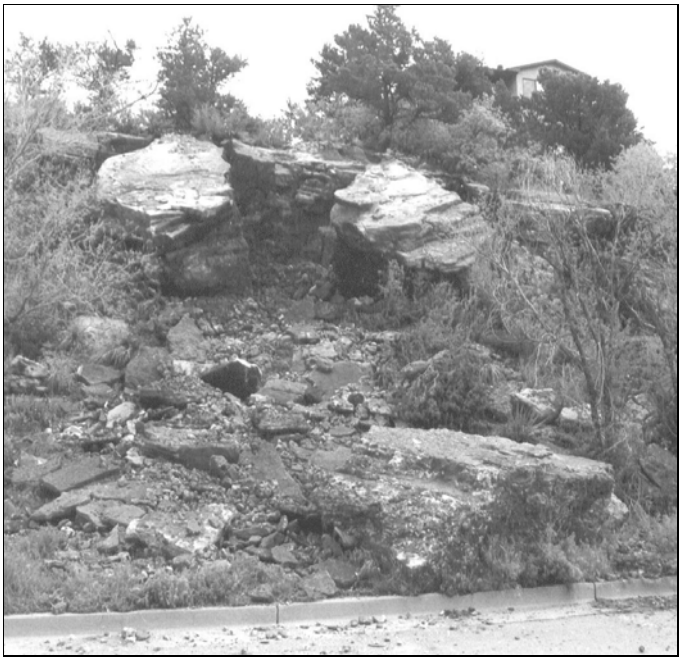
While it may be appropriate for a consumer protection statute to assume that appropriate hazard analyses have been completed at previous development approval stages, the statute needs to be revised or replaced with a new statute that: 1) requires verification of the earlier assessment of potential natural hazard problems and 2) ensures mitigation or avoidance of problems at the planning, development, and construction stages. If all of the existing statutory requirements are followed, the buyer would have specific information regarding the actual conditions found on the site, an analysis of the extent of the identified risks, and could use that information to make an informed decision. Instead, the current statute only places the responsibility on the developer or builder, the people who want money from the prospective buyer, to disclose potentially negative information to the buyer.

SB 13 requires that a developer or builder "provide the purchaser with a copy of a summary report of the analysis and the site recommendations."[66] For sites in which significant potential for expansive soils is recognized, the builder or his representative shall supply each buyer with only general information: 1) a copy of a publication detailing the problems associated with such soils, 2) building methods to address these problems during construction, and 3) suggestions for care and maintenance to address such problems.[67] Any builder or developer failing to provide the report or publication is subject to a civil penalty of five hundred dollars payable to the purchaser.[68] The requirements do not apply to any individual constructing a residential structure for his own residence.[69]

One CGS publication, Special Publication 43, is helpful in meeting the statutory requirement for the general expansive soils information.[70] This and other CGS publications are introduced in Section VII. Also, the appendices of this guide include selected sections from some of the CGS publications. At the time of the enactment of SB 13, several other documents were published to inform construction industry professionals of the new statutory requirements, including articles in the Colorado Lawyer and Colorado Association of Homebuilders newsletter.[71] In addition to pointing out potential liabilities and affirmative duties of builders and others under the act, some of these publications also mention that the bill is somewhat vague. Research of the legislative history of the

bill reveals that the striking of some of the provisions during adoption process significantly weakened the statute[72] [see Appendix 2.c.].

Even though the statute is weak and the civil penalty remedy under the statute is minor, a builder can be liable for significant damages in a lawsuit involving problems with expansive soils or other natural hazards. In *Sprung v. Adcock*,[73] a 1995 Colorado Court of Appeals case, a homeowner was awarded $446,374.00 plus an undisclosed amount for negligence, breach of warranty, and misrepresentation. Sprung, the owner, contracted with Adcock and others to build his home. The contract required that an engineer conduct a soil and foundation study. The study that was prepared recommended caissons drilled to a minimum of five feet into the bedrock to support the foundation because expansive soils were present on the site. The contractor did not inform the owner of the contents of the soils report and did not construct the foundation according to the report's recommendations. The owner won the suit and collected damages from the architect, the construction manager, the engineer, and others. An award of $500.00 for the violation of C.R.S. § 6-6.5-101 by the builder was also granted to the owner.



Block slide in Manitou Springs, Colorado. Photo by John Himmelreich.

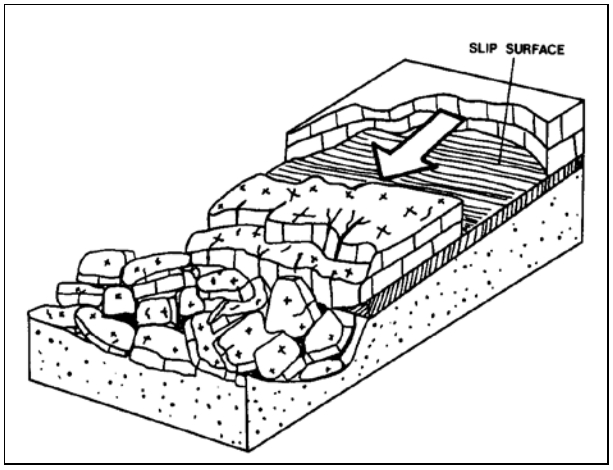


Diagram of block slide. (From Jochim and others, 1988).

ADDITIONAL STATUTORY REQUIREMENTS ADDRESSING NATURAL HAZARDS

Debris flow in clean wind blown sands, Briargate area of Colorado Springs. Photo by John Himmelreich.

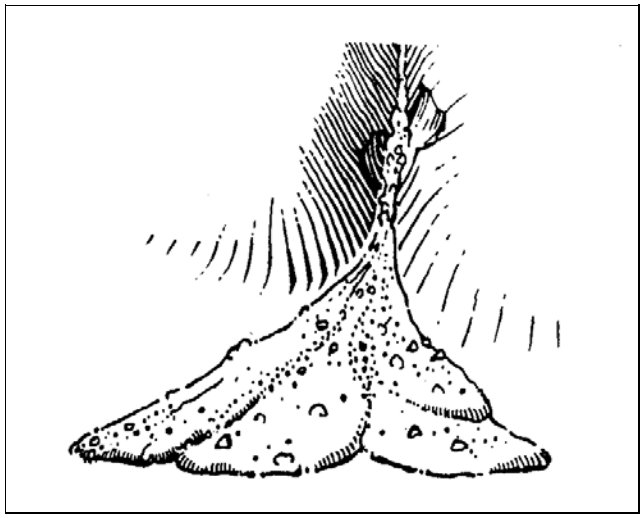


Diagram of debris flow. (Source unknown).

SECTION V: ADDITIONAL STATUTORY REQUIREMENTS ADDRESSING NATURAL HAZARDS

Many Colorado statutes address natural hazard and geologic issues related to land use through regulations that may be easily overlooked. Some of these are summarized in this section (in alphabetical order).

A. Coal Mining.[74]

Applicants for coal mining permits are required to file a performance bond sufficient to meet reclamation obligations and to "give consideration to such factors as topography, geology of the site, hydrology, and revegetation potential."[75] In addition to a detailed section on environmental protection performance standards,[76] the state is authorized to designate areas unsuitable for surface coal mining if the operations will "affect natural hazard areas in which such operations could substantially endanger life and property, such lands to include areas subject to frequent flooding and areas of unstable geology."[77]

B. Groundwater.[78]

The Colorado Ground Water Commission regulates the appropriation of groundwater for beneficial use in seven designated basins along the Front Range.[79] In determining whether a proposed use will create unreasonable waste or unreasonably affect the rights of other appropriators, the commission takes into consideration: 1) the area and geologic conditions, 2) the average annual yield and recharge rate of the appropriate water supply, 3) the priority and quantity of existing claims of all persons to use the water, 4) the proposed method of use, and 5) all other matters appropriate to such questions.[80] In other areas of Colorado, these matters are handled by the local Division of Water Resources or the State Engineer's Office.

Contractors who construct water wells and install pumps are regulated under state statutes and must be licensed in Colorado.[81] A state board oversees the licensing requirements and enforces the state regulations.[82] The board adopts rules and regulations regarding the construction, use, and abandonment of monitoring and observation wells, dewatering wells, and test holes necessary to safeguard the public health of the people of Colorado. The board may require that such wells or holes be designed, constructed, used, taken out of service by a registered professional engineer, professional geologist, licensed well construction contractor, or a person directly employed by or under the supervision of one of these individuals.[83]

C. Hazardous Waste Disposal Sites.

Hazardous waste disposal sites are heavily regulated in Colorado.[84] These sites have the potential to create an extremely serious situation if affected by natural hazards. State statutes provide that within ten working days of an application for a Certificate of Designation for a hazardous waste disposal site and prior to further consideration, the local government must forward a copy of the application to the Department of Health and to the Colorado Geological Survey. CGS reviews the application and makes recommendations on the geological suitability of the proposed hazardous waste site based upon the geological, hydrological, climatological, geochemical, and geomorphological characteristics of the site, within 60 days of the receipt of the application.[85]

Within ninety days of its receipt of the application, CGS is required to make findings of fact on the technical merits of the application and provide the findings of fact to the referring entity.[86] The findings are to include at a minimum: 1) whether the site could be designed and operated in compliance with applicable rules and regulations, 2) a determination as to whether the site is located within an area designated to be optimally suitable for hazardous waste disposal by the most recent study of the Colorado Geological Survey or whether the site is suitable for the land disposal of hazardous waste as demonstrated by reliable geologic, hydrologic, and other scientific data, and 3) a recommendation to the governing entity as to whether the application for a Certificate of Designation should be approved.[87]

D. Individual Sewage Disposal Systems (ISDS).

Individual sewage disposal systems are regulated by the Colorado Department of Public Health and Environment (CDPHE) and its local offices.[88] The state legislature required local boards of health to adopt rules and regulations for individual sewage disposal systems within their respective areas of jurisdiction prior to October 1, 1973, unless served exclusively by central sewage treatment works.[89] If a local government did not create their own rules, the state provided mandatory rules. The minimum requirements for the rules are to be the same for all areas of the state, "except as may be appropriate to provide for differing geologic conditions."[90]

Under statutory authority, local health boards may consider the prohibition of permits for individual sewage disposal systems in defined areas that contain or are subdivided for a density of more than two dwelling units per acre. The local health board is required to hold a public hearing to define the "unsuitable areas." The statute provides that "in such a hearing, the local board of health may request affected property owners to submit engineering and geological reports concerning the defined area and to provide a study of the economic feasibility of constructing a sewage treatment works."[91]

These statutes were recently amended by HB 1113 in 1997. Some of the changes included 1) expansion of testing requirements beyond percolation testing to "other soils evaluations," 2)

requirement for a minimum distance of sewage systems from pertinent factors including groundwater and bedrock, and 3) professional qualification requirements.[92]

E. Oil and Gas Unit Operations.

In the development of agreements for oil and gas unit operations, the Colorado Oil and Gas Commission "...shall require the production of, or may itself produce such geological, engineering, or other evidence, at the hearing or at any continuance thereof, as may be required to protect the interests of all interested persons."[93]

F. Petroleum Storage Tanks.

Consultants working with petroleum storage tanks are required to register with the Department of Labor and Employment and certify compliance with all applicable regulations, which include the identification of natural hazard risks.[94] The registration form provides information regarding revocation and the possibilities of criminal proceedings and penalties for non-compliance. This form could also be used as a model for other applications [see Appendix 4].

Leakage of regulated substances from underground storage tanks constitutes a potential threat to the waters and the environment of Colorado. The Colorado statutes regulating these issues are generally based on the requirements contained in 42 U.S.C. 6991.[95] Under the state statutes, local government regulations may not be more stringent than the state statutes, except as applied by adopted uniform fire codes. The Colorado Petroleum Storage Tank Committee may grant a site-specific exemption when the applicant demonstrates that such an exemption would be cost beneficial and serve the health, safety, or economic interest of its citizens based on consideration of local hydrologic, geologic, or other conditions, including location of population concentrations or commercial areas.[96]

G. Reservoirs.[97]

The right to store water for later application to beneficial use is regulated in Colorado and requires appropriate geologic investigation.[98] Reservoirs under a certain size, or constructed as livestock water tanks, are exempted from regulation.[99]

H. School Districts.

School districts in Colorado must consult with local governments and the CGS regarding potential swelling soil, mine subsidence, and other geologic hazards.[100] School districts are also required to determine the geologic suitability of the site for its proposed use prior to the acquisition of land for school building sites or construction of any buildings on school district property.[101]

I. Solid Waste Disposal Sites.[102]

In 1991, Colorado took an aggressive statewide approach to solid waste management. Solid waste disposal includes the storage, treatment, utilization, processing, or final disposal of solid wastes. Because of the long-term potential for contamination or other environmental damages, the assessment of natural hazard risks is an extremely important part of the approval process for solid waste disposal sites.

A Certificate of Designation is required from the governing body having jurisdiction over the area in which the proposed facility is located. An application for an approved solid waste disposal site addresses requirements of the local government and the Colorado Department of Public Health and Environment, including engineering, geological, hydrological, and operational data. Applications are processed by the local government and referred to the Department of Health for a technical review. The approval process takes several factors into consideration and requires a public hearing. Stringent requirements apply to closure and post-closure management of a solid waste disposal site to insure that environmental protections are adequately maintained.

J. State Recreational Trails.[103]

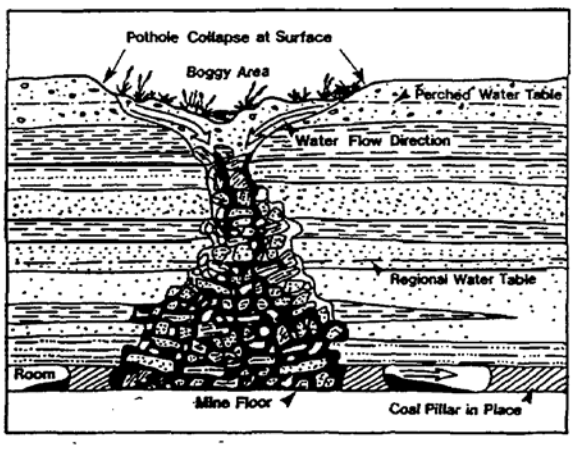
The Colorado Recreational Trails Committee coordinates trail development between local governments and assists in the formation of their trail plans. The legislative declaration states:

> In order to provide for the greatly increasing outdoor needs of a rapidly expanding Colorado population... and for the conservation, development, and use of natural resources against fire and other natural and geologic hazards... it is hereby declared to be the policy of this state...to increase accessibility and encourage use of natural resources... provide opportunity for development of public and private facilities for persons visiting and utilizing natural resources... encourage an increase in compatible recreational activities as influences for the improvement of the health and welfare of the people... and to provide for the needs of specialized recreational motor vehicles...[104]

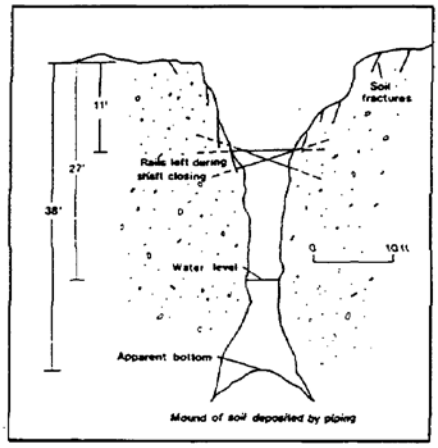
In carrying out their responsibility, the committee is directed to, "review records of easements and other interests in land which are available and may be adapted for recreational trail usage, including public lands, utility easements, floodplains, railroad and other rights-of-way, geological hazard areas, gifts of land or interests therein, and steep slope areas."[105]

Subsidence pit in the Cragmoor area of Colorado Springs (left). Collapse of vertical shaft; Rockrimmon area of Colorado Springs (right). Photos by John Himmelreich.

RESPONSIBILITIES OF PRACTITIONERS AND PROFESSIONAL ASSOCIATIONS



Cross-sectional view of a subsidence pit.



Cross-sectional view of an air shaft.

From Hynes, 1996.

SECTION VI: RESPONSIBILITIES OF PRACTITIONERS AND PROFESSIONAL ASSOCIATIONS

A. Statutory Requirements and Definitions of Geologist and Geology.

As shown above, many Colorado statutes require the preparation of analyses and reports about geologic and soil conditions. House Bill 1574 in 1973 [see Appendix 2.d.], attempted to prevent engineers with little or no training in the geological sciences from preparing reports and studies related to the identification and analysis of geologic hazards. This law also defined "professional geologist" in terms of education and experience, and statutorily defined the practice of geology. It specifically requires that reports containing geologic information are to be prepared or approved by a professional geologist. This law was somewhat of a legislative concession given to geologists in dealing with non-registration, which was at issue at that time. Colorado statutes provide that:

> Any report required by law or by rule and regulation, and prepared as a result of or based on a geologic study or on geologic data, or which contains information relating to geology, as defined in C.R.S. § 34-1-201 (2), and which is to be presented to or is prepared for any state agency, political subdivision of the state, or recognized state or local board or commission, shall be prepared or approved by a professional geologist...[106]

The statutory definition of "geology" is:

> The science which treats of the earth in general; the earth's processes and its history; investigation of the earth's crust and the rocks and other materials which compose it; and the applied science of utilizing knowledge of the earth's history, processes, constituent rocks, minerals, liquids, gasses, and other materials for the use of mankind.[107]

A "geologist" is "a person engaged in the practice of geology."[108] Geologists are not licensed or registered under Colorado law, but a "professional geologist" by statutory definition is:

> A person who is a graduate of an institution of higher education which is accredited by a regional or national accrediting agency, with a minimum of thirty semester (forty-five quarter) hours of undergraduate or graduate work in a field of geology and whose postbaccalaureate training has been in the field of geology with a specific record of an additional five years of geological experience to include no more than two years of graduate work.[109]

Geologists are not registered or licensed in Colorado, but the American Institute of Professional Geologists provides membership for professional geologists and a national certification program.

B. Statutory Requirements and Definitions of Engineer and Engineering.

It is important to understand that the practice of engineering does not encompass the practice of geology, although there are areas of overlap between the two professions. Under Colorado statutes, "engineering" means the "analysis or design work requiring intensive preparation and experience in the use of mathematics, chemistry, and physics and the engineering sciences."[110] An "engineer" is "a person who, by reason of intensive preparation in the use of mathematics, chemistry, physics, and engineering sciences, including the principles and methods of engineering analysis and design, is qualified to perform engineering work" as defined by the statutes.[111] A "professional engineer" is an engineer duly registered and licensed pursuant to Colorado law,[112] and the "practice of engineering" is:

> The performance for others of any professional service or creative work requiring engineering education, training, and experience and the application of special knowledge of the mathematical and engineering sciences to such professional services or creative work, including consultation, investigation, evaluation, planning, design, surveying, and the observation of construction to evaluate compliance with plans and specifications in connection with the utilization of the forces, energies, and materials of nature in the development, production, and functioning of engineering processes, apparatus, machines, equipment, facilities, structures, buildings, works, or utilities, or any combination or aggregations thereof, employed in or devoted to public or private enterprise or uses.[113]

Licensing requirements for engineers in Colorado include education, experience, and passing a state examination.[114] Professional engineers are also bound by PEPLS Bylaws and Rules of Procedure, Rules of Professional Conduct, and Board Policy Statements. These are published annually and provided to each registrant listed in the PEPLS Board Annual Report and Roster. The practice of engineering in violation of any of the statutory provisions is a class 3 misdemeanor and can be enforced by injunction in Colorado district courts.[115] There are several exemptions to the licensing requirements for engineers. These include persons who perform engineering services for themselves, individuals who are employed by and perform engineering services solely for a county, city and county, municipality, or the federal government, and utilities or their employees or contractors when performing services for another utility during times of natural disasters or emergency situations.[116]

Other professions associated with land use have varying degrees of regulation.[117] Architects are licensed and controlled under state law similar to engineers and attorneys. Land Surveyors are licensed in Colorado.[118] Land use planners are not required to be certified or licensed in Colorado, but the American Planning Association provides membership for practicing planners and a national certification program.

C. PEPLS.

The Colorado Board of Registration for Professional Engineers and Professional Land Surveyors (PEPLS) is the state board that oversees the registration of professional engineers and professional land surveyors in Colorado.[119] In response to concerns regarding damage to residences constructed on expansive soils and bedrock in Colorado, PEPLS helped form a Soils Task Force in May, 1994 to study some of the issues[120] [see Appendix 5.a.]. The task force had broad public and private representation and had the general goal of making recommendations pertaining to the practice of engineering and the design and review of structures in expansive soil areas found throughout Colorado and steeply dipping bedrock found along the Front Range.

The task force also became aware that although professional societies and licensing authorities recognized the important distinctions between the science of geology and the field of engineering, abuses of those distinctions were common. A discussion of this issue by Michael West, one of the task force members, is included in Appendix 5.b. The task force efforts resulted in the adoption of Policy Statement 15 by the PEPLS board.

The task force identified four elements of the general problem: 1) lack of proper disclosure of hazards during all phases of property development, from zoning through construction and subsequent property development, 2) lack of proper public education regarding the risks associated with expansive soils, 3) lack of standard practice and quality of investigations, and 4) lack of land use planning and design that considers soils risks and site and off-site drainage.

The task force studied the issues by 1) using a multi-disciplinary approach, 2) defining their study to include natural geologic hazards based on the statutory definition of soils hazards as one category of natural hazards found at C.R.S. § 24-65.1-103 (HB 1041), and 3) placing less emphasis on resolution of issues beyond the scope of control of the PEPLS board. They acknowledged the professional responsibility of engineers practicing in areas of natural hazards to demonstrate 1) knowledge of design and construction methods used to mitigate the effects of natural hazards and 2) ability to conduct investigations necessary to evaluate the impacts of hazards on existing and proposed construction.

The task force considered many possible solutions, including 1) the development of statewide standards of practice, 2) specialty registration for engineers, and 3) establishment of measures to guide engineers through a board policy regarding practice associated with hazard areas. The first two were rejected as unfeasible, ineffective, or they could not be directly accomplished by the board. The task force also recommended that the policy statement be enforced by the PEPLS board through disciplinary actions under C.R.S. § 12-25-108(1)(b) or (g), regarding failure to meet generally accepted standards of engineering practice, and through other actions and authority.[121] Based on the task force recommendations, the PEPLS board adopted *"Policy Statement 15 - Engineering in*

Designated Natural Hazard Areas" on February 20, 1995 to implement the third solution considered by the task force.[122]

Policy Statement 15 addresses some important issues. The policy applies to "engineers performing soils (geotechnical) investigations, construction observation, and design of structures, grading, utilities, streets, and remedial work." Under the policy statement, engineers are required to demonstrate knowledge and expertise in methods to mitigate hazards and construction guidelines adopted by local governments.

The policy statement sets forth four specific guidelines for implementation: 1) The first guideline requires engineering registrants to apply generally accepted standards of practice and to be thoroughly familiar with applicable natural hazard legislation and local government policies and regulations regarding natural hazards. 2) The second guideline requires engineers to acknowledge that a multi-disciplinary approach is necessary to effectively mitigate effects from natural hazards. 3) The third guideline requires that knowledge of natural hazards should be demonstrated by attendance at continuing education courses designed for that purpose. 4) The fourth guideline requires engineers to disclose the existence of natural hazards, risks, possible methods of mitigation, and chances of success of mitigation. This guideline also prohibits remedial work where the intent is to disguise either hazards or existing damage.[123]

The task force was sent on "mission impossible" in addressing these issues, but they did succeed in identifying the core problems regarding natural hazard issues that have plagued Colorado since the 1960's. The lack of disclosure, education, standard practices, and proper planning and design are the same fundamental issues underlying SB 35, HB 1041, SB 13, and other state land use legislation. The task force kept a broad perspective in defining and looking at possible solutions to the issues, as reflected by the broad representation on the task force and the broad directive to address the issues. Policy Statement 15 includes practical advice, restates information contained in enforceable statutes and regulations, and addresses standards of practice.

The task force completed their task and established good policy for the PEPLS board, but a much more serious and comprehensive effort is required before more effective solutions to these issues are in place in Colorado. Because engineers play a major role in designing solutions to natural hazard problems, a heavy burden has been placed on engineers to follow the Policy Statement 15 guidelines. Those who don't follow the guidelines may be subject to not only disciplinary action, but also to potential civil liability resulting from litigation.

D. Fields of Expertise.

In 1973, the California geology and engineering boards[124] established a "Fields of Expertise" document that sets forth tasks typically performed only by geologists and only by engineers, and tasks performed by practitioners in both fields.[125] This document was originally developed as an internal

document to help clarify which board had jurisdiction for purposes of controlling unlicensed activities. The document was reviewed in 1989 by both boards, and each board made minor modifications for their own purposes. No joint actions were taken at that time. In 1996 the document was reviewed again by both boards. Only the California Board of Registration for Professional Engineers and Land Surveyors (BORPELS) adopted the revised version as their policy under Resolution 96-10[126] [see Appendix 6.a.]. They published it in their Spring 1997 bulletin.

Geologists in Colorado have been aware of the fields of expertise distinctions for quite some time[127] [see Appendix 6.b.]. These distinctions are discussed in CGS Special Publication 6, published in 1974[128] [see Appendix 3].

The publication of the fields of expertise document in California precipitated a variety of reactions, some of them negative. One general concern that was widely expressed, mostly by geologists, was that some activities were improperly classified and needed further review. Following the publication of the document, it began to be used in ways it was not originally intended, such as the establishment of practice limitations by governmental agencies and insurance companies. In August, 1997, the California Board of Registration for Geologists and Geophysicists (BRGG) voted not to adopt the latest version because of the confusion and misunderstandings regarding its intended use and its actual use. The fields of expertise document is currently being considered for use in Colorado and has been reviewed by several professional associations, CGS, and the PEPLS board [see Appendix 6.c.].

The BRGG publishes several other useful publications, including: 1) *Consumer Guide to Geological and Geophysical Services*, 2) *Guidelines for Engineering Geologic Reports*, and 3) *Guidelines for Groundwater Investigation Reports*, and 4) a website at www.dca.ca.gov/geology.

E. AEG.

The AEG, Association of Engineering Geologists, is a national organization with several different classes of membership.[129] Member and associate membership classes have voting privileges, and membership requires a degree in geology, engineering geology, or geological engineering, or a degree in a related field. The member class requires five years of qualifying professional geoscience experience. The mission of the AEG is "to provide leadership in the development and application of geologic principles and knowledge to serve engineering, environmental, and public needs" [see Appendix 7.a.; this attachment also describes the subdiscipline of engineering geology].

The AEG has an adopted definition of an "engineering geologist" as "a geologist with a thorough understanding of engineering principles who applies his scientific knowledge and experience to the works of man where the geologic environment affects their planning, location, feasibility, design, construction, operation, and maintenance." The AEG's official definition additionally describes professional responsibilities, necessary training, and typical duties.

The Rocky Mountain Section of the AEG has a sophisticated legislative and regulatory affairs committee with a detailed set of directives, including the monitoring of appropriate legal and other developments that affect the profession. They provide information and direction for necessary actions and act as a conduit for distribution of information so that members can observe and comply with the requirements and intent of applicable laws[130] [see Appendix 7.b.]. The AEG also has several available publications, including a summary of key laws related to geology and land use in Colorado and discussions of licensure issues[131] [Appendix 7.c.]. Professional practice for engineering geologists is described in several AEG publications.[132]

F. ASBOG.

ASBOG is the Association of State Boards of Geology, a national organization that helps coordinate efforts in various states regarding the registration and qualifications of geologists.[133] Twenty-seven states now have registration or certification laws, and seven more are actively pursuing registration laws[134] [see Appendix 7.d.]. This brochure also provides information about the important differences between the practices of geology and engineering. The association also conducted a nationwide survey to determine the tasks carried out by licensed professional geologists and has developed a national examination for the licensure of professional geologists[135] [see Appendix 7.e.]. In Colorado, identification procedures for geologic hazards and geologists' tasks are described in CGS Special Publication 6, pages 106 - 116.[136]

G. Other Professional Associations.

Several other national professional associations and regional or state chapters provide industry information to practicing professionals: 1) AIPG, American Institute of Professional Geologists,[137] 2) CAGE, Colorado Association of Geotechnical Engineers 3) ASCE, American Society of Civil Engineers 4) AGI, American Geological Institute, and 5) RMAG, Rocky Mountain Association of Geologists [see Appendix 7.f.]. A coalition of representatives from professional associations in Colorado has recently been formed to address legislative, regulatory, professional practice, and other issues. The coalition discusses issues affecting all members and acts as a vehicle for collecting and conveying information to their associates. One method used by this group to address different viewpoints on certain issues is panel discussions that are open to the public.

H. The Hard Rock Truth about Professional Responsibilities.

An interdisciplinary approach to natural hazard issues involves not only geologists and engineers, but planners, architects, lawyers, builders, public officials, and a host of other individuals and professions. Properly addressing natural hazard issues requires the cooperation and mutual respect of all of those involved. While most of these players are generally cooperative with each

other, it is easy to lose sight of the value of collective reasoning or a viewpoint that is broader than that of one individual or profession.

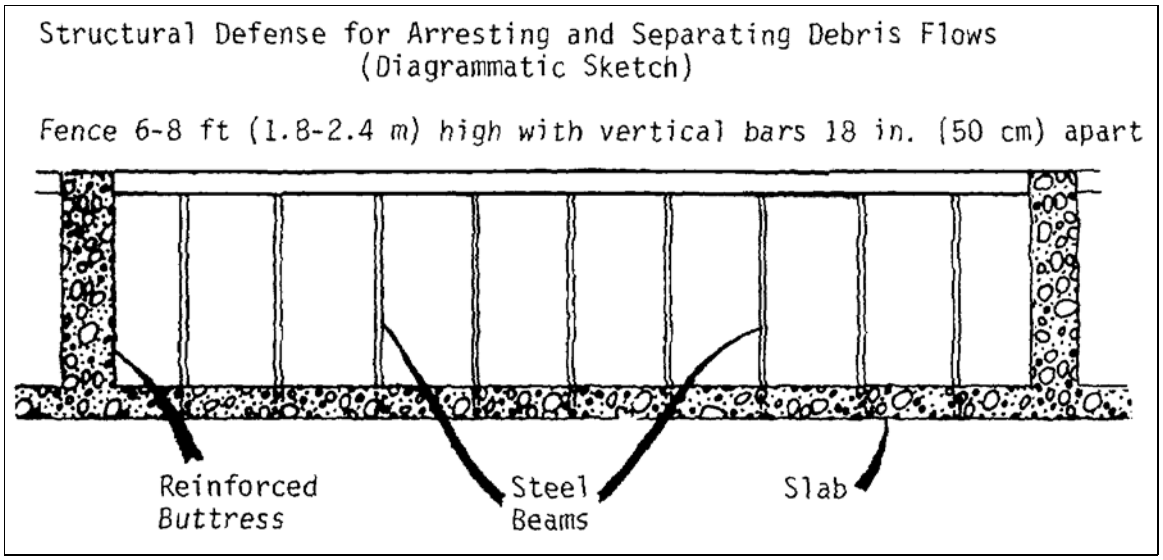
A problem of this nature is apparent in Colorado between two of the most important natural hazard practitioners -- geologists and engineers. However, this problem is not unique to Colorado, as shown by the "Fields of Expertise" (a.k.a. "Turf War") issue in California and other areas. The important perspective for Colorado is that as growth and development continue to test and define the boundaries of mitigation versus avoidance of natural hazards, more professional coordination and cooperation is absolutely necessary between geologists and engineers.

The important guiding factor to keep in mind is that the expertise of every profession involved is valid and must be considered in the process of determining the appropriate solution to any natural hazard problem. The many specialized fields of expertise within each profession further complicate efforts to keep the proper focus. Additionally, public and cultural concerns play a big role in any planning or decision-making process.

One broad generalization that helps to bring the correct focus on the distinctions between the responsibilities of geologists and engineers in addressing natural hazards is to envision the engineering responsibilities as quantitative and the geological responsibilities as qualitative. Certainly there will always be considerable overlap between the two types of responsibilities, but these should be seen as assets, not conflicts. If each profession can accomplish what they do best and know when to seek the other's input, solutions to natural hazard problems might be achieved in a more efficient manner. A simple shift in attitude in many cases would go a long way towards developing better solutions to real problems.

Debris fence in Golden, Colorado neighborhood. Photo by John Himmelreich.

ROLE OF THE COLORADO GEOLOGICAL SURVEY



Effect: Large boulders and debris are stopped; smaller material and mud is washed through and over structure and continues as a debris flood rather than as a debris flow. (From Mears, 1977).

SECTION VII: ROLE OF COLORADO GEOLOGICAL SURVEY

A. Overview

The Colorado Geological Survey (CGS) plays a central role in assisting local governments, citizens, and professionals in identifying and addressing natural hazards.[138] The CGS has an extensive data base of publications, maps, and electronic information available to the public, and it provides a variety of services either at no cost or based on a fee schedule to cover direct costs.

The CGS is a division of the Colorado Department of Natural Resources. Its statutory purpose is "...to coordinate and encourage by use of appropriate means the full development of the state's natural resources, as the same are related to the geological processes that affect realistic development of human and mineral utilization and conservation practices and needs in the state of Colorado, all of which are designed to result in an ultimate benefit to the citizens of the state."[139] The CGS also controls the Colorado avalanche information center that carries out a program of avalanche forecasting and education.

Current statutes set forth several specific objectives for the CGS that address land use issues, including: 1) to assist, consult with, and advise existing state and local governmental agencies on geologic problems, 2) to conduct studies to collect geologic information, 3) to evaluate the physical features of Colorado with reference to present and potential human and animal use, 4) to prepare, publish, and distribute maps, reports, and bulletins when necessary to achieve stated purposes, and 5) to determine areas of natural geologic hazards that could affect the safety of or economic loss to citizens of Colorado.[140]

The CGS is authorized to provide services to the public, industries, and local government, and to collect fees for the direct costs of the services.[141] However, the CGS cannot directly compete with consultants by entering into contracts with the pubic and industries for providing services.[142]

The CGS is also responsible for reviewing land use applications from local governments. Under the county subdivision requirements (SB 35), there is a 21-day review period for information sent out to reviewing agencies. If the CGS does not provide a response within the allowed time period, the local government may approve the request without the benefit of the reviewing agency comments.

For most land-use applications, CGS reviews the submitted information and sends back one of four basic responses: 1) the submitted findings and recommendations are adequate, 2) the recommendations are mostly adequate and additional suggestions are given, 3) potential problems known to CGS are not recognized or addressed in the application, and more information is needed, or 4) the project is not feasible for geologic or technical reasons. The CGS reviews are advisory only and non-binding, so a local government entity may approve a development request regardless of the

CGS findings[143] [see Appendix 8.a.]. Since 1978, the CGS has published documents that describe their review procedures [144] [see Appendix 8.b.].

Model guidelines for engineering geology reports are included in CGS Special Publication 12[145] [see Appendix 8.c.]. The reports should: 1) describe all geologic conditions at site, 2) identify and interpret correctly the impact of the development as proposed based on site conditions, 3) make complete and reasonable recommendations regarding the mitigation of adverse conditions, 4) formulate a development plan that incorporates all impactive geologic conditions based on data and interpretation, 5) avoid use of data and interpretation for justification of the proposed development, 6) include statements of credit and qualification of preparer as part of report, and 7) include evidence of compliance with state statutes and local regulations.[146]

B. Colorado Geological Survey Publications.

The Colorado Geological Survey has many publications that assist the public in developing a general understanding of geologic and land use issues, including maps, studies, and technical reports regarding specific areas or problems, all of which can be used by the public and practicing professionals. For a complete list, contact CGS for a catalog of publications, or access the CGS website located at: dnr.state.co.us/geosurvey.

A good place to start any research on natural hazard issues is an informative booklet entitled *Solving Land-Use Problems*[147] [see Appendix 8.b.]. This booklet summarizes the types of assistance available to local government planners, building officials, and others for issues regarding housing, infrastructure, planning, and environmental issues. The booklet also gives an overview of the major geologic features of the state and common types of natural hazards. It includes specific information sheets containing avalanche and coalbed methane facts. The booklet also contains a description of the types of natural hazard reviews performed by the CGS, a standard fee schedule for commonly-used services, and a list of selected publications generally applicable to land use issues.

CGS has also developed a quarterly newsletter as part of their public relations efforts, entitled *"Rock Talk."* This newsletter provides current information regarding CGS activities, publications, procedures, and other general information. In the last decade, CGS has also developed an extensive Geographic Information System (GIS) library that can be combined with local government GIS or other data systems for planning and analysis purposes.

Three specific CGS publications are excellent resources for information regarding natural hazards. The first is CGS Special Publication 43, *A Guide to Swelling Soils for Colorado Homebuyers and Homeowners.*[148] This is a recent publication that is intended to update and replace two previous CGS publications, SP 14 and SP 11.[149] The first part of the book is a summary of some of the information required under the Hazard and Soils Disclosure requirements of C.R.S. § 6-6.5-101 (SB 13). The second part is a guide to swelling soils that provides more detailed information

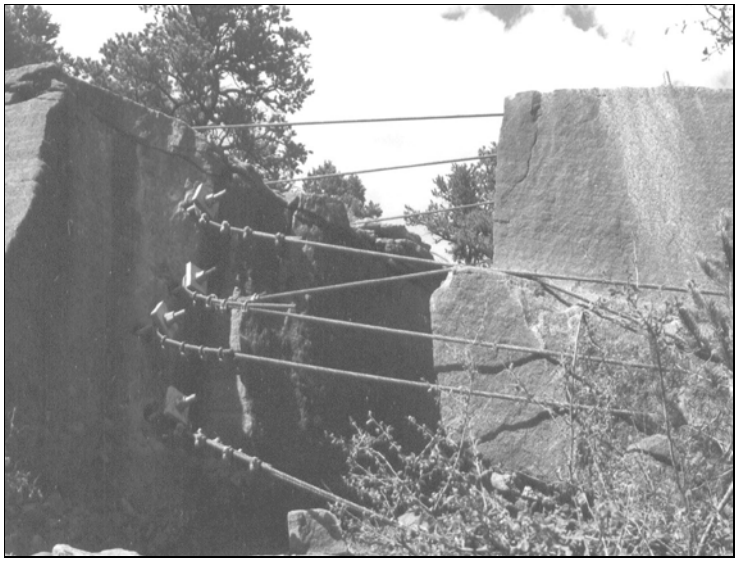
about specific types of problems, and general methods to avoid or mitigate some geologic problems. This publication is easy to review and understand, and contains extensive illustrations, photos, and charts.

The second CGS publication is Special Publication 12, *Nature's Building Codes: Geology and Construction in Colorado.*[150] This book was prepared as a result of the Colorado Land Use Commission's work in the early 1970's. Although the book was first published in 1979, it is still in print and it remains an invaluable source of information for topics and examples of geologic problems including flooding, mountain torrents, erosion and deposition, mud and debris flows, debris fans, landslides, rockfalls, and swelling and collapsing soils. Appendices include a homebuyers' geotechnical inspection guide, a guide for the preparation of engineering geology reports in Colorado, and sources of additional information [see Appendix 8.c.].

The third CGS publication is Special Publication 6, *Guidelines and Criteria for Identification and Land-Use Controls of Geologic Hazard and Mineral Resource Areas*[151] [see Appendix 3]. This book was designed to supplement HB 1041 regulations regarding natural hazards. It contains detailed definitions and information about the geologic hazards and mineral resources listed in HB 1041, procedures for identification of natural hazards, qualifications of investigators, and suggestions and model regulations for local governments in implementing HB 1041. For local governments implementing natural hazard regulations, this publication provides additional descriptive information and a glossary to expand the statutory definitions. This book is an invaluable resource for planners and governmental entities who have not yet implemented HB 1041 or other regulations for natural hazards.

Another publication which is currently out of print but may be available in some libraries, is CGS Special Publication 8, *Geologic Factors in Land-Use Planning,* edited by David C. Shelton. This publication was developed as a result of HB 1041 and was originally printed in 1977. Taking a land-use perspective, it addresses several natural hazards, such as slope failure, ground subsidence, and hydrologic problems in land development planning. It also contains case studies of early HB 1041 implementation in Colorado. Although some of the information is somewhat dated, the land use perspective is an invaluable resource for current natural hazard planning efforts.

The important thing to remember in addressing natural hazard issues is that they really are as old as the hills, and that previously developed publications are generally applicable today. Addressing natural hazard situations does not require that the various professions involved in this interdisciplinary process reinvent the wheel -- it only requires that the wheel be used collectively to get to safer ground.



Potential rockfall in 1995, and eventual stabilization of rock with cable lashing. Photos by John Himmelreich and Marty Essigmann.

PERSPECTIVES AND GOALS:
SETTING THE STAGE FOR CHANGE

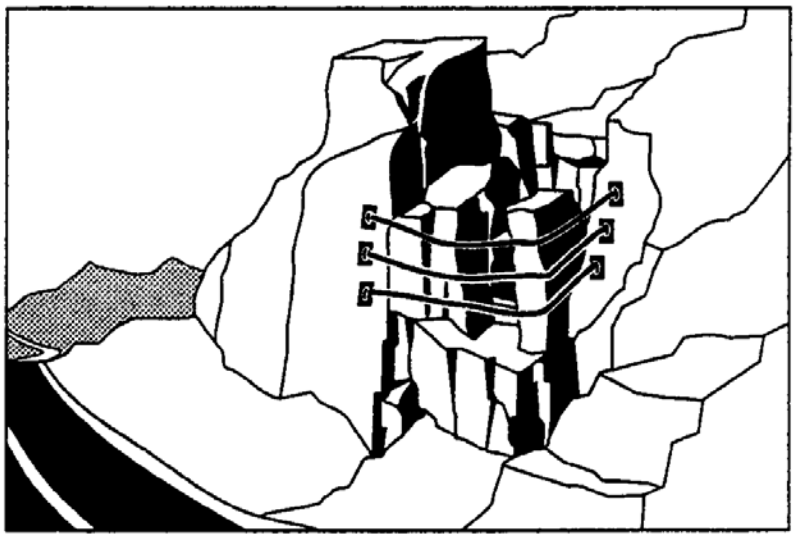


Figure 5. Cable lashing.

The wrapping of high density cables around potentially unstable rock features is known as cable lashing. The cables are then anchored in nearby stable rock formations. (From White 1997).

SECTION VIII: PERSPECTIVES AND GOALS: SETTING THE STAGE FOR CHANGE

This discussion and compilation of information has many uses and purposes. It is generally intended to reach out to professionals of many disciplines and point out the breadth and depth of Colorado's geologic hazard regulations as well as their inefficiencies and ambiguities. However, the status of our current land development laws is easily criticized: 1) they are not written clearly or the adopted version does not serve its intended purposes 2) they are misleading, misinterpreted, or unknown to professionals, 3) they are ineffective or incomplete, and 4) they have not been enforced.[152]

Growth will not stop in Colorado and we must learn to make better land-use decisions in order to protect the beauty of our state and provide a safe environment for our citizens. One tangible answer to growth pressures is to enact or enforce meaningful regulations that address appropriate factors such as environmental limitations on development. A quote from Governor Roy Romer, who initiated the Smart Growth program, is an important call to action for everyone in the land-use industry:

> Colorado's economy is among the healthiest in the nation which means good jobs for our citizens. But, it also means that others will continue to come to our state and our population will continue to grow, putting increased strains on valuable resources -- schools, recreational opportunities, affordable housing, and transportation systems. It is clear that we will need to focus on smart growth for the foreseeable future. Our efforts, large and small, must continue in order to make sure that all Colorado communities remain the best places to live, work, and raise a family.
>
> -Governor Roy Romer, *Smart Growth and Development News,* Oct.1997.

The key to reducing natural hazard disasters and accomplishing better growth lies in detecting risks at an earlier stage in the development process, before damages and economic and environmental losses occur. This requires a shift from the current approach of reacting to problems after they occur, to a proactive approach involving the proper identification and avoidance or mitigation of natural hazard risks. Local governments need to refrain from making decisions based on insufficient information and from taking actions that compound and perpetuate reactive practices.

A review of the development of state land-use laws developed since the 1970's indicates goals and purposes very similar to the opinions that are being expressed today. Because previous statewide efforts have established an effective regulatory framework that also protects the independence of our local government entities, beginning to accomplish today's important goals only requires a review of existing documents and regulations.

Local governments have broad authority to enact land-use regulations that specifically address both political concerns and the environmental conditions in their areas. With this authority, problems and ambiguities in the state statutes can be overcome, and local concerns and issues can be properly addressed. It is important for local governments to understand the linkages between the various laws and develop strong local regulations based on a statewide perspective.

Better communication and cooperation between practicing professionals is also required. Through an interdisciplinary approach to the decision-making process, each profession can contribute its best efforts and knowledge to a particular situation. Methods, criteria, or standards that have already been established for a certain purpose may be applicable in new ways or to address a different situation. Practitioners need to keep an open perspective so that they can take advantage of these types of opportunities.

Educational efforts of individuals and various organizations can also develop better understanding and increased awareness of the issues. During the last few years, the authors have been proactive in this educational process.[153] The Colorado Geological Survey has also been very active in the educational process, including sponsoring geologic hazard seminars in Denver (1995), Colorado Springs (1996), Montrose (1997), and Glenwood Springs (1998).

Improving Colorado's future can be accomplished only through taking action. The proper approach to solving natural hazard problems involves a combination of efforts: 1) short-term measures to reduce improper decisions, 2) long-range planning programs at both the state and local levels, 3) establishing proper regulations at the local government level, 4) cooperative utilization of appropriate professional expertise, and 5) coordinated implementation of all land-use and growth management tools.

Debris flows from fatal July 24, 1965 storm damage the Hippo House at Cheyenne Mountain Zoo. Photo courtesy of the Pikes Peak Library District.

END NOTES

1. Erin J. Johnson is an attorney and land-use planner in Cortez, Colorado. Her office is located at 925 S. Broadway, Suite, 206, Cortez, Colorado, 81321. Ms. Johnson encourages comments on this article and can be contacted at 970 565-2628; e-mail at: erin@fone.net. The information contained in this article is intended as an educational tool to provide a general overview of various statutory powers and legal issues associated with land use matters and natural hazards. Please consult with appropriate professionals before taking any action on a specific land use or natural hazard matter.

2. John W. Himmelreich, Jr, is a professional geologist in Colorado Springs, Colorado. His offices are located at 20 Boulder Crescent, Colorado Springs, Colorado 80903. Mr. Himmelreich encourages comments on this article and can be contacted at 719-338-3499; e-mail at: the.himmelreichs@mci2000.com.

3. James M. Soule, *Colorado's Land-Use Trends and Geologic-Hazards Problems,* (CGS 1996). [Appendix 1]

4. Rich Landen, *Property Values Shift with Soil*, Colorado Springs Gazette Telegraph, Sept. 8, 1996.

5. For more information, contact the Smart Growth and Development Action Center, 1313 Sherman Street, Room 521, Denver, CO 80203; 303-866-2817 or 1-800-899-GROW; growth feedback@csn.net; http://www.state.co.us/smartgrowth.

6. For more information contact the Colorado Chapter of the American Planning Association, 3867 Tennyson Street, Denver, CO 80212-2107; Janet Leo, Secretary, 303-480-6780.

7. W. P. Rogers, et al, *Guidelines and Criteria for Identification and Land-Use Controls of Geologic Hazard and Mineral Resource Areas*, CGS Special Publication 6, (1974, reprinted 1979).

8. The perspective in this section was gained through personal communication with Michael West, Michael W. West & Associates, Inc.

9. *See* Barbara J. Green and Brant Siebert, *Local Governments and House bill 1041: A Voice in the Wilderness*, 19 Colo. Law. 2245 (1990).

10. C.R.S. § 24-1-101.

11. *Id.*

12. C.R.S. § 24-65-102(1).

13. C.R.S. § 24-65-104(1)(c). On the commission, however, neither engineers nor geologists were represented.

14. C.R.S. § 24-65-104(1)(a).

15. C.R.S. § 24-65-104(1)(b).

16. *Id.*

17. John W. Rold, *The Governor's Conference on Environmental Geology*, CGS Special Publication 1, (1969).

18. SB 35-1972 amended or added C.R.S. § 30-28-105, 110, 101(1) to (11), 133, 136 -137, and 31-23-125.

19. C.R.S. § 24-65-105(1).

20. *See* Kirk Wickersham, Jr., *Land Use Management in Colorado: Past, Present, and Future*, 6 Colo. Law. 1779 (Oct 1977).

21. Many articles about HB 1041 regulations have been published in addition to official guidelines and model regulations. These include the entire October, 1977 issue of the Colorado Lawyer (six separate articles from land use symposium); Nicholas P. Panos, *HB 1041 as a Tool for Municipal Attorneys*, 23 Colo. Law. 1309 (June 1994); Barbara J. Green and

Brant Siebert, *supra* note 9; *Land Use Guidelines for Natural and Technological Hazards Planning*, Division of Local Government, (March, 1994); Erin Johnson, *House Bill 1041 in the Local Planning Process*, Symposium Abstract, Geologic Hazards Engineering Practices in Western Colorado (CGS May 8, 1997). In addition to general background about the development of HB 1041 regulations in these articles, it is interesting to note the similarity between many of the "pro-planning" comments made in the 1970's articles and political commentary being made today.

22. SB 377 in 1973 would have established land use and growth policies for the state and required regional plans. Although developed under the land use commission's general planning program, the land use commission itself joined developers and local officials in opposing and defeating the bill. *See* Kirk Wickersham, Jr., *supra,* note 20.

23. *See House Bill 1041, Model Land Use Regulations*, (Colorado Land Use Commission, September 1976).

24. C.R.S. § 24-65.1-103(13).

25. C.R.S. § 24-65.1-103(8).

26. *Id.*

27. *Supra*, note 7. (CGS SP 6)

28. *See* David C. Noe, *Heaving-Bedrock Hazards, Mitigation, and Land-Use Policy: Front Range Piedmont, Colorado*, 4 Envitl. Geosci. 48 (1997). This article is an excellent summary of the subject that contains significant technical information and is generally understandable to the layperson. It has recently been published as CGS Special Publication 45.

29. C.R.S. § 24-65.1-103(21).

30. C.R.S. § 24-65.1-103(7).

31. *Id.*

32. C.R.S. § 24-65.1-401 *et seq.*

33. *Id.*

34. *Id.*

35. C.R.S. § 24-65.1-401(1).

36. C.R.S. § 24-65.1-402(3).

37. *See Dill v. Board of County Comm'rs*, 1996 Colo. App. LEXIS 265 (Ct. App. 1996); *City of Colo. Springs v. Board of County Comm'rs,* 895 P.2d 1105 (Ct. App. 1994); *City of Denver v. Board of County Comm'rs,* 782 P.2d 753 (S. Ct. 1989); *Tri-state Generation & Transmission Ass'n v. Board,* 600 P.2d 103, 42 Colo. App. 479 (Ct. App. 1979).

38. *See* Michael D. White and Raymond L. Petros, *Land Use Legislation: H.B. 1034 and H.B. 1041*, 6 Colo. Law. 1686 (Oct 1977).

39. C.R.S. § 29-20-102.

40. C.R.S. § 29-20-104.

41. *See* Christopher J. Warner, *Of Growth Controls, Wilderness and the Urban Strip*, 6 Colo. Law. 1730 (Oct 1977).

42. C.R.S. § 30-28-103(1) and 30-28-106(1) county; 31-23-203 and 31-23-206(1) municipal.

43. C.R.S. § 30-28-105, -106(2).

44. C.R.S. § 30-28-106, -107 county; 31-23-206, -207 municipal.

45. C.R.S. § 30-28-111 county; 31-23-301 municipal.

46. Jefferson County Land Development Regulations, Part III, Section 10 and Section 11.

47. City of Colorado Springs Zoning Code, Article 3: General Site Development Standards, Part 5: Geological Hazard Study and Mitigation. For more information, contact the City of Colorado Springs, Development Services Division, 30 S. Nevada Avenue, Suite 301, Colorado Springs, CO 80903.

48. Town of Telluride Geologic Hazard Area Control Regulations (1978), Mt. Crested Butte Land Use Guide (Oct. 1977), and the City of Glenwood Springs Geologic Hazards Ordinance (1981). Keep in mind that land use regulations developed in the 1970's may lack detail that generally accompanies 1990's regulations. Three other statewide organizations can provide additional information and contacts: Division of Local Government; CCI: Colorado Counties, Inc.; and CML: Colorado Municipal League.

49. C.R.S. § 30-28-133(3)(b)(II).

50. C.R.S. § 30-28-136(1)(g).

51. C.R.S. § 30-28-133(5).

52. C.R.S. § 30-28-133(6)(c).

53. C.R.S. § 30-28-136 (1)(I).

54. C.R.S. § 30-28-136(1)(g).

55. C.R.S. § 30-28-136(1)(f).

56. C.R.S. § 30-28-101(10)(d).

57. C.R.S. § 31-23-214.

58. C.R.S. § 24-67-102(1)(c).

59. C.R.S. § 24-67-102(1).

60. C.R.S. § 24-67-105(7).

61. *See* Erin J. Johnson and Edward H. Ziegler, *Development Agreements: Analysis, Colorado Case Studies, and Commentary,* (Rocky Mountain Land Use Institute 1993).

62. C.R.S. § 24-68-105(1)(b).

63. C.R.S. § 24-68-105(2).

64. *See* Daniel R. Mandelker, *State and Local Government in A Federal System*, at 110-143 (3rd ed., The Michie Company, 1992).

65. *City and County of Denver v. State of Colorado*, 788 P.2d. 764 (Colo. 1990).

66. C.R.S. § 6-6.5-101(1).

67. *Id.*

68. C.R.S. § 6-6.5-101(2).

69. C.R.S. § 6-6.5-101(3).

70. D.C. Noe, C.L. Jochim, and W.P. Rogers, *A Guide to Swelling Soils for Colorado Homebuyers and Homeowners,* CGS Special Publication 43, (1997).

71. *See* Stuart W. McKinley, *Building on Expansive Soils: Colorado's Legislative Response*, 14 Colo. Law. 379 (March 1985); John L. Livingston, *Liability of Broker for Non-Inspection: New Frontiers*, 14 Colo. Law. 776 (May, 1985); *Legislative Update*, Colorado Association of Homebuilders (CAHB) In-House Newsletter, Vol 1, Number 6, (June 1984); Memo, Homebuilders' Association of Metropolitan Denver, undated; Memo, CAHB Executive Vice President to CAHB Builder Members, (May 21, 1984); *Memorandum Re: S.B. 13*, Cole, Hecox, Tolley, Keene, & Beltz, P.C., Attorneys at Law, (1984); Letter, CGS to CAHB (May 11, 1984).

72. *See* Legislative Drafting Office, No. 84-0169/1 for the original draft of the bill. *See also* tapes of Senate Debate (1/11/84) and House Debate (3/12/84).

73. *Sprung v. Adcock*, 903 P.2d 1224 (Ct. App. 1995).

74. C.R.S. § 34-33-101 *et seq.*

75. C.R.S. § 34-33-113.

76. C.R.S. § 34-33-120.

77. C.R.S. § 34-33-126.

78. C.R.S. § 37-90-101 *et seq.*

79. C.R.S. § 37-90-107(1).

80. C.R.S. § 37-90-107(5).

81. C.R.S. § 37-91-101 *et seq.*

82. C.R.S. § 37-91-103.

83. C.R.S. § 37-91-104.

84. C.R.S. § 25-15-101 *et seq.*

85. C.R.S. § 25-15-202(4).

86. *Supra,* note 84.

87. *Id.*

88. C.R.S. § 25-10-101 *et seq.*

89. C.R.S. § 25-10-104(1).

90. C.R.S. § 25-10-105.

91. C.R.S. § 25-10-110.

92. *See* Colorado Advance Legislative Service, House Bill 1113-97. The bill was approved March 28, 1997, and made effective as of July 1, 1997. It was authored by Representatives Sullivant, Entz, and Young, and Senators Norton, Hopper, and Rupert.

93. C.R.S. § 34-60-118(4)(c).

94. C.R.S. § 8-20.5-101 *et seq*. For information on form contact Colorado Department of Labor and Employment, Oil Inspection Section, Environmental Consultant Registration Program, 1515 Arapahoe St, Tower 3, Suite 610, Denver, CO 80202-2117.

95. C.R.S. § 8-20.5-201 *et seq*.

96. C.R.S. § 8-20.5-205.

97. *See* C.R.S. § 37-87-101 *et seq*.

98. C.R.S. § 37-87-102(3)(a).

99. C.R.S. § 35-49-103.

100. C.R.S. § 22-32-124(1).

101. *Id.*

102. *See* Regulations Pertaining to Solid Waste Disposal Sites and Facilities, 6 CCR 1007-2 (Sept. 1997), *and see* C.R.S. § 30-20-100.5 *et seq*.

103. C.R.S. § 33-11-101 *et seq*.

104. C.R.S. § 33-11-102(1). The statutory language is unclear and it is difficult to determine the actual legislative intent.

105. C.R.S. § 33-11-106. Statutory language similarly unclear. The committee is directed to review interests in land that could be adapted for use as trails, but the lists of "interests" includes floodplains, geologic hazard areas, and steep slopes.

106. C.R.S. § 34-1-202.

107. C.R.S. § 34-1-201(2).

108. C.R.S. § 34-1-201(1).

109. C.R.S. § 34-1-201(3).

110. C.R.S. § 12-25-102(4).

111. C.R.S. § 12-25-102(3).

112. C.R.S. § 12-25-102(11).

113. C.R.S. § 12-25-102(10).

114. C.R.S. § 12-25-114.

115. C.R.S. § 12-25-106(6).

116. C.R.S. § 12-25-103.

117. C.R.S. § 12-4-101, Architects; 12-5-101, Attorneys; 12-61-101, Real Estate Agents. Landscape Architects were licensed in Colorado until 1977, *see* C.R.S. § 12-45-101.

118. C.R.S. § 12-25-101 *et seq.*

119. C.R.S. § 12-25-106.

120. *The Board Addresses Engineering in Natural Hazard Areas*, PEPLS Board News Official Newsletter, Volume VII, (July 1995).

121. *Id.*

122. Policy Statement 15 is published in several places, including the PEPLS Board News bulletin, *supra,* note 120.

123. The PEPLS board is currently considering proposed changes to Policy Statement 15 that will help clarify it and better serve its intent.

124. The California Board of Registration for Geologists and Geophysicists (BRGG) can be contacted at 2535 Capital Oaks Drive, Suite 300A, Sacramento, CA 95833; 916-263-2113; e-mail geo-bd@ix.netcom.com. The California Board of Registration for Professional Engineers and Land Surveyors (BORPELS) can be contacted at P.O. Box 349002, Sacramento, CA 95834-9002; 916-263-2222.

125. *See Board Votes Not to Adopt Fields of Expertise Document*, BRGG Information Bulletin 98-01.

126. BORPELS Policy Resolution #96-10, included in Information Bulletin 98-01, *id.*

127. *See* Letter, CGS to PEPLS board re: review of Fields of Expertise document, February 20, 1998. [Appendix 6.b.].

128. *Supra,* note 7 (CGS SP 6).

129. The national AEG association can be contacted at 323 Boston Post Road, Suite 2D, Sudbury, MA 01776; 508-443-4639. The Rocky Mountain Section of the AEG can be contacted at P.O. Box 280663, Lakewood, CO 80228-0663.

130. *Aims and Goals,* Rocky Mountain Section AEG Legislative and Regulatory Affairs Committee, (October 13, 1997) [Appendix 7.b.].

131. *See Summary of Some Key Laws Related to Geology and Land Use in Colorado,* Rocky Mountain Section AEG Legislative and Regulatory Affairs Committee, (October 10, 1997) [Appendix 7.c.]; *and see* Robert E. Tepel, *Professional Licensure for Geologists, An Exploration of Issues,* (AEG Special Publication No. 7, 1995).

132. Association of Engineering Geologists publications on professional practice include: *Engineering Geology Practice in Southern California,* Special Publication 4; *Professional Practice Handbook,* Special Publication 5, 1993 ed.; *Preliminary Environmental Assessment,* Short Course Notebook, No. 2; *EXPERT, Guide to Forensic Engineering and Service as an Expert Witness,* Short Course Notebook; *List of ASTM Standards, Methods, and Guidelines Useful in the Practice of Environmental and Engineering Geology*; *LIMITATION ON LIABILITY: A Handbook for Design and Technical Consultants,* ASFE.

133. ASBOG can be contacted at P.O. Box 11591, Columbia, SC 29211-1591; 803-799-1047; http://geosun1.sjsu.edu/asbog.

134. *Why Geologists?*, Brochure, ASBOG, (Nov. 10, 1997) [Appendix 7.d.]; ASBOG can be contacted by e-mail: 102667.2674@compuserve.com.

135. *Tasks of a Licensed Professional Geologist*, Brochure, ASBOG, (Feb 1997) [Appendix 7.e.]. ASBOG can be contacted by e-mail: 102667.2674@compuserve.com.

136. *See supra*, note 7. (CGS SP 6)

137. AIPG publishes *The Citizen's Guide to Geologic Hazards* (1993).

138. C.R.S. § 34-1-101 *et seq*.

139. C.R.S. § 34-1-101.

140. C.R.S. § 34-1-103.

141. C.R.S. § 34-1-105(1)(a).

142. C.R.S. § 34-1-104.5.

143. *See* David C. Noe, *Overview of Geologic Hazards and Land-Use Reviews in Local Planning Decisions*, Conference Abstract, Geologic Hazards and Engineering Practices in Western Colorado, CGS, (May 8, 1997). [Appendix 8.a.]

144. *See* W.R. Junge and D.C. Shelton, *The Geologic Review Process,* (CGS 1978). *See also Solving Land Use Problems*, CGS, undated.[Appendix 8.b.].

145. *See* David Shelton and Dick Prouty, *Nature's Building Codes: Geology and Construction in Colorado*, CGS Special Publication 12, (1979). [Appendix 8.c.]

146. *Id.*

147.*See Solving Land Use Problems*, *supra,* note 144.

148. *Supra*, note 70. (CGS SP 43)

149. Candace L. Jochim, *Home Landscaping and Maintenance on Swelling Soil*, CGS Special Pub 14, (revised fifth printing 1987); and Wesley G. Holtz and Stephen S. Hart, *Home Construction on Shrinking and Swelling Soils*, CGS Special Publication 11, (1978).

150. *See supra,* note 145. (CGS SP 12)

151. *Supra,* note 7. (CGS SP 6)

152. *See* John W. Himmelreich, Jr., *Legislative and Regulatory Issues Affecting Geologists and Engineers in Professional Practice in Colorado,* AEG NEWS, Winter, 1998, Vol. 41, No1., at 45.

153. Erin Johnson is a frequent speaker on topics involving land use and planning, and is available for both speaking and teaching engagements. She is a member of the American Institute of Certified Planners, the American Planning Association, and APAColorado. Erin participates in national, state, and local bar associations. She is a member of the MontDolores Homebuilders' Association in Cortez, Colorado. Ms. Johnson is an active participant in local, regional, and state-wide land-use and planning issues.

Ms. Johnson is a co-editor and contributing author of *The Good Neighbor Guidebook for Colorado*, a forthcoming publication that provides useful information for all citizens of Colorado regarding land stewardship, basics of Colorado law, and how to be a good neighbor to everyone in Colorado.

John Himmelreich has presented *Legislative and Regulatory Issues Affecting Geologists and Engineers in Professional Practice in Colorado* on several occasions: Rocky Mountain Section Assn. Of Engineering Geologists (Oct. 14, 1997); Pikes Peak Environmental Forum (Nov. 21, 1997); Colorado Assn. of Geotechnical Engineers (Jan. 14, 1998); Housing and Building Assoc. Of the Pikes Peak Region (Feb. 12, 1998); Combined Seminar for AEG, CAGE, and ASCE

(Apr. 17, 1998).

Mr. Himmelreich is an active member of the AEG and serves as the chairman of the Legislative and Regulatory Affairs Committee for the Rocky Mountain Section. He is also a member of the Geologic Hazards Committee of the Colorado Natural Hazards Mitigation Council. On the local level, he is a member of the Housing and Building Assn. Of Colorado Springs/Pikes Peak Region. John is an active participant in local, regional, and state-wide regulatory and geologic issues. Mr. Himmelreich is available for both speaking and teaching engagements.

APPENDIX 1

Colorado's Land-Use Trends and Geologic Hazards Problems, James M. Soule (CGS 1996).

Colorado's Land-Use Trends and Geologic-Hazards Problems

James M. Soule
Colorado Geological Survey
March 1996

SUMMARY

- Urban centers are expanding peripherally while simultaneously filling in the "leap-frogged" parcels of the seventies and eighties. Many of these parcels were not developed before because geologic and related conditions made high(er) density development too problematical. Earlier development typically was on larger lots where larger, more expensive houses were built with, effectively, more open spaces among them. The present, relatively higher, property values partially offset this, i.e. smaller lot sizes with larger houses. This trend is seen in all of the Front Range cities and larger Western Slope towns and cities.
- Virtually all of Colorado's towns and cities are growing. This was not the case during the "energy boom" of the mid-seventies to eighties. Many smaller communities, e.g. Castle Rock, Lamar, Loveland, Montrose, and Ouray, which saw virtually no growth pressure then, are now experiencing pressure to expand into areas with severe geologic constraints.
- Mountain-area towns with a strong recreational base are experiencing larger numbers of year-around residents. Most of these persons are not dependent on a local economy, but rather have outside sources of support and/or work via telecommunications. These people frequently perceive that they can afford the high costs of construction in very difficult (and frequently geologic-hazard-prone) terrain as well as the physical isolation which severe winter weather and related hazards, e.g., snow avalanches, can cause. Providing basic services such as road repair, maintenance, and clearing as well as emergency-medical, fire and police protection, and public-school-transport services to such persons can severly impact local-government and other public financial and personnel resources.
- The rapid growth in numbers and size of RV parks and second home developments and the summer influx of part-year residents, e.g., construction workers, tourists, and the retired, result in seasonal communities which frequently are located in places which are difficult to provide services for and/or are physically dangerous. Examples include stream sides, steeper slopes, and places with poor suitability for safe sewage disposal.
- In several of the less populous counties, e.g. Jackson and Las Animas, most of the new subdivisions are ones with 35-acre or larger lots. Examples of these occur in virtually all counties except Denver. These are not subject to most of the state's land-use laws, i.e. they are not legally subdivisions.
- Federal and State environmental laws and regulations have effectively expanded the definitions of geologic hazards, including those related to petroleum-product storage and releases, sanitary landfilling of ordinary refuse, and disposition of hazardous materials such as uranium-mill tails and other wastes produced by mines. All of these affect permitting of surface (and subsurface) uses by appropriate authorities, who include County Commissioners through their planning departments and the Colorado Division of Minerals and Geology.
- The long-standing land-use conflicts between mining and other operations, e.g. gravel extraction and oil-and-gas production, and urbanization and agriculture continue.

APPENDIX 2

Legislative Materials:

a. House Bill 1041 Definitions, C.R.S. § 24-65.1-103.

b. Senate Bill 13, C.R.S. § 6.6.5-101.

c. Senate Bill 13, Original Draft of Bill, Legislative Drafting Office No. 84 0169/1

d. House Bill 1574, C.R.S. § 34-1-201, -202.

24-65.1-103. Definitions pertaining to natural hazards.

As used in this article, unless the context otherwise requires:

(1) 'Aspect' means the cardinal direction the land surface faces, characterized by north-facing slopes generally having heavier vegetation cover.

(2) 'Avalanche' means a mass of snow or ice and other material which may become incorporated therein as such mass moves rapidly down a mountain slope.

(3) 'Corrosive soil' means soil which contains soluble salts which may produce serious detrimental effects in concrete, metal, or other substances that are in contact with such soil.

(4) 'Debris-fan floodplain' means a floodplain which is located at the mouth of a mountain valley tributary stream as such stream enters the valley floor.

(5) 'Dry wash channel and dry wash floodplain' means a small watershed with a very high percentage of runoff after torrential rainfall.

(6) 'Expansive soil and rock' means soil and rock which contains clay and which expands to a significant degree upon wetting and shrinks upon drying.

(7) 'Floodplain' means an area adjacent to a stream, which area is subject to flooding as the result of the occurrence of an intermediate regional flood and which area thus is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Mainstream floodplains;

(b) Debris-fan floodplains; and

(c) Dry wash channels and dry wash floodplains.

(8) 'Geologic hazard' means a geologic phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Avalanches, landslides, rock falls, mudflows, and unstable or potentially unstable slopes;

(b) Seismic effects;

(c) Radioactivity; and

(d) Ground subsidence.

(9) 'Geologic hazard area' means an area which contains or is directly affected by a geologic hazard.

(10) 'Ground subsidence' means a process characterized by the downward displacement of

surface material caused by natural phenomena such as removal of underground fluids, natural consolidation, or dissolution of underground minerals or by man-made phenomena such as underground mining.

(11) 'Mainstream floodplain' means an area adjacent to a perennial stream, which area is subject to periodic flooding.

(12) 'Mudflow' means the downward movement of mud in a mountain watershed because of peculiar characteristics of extremely high sediment yield and occasional high runoff.

(13) 'Natural hazard' means a geologic hazard, a wildfire hazard, or a flood.

(14) 'Natural hazard area' means an area containing or directly affected by a natural hazard.

(15) 'Radioactivity' means a condition related to various types of radiation emitted by natural radioactive minerals that occur in natural deposits of rock, soil, and water.

(16) 'Seismic effects' means direct and indirect effects caused by an earthquake or an underground nuclear detonation.

(17) 'Siltation' means a process which results in an excessive rate of removal of soil and rock materials from one location and rapid deposit thereof in adjacent areas.

(18) 'Slope' means the gradient of the ground surface which is definable by degree or percent.

(19) 'Unstable or potentially unstable slope' means an area susceptible to a landslide, a mudflow, a rock fall, or accelerated creep of slope-forming materials.

(20) 'Wildfire behavior' means the predictable action of a wildfire under given conditions of slope, aspect, and weather.

(21) 'Wildfire hazard' means a wildfire phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property. The term includes but is not limited to:

(a) Slope and aspect;

(b) Wildfire behavior characteristics; and

(c) Existing vegetation types.

(22) 'Wildfire hazard area' means an area containing or directly affected by a wildfire hazard.

History.--Source: L. 74: Entire article added, p. 336, 1, effective May 17.

ARTICLE 6.5
SOIL AND HAZARD ANALYSES OF RESIDENTIAL CONSTRUCTION

Section
6-6.5-101. Disclosure to purchaser - penalty.

6-6.5-101. Disclosure to purchaser - penalty.

(1) At least fourteen days prior to closing the sale of any new residence for human habitation, every developer or builder or their representatives shall provide the purchaser with a copy of a summary report of the analysis and the site recommendations. For sites in which significant potential for expansive soils is recognized, the builder or his representative shall supply each buyer with a copy of a publication detailing the problems associated with such soils, the building methods to address these problems during construction, and suggestions for care and maintenance to address such problems.

(2) In addition to any other liability or penalty, any builder or developer failing to provide the report or publication required by subsection (1) of this section shall be subject to a civil penalty of five hundred dollars payable to the purchaser.

(3) The requirements of this section shall not apply to any individual constructing a residential structure for his own residence.

History.--Source: L. 84: Entire article added, p. 294, 1, effective July 1.

NOTE

Law reviews. For article, 'Building on Expansive Soils: Colorado's Legislative Response', see 14 Colo. Law. 379 (1985).

LDO NO. 84 0169/1 SENATE BILL NO. 13

STATE OF COLORADO

BUSINESS AFFAIRS & LABOR

BY SENATOR Arnold

A BILL FOR AN ACT

CONCERNING MANDATORY ANALYSES OF LAND DEVELOPED FOR RESIDENCES.

Bill Summary

(Note: This summary applies to this bill as introduced and does not necessarily reflect any amendments which may be subsequently adopted.)

Requires every developer or builder of a residence for human habitation to conduct tests of the land and soil before commencing construction. Requires disclosure of a report of such tests to the purchaser before closure.

Be it enacted by the General Assembly of the State of Colorado:

SECTION 1. Title 6, Colorado Revised Statutes, as amended, is amended BY THE ADDITION OF A NEW ARTICLE to read:

ARTICLE 6.5

Soil and Hazard Analyses of Residential Construction

6-6.5-101. Soil and hazard analyses required. Every developer or builder of residential structures for human habitation shall analyze the hazard potentials of the land and soil on which these structures are to be constructed before commencing such construction. Such analysis shall be

Capital letters indicate new material to be added to existing statute.
Dashes through the words indicate deletions from existing statute.

conducted by qualified professional geologists or registered professional engineers knowledgeable in the fields of geologic hazards and soils engineering and shall address all potential hazards to the structural stability of the structures presented by the land and soil, shall include appropriate tests and observations for the presence of expansive soils, and shall suggest positive methods for limiting the potential for structural damage.

6-6.5-102. Disclosure to purchaser. Before closing the sale of any new residence for human habitation, every developer or builder shall provide the purchaser with a copy of a summary report of the analysis and the site recommendations if such exist. For sites in which significant potential for expansive soils is recognized, the builder shall supply each buyer with a copy of special publication 14 of the Colorado geological survey entitled "Home Landscaping and Maintenance on Swelling Soil".

SECTION 2. Effective date - applicability. This act shall take effect July 1, 1984, and shall apply to residential construction commencing on or after said date.

SECTION 3. Safety clause. The general assembly hereby finds, determines, and declares that this act is necessary for the immediate preservation of the public peace, health, and safety.

34-1-201. Definitions.

As used in this part 2, unless the context otherwise requires:

(1) 'Geologist' means a person engaged in the practice of geology.

(2) 'Geology' means the science which treats of the earth in general; the earth's processes and its history; investigation of the earth's crust and the rocks and other materials which compose it; and the applied science of utilizing knowledge of the earth's history, processes, constituent rocks, minerals, liquids, gasses, and other materials for the use of mankind.

(3) 'Professional geologist' is a person who is a graduate of an institution of higher education which is accredited by a regional or national accrediting agency, with a minimum of thirty semester (forty-five quarter) hours of undergraduate or graduate work in a field of geology and whose postbaccalaureate training has been in the field of geology with a specific record of an additional five years of geological experience to include no more than two years of graduate work.

History.--Source: L. 73: p. 610, 1. C.R.S. 1963: 51-3-1.

34-1-202. Reports containing geologic information.

Any report required by law or by rule and regulation, and prepared as a result of or based on a geologic study or on geologic data, or which contains information relating to geology, as defined in section 34-1-201 (2), and which is to be presented to or is prepared for any state agency, political subdivision of the state, or recognized state or local board or commission, shall be prepared or approved by a professional geologist, as defined in section 34-1-201 (3).

History.--Source: L. 73: p. 610, 1. C.R.S. 1963: 51-3-2.

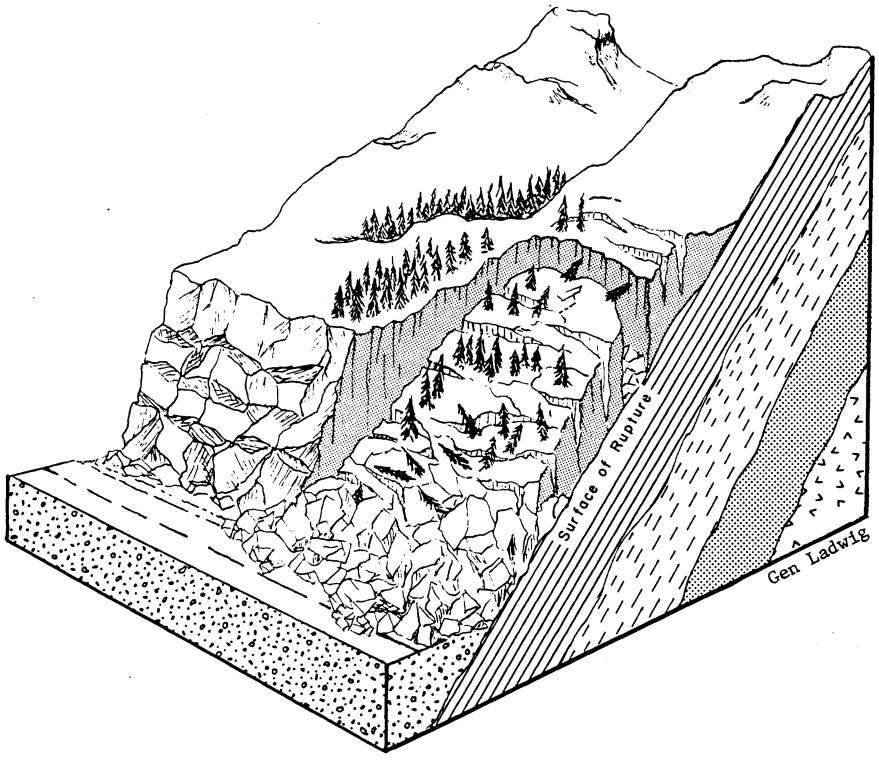
APPENDIX 3

Guidelines and Criteria for Identification and Land-Use Controls of Geologic Hazard and Mineral Resource Areas, William P. Rogers (Selected portions of CGS SP 6)

Special Publication 6

Guidelines and Criteria for Identification and Land-Use Controls of Geologic Hazard and Mineral Resource Areas

by
W. P. Rogers, L. R. Ladwig, A. L. Hornbaker, S. D. Schwochow,
S. S. Hart, D. C. Shelton, D. L. Scroggs, and J. M. Soule



Colorado Geological Survey / Dept. of Natural Resources / Denver, Colorado / 1974

Reprinted 1979

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VI. Qualifications of Investigators

For identification of geologic areas of state interest as required by House Bill 1041, certain minimal standards of professional training and competence should be required of any geologist doing such work. Agencies reviewing or otherwise aiding in such work should monitor and require acceptable levels of competency and professional work from all individuals submitting reports.

A. Professional Geologist

House Bill 1574 enacted in 1973 makes the following stipulation concerning geologic reports:

> 53-3-2. Reports containing geologic information. Any report required by law or by rule and regulation, and prepared as a result of or based on a geologic study or on geologic data, or which contains information relating to geology, as defined in section 51-3-1(3), and which is to be presented to or is prepared for any state agency, political subdivision of the state, or recognized state or local board or commission, shall be prepared or approved by a professional geologist, as defined in section 51-3-1(4).

The same act defines professional geologist as follows:

> 51-3-1. (4)(a) "Professional geologist" is a person who is (b) A graduate of an institution of higher education which is accredited by a regional or national accrediting agency, with a minimum of thirty semester (forty-five quarter) hours of under-graduate or graduate work in a field of geology and whose postbaccalaureate training has been in a field of geology with a specific record of an additional five years of geological experience to include no more than two years of graduate work.

As in other disciplines, most professionals in geology are specialized. In addition to the minimum education or experience required by the Act, professional geologists should therefore have a specific background in the specialty to which they are addressing themselves, e.g. engineering and environmental geology, mineral deposits, or hydrology.

The stipulation that work on a specific geologic project be done by professional geologists with a specialty and experience in that area is of utmost importance. This will result in the greatest assurance that such work will be of acceptable quality and have the highest probability of long-term utility and benefit to the people of the State of Colorado.

B. Engineering Geologist

Engineering geology is a commonly accepted specialty within the profession of geology and is defined as "the application of geologic knowledge and principles in the investigation and evaluation of naturally occurring rock and soil for use in the design of civil works." (Uniform Building Code, Chapter 70, 1973). An engineering geologist must be well qualified, through both education and experience, in field geology and identification of geologic hazards. If these qualifications are met, the engineering geologist should be capable of producing maps and reports acceptable to both local government and the state in H.B. 1041 hazard investigations.

C. Professional Engineer

Professional engineers are persons who meet certain qualifications and have passed an examination as set forth by the State Board of Registration for Professional Engineers and Land Surveyors. As defined in the 1965 Permanent Cumulative Supplement to the Colorado Revised Statutes 1963, Chapter 51, article 1, Section 51-1-2, subsection (4) an engineer is defined as:

> "...a person who, by reason of intensive preparation in the use of mathematics, chemistry, physics, and engineering sciences, including the principles and methods of engineering analysis and design, is qualified to perform engineering work as defined in this areticle."

Subsection (5) of the same section defines "Professional Engineer" as: "...an engineer duly registered and licensed."

As within the geologic profession, there are specialties within the ranks of the professional engineers such as civil, soils, structural, and electrical. All professional engineers are obviously not qualified to work within the area of soils, slope stability, hydrology, rock mechanics, or geology. Such work should require experience and competency in those specialties.

D. General Summary

It is important that the geologic portion of a hazard investigation be carried out by, or under responsible charge of a qualified professional geologist, especially an engineering geologist, and that his signature be on the report. It is equally important that if part of the investigation is concerned with soil mechanics, foundation design requirements or other engineering or design aspects, then that portion of the investigation should be performed by a qualified professional engineer and that report should be signed by the engineer who performed the work.

Obviously some tasks should only be performed by qualified geologists and some should only be performed by qualified engineers. Others could be adequately handled by either profession. Persons who would like more detailed information on the qualifications of engineering geologists and civil engineers to perform certain work are referred to an excellent article, "Guidelines for Practice in California-- Engineering Geologists versus Civil Engineers" in the Eleventh Annual Symposium on Engineering Geology and Soils Engineering edited by Wilferd W. Peak, April 1973, available from Idaho State University Department of Geology and Engineering.

APPENDIX 4

Storage Tank Fund Professional Environmental Scientist Registration Form and other form templates.

COLORADO PETROLEUM STORAGE TANK FUND

Consultant Registration Program – INDIVIDUAL FORM (Professional Environmental Scientist) Article 2, Part 3

Attach this individual registration form to the COMPANY registration form

Individual Registration #_____
(Leave blank. For OIS use only.)

Name	Phone # ( )	Fax # ( )
Mailing address Company Street or P.O. Box City/State/ZIP		

Years of qualifying experience: _____ years. ***"Qualifying experience" means experience pertinent or related to site assessments, remedial investigations, and corrective actions necessary to remediate petroleum-contaminated water or soil. If you do not have at least five (5 years) of qualifying experience, STOP HERE. You do not meet the minimum requirements to register as a professional environmental scientist.***

Check each box that applies. If you cannot check at least one of the following boxes, STOP HERE. You do not meet the minimum requirements to register as a professional environmental scientist.

- ☐ I am a registered professional engineer. Reg. #_____. Exp. date_____. Issuing state_____
- ☐ I am a registered professional geologist. Reg. #_____. Exp. date_____. Issuing state_____
- ☐ Other professional certification. Attach separate page with name, issuing agency, expiration date, criteria.
- ☐ I am a graduate of an institution of higher education that is accredited by a regional or national accrediting agency. Name, city, state of institution:_____. I have successfully completed (grade of "C" or better) at least 30 semester (or 45 quarter) hours of undergraduate or graduate work in one of the following: engineering; industrial hygiene; a biological, chemical, environmental, or physical science.

Have you ever been convicted of, entered into a plea agreement, or entered a plea of nolo contendere to any crime involving a violation of Colorado or federal environmental laws or regulations, including any violation of laws or regulations governing Colorado's Petroleum Storage Tank Fund? *If you checked "yes," STOP HERE. You do not meet the minimum requirements to register as a professional environmental scientist.*	☐ No ☐ Yes

CERTIFICATION

I hereby certify that the information provided on this registration document is true and complete to the best of my information, knowledge and belief. I will notify the Oil Inspection Section within 30 days of any change in this information. I understand that providing false information may cause my Registration to be revoked and may subject me to criminal proceedings and penalties. I authorize the State of Colorado and any agent acting on its behalf to conduct an inquiry into any information provided in this registration document. I agree to cooperate with such inquiry to the best of my ability, and to provide to the Oil Inspection Section on its request documentation to support any information provided herein, including official "sealed" college/university transcripts and professional licenses.

Date_____ Signed_____

Print/type name_____

Subscribed and sworn to before me in the county of _____, state of _____ on this _____ day of _____, 199_____. My commission expires_____.

*Notary public signature:*_____

COLORADO PETROLEUM STORAGE TANK FUND

Consultant Registration Program – COMPANY FORM
Article 2, Part 2

Don't forget to attach:

1. INDIVIDUAL registration form(s)
2. Company QA/QC Plan
3. Company Health & Safety Plan

Send completed, signed, notarized form, with attachments, to:

Colorado Department of Labor and Employment
Oil Inspection Section
Attn: Environmental Consultant Registration
1515 Arapahoe St.
Tower 3, Suite 610
Denver, CO 80202-2117

Company Registration # _____
(Leave blank. For OIS use only.)

Company name		
Company street address Street City/State/ZIP		
Company mailing address (if different from street address) Street or P.O. Box City/State/ZIP		
Key contact person Name:	Phone # ( )	Fax # ( )
List 3 clients for whom the registering company has performed petroleum remediation during the last 12 months		
1.	Name Mailing address Key contact person: Name	Phone # ( )
2.	Name Mailing address Key contact person: Name	Phone # ( )
3.	Name Mailing address Key contact person: Name	Phone # ( )
Has the registering company ever been convicted of, entered into a plea agreement, or entered a plea of nolo contendere to any crime involving a violation of Colorado or federal environmental laws or regulations, including any violation of laws or regulations governing Colorado's Petroleum Storage Tank Fund? *If you checked "yes," STOP HERE. You do not qualify to register with this program.*		☐ No ☐ Yes
Has the registering company's environmental consultant registration ever been revoked? *If you checked "yes," explain on a separate page and attach.*		☐ No ☐ Yes

List each professional environmental scientist employed by the registering company. Attach to this form a signed and notarized registration form for each such person. *If there are no such employees, STOP HERE. You do not qualify to register with this program.*	
Name	Title
Attach a copy of your generic quality assurance/quality control plan, to include standard field procedures, sampling procedures, etc.	
Attach a copy of your generic health and safety plan.	

CERTIFICATION

I hereby certify that the information provided on this registration document is true and complete to the best of my information, knowledge and belief. I understand that providing false information may cause my Registration to be revoked and may subject me to criminal proceedings and penalties. I authorize the State of Colorado and any agent acting on its behalf to conduct an inquiry into any information provided in this registration document or attachments to it, and I agree to cooperate with such inquiry to the best of my ability. I am the appropriate person to execute this document on behalf of the registering company. I understand that any conviction, plea bargain, or plea of nolo contendere to any crime involving a violation of Colorado or federal environmental laws and regulations, including any violation of regulations governing Colorado's Petroleum Storage Tank Fund, shall disqualify a person or a company from performing remedial activities for which Fund reimbursement is sought.

On behalf of the registering company, I further certify that the registering company will perform the following to the best of its ability:

- Abide by all federal, Colorado, and local statutes, ordinances, regulations, guidelines, standards, practices, policies and other requirements pertaining to assessing and remediating petroleum contamination in soil and water.
- Notify the Oil Inspection Section, in writing, within 30 days of any change in information provided in this registration.
- Comply with *Colorado's Reasonable Cost Guidelines*. This includes providing to any client who may seek reimbursement from the Petroleum Storage Tank Fund a copy of the *Guidelines*, advising the client that any otherwise allowable costs billed at rates exceeding those set forth in the *Guidelines* will not be reimbursed at a rate higher than the *Guidelines* rate unless the Petroleum Storage Tank Committee considers the higher rate(s) to be justified, and submitting invoices that are compatible with the *Guidelines*.
- All activities billed at labor rates for a principal, senior engineer/scientist, project manager or project engineer/manager will be conducted by a registered professional environmental scientist. Attached is a registration form for each individual employed by this company who has certified that he/she meets the qualifications for professional environmental scientist.
- Not mark up materials or services provided by any company or person with whom the registering company has a financial interest.

Date _____ Signed _____

Fed. tax ID #_____ Print/type name _____

Print/type title _____

Subscribed and sworn to before me in the county of _____, state of _____ on this _____ day of _____, 199_____. My commission expires_____.

*Notary public signature:*_____

DRAFT

City of

Consultant Registration Program-INDIVIDUAL FORM
Professional Engineering Geologist

Attach this individual registration form to the COMPANY registration form

Individual Registration #_____
(For City Use Only)

Name Phone# ( ) Fax#( )
Mailing Address
Company
Street or P.O. Box
City/State/ZIP

DRAFT

Years of qualifying experience:_____ years. "Qualifying experience" means experience pertinent to the identification, investigation, evaluation, and control of natural and geologic hazards such as earthquakes, floods, landslides, debris flows, expansive soils and bedrock, etc. and; the investigation and evaluation of geologic conditions which affect structural works such as bridges, buildings, canals, dams, roadways, pipelines, power plants, tunnels, towers, earthwork, etc. If you do not have at least five (5) years of post-graduation geologic experience which includes two (2) years "qualifying experience", STOP HERE. You do not meet the minimum requirements to register as a professional engineering geologist.

Check each box that applies. If you cannot check at least one of the following boxes, STOP HERE. You do not meet the minimum requirements to register as a professional engineering geologist.

[ ] I am a registered professional geologist. Reg.#_____. Exp. date_____. State_____

[ ] I am a certified professional geologist (AIPG). Reg.#_____.

[ ] Other professional certification. Attach data with name, issuing agency, expiration date, criteria.

[ ] I am a graduate of an institution of higher education that is accredited by a regional or national accrediting agency. Name, city, state of institution:_____.
I have successfully completed (grade of "C" or better) at least 30 semester (or 45 quarter) hours of undergraduate or graduate work in a field of geology.

Have you ever been convicted of, entered into a plea agreement, or entered a plea of nolo contendere to any crime involving a violation of Colorado or federal laws or regulations related to geology or engineering?
[ ] No
[ ] Yes If yes, attach explanation.

CERTIFICATION

I hereby certify that the information provided on this registration document is true and complete to the best of my information, knowledge, and belief. I will notify the City within 30 days of any changes in this information. I understand that providing false information may cause my Registration to be revoked and may subject me to criminal or civil proceedings and penalties. I authorize the City of and any agent acting on its behalf to conduct an inquiry into any information provided in this registration document. I agree to cooperate with such inquiry to the best of my ability, and to provide to the City of on its request documentation to support any information provided herein, including official "sealed" college/university transcripts and professional licenses.

Date_____ Signed_____

Print/type name_____

DRAFT

Subscribed and sworn to before me in the county of_____, state of_____

on this _____ day of _____, 199_____. My commission expires _____.

Notary public signature: _____

DRAFT

City of	Consultant Registration Program--COMPANY FORM

Send completed, signed, notarized form, with attachments to:

Don't forget to attach:
1. INDIVIDUAL registration form(s)

City of

Attn: Consultant Registration Program

Company Registration # _____
(City Use Only)

Company Name
Company address and street City/State/ZIP
Company mailing address (if different from street address) Street or P.O. Box City/State/ZIP
Key contact person Name:_____ Phone #: ( )_____Fax #: ( )_____
List 3 clients for whom the registered company has performed engineering geologic investigations during the last 12 months. Name: Mailing address Key contact person name: Phone # ( )
Name: Mailing address Key contact person name: Phone # ( )
Name: Mailing address Key contact person name: Phone # ( )
Has the registering company ever been convicted of, entered into a plea agreement, or entered a plea of nolo contendere to any crime involving a violation of Colorado or federal laws or regulations related to geology or engineering? [ ] Yes If yes, attach explanation. [ ] No

DRAFT

List each professional engineering geologist employed by the registering company. Attach to this form a signed and notarized registration form for each such person. If there are no such employees, STOP HERE. You do not qualify to register with this program.

Name	Title

CERTIFICATION

I hereby certify that the information provided on this registration document is true and complete to the best of my information, knowledge, and belief. I understand that providing false information may cause my Registration to be revoked and may subject me to criminal or civil proceedings and penalties. I authorize the City of and any agent acting on its behalf to conduct an inquiry into any information provided in this registration document or attachments to it, and I agree to cooperate with such inquiry to the best of my ability. I am the appropriate person to execute this document on behalf of the registering company. I understand that any conviction, plea bargain, or plea of nolo contendere to any crime involving a violation of Colorado or federal geology or engineering laws and regulations, shall disqualify a person or a company from the consultant registration program.

On behalf of the registering company, I further certify that the registering company will perform the following to the best of its ability:

- **Abide by all Colorado and local statutes, ordinances, regulations, guidelines, standards, practices, policies, and other requirements pertaining to assessing geologic hazards.**
- **Notify the City of , in writing, within 30 days of any change in information provided in this registration.**
- **Geologic studies to be submitted to the City of shall be prepared by or approved (signed) by a registered engineering** professional **geologist.**

Date_____ **Signed**_____

Fed. tax ID# _____ **Print/type name**_____

Print/type title _____

Subscribed and sworn to before me in the county of_____, **state of** _____

on this _____ **day of** _____, **199**_____. **My commission expires** _____.

Notary public signature: _____

APPENDIX 5

Policy Statement 15 Materials:

a. Board News, Official Newsletter, Volume VII, July 1995 (w/Policy Statement 15 revised)

b. Mike West discussion of Policy Statement 15

Note: This is the first printing to include the revised Policy Statement 15

BOARD NEWS

OFFICIAL NEWSLETTER
Volume VII - July 1995

Colorado State Board of Registration for Professional Engineers and Professional Land Surveyors

Roy Romer, Governor ▌ Joseph A. Garcia, Executive Director, Dept. Of Regulatory Agencies ▌ Bruce Douglas, Director, Division of Registrations

THE BOARD ADDRESSES ENGINEERING IN NATURAL HAZARD AREAS
Soils Task Force Report

In May 1994, Senator Bill Schroeder met with representatives of the engineering community and outlined concerns regarding performance of residences constructed on expansive soils and bedrock in Colorado. In response, the Colorado Board of Registration for Professional Engineers and Professional Land Surveyors ("Board") helped to form a Soils Task Force. The purpose of the Task Force was to make recommendations to the Board pertaining to the practice of engineering and the design and review of structures in expansive soils found throughout Colorado, and steeply dipping bedrock found along the eastern flank of the Front Range. The Task Force was formed last summer and met periodically from September 1994 to January 1995. The efforts of the Task Force are summarized here.

During the early meetings, the Task Force attempted to define the perceived problem to include: 1) lack, and timing, of proper disclosure of soil hazards during all phases of property development, from zoning through construction and subsequent property transfers; 2) lack of proper education of the public regarding risks associated with expansive soils; 3) lack of standard practice and quality of investigations; and 4) lack of land use planning and design which considers soils risks, and site and off-site drainage. Our discussions then focused on the development of "standards," with less emphasis on the other problem components which are not within the authority of the Board. We discovered existing legislation, C.R.S. 24-65.1-202 (2), which identifies soils hazards as one category of natural hazards. Our subsequent discussions dealt with natural geologic hazards.

The Task Force acknowledges that professional engineers practicing in the design of foundations, grading and drainage, buried utilities, streets and remedial repairs in areas of natural hazards should demonstrate knowledge of the design and construction methods used to mitigate the effects of such hazards, and the investigations necessary to evaluate impacts of hazards on existing and proposed construction. We considered many possible solutions, including Task Force development of statewide "standards of practice", which was rejected because such standards are too much of a moving target, do not reflect area-specific practice, and would require far more numerous standards than the Task Force can effectively develop. Specialty registration for engineers was also considered and rejected because many different engineering specialties are involved, it would require modification of the engineering practice law, would be slow and divisive for the engineering community, and has not proven to be effective in reducing problems in other states where specialty registration exists.

The Task Force recommended to the Board that they consider measures to guide engineers practicing in hazard areas by establishing a Board policy regarding such work. Disciplinary action could then be based upon C.R.S. 12-25-108 (1) (a) regarding failure to meet generally accepted standards of engineering practice.

As a result of these discussions, the Task Force recommended that the Board adopt Policy Statement 15 - Engineering in Designated Natural Hazard Areas, which the Board did at its February 20, 1995 meeting. The text of that policy is found in this newsletter in the section on "Recently Adopted Policies."

-Diana Homer, PE, Board Member

In This Issue ...

Michael W. West and Associates, Inc.
Consulting Engineers and Geologists

Engineering Geology, Ground Water Hydrology
Seismotectonics and Earthquake Engineering,
Geotechnical Engineering,
Engineering Risk Management

P.O. Box 696
Castle Rock, CO 80104-0696
(303) 688-6064
FAX (303) 688-0206
E-Mail: MWWAI@ibm.net

September 20, 1998

BY FAX (303) 866-2461

Dr. Pat Rogers
Colorado Geological Survey

SUBJECT: Expert Opinion with Respect to PEPLS Policy Statement 15.

Dear Pat:

Cited below are expert opinions I recently expressed on PEPLS Policy Statement 15 in a lawsuit involving geologic hazards. You may freely quote or publish these opinions as you wish so long as no reference is specifically made to the location, nature, or outcome of the lawsuit.

"POLICY STATEMENT 15 - State Board of Registration for Professional Engineers and Professional Land Surveyors (1995)

In 1994, the State Board of Registration for Professional Engineers and Professional Land Surveyors (PEPLS) convened a Task Force to address complaints relating to the work of Colorado Registered Professional Engineers in natural hazard areas. After several months of deliberation, the Task Force recommended that the PEPLS Board adopt a Policy Statement that defines the appropriate role for a Professional Engineer performing work in natural hazard areas as defined by House Bill 1041. In addition, the Task Force recommended adoption of specific guidelines defining a professional engineer's responsibilities when performing work in natural hazard areas. This policy statement was formally adopted by the PEPLS Board on February 20, 1995. An engineer found to be in violation of the policy statement and guidelines may be disciplined by the PEPLS Board.

The fields of geotechnical engineering and the science of geology are largely separate and distinct, and this distinction is recognized by professional societies and licensing authorities. Pure geologists are seldom recognized as engineers or are professionally licensed in engineering. Similarly, few engineers are recognized as geologists or are licensed as geologists where such registration laws exist. Early in the history of Senate Bill 35 and House Bill 1041, engineers attempted to perform geologic studies and hazard assessments with generally poor results. Accordingly, House Bill 1574 (1973) required that any geologic study or geologic data prepared for any state agency or political subdivision be prepared by a professional

geologist. The law went on to define a professional geologist in terms of educational requirements and minimum experience. The intent of this law was twofold: (1) to bring the appropriate education and experience to bear on issues that were fundamentally geological in nature; and (2) to prevent engineers, with little or no training in the geological sciences, from preparing reports and studies related to the identification and analysis of geologic hazards.

Although the situation improved, abuses and problems continued to occur. In 1995, the PEPLS Board issued Policy Statement 15 which addressed continuing problems of engineers attempting to perform geologic hazard studies and analyses without proper training and education. Implicit in this policy statement is the fact that engineering studies in geologic hazard areas require a multidisciplinary approach encompassing the field of geology as well as other non-engineering professionals. Also implicit in the policy statement is a requirement that engineers be open and forthright about the existence of natural hazards, risks to their clients and the public, methods of mitigation, and the chances of success in mitigation. This statement applies to all stages of the design process from feasibility through final design and construction. The statement also specifically states that local government policies, or lack thereof, do not relieve a registrant of sound engineering practice in the recognition and mitigation of natural hazards. The adoption of this guideline and issuance to the engineering community provides a basis for disciplinary action."

If you have any questions or if I can be of further service, please do not hesitate to call.

Very truly yours,

MICHAEL W. WEST & ASSOCIATES, INC.

By: Michael W. West, Ph.D., P.E.
President

POLICY STATEMENT 15 (REVISED 8/7/98)

(15) SUBJECT: Engineering in Natural Hazard Areas

In areas having "Natural Hazards" defined in section 24-65.1-101 et. seq., C.R.S., such as expansive soil and rock, corrosive soils and unstable slopes, engineers performing soils (geotechnical) investigations, construction observation, and design of structures including foundations, grading and drainage, buried utilities, streets and pavements, and remedial work to these improvements shall demonstrate knowledge and incorporate knowledge of and expertise in: 1) methods used to mitigate such hazards and, 2) investigation, design and construction guidelines adopted by local governments.

It is the opinion of the Board that this policy statement should be implemented by the following guidelines:

1. Recognition and Mitigation of Natural Hazards

   Registrants should be thoroughly familiar with applicable natural hazard legislation and local government policies and regulations for the mitigation of effects of natural hazards. Local government policies and regulations may vary. It is the responsibility of each registrant to become familiar with the applicable policies and regulations. Local government policies and regulations, or lack thereof, concerning natural hazards do not relieve the registrant of sound engineering practice in the recognition and mitigation of natural hazards.

2. Multi-Disciplinary Approach

   Registrants should recognize and acknowledge that the mitigation of effects from natural hazards requires a multi-disciplinary approach encompassing the fields of engineering, geology, hydrology, architecture, and land-use planning. It is incumbent on the registrant that these fields are adequately represented in the mitigation of natural hazards through demonstrated knowledge and experience. In general, the Board believes that individual registrants are unlikely to possess the necessary knowledge and expertise to deal with all natural hazards in all cases.

3. Education

   Knowledge of natural hazards should be demonstrated by attendance at courses on natural hazards sponsored by the Colorado Geological Survey, universities, local government, or professional societies. Registrants should be prepared to demonstrate appropriate knowledge and expertise.

4. Disclosure

   Registrants should be open and forthright about the existence of natural hazards, risks to their clients and the public, methods of mitigation, and the chances of success in mitigation. This applies to all stages of the design process, from feasibility through final design and construction. Registrants should not knowingly take part in remedial work in natural hazard areas where the intent is to disguise either the hazards or existing damage.

(Adopted 02-20-95/Rev.08-07-98)

APPENDIX 6

Fields of Expertise Materials:

a. California Policy Resolution #96-10 Regarding Fields of Expertise for Geologists and Civil Engineers.

b. Letter from the Colorado Geological Survey to the PEPLS Board, Review of Fields of Expertise and Professional Environmental Scientist Documents, (Feb. 20, 1998) (w/o attachments).

c. Memorandum from the PEPLS Board re: Geology vs. Engineering and Colorado Petroleum Storage Tank Fund Consultant Registration Program, (Mar. 19, 1998) (w/o attachments).

Board of Registration for Professional Engineers and Land Surveyors

Policy Resolution: #96-10

Approved Date: October 18, 1996

Revision Date: February 28, 1997

POLICY RESOLUTION #96-10 REGARDING FIELDS OF EXPERTISE FOR GEOLOGISTS AND CIVIL ENGINEERS

REPORT:

In February 1995, at the joint Civil and Geotechnical Technical Advisory Committee (TAC) meeting, TAC members determined that an update of the Fields of Expertise document was needed. The document was developed in conjunction with the Geology Board and adopted by both boards in March 1989. The TAC members felt that the document should include additional new and developing areas of practice.

Representatives of the Geotechnical TAC have met three times with representatives of the Geology Board to revise the document. The preamble was developed by Gary Duke, the DCA attorney for both boards.The Civil and Geotechnical TAC members have recommended Board approval at the September 25, 1996, TAC meeting. Approval by the Geology Board is expected at the December 1996 meeting of the Geology Board.

After Policy Resolution #96-10 was adopted on October 18, 1996, the Geology Board met and has recommended the following revision: "Ground motion: Deterministic and probabilistic analysis" be added under the Both column in the *Earthquakes and Ground Vibrations* section.

PROPOSED MOTION:

That the revised "Fields of Expertise" document be adopted as attached.

MOTION:

The Board of Registration for Professional Engineers and Land Surveyors approved the attached revised "Fields of Expertise" for Geologists and Civil Engineers as Policy Resolution #96-10, at the February 28, 1997, Board Meeting.

State of California Department of Consumer Affairs

BOARD OF REGISTRATION FOR
PROFESSIONAL ENGINEERS AND LAND SURVEYORS
2535 CAPITOL OAKS DRIVE, SUITE 300, SACRAMENTO, CA 95833-2926
MAILING ADDRESS: P. O. BOX 349002, SACRAMENTO, CA 95834-9002
TELEPHONE: (916) 263-2222 CALNET: 8-435-2222
FAX: (916) 263-2246 or (916) 263-2221

FIELDS OF EXPERTISE

This memorandum was prepared to assist the Board of Registration for Professional Engineers and Land Surveyors and the Board of Registration for Geologists and Geophysicists to clarify and differentiate between the responsibilities and duties of registered civil engineers and geologists. This document reviews the "gray" areas where civil engineering and geology overlap and lists activities that are normally performed by both professions. This document also identifies activities within the scope of professional practice of civil engineering and geology. As such, this memorandum is a statement of both respective boards' philosophy, intent, and general collective opinion.

The following tables may be used to assist either boards' staff when a dispute or complaint is filed, and can be used or modified depending on the circumstances. Individual professionals in each discipline should only practice in the field of expertise in which they are competent. This document does not refer to the practice of geophysics.

The terms qualitative and quantitative, as used in several places in the following table, should be understood in the following sense: Quantitative is defined as concerned with the measurement of phenomena; Qualitative is defined as the assessment of a phenomena without measurement.

These policies and guidelines are not intended to be rules or standards of application rigidly adhered to without discretion. Likewise, such policies are not intended to implement, interpret, or make specific the law enforced or administered by either board, and are not intended to govern either boards' procedures. The foregoing policies are merely recommendations which incorporate the collective opinion of both boards at a particular moment in time. Consequently, the foregoing guidelines are informational and are not regulations. The guidelines have no force of law and are not intended to set standards of practice. Language used has been carefully gleaned from mandatory requirements.

Registered Geologist	Both	Registered Civil Engineer
CLASSIFICATION AND PHYSICAL PROPERTIES		
Rock description and classification Origins of rock Source area	Visual soil description Wentworth - Unified soil classification system and testing	Testing of earth materials for physical properties
ROCK MECHANICS		
Description Rock structure, e.g. joints, faults, fractures, bedding Qualitative performance of rock masses	In-situ testing Regional-Local	Quantitative performance of rock masses, e.g. rock testing, stress distribution and rebound evaluation
SOIL AND ROCK MAPPING		
Geologic mapping Geomorphology Subsurface geology Stratigraphy Air photo geologic interpretations	Geometric relationships Soil type mapping	Photogrammetric interpretations
SLOPE STABILITY		
Interpretative stability of rock cut slopes Geologic and geomorphic analyses Spacial relationship	Excavation in hilly terrain Causative agents Natural slopes	Quantitative slope design and analysis utilizing material properties, hydrostatic forces and configuration

Attachment, Policy Resolution 9610, Page 1

Registered Geologist	Both	Registered Civil Engineer
PROJECT PLANNING		
Development of geologic parameters Geologic feasibility	Evaluation of effects of geologic conditions on proposed projects	Engineering of effects of subsurface conditions on proposed project Economic studies
SURFACE WATERS		
	Stream description Silting potential Erosion potential Source of base flow Sedimentary processes Source of material	Volume and rate of runoff Design of works for control Coastal and river engineering Hydrology
GROUNDWATER		
Hydrogeology Geologic structural controls	Occurrence Direction of movement Drainage Mathematical treatment of well systems Well design Well Monitoring Subsidence Development concepts Field permeability;Transmissivity Underflow studies Specific yield Regulation of supply Storage computation Water quality Characteristics of water-bearing and non-water bearing materials Dewatering systems	Engineering hydrology Filter Design Economic considerations Laboratory permeability
EARTHQUAKES AND GROUND VIBRATIONS		
Location of faults Evaluation of potential fault activity Qualitative ground vibration analysis Seiches and tsunamis Qualitative evaluation of lateral spreading and liquefaction	Seismicity Historic record of earthquakes Ground Motion: Deterministic and probabilistic analysis	Ground response to seismic activity Seismic design criteria for structures Laboratory soil dynamics tests Quantitative ground vibration analysis Liquefaction mitigation Quantitative evaluation of lateral spreading and liquefaction
SUBSURFACE EXPLORATION		
Down-hole observations for structure geometry Fault trenching	Planning Supervision Observation Logging of borings or trenches Sampling In-situ testing	

Registered Geologist	Both	Registered Civil Engineer
CONSTRUCTION OBSERVATION		
Rock grouting	Chemical grouting Excavation in rock material Tunnel construction Remediation of contaminated sites Conduits Foundation conditions site grading and excavations	Pavements Earthwork compaction Soil grouting
EXPANSIVE MATERIALS		
Qualitative evaluation of expansion potential	Visual identification Geochemical effects Expansive Bedrock	Lab testing Quantitative evaluation of expansion potential Design of mitigation
REGULATORY REQUIREMENTS		
Provide geology input as required		Provide engineering analysis as required
EMBANKMENT FILL		
	Visual classification Evaluation of borrow sites Seepage control measures Removal of unsuitable material	Design and construction Quality Specifications Evaluation of potential deformations Evaluation of stability and foundation Evaluation of borrow material
INTERPRETATION AND INSTALLATION OF INSTRUMENTATION		
	Vadose zone monitoring Water level recorders Slope inclinometers Rock stress and deformation devices Piezometers and observation wells Settlement movements Seismometers and accelerometers Water quality monitoring Tiltmeters Stream gages Meteorology stations	Pore water pressure monitoring Soil pressure devices Pile load testing Vibration monitoring and analysis Tensioning tie-backs
GEOSYNTHETICS		
	Field welding Installation Filtering properties	Interpretation of strength Liner design Flexible pavement design Soil reinforcement design

Registered Geologist	Both	Registered Civil Engineer
GROUND AND WATER CONTAMINATION		
	Well logging Water observations Well design, installation, analysis and abandonment Toxic pits Toxic fluid monitoring Underground tanks Solid waste disposal sites Waste discharge to land Site characterizations Plume characteristics Broad studies encompassing planning, coordination of disciplines including professional engineers, analysis and findings, preparation of conclusions and recommendations	Design of site characterization studies Design of remediation systems
SOLID WASTE FACILITIES		
Aquifer characterization Faulting Fault age dating Landslide geometry Geology reports required by regulation	Pump testing Flow nets Water sampling Contaminant transport Air sparging Filters Water budget Deterministic and probabilistic analysis	Construction Quality Assurance (CQA) plan and administration Drainage design Plans and specifications Slope stability analysis Leachate and gas collection design Contaminate design Engineering reports required by regulation

AREAS OF JOINT PRACTICE

Site Selections
Planning investigations
Conducting field exploration
Selecting samples for testing
Interpreting data
Describing and explaining site conditions
Input to Urban Planning
Input to environmental studies

STATE OF COLORADO

COLORADO GEOLOGICAL SURVEY
Division of Minerals and Geology

Department of Natural Resources
1313 Sherman Street, Room 715
Denver, Colorado 80203
Phone (303) 866-2611
FAX (303) 866-2461

DEPARTMENT OF NATURAL RESOURCES

February 20, 1998

Angeline C. Kinnaird, Program Administrator
State of Colorado Board of Registration for
Professional Engineers and Professional Land Surveyors
1560 Broadway, Suite 1370
Denver, CO 80202

Re: **Review of "Fields of Expertise" and "Professional Environmental Scientist" Documents**

Dear Ms. Kinnaird:

At your request (Attachment 1), I have reviewed two documents for the PEPLS Board of Registration on behalf of my agency, the Colorado Geological Survey (CGS). The documents include:

1) A memorandum, "*Fields of Expertise*," from the California Board of Registration for Professional Engineers and Land Surveyors, that contains a listing of duties unique to, and those shared by professional geologists and engineers.

2) A manual, "*Consultant Registration Program*," from the Colorado Storage Tank Fund, which would allow geologists, engineers, and other professionals to register as a "*Professional Environmental Scientist*."

In addition to our review, and with your permission, I forwarded your request to other professional geological organizations in Colorado for review and comment (Attachments 2 and 3). These organizations include the American Institute of Professional Geologists (AIPG), Colorado Section; Association of Engineering Geologists (AEG), Colorado Section; and the Colorado Ground Water Association (CGWA). We have received several responses from officers and members of these organizations; their responses are attached.

Review of California "*Fields of Expertise*" Document

The "*Fields of Expertise*" document offers a listing of responsibilities and duties that are performed exclusively by Registered Geologists and by Registered Civil Engineers, and those responsibilities and duties that are typically shared by both professions. The version of the document being considered by the Colorado PEPLS board is one that has been adopted by an equivalent registration board in California (BORPELS). There is controversy surrounding the document and its proposed use(s). The California Board of Registration for Geologists and Geophysicists (BRGG) voted in October 1997 not to adopt the document "...because of confusion and misunderstandings regarding its intended use" (Attachment 4).

The "Fields of Expertise" document was created in 1973, with input from both of the California boards of registration (BRGG and BORPELS). It was intended to be a *guidance document*, and has served as an *internal tool* to establish the jurisdictional responsibilities between the boards. The two boards conducted additional reviews of the document in 1989 and 1996; however, they could not come to a complete agreement on the contents. Both boards adopted different versions of the document for internal use. Controversy arose when the California BORPELS adopted its version of the "*Fields of Expertise*" document as its policy. By exceeding the original intent of the document to include policy (force of law), the California BORPELS has caused harm to the professional geological community. The controversy centers on the following points:

1. There is disagreement between the boards about the classification of certain tasks listed in the document, some of which may be improperly classified.
2. The BORPELS' version of the document gives the erroneous impression that only engineers are allowed to perform quantitative measurements.
3. Geologists' activities have been curtailed or constrained by third-party groups, such as public agencies, insurance companies, and other private organizations, as a result of the limited activities "allowed" by the policy.
4. There are additional sub-professions (e.g., Engineering Geologist, Geological Engineer, and Geotechnical Engineer) that are not considered in this document. The distinction between tasks and qualified practitioners becomes even more blurred if these sub-professions are considered.

Geologists in Colorado have long been aware of the California "*Fields of Expertise*" document. Our agency published guidelines and criteria for the identification and mitigation of geologic hazards as required by Colorado's (then-new) land-use laws in CGS Special Publication 6 (Rogers and others, 1974). SP-6 referred to a published discussion of the "*Fields of Expertise*" document as part of a section entitled "*Qualifications of investigators*" (Attachment 5).

The topic of qualification and fields of expertise is of great interest and concern to Colorado geologists. There is no registration board for geologists in Colorado; however, the practice of geology is defined and accounted for under State law. Geological investigations and reports are required as part of subdivision regulations (Senate Bill 35, 1972; C.R.S. 30-28-133(3)(b)) and geological-hazard regulations (House Bill 1041, 1974; C.R.S. 24-65.1-101 et seq.). House Bill 1574, 1973 (C.R.S. 34-1-201 et seq.) specifies qualifications for the profession, "Professional Geologist," and for authors and/or reviewers of reports containing geologic information (see Attachment 5). Under State law, Professional Geologists are responsible for geologic investigations and for preparing and/or approving reports that contain geological data and/or information.

As a state agency, the CGS conducts technical reviews of geologic-suitability reports under the provisions of Colorado subdivision laws (Senate Bill 35, 1972; C.R.S. 30-28-(1)(i). We have no regulatory authority over this activity; our job is to provide technical guidance to county planning departments, to help them as they evaluate documents submitted by a developer and/or the developer's consultants. One of our present concerns is that many, if not most, of the "geologic" reports we receive for review are written and signed by Professional Engineers, apparently in violation of state law.

The Colorado Geological Survey is concerned about the intent and proposed use(s) of the California "*Fields of Expertise*" document (BORPELS version) in Colorado. Officers and members of professional

geological organizations in the state share this concern (Attachments 6, 7, and 8). We agree with the California BRGG that the document is inappropriate for use as a *policy* instrument. However, the document has a history of value as an internal set of guidelines. We feel that it also has value as a point of dialog between geologists and engineers. We would welcome the opportunity to work with the PEPLS board and representatives from professional geological and engineering organizations to identify and address points of concern with this document. We are available to work with the board on other issues that involve the practices of geology and engineering.

Review of "Professional Environmental Scientist" Document

At the time of your request, I was unfamiliar with the Colorado Petroleum Storage Tank Fund (CPSTF) program, or with its concept of "*Professional Environmental Scientist.*" After reading the document, my impression is that the concept, duties, and limitations of a "*Professional Environmental Scientist*" are not clearly defined. The term "registration" does not appear to have the same meaning for the CPSTF program as it does for professional registration of engineers or geologists. I would suggest that the title "*Professional Environmental Scientist*" should be replaced by a number of titles that describe the applicant's professional standing, such as "Professional Environmental Engineer," "Professional Environmental Geologists," etc.

I have forwarded for this document to Jeffrey Hynes, Senior Engineering Geologist, who will provide another response for our agency under separate cover. Jeff is the CGS point-of-contact for environmental issues, and has particular experience with hazardous material and underground storage tank issues. His review response should reach your office during the week of February 22-27. Also, I have attached a response from AIPG concerning the "*Professional Environmental Scientist*" document (Attachment 9).

Thank you for allowing the Colorado Geological Survey and representatives from professional geological organizations to review these two documents for you. I hope that these comments are of value to the PEPLS board. Please call me if the CGS can be of continued assistance to you regarding issues that affect the geology and engineering professions.

Sincerely,

David C. Noe
Professional Geologist

Attachments:

1. Request for review of documents from Angeline Kinnaird, PEPLS Program Director, 11/24/97
2. Request for review of documents from David Noe, CGS, to geological organizations, 1/22/98
3. Names and addresses of geological-organization and agency reviewers
4. California Board of Registration for Geologists and Geophysicists Information Bulletin 98-01 (excerpt)
5. "Qualifications of investigators," from CGS Special Publication 6 (excerpt)
6. Review letter from William H. Bellis, President, Colorado Section, AIPG
7. Review letter from Gary C. Mitchell, Legislative Affairs, Colorado Section, AIPG
8. Review letter from William Gallant, California Registered Geologist
9. Review letter from William H. Bellis, President, Colorado Section, AIPG

STATE OF COLORADO

STATE BOARD OF REGISTRATION FOR PROFESSIONAL ENGINEERS AND PROFESSIONAL LAND SURVEYORS
Angeline C. Kinnaird
Program Administrator
1560 Broadway, Suite 1370
Denver, CO 80202
Phone (303) 894-7788, FAX (303) 894-7790

Department of Regulatory Agencies
Joseph A. Garcia
Executive Director

Division of Registration
Bruce M. Douglas, Director

Roy Romer
Governor

MEMORANDUM

TO: **David C. Noe, Professional Geologist, Colorado Geological Survey**
William H. Bellis, CPG, President, Colorado Section, AIPG
Mark Hamouz, PE, Chair, Business Practices, Consulting Engineers of Colorado
John R. Clark, PE, President, ASCE
Dennis M. Whitney, PE, President, PEC
John Himmelreich, Association of Engineering Geologists

FROM: **Angie Kinnaird, Program Administrator, PE/PLS Board**

DATE: **March 19, 1998**

RE: **Geology versus Engineering and Colorado Petroleum Storage Tank Fund Consuitant Registration Program**

At their March 13, 1998 meeting, the Board of Registration for Professional Engineers and Professional Land Surveyors reviewed the feedback received from many of you interested in the above-referenced issues. The Board wishes to thank you for providing this input.

Concerning the issue of geology versus engineering and where the two fields overlap and diverge, the Board believes that a consensus among the interested professional associations is essential for the Board to appropriately enforce the Engineering Practice Act. To that end, the Board requests that the related groups embark on a discussion and attempt to clarify the gray area between the two professions. The Board also asks that you keep them informed as to your activity in this effort.

With regard to the Colorado Petroleum Storage Tank Fund Consultant Registration Program, the Board is sending a letter to the State Inspector of Oils, Richard Piper, to further define its concerns and recommendations. Your comments are attached for his review. It is the Board's hope that we will be able to come to resolution on this matter in the near future.

I have limited the distribution of this memo for logistical reasons but please pass this information on to those who may be interested. Please call me if you have any questions at 303/894-7784.

Attachments
Cc: Sandy Donnel, CECC
Roberta Bourne, PEC
h:\eng\bdcorres\9803mtg\geomemo

APPENDIX 7

Professional Practice Materials:

a. Mission and Aims of the AEG.

b. *Aims and Goals* (RM AEG 1997)

c. *Summary of Some Key Laws Related to Geology and Land Use in Colorado*, (AEG LRA 1997)

d. *Why Geologists?*, brochure, (ASBOG 1997).

e. *Tasks of a Licensed Professional Geologist*, brochure, (ASBOG 1997).

f. Professional Organization Addresses

MISSION AND AIMS OF THE ASSOCIATION OF ENGINEERING GEOLOGISTS

The mission of AEG is to provide leadership in the development and application of geologic principles and knowledge to serve engineering, environmental, and public needs.

The aims of the Association are to advance Engineering Geology and to:

promote public safety and welfare;
promote public understanding and acceptance of the field of Engineering Geology;
establish and maintain high documents and professional standards;
monitor legal or other developments that would affect the profession of Engineering Geology, to provide information on their potential effect, and to provide an organization for concerted action when desired;
provide for discussion of subjects and problems within the field of interest of the Engineering Geology profession;
provide a medium for distribution of information and technical papers of interest to engineering geologists; and,
encourage all qualified individuals and organizations interested in furthering the field of Engineering Geology to apply for membership.

ENGINEERING GEOLOGY

Engineering Geology is geologic work that is relevant to engineering, environmental concerns, and the public health, safety, and welfare.

"Engineering Geology" is defined by the Association of Engineering Geologists as the discipline of applying geologic data, techniques, and principles to the study both of a) naturally occurring rock and soil materials, and surface and subsurface fluids, and b) the interaction of introduced materials and processes with the geologic environment, so that geologic factors affecting the planning, design, construction, operation, and maintenance of engineering structures (fixed works) and the development, protection, and remediation of ground-water resources, are adequately recognized, interpreted, and presented for use in engineering and related practice. The Engineering Geologist utilizes specialized geologic training and experience to provide quantitative geologic information and recommendations based on it, as well as judgmental recommendations.

In recent decades the scope of Engineering Geology practice has grown beyond its original close connection to civil engineering practice. Engineering Geologists now work with and for land-use planners, environmental specialists, architects, public policy makers, and property owners to provide geologic information on which they base decisions.

Some of the major activities of Engineering Geologists include the following:

1. The investigation of foundations for all types of major structures, such as dams, bridges, power plants, pumping plants, airports, large buildings, and towers;
2. The evaluation of geologic conditions along tunnel, pipeline, canal, railway, and highway routes;
3. The exploration and development of sources of rock, soil and sediment for use as construction material;
4. The investigation and development of surface and ground-water resources; ground-water basin management; protection and remediation of ground-water resources;
5. The evaluation of geologic hazards such as landslides, faults and earthquakes, radon, asbestos, subsidence, expansive and collapsible soils, expansive bedrock, cavernous rock, and liquefaction;
6. Evaluation of geologic conditions (including ground water) affecting residential, commercial, and industrial land use and development;
7. Construction geology, including slope stability, dewatering, subdrains, grouting considerations, and excavatability;
8. Safe disposal of waste to the Earth;
9. Engineering Geologists participate in land-use planning, environmental impact report research, mined land reclamation, timber harvest planning, and insurance and forensic investigations.

The Engineering Geologist, in cooperation with the civil engineer, bears an important share of the responsibility for the public health, safety, and welfare insofar as engineering works are affected by geologic factors. The engineering profession has distinctively and effectively met its responsibility to the public through state registration laws throughout the United States. The Association of Engineering Geologists has published a Suggested Geologists Practice Act to assist in achieving professional registration for geologists.

The Association of Engineering Geologists is devoted to developing a spirit of professional responsibility on the part of Engineering Geologists. Through the Association, attention is focused on Engineering Geology and its expanding role. The Association seeks to maintain high professional standards and enhance awareness of the responsibility of the Engineering Geologist to the public in general.

In the final analysis, Engineering Geology is people geology. Engineering Geology exists because people want to modify the geologic environment for their use and convenience, want to live in harmony with it, and occasionally manage to come into conflict with it. Helping people understand their geologic environment, accommodate themselves to it, and correct their geo-environmental mistakes, is what Engineering Geologists do.

ROCKY MOUNTAIN SECTION
ASSOCIATION OF ENGINEERING GEOLOGISTS
POST OFFICE BOX 280663 LAKEWOOD, COLORADO 80228-0663

LEGISLATIVE AND REGULATORY AFFAIRS COMMITTEE

AIMS AND GOALS

The aims of the Legislative and Regulatory Affairs (LRA) Committee are to monitor legal or other developments that would affect the profession of Engineering Geology, to provide information on their potential effect, to provide organization for concerted action when desired, and to provide a medium for distribution of information relative to the findings.

The goals of the LRA Committee are to provide Engineering Geologists with the background and knowledge of legal and other developments that affect the profession so that members can observe and comply with the requirements and intent of all applicable laws, codes, and regulations.

METHODS

1) Compile, review, and summarize existing state legislation related to the practice of Engineering Geology.

2) Compile, review, and summarize existing state rules, regulations and guidelines related to the practice of Engineering Geology.

3) Compile a list of counties and municipalities with existing local rules, regulations, or guidelines related to the practice of Engineering Geology. Provide information on where information can be obtained from those governmental agencies.

4) Establish a method to distribute the information developed by the LRA Committee (newsletter, homepage, e-mail, publication).

5) Compile a list of other professional and government organizations which may be of help to Engineering Geologists in legal and related matters.

6) Provide assistance to other professional organizations and government agencies in developing, reviewing, and providing recommendations on matters related to the LRA Committee.

7) Represent the Association of Engineering Geologists in Intersociety Committee meetings.

8) Advocate the profession of Engineering Geology through encouragement of the enforcement of legislation and regulations.

9) Compile and provide information about pending state and local legislation and its potential effects on issues related to Engineering Geology.

Prepared October 13, 1997

ROCKY MOUNTAIN SECTION
ASSOCIATION OF ENGINEERING GEOLOGISTS
POST OFFICE BOX 280663 LAKEWOOD, COLORADO 80228-0663

LEGISLATIVE AND REGULATORY AFFAIRS COMMITTEE

SUMMARY OF SOME KEY LAWS RELATED TO GEOLOGY AND LAND USE IN COLORADO

NOTE: This summary is provided for information purposes only. The reader is cautioned to refer to State Statutes for wording of the law and to rely on legal counsel for interpretations, advise, and opinions. This is not a complete list of the laws related to geology and/or land use.

1) Senate Bill 35 (1972): C.R.S. 30-28-101, et seq., is the major land subdivision legislation passed by the Colorado General Assembly. It is widely referred to as Senate Bill 35. It requires that all proposed developments of land in unincorporated areas, dividing property into two or more parcels shall be accompanied by reports on the geologic characteristics significantly affecting the proposed land use. The reports are to determine the impact of such characteristics on proposed subdivisions. The reports, plans, and other supporting documents for the proposed development shall be submitted to the Colorado Geological Survey for an evaluation of the geologic factors which would have a significant impact on the proposed use of the land.

   The law additionally requires 1) reports concerning streams, lakes, topography, and vegetation, 2) evaluations of potential radiation hazards, and 3) maps and tables concerning the suitability of types of soil in a proposed subdivision, 4) adequate evidence that a water supply that is sufficient in terms of quality, quantity, and dependability will be available to insure an adequate supply of water for the type of subdivision proposed, and 5) evidence of adequate sewage disposal conditions.

2) House Bill 1529 (1973): C.R.S. 34-1-301, et seq. is commonly know as the "Sand and Gravel Bill." It states that "After July 1, 1973, no board of county commissioners, governing body of any city and county, city, or town, or other governmental authority which has control over zoning shall, by zoning, rezoning, granting a variance, or other official action or inaction, permit the use of any area known to contain a commercial mineral deposit in a manner which would interfere with the present or future extraction of such a deposit by an extractor."

   The law applies to any county, or city and county, having a population of 65,000 inhabitants or more according to the latest federal decennial census. It also requires local government to adopt a master plan for the extraction of commercial mineral deposits.

3) House Bill 1041 (1974): C.R.S. 24-65.1-101, et seq. states that "Local Governments shall be encouraged to designate areas and activities of state interest and after such designation, shall administer such areas and activities of state interest and promulgate guidelines for the administration thereof." Included as items of state interest are geologic hazards including avalanches, landslides, rockfalls, mudflows, and debris fans, unstable or potentially unstable slopes, seismic effects, radioactivity, ground subsidence, and expansive soil and rocks. This statute legally defines natural hazards and geologic hazards.

   The law requires the Colorado Geological Survey to assist local governments in identifying, designating, and adopting guidelines for the administration of such areas of state interest. The law states that "In geologic hazard areas all development shall be engineered and administered in a manner that will minimize significant hazard to public health and safety or to property due to geologic hazards." Similarly, "Mineral resource areas. . . shall be protected and administered in such a manner as to permit the extraction and exploration of minerals therefrom unless extraction and exploration would cause significant danger to public health and safety."

4) House Bill 1034 (1974): C.R.S. 29-20-101, et seq. is known as the "Local Government Land Use Control Enabling Act of 1974." It specifically authorizes local government to oversee the use of land by "regulating development and activities in hazardous areas." This statute is perhaps the broadest statement of local government's authority to control development in geologically hazardous areas.

5) House Bill 1574 (1974): C.R.S. 34-1-201 and 202 requires that all geologic reports prepared for governmental review must be prepared by a professional geologist. A professional geologist is defined in this statute as an individual with at least 30 semester hours of geologic education and five years of experience as a geologist.

6) House Bill 1045 (1984): C.R.S. 22-32-124, et seq. Requires school districts to submit reports regarding geologic suitability for raw land purchases, new school plans, and improvements to existing schools to the CGS for review.

7) Senate Bill 13 (1984): C.R.S. 6-6.5-101, Soil and Hazard Analyses of Residential Construction - Disclosure to Purchaser - Requires the developer or builder of a new residence to provide the purchaser with a summary of soil and hazard analyses and the site recommendations. This should be done at least fourteen days prior to closing the sale. On those sites where significant potential for expansive soils is found, the builder must supply the buyer with a publication that addresses (a) problems associated with such soils; (b) building methods to address these problems; and © suggested care and maintenance. The CGS has re-written and published a popular swelling soils book for home buyers and homeowners that addresses items (a-c).

HOW DO THEY WORK TOGETHER?

Geologists interpret, engineers design and build. Geologists investigate earth materials and processes and advise how to compensate for those conditions to assure safety. Engineers take this information, and working with geologists, determine how to design and build safe structures.

WHAT WILL IT COST THE TAXPAYERS?

Nothing. Registration is typically self-funded by fees paid by the registrants

WHO SERVES ON REGISTRATION BOARDS?

Ordinarily, these boards are composed of representatives from the profession and the public. The board members are appointed by state governors with the advice and consent of the legislatures.

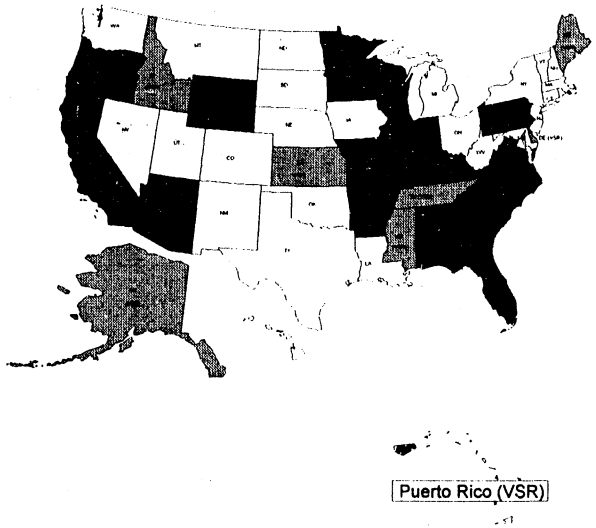
DO ANY STATES REGISTER GEOLOGISTS?

Yes. Twenty-seven states now have registration or certification laws: Alabama, Alaska, Arizona, Arkansas, California, Delaware, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky, Maine, Minnesota, Mississippi, Missouri, North Carolina, Oregon, Pennsylvania, South Carolina, Tennessee, Virginia, Wisconsin, and Wyoming. Puerto Rico has also passed a registration law. The following states are actively pursuing registration laws: Maryland, Nebraska, Ohio, Oklahoma, Texas, Utah, and Washington.

Print date: November 10, 1997

United States (AK, HI, & PR Inset)
ASBOG Member Status

Member Board Regulatory (MBR)	(18)
Visitor State Regulatory (VSR)	(8)
Visitor State Non-Regulatory (NVSR)	(25)



ASBOG

National Association Of State Boards Of Geology

WHY GEOLOGISTS?

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GEOLOGY AS A PROFESSION

Geologists make use of their special knowledge for the benefit of others. No profession affects the public more than geology. "Civilization exists by geological consent, subject to change without notice." a popular quotation with much merit.

WHY REGISTER GEOLOGISTS?

The application of geologic principles and the development of geologic data are integral parts of many actions involving public health, safety, and welfare. Professional geologists working with others can determine and apply sound geologic procedures that will serve to avoid endangerment of the public or the environment.

HOW WILL THE PUBLIC BE PROTECTED?

First, no one may be represented as a geologist unless duly registered. Second, registration boards are typically endowed with the authority to monitor and enforce the registration law.

WHO CAN BECOME REGISTERED AS A GEOLOGIST?

While it will vary from state to state, typically individuals who have a college degree in geology or a closely related field and five years of geological work experience can qualify for registration. In most stages, an examination is also required to demonstrate minium competence in both the fundamentals and the practice of geology.

MORE SPECIFICS PLEASE

Registration would help assure that qualified reputable individuals are providing accurate geologic information to the public in such areas as:

- *geologic mapping*
- *groundwater resource and development protection*
- *mineral resource evaluation*
- *oil and gas development*
- *safe oil, gas, water, or mineral drilling*
- *accurate and reliable information to government agencies for public use*
- *environmental geology issues*
- *land surface stability*
- *sanitary landfill siting*
- *toxic, nuclear, and hazardous waste disposal siting*
- *contaminated soil and groundwater investigations*
- *mined-land reclamation*
- *acid mine drainage*
- *dam and impoundment construction*
- *highway construction*

GEOLOGY SOUNDS A LOT LIKE ENGINEERING. WHAT'S THE DIFFERENCE?

Geologist are trained to consider the entire physical environment, the materials that compose it, and the dynamic processes that drive it.

Engineers are more concerned with facility design including material and structural properties, construction considerations and safety factors.

Geologists and engineers generally work together making sure that all natural and man-made influences are considered in a project.

WHY DON'T GEOLOGISTS REGISTER AS ENGINEERS?

Geologists have education and professional experience that is specifically directed toward investigating the earthen materials that affect the public.

No other profession has similar education and professional experience.

WHY NOT HIRE ENGINEERS TO CERTIFY GEOLOGISTS' WORK?

For public protection, persons can only certify work for which they were trained in the fundamental geologic principles and have the necessary experience. Geologists are trained and have experience in geologic interpretation of earthen materials; engineers are trained and have experience in designing and building. These are two distinctively different professions. However, because of the close relations between those who interpret and those who design and build, geologists and engineers must work together and in a supportive fashion.

CAN AN ENGINEER REGISTER AS A GEOLOGIST?

Yes, if qualified as a geologist.

The response from professional geologists to the questionnaire was outstanding, resulting in the representation of the practice in 48 of the 50 states. The statistical uniformity of the profession across the United States is remarkable with a correlation coefficient in excess of 95 percent. This national task analysis demonstrates that the professional practice of geology is very similar regardless of the geographic location of the practitioner. This similarity in the professional practice of geology makes it possible for ASBOG to develop and administer the nationwide examinations.

The task analysis forms the basis for ASBOG's fundamental and practice examinations required by some states for licensure as a professional geologist. The results of the task analysis were used to determine the percentage of time spent, and significance of, each task performed by a licensed geologist. This information was then used to design the examinations. Tasks were evaluated to determine what percentage of time the "national average licensed geologist" spends performing a specific task within each task domain. These data were then combined to determine the percentage of each examination that would include questions from each domain. The results of this analysis for the Fundamentals of Geology Examination are shown below:

Task Domains	Percent Time
Research, Field Methods, Communication	37
Mineralogy	3
Petrography/Petrology	8
Stratigraphy & Historical Geology	11
Structural Geology	12
Geochemistry	1
Paleontology	2
Geophysics	2
Geomorphology	4
Hydrogeology	12
Engineering Geology	4
Mining Geology	2
Petroleum Geology	2

ASBOG

Provided as a public education service by:
The Committee on Academic Relations
February 1997

National Association of State Boards of Geology
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ASBOG

TASKS OF A LICENSED PROFESSIONAL GEOLOGIST

or

What Should a Candidate Know Before Taking the ASBOG Examination for Licensure as a Professional Geologist?

The National Association of State Boards of Geology (ASBOG) is an organization of state boards who are working together to develop, design and administer national examinations for the licensure of professional geologists. The Fundamentals of Geology Examination assumes that the candidate has a four-year degree in geology with limited field or professional experience. As part of the development of the examination, ASBOG recently completed a nationwide survey of licensed geologists to determine the tasks that are performed by entry level professionals. The list of tasks shown on the inside of this sheet has been provided as a guide to the candidate and the academic community in preparing for ASBOG licensure examinations.

Tasks Carried Out by Licensed Professional Geologists

Research, Field Methods and Communications
- Evaluate property/mineral rights
- Interpret regulatory constraints
- Identify, locate and utilize available data sources
- Plan and conduct field operations
- Construct borehole and trench logs
- Design and conduct laboratory programs and interpret results
- Develop and utilize Quality Assurance/Quality Control procedures
- Construct and interpret maps and other graphical presentations
- Write and edit geologic reports
- Interpret and analyze aerial photos/imagery
- Design and interpret data from geologic monitoring programs
- Read and interpret topographic and bathymetric maps

Mineralogy
- Identify minerals and their characteristics
- Identify mineral assemblages
- Determine probable genesis and sequence of mineral assemblages
- Identify minerals on the basis of chemical composition
- Predict subsurface mineral characteristics on the basis of exposures and drillholes

Petrography/Petrology
- Identify and classify major rock types
- Determine physical properties of rocks
- Determine chemical properties of rocks
- Determine types and/or degrees of rock alteration
- Determine suites of rock types

Geochemistry
- Establish analytical objectives and approaches
- Evaluate geochemical data
- Construct models based on results of geochemical analyses
- Make recommendations based upon results of geochemical analyses

Stratigraphy/Historical Geology
- Identify rock sequences
- Establish relative position of rock units
- Determine relative and absolute ages of rocks
- Interpret depositional environments
- Perform facies analyses
- Correlate rock units
- Interpret geologic history
- Establish stratigraphic classifications

Structural Geology
- Identify structural features and their interrelationships
- Select features for structural analyses
- Determine orientation of structural features
- Perform qualitative and quantitative structural analyses
- Map structural features
- Correlate separated structural features
- Interpret structural features
- Interpret tectonic history

Paleontology
- Identify applicable type of paleontological investigation
- Estimate relative geologic ages of rocks
- Identify fossils
- Correlate rocks biostratigraphically
- Identify fossil assemblages and make paleontological interpretations

Geomorphology
- Identify landforms
- Determine methods of geomorphic investigation
- Perform geomorphic field investigations
- Determine geomorphic processes and development of landforms and soils
- Interpret geomorphic field data
- Determine age relationships of landforms and soils
- Identify potential hazardous geomorphological conditions

Geophysics
- Select methods of geophysical investigations
- Perform geophysical investigations in the field
- Perform geological interpretation of geophysical data
- Identify potentially hazardous geological conditions by using geophysical techniques

Hydrogeology
- Design and interpret data from hydrologic testing programs
- Utilize chemical data to evaluate hydrogeologic conditions
- Apply geophysical methods to analyze hydrogeologic conditions
- Determine physical and chemical properties of aquifers and vadose zones
- Determine groundwater flow systems
- Evaluate groundwater resources
- Evaluate groundwater quality
- Design wells and drilling programs
- Develop groundwater resources management programs
- Plan and evaluate remedial action programs

Engineering Geology
- Provide geological information and interpretations for engineering design
- Identify and evaluate potential seismic and other geologic hazards
- Provide geological consultation during and after construction
- Develop and interpret engineering geology maps and sections
- Evaluate materials resources
- Define and establish site election and evaluation criteria
- Design and implement field and laboratory programs
- Describe and sample soils for geologic analyses and material properties testing

Mining Geology
- Formulate exploration programs
- Implement field investigations on prospects
- Perform geologic interpretations for mineral reserves
- Perform economic analyses/appraisals
- Provide geologic interpretations for mine development and production activities
- Provide geologic interpretations for mine abandonments/closures/restorations

Petroleum Geology
- Formulate exploration programs
- Implement field investigations on prospects
- Perform geologic interpretations of physical properties and hydrocarbon reserves
- Perform petroleum economic analyses/appraisals
- Provide geologic interpretations for petroleum development and production activities
- Provide geologic interpretations for abandonments/closures/restorations

PROFESSIONAL ORGANIZATION ADDRESSES

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Fax: (703) 379-7563

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Web: http://geoweb.tamu.edu/aeg/

Association of Engineering Geologists (RMS)
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Colorado Association of Geotechnical Engineers
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Rocky Mountain Association of Geologists
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Fax: (303) 628-0546
Homepage: www.rmag.org

APPENDIX 8

Selected Colorado Geological Survey Materials

a. *Overview of Geologic Hazards and Land-Use Reviews in Local Planning Decisions,* David C. Noe, (CGS 1997). (Includes PEPLS Policy Statement 15, 1995).

b. *Solving Land-Use Problems* (CGS).

c. *Nature's Building Codes: Geology and Construction in Colorado*, David C. Shelton and Dick Prouty, (CGS SP 12 1979) (Selected portions).

Overview of Geologic Hazards and Land-Use Reviews in Local Planning Decisions

David C. Noe, Colorado Geological Survey

The purpose of this paper is to give an overview of natural and geologic hazards, as legally defined in Colorado, and to describe the role of the Colorado Geological Survey (CGS) in conducting land-use reviews and assisting local governments in making land-use decisions. This abstract discusses the purpose of the CGS with respect to land use activities; defines natural and geologic hazards; describes subdivider reporting responsibilities and the CGS review process in relationship with pertinent state statutes and local regulations; and lists resources on the topics of geologic hazards and land-use considerations.

The Colorado Geological Survey

The Colorado Geological Survey (CGS) was created in 1967, as an agency within the Department of Natural Resources. The CGS enabling act, House Bill 1282 (1973)[1], sets forth the following general purposes for the agency with regard to land-use activities:

(1) assist, consult with, and advise existing state and local governmental agencies on geologic problems; and

(2) determine areas of natural geologic hazards that could affect the safety of or (cause) economic loss to the citizens of Colorado

In addition, the CGS is charged with conducting studies, collecting geologic information, and publishing maps, reports, and bulletins when necessary to achieve these purposes.

Natural Hazards and Geologic Hazards

Natural hazards and geologic hazards are legally defined in House Bill 1041 (1974)[2]. Natural hazards consist of *geologic hazards, wildfire hazards, and floods*. The natural hazards named and defined in this statute are: avalanche; corrosive soil; debris-fan floodplain; dry wash channel and dry wash floodplain; expansive soil and rock; floodplain; ground subsidence; mudflow; radioactivity; seismic effects; siltation; unstable or potentially unstable slope; and wildfire.

A geological hazard is defined as "a geologic phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property." The term includes, but is not limited to: avalanches; landslides; rock falls; mudflows; unstable or potentially unstable slopes; seismic effects; radioactivity; and ground subsidence.

There are several geologic phenomena that qualify as geologic hazards that are not named as such in the statute. These include: debris flows; expansive soils; heaving bedrock; corrosive soils; erodible soils and rock; and coal-bed methane seeps.

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[1] C.R.S. 34-1-101, et seq., Colorado Geological Survey.

[2] C.R.S. 24-65.1-101, et seq., Areas and Activities of State Interest.

Geologic Land-Use Report Submittals

Several state statutes and/or state agency regulations specify requirements for the submission of geologic suitability reports in conjunction with land-use applications. Other statutes address the manner in which geologic hazards are to be addressed and disclosure of hazards and/or soil conditions to new home buyers. These are summarized as follows:

Senate Bill 35 (1972)[3] requires subdividers to submit reports concerning geologic characteristics, potential radiation hazards, soil suitability, storm drainage plans, on-lot sewage disposal, and any soil or topographic conditions that present hazards or require special precautions. Areas of a proposed subdivision where such relevant site characteristics exist must be identified by the subdivider, and the proposed uses of those areas should be shown to be compatible with such conditions. SB 35 directs county planning agencies to refer a copy of the preliminary plan submittal to the CGS for review.

House Bill 1045 (1984)[4] requires school districts to submit reports regarding geologic suitability for raw land purchases, new school plans, and improvements to existing schools to the CGS for review.

The Colorado Department of Public Health and Environment, Water Quality Division (CDPHE-WQD) requires applicants for new or replacement water treatment facilities having 2,000 gpd or greater capacity to submit geologic suitability reports. Such reports are referred to the CGS for review.

For areas designated by counties as geological hazard areas under HB 1041, the statute requires that all developments shall be engineered and administered in a manner that will minimize significant hazards to public heath and safety or to property. Local government agencies are instructed to administer such areas in a manner which is consistent with model guidelines for land use in each of the natural hazard areas. The model guidelines for geologic-hazard areas were published by the CGS in 1974[5].

Senate Bill 13 (1984)[6] requires the developer or builder of a new residence to provide the purchaser with a summary of soil and hazard analyses and the site recommendations. This should be done at least fourteen days prior to closing the sale. On those sites where significant potential for expansive soils is found, the builder must supply the buyer with a publication that addresses (a) problems associated with such soils; (b) building methods to address these problems; and (c) suggested care and maintenance. The CGS has re-written and published a popular swelling soils book for homebuyers and homeowners that addresses items (a-c)[7].

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[3] C.R.S. 30-28-101, et seq., County Planning and Building Codes.

[4] C.R.S. 22-32-124, et seq., Building Codes - Zoning - Planning.

[5] CGS Special Publication 6. See listing in "Resources" section.

[6] C.R.S. 6-6.5-101, Soil and Hazard Analyses of Residential Construction.

[7] CGS Special Publication 43, which replaced Special Publications 11 and 14 in 1997. See listing in "Resources" section.

House Bill 1574 (1973)[8] states the following requirements for geologic-report writers:

> Any report required by law or by rule or regulation, and prepared as a result of or based on a geologic study or on geologic data, or which contains information relating to geology ...and which is to be presented to or is prepared for any state agency, political subdivision of the state, or recognized state or local board or commission, shall be prepared or approved by a professional geologist.

The statute defines a "professional geologist" as:

> ...a person who is a graduate of an institution of higher education which is accredited ..., with a minimum of thirty semester (forty-five quarter) hours of undergraduate or graduate work in a field of geology and whose post-baccalaureate training has been in the field of geology with a specific record of an additional five years of geological experience to include no more than two years of graduate work.

Geologic Land-Use Report Reviews

The CGS, under SB 35, is charged with evaluating geologic factors which would have a significant impact on the proposed use of the land for subdivision purposes by reviewing preliminary plat applications. The agency conducts a variety of special-use reviews and provides technical assistance to county and city governments, under HB 1041. Similarly, it reviews plans for schools and water treatment facilities, under HB 1045 and for the CDPHE-WQD. Subdivision (i.e., SB 35) reviews account for a majority of CGS review activities. The CGS is authorized, under HB 1572 (1983)[9], to establish and collect fees to recover direct costs of providing review services. A review period of twenty-one days is specified by SB 35.

For most cases, the CGS receives and reviews geologic-suitability reports (under various titles such as "geologic" or geotechnical"), drainage reports, and a plat map for proposed SB 35 subdivisions. A CGS engineering geologist visits the actual subdivision site and performs a reconnaissance in order to check the submitted information. The reviewer then writes a review letter to the local-government planning agency from which the submittal packet was sent. There are four basic levels of response: (1) the submitted findings and recommendations are completely adequate; (2) they are mostly adequate, and additional suggestions are given; (3) more information is needed because potentially serious geologic problems were not sufficiently recognized or addressed; or (4) the project is infeasible for geologic or technical reasons. The CGS reviews are advisory in nature, and are therefore non-binding. The local-government planning agency may choose to disregard the CGS review, although this is seldom the case.

Each site will have unique geologic conditions, and must therefore be investigated and reported accordingly. For preliminary plat-level reports, the geologic investigation should go beyond a simple reconnaissance; it should be a solid preliminary level investigation that addresses subsurface as well as surface conditions. The extent and depth of the subsequent CGS review is determined primarily by the complexity of the project and the severity of geologic constraints.

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[8] C.R.S. 34-1-201, et seq., Geology.

[9] C.R.S. 34-1-105, Colorado Geological Survey.

Model engineering geology report guidelines can be found in CGS Special Publication 12[10]. Such reports should describe all geologic conditions at the project site, identify and interpret correctly the impact of those conditions on the development as proposed, and make complete and reasonable recommendations regarding the mitigation of any adverse conditions and/or mineral-resource conflicts. In general, the geologic data and interpretations should be used to formulate a development plan that incorporates all impactive geologic conditions. The data and interpretations should not be used solely as a justification for the proposed development.

The geologic community has, through time, strayed from including statements of credit and qualification as part of a geologic-suitability report (i.e., who supervised the investigation, who did the field work, and the qualifications of those workers as professional geologists as defined in HB 1574). We at CGS suggest that all geologists should return to this practice to ensure the credibility of the engineering geology profession. In addition, a statement should be made that the report is in compliance with the appropriate state statute and local-government regulations, and those statutes/regulations should be specifically cited.

Resources

A variety of resources are available to the professional geologist and other practitioners who wish to learn more about geologic hazards and associated land-use planning.

State statutes and local regulations. Developers, geologists, and engineers should be familiar with the statutes and local land-use regulations that are applicable within the jurisdiction in which their projects are located. The statutes are found in the Colorado Revised Statutes. The local land-use regulations are available through county or city planning departments.

CGS publications. The CGS has published numerous books, reports, and maps that may be used in conjunction with land-use planning. The information contained within these publications ranges form general to site-specific in scope, and may address single or numerous topics. Some of the most useful CGS publications, with regard to land-use activities, are:

Special Publication 6 (1974), *Guidelines and criteria for identification and land-use controls of geologic hazard and mineral resource areas*, by W.P. Rogers and others. These are the model guidelines, created under HB 1041, for use by local governments in their land-use regulations. The book lists qualifications for professional geologists, engineering geologists, and professional engineers, as well as the responsibilities of geologists and engineers with respect to technical-report preparation.

Special Publication 12 (1979), *Nature's building codes -- Geology and construction in Colorado*, by D.C. Shelton and D. Prouty. This booklet describes and illustrates different natural hazards, and discusses numerous aspects of geology as related to land-use planning. Model engineering geology report guidelines are included.

[10] In Appendix E of that booklet. See listing in "Resources" section.

Special Publication 43 (1997), *A guide to swelling soils for Colorado homebuyers and homeowners*, by D.C. Noe and others. This book is geared toward satisfying the disclosure requirements for new-home buyers in accordance with SB 13. The book substantially updates and replaces two older CGS publications (Special Publications 11 and 14).

Free booklet, *Colorado Geological Survey -- Solving land-use problems*, by J.M. Soule and others.

A listing of other pertinent CGS publications is available at the conference.

1041 Maps. House Bill 1041 directed counties to create their own geologic-hazard maps to establish areas of state interest (natural hazard areas) and to serve as planning tools. The counties used the CGS and/or private-sector consulting geologists to produce the maps, which are basically reconnaissance-level studies. These maps should be regarded as being a starting point for any site-specific geologic-suitability investigation. A particular county's 1041 maps are available for inspection at the county planning department, as well as at the CGS.

Ground Subsidence Library. The CGS maintains a library of coal-mine and associated ground-subsidence hazard reports and maps for use by geologic and engineering consultants.

Professional descriptions. Engineering geologists and geotechnical engineers perform certain overlapping functions. Some practitioners qualify as both, but most are either a geologist or and engineer. The definition and typical scope-of-work of a professional engineering geologist is included in Attachment 1. The role of and limitations of engineering in designated natural hazard areas is given in Attachment 2.

ATTACHMENT 1: Definition of Engineering Geologist (Association of Engineering Geologists)

WHAT IS AN ENGINEERING GEOLOGIST?

An engineering geologist is a geologist with a thorough understanding of engineering principles who applies his scientific knowledge and experience to the works of man where the geologic environment affects their planning, location, feasibility, design, construction, operation, and maintenance. The engineering geologist uses geologic data, techniques and principles to apply judgment and experience responsibly to the study of rock, soil, and subsurface fluids to assure that the geologic parameters of these materials are recognized, interpreted, and presented for use in engineering or resource management practice. Basic training of engineering geologists includes geology, earth sciences, geological engineering, and geotechnical engineering. Typical duties involve:

the investigation, evaluation, and control of naturally occurring geologic hazards such as earthquakes, floods, landslides, etc

the investigation and evaluation of geologic conditions which affect structural works such as bridges, buildings, canals, dams, highways, pipelines, power plants, towers, tunnels, etc

the exploration and development of naturally occurring material for use as a resource by man such as construction aggregates, minerals, petroleum, etc

the investigation and evaluation of geologic conditions which affect the potential and occurring environmental hazards as related to land use and public safety

ATTACHMENT 2: Engineering in Designated Natural Hazard Areas (Colorado State Board of Registration for Professional Engineers)

Policy Statement 15 - Engineering in Designated Natural Hazard Areas

In areas designated as "Natural Hazards" in accordance with section 24-65.1-202 (2), C.R.S., engineers performing soils (geotechnical) investigations, construction observation, and design of structures including foundations, grading and drainage, buried utilities, streets and pavements, and remedial work to these improvements shall demonstrate knowledge and incorporate knowledge of and expertise in: 1) methods used to mitigate such hazards and, 2) investigation, design and construction guidelines adopted by local governments pursuant to their authority established in section 24-65.1-202 (2), C.R.S. It is the opinion of the Board that this policy statement should be implemented by the following guidelines:

1. Recognition and Mitigation of Natural Hazards

   Registrants should be thoroughly familiar with applicable natural hazard legislation (section 24-65.1-202 (2), C.R.S., etc.) and local government policies and regulations for the mitigation of effects of natural hazards. Local government policies and regulations may vary. It is the responsibility of each registrant to become familiar with the applicable policies and regulations. Local government policies and regulations, or lack thereof, concerning natural hazards do not relieve the registrant of sound engineering practice in the recognition and mitigation of natural hazards.

2. Multi-Disciplinary Approach

   Registrants should recognize and acknowledge that the mitigation of effects from natural hazards requires a multi-disciplinary approach encompassing the fields of engineering, geology, hydrology, architecture, and land-use planning. It is incumbent on the registrant that these fields are adequately represented in the mitigation of natural hazards through demonstrated knowledge and experience. In general, the Board believes that individual registrants are unlikely to possess the necessary knowledge and expertise to deal with all natural hazards in all cases.

3. Education

   Knowledge of natural hazards should be demonstrated by attendance at courses on natural hazards sponsored by the Colorado Geological Survey, universities, local government, or professional societies. Registrants should be prepared to demonstrate appropriate knowledge and expertise.

4. Disclosure

   Registrants should be open and forthright about the existence of natural hazards, risks to their clients and the public, methods of mitigation, and the chances of success in mitigation. This applies to all stages of the design process, from feasibility through final design and construction. Registrants should not knowingly take part in remedial work in natural hazard areas where the intent is to disguise either the hazards or existing damage.

(Adopted February 20, 1995)

COLORADO
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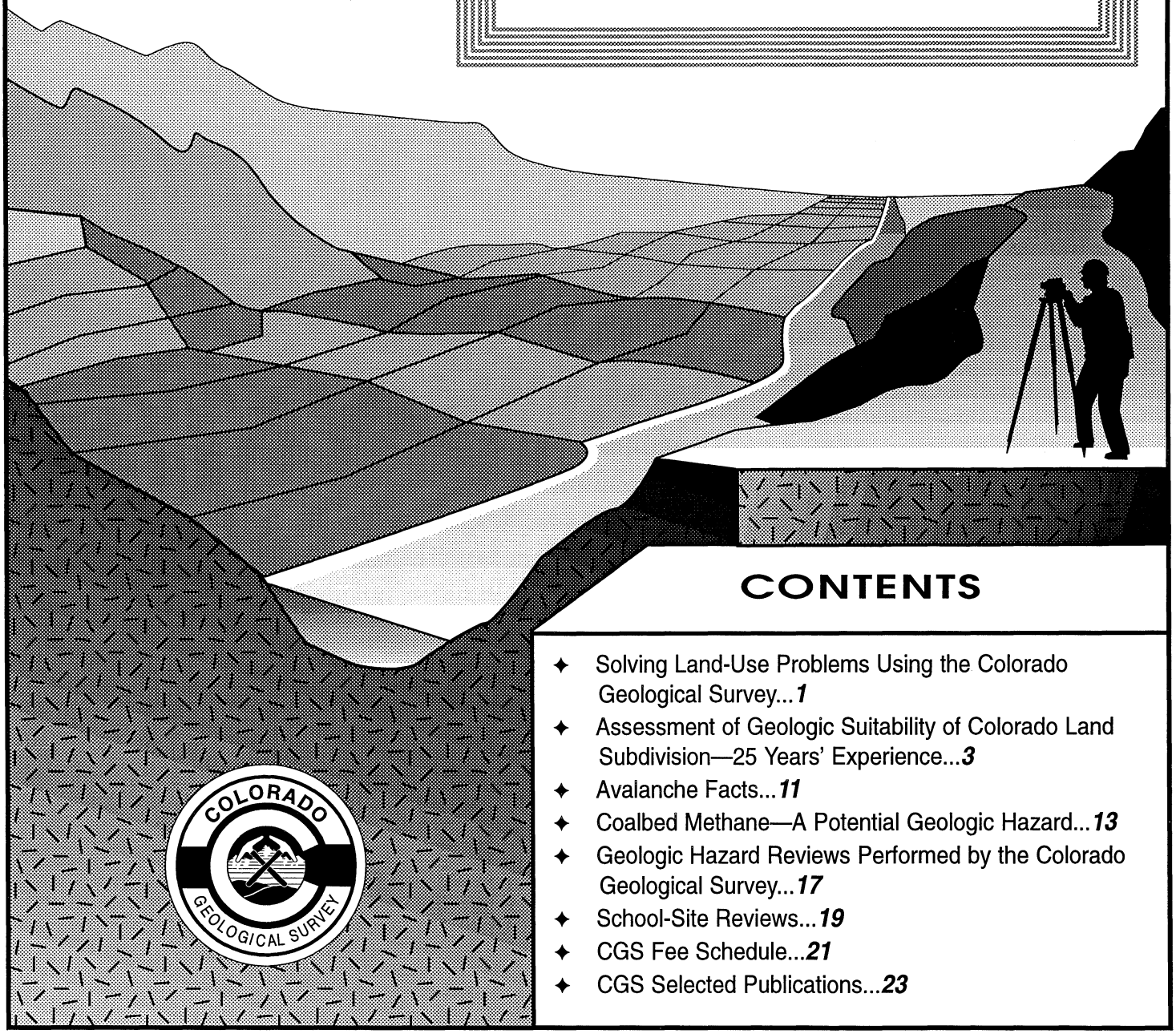
September 1998

COLORADO GEOLOGICAL SURVEY

Solving Land-Use Problems



CONTENTS

SOLVING LAND-USE PROBLEMS USING THE COLORADO GEOLOGICAL SURVEY

HISTORY AND EXPERIENCE

For over two decades, the Colorado Geological Survey (CGS) has assisted Colorado county governments with geologic-hazard problems and other geologic concerns related to proposed land-use changes. Initially, most of the cases were for residential subdivisions in unincorporated areas. Senate Bill 35 (1972) directs CGS to review and report on these to the Boards of County Commissioners through their planning departments. In recent years, this function has evolved into a wide range of land-use reviews and environmental studies. These services are also frequently provided, at their request, to municipalities and other entities.

HOUSING

Currently, the services that the CGS offers to Counties usually focus on county planners and, indirectly, building officials who have responsibility for the reasonable safety and feasibility of new housing construction. CGS services include geological and geotechnical reviews of site-investigation documents which are supplied by the developer for a proposed subdivision. The ultimate customers are elected officials who make the actual land-use decisions and policies. The topography, rocks, and soils of our State can present extremely difficult design and construction problems and if these are not considered adequately in planning, engineering, and construction, the citizen homeowner can eventually be presented with maintenance problems for his residence that are costly or even impossible to solve.

INFRASTRUCTURE

The serviceability of the public infrastructure can be drastically affected by adverse geologic conditions too. Road alignments and construction,water-supply and water-treatment facility siting and expansions, school-site acquisition and school-facility construction, (H.B. 1045, 1984) and landfill and mine locations are several of the kinds of cases with which the Survey has developed experience over many years.

Sometimes, such cases involve controversy and, by making objective investigations and realistic reviews for public officials, the decisions can be made using relevant geologic facts. This can be important to public confidence in local government even when an adversarial, fractious atmosphere is prevalent, as is frequently the case with gravel pits, mines, quarries, and landfills.

PLANNING

To improve land-use planning, the Survey can conduct topical studies of geologic conditions and processes. Examples of especially problematical and costly-to-mitigate geologic hazards are expansive, heaving, settling, and corrosive soils, rapid mass movements such as rockfalls and debris flows, and large-scale landslides in developing mountainous areas or critical transportation and utility corridors. Interpretive, intermediate- to large-scale geologic mapping and investigations of soils and bedrock, when appropriately formatted, can be used by planners and developers to identify potential geology-related problems early in the process.

The Survey has worked recently with Jefferson and Douglas Counties (see section below titled "Working With Counties. . .") to study soil-related problems which have cost homeowners and local governments millions of dollars. Other recent cases include ongoing studies of landslides at the Dowd's Junction infrastructure-complex corridor west of Vail, assistance to the City of Grand Junction with a subdivision area on a landslide immediately above the Colorado River, monitoring of the continuing debris-flow threats to the I-70 corridor from the 1994 Storm King Mountain burn area, and the Town of Vail with mitigation of severe rockfall hazards near Booth Creek.

ENVIRONMENT

With the advent of new State and Federal environmental laws and regulations, the Survey now works for the Colorado Department of

Transportation and other State agencies in site investigations and remediations of underground-storage-tank sites. The U.S. Forest Service is benefiting from the Survey's inventory and assessment of environmental and ground-water degradations and hazardous mine openings caused by past mining and other activities on lands under its jurisdiction.

GEOGRAPHIC INFORMATION SYSTEMS

One of the greatest challenges of land use planning is that of compiling and comparing all relevant information about an area and making an informed decision about how that area should be managed. This requires assembling a variety of dissimilar sets of information and synthesizing them into a usable form.

For the last ten years, CGS has utilized computer-based technologies to help Colorado governments resolve land-use issues which have geologic problems and concerns. More recently, Geographic Information System (GIS) technologies have become available which greatly enhance our ability to provide decision support to county and local governments on these issues. Also, CGS now manages a GIS library of digital geologic and geographic data which, when combined with county and local-government data sets, can be used to better understand the full range of factors affecting an area of concern. This GIS technology allows scientists, in partnership with government decision-makers, to integrate a wide variety of information into a unified form and helps to visualize various combinations of data to gain a better understanding of the potential impacts of land use decisions.

WORKING WITH COUNTIES: RECENT EXAMPLES OF CGS LAND-USE-PLANNING ASSISTANCE

A belt of land along the central Front Range foothills in Colorado is experiencing tremendous population growth, but has been beset with problems due to the post-construction development of a distinctive type of ground heave. The ground deformations assume the form of low, linear mounds and have caused millions of dollars in property damage to houses, commercial buildings, roadways and utility lines. Early attempts to solve the problem using conventional engineering technology were largely unsuccessful.

The Colorado Geological Survey has assumed a leading role in determining that this costly problem is clearly and fundamentally geologic and has undertaken steps to assist planning agencies in Jefferson and Douglas Counties to deal with the problem according to the particular needs of each county.

In Jefferson County, suburban growth in the affected area has occurred for nearly two decades and continues to this day. Based on the high demand for homes in this area, it is unlikely that actual growth will be discouraged. The CGS and Jefferson County have worked cooperatively to study the causes and areal extent of heaving ground at selected research sites in the County. County officials and staff have been informed of the presence, magnitude, and nature of the problem during a series of CGS-led field trips which visited impacted areas. Finally, CGS geologists chaired two subcommittees of the Jefferson County Expansive Soils Task Force in 1994. The Task Force delineated an overlay district of potentially heaving ground and developed a comprehensive set of amendments to the land-development regulations for explicitly recognizing and mitigating problem areas. The overlay-district map was created for the County in digital form by the CGS using a Geographic Information System (GIS) format which is fully compatible with its other existing GIS-mapping and planning functions.

Douglas County, in contrast, has seen only limited development within its Front Range foothills area. However, very costly damage has occurred there and the pressure to develop the area is extreme. The County is in an advantageous position to modify its long-range planning goals for this area because so much land remains unplatted. The CGS was contracted by Douglas County to delineate a geology-specific overlay district map (CGS Open File Report 95-5), again using a GIS digital format, and to consider recommendations for future prudent land use in the area of potentially heaving bedrock, including creative delineation of areas which may be considered for low-impact use such as open space.

In both counties, the Colorado Geological Survey continues to be active in reviewing proposed subdivisions which are located within the overlay districts to help ensure that future homeowners, and county agencies, will not be exposed to undue financial or safety risks from heaving-ground hazards.

HISTORY OF S.B. 35 & H.B. 1041

ASSESSMENT OF GEOLOGIC SUITABLIITY OF COLORADO SUBDIVISIONS— 25 YEARS' EXPERIENCE

BY JAMES M. SOULE

ABSTRACT

Since 1972, when the enabling Colorado statute was enacted, the Colorado Geological Survey (CGS) .has reviewed required engineering geologic reports for subdivisions prepared for county planning departments by private consultants. These consultants are retained by subdividers of unincorporated land who propose parcels of 35 acres or less. CGS' role is to advise county officials about report adequacy in indicating potentially adverse geologic conditions. Regardless of our findings, the final decision about acceptance of a submitted report is always by a county government.

The majority of these subdivisions are residential and many are for "recreational homes" in remote, mountainous localities. CGS has been placed in a similar role by municipalities for cases where reviews have been voluntarily requested. Several hundred reviews are done annually statewide. Review activity has reflected mountain development, usually in skiing or all-season resorts, economic and population growth along the Front Range and established smaller communities throughout the State, and energy-resource-development-related growth in western Colorado. During the nineties, virtually all of Colorado has seen economic and population growth and this is reflected in the review activity.Some of the reviews have corroborated consultants' recommendations entirely; others have indicated where additional study and remedial-engineering work needed to be done; and a few have demonstrated the nearly complete technical and/or economic infeasibility of a land-development proposal.

This discussion is about the general background of CGS involvement with geologic hazards in land subdivisions and, mostly without citing specific cases, some of our experiences in evaluating the adequacy of geotechnical reports. In many cases, monetary savings and/or reduction in likelihood of future engineering-performance and safety problems have been realized.

INTRODUCTION

Shortly after its reestablishment in 1969, and coincident with a period of rapid economic and population growth in Colorado, the fledgling Colorado Geological Survey (CGS) became involved with geotechnical problems caused by land development. The earliest, and then very innovative, published work which was used by the CGS to convey geologic information to county land-use planners was that of Gardner and Hart (1971) for the Golden 7.5-minute quadrangle (west Denver metropolitan area-Figure 1, Locality 1). Subsequently, Rogers and Rold (1972) studied the serious and practically insurmountable geologic-hazard problems which could have been caused by proposed development of the, now defunct, destination ski-area complex at Marble, Gunnison County (Locality 2).

This involvement with geologic-hazards continues to the present and was mandated formally by legislation in 1972 (Senate Bill 35). House Bill 1041 (1974) was enacted and the CGS responded with legal definitions of geologic hazards and guidelines for investigation of them (Rogers and others, 1974). This legislation also instructed counties that the geologic hazards defined and discussed therein are "matters of State interest" and to better facilitate safe land development in geologic-hazard areas, mapping of these hazard areas should commence and that the State would offer technical support for the work.

The CGS and several private contractors initiated numerous pilot mapping programs and topical studies to respond to this directive (Amuedo and Ivey, 1975; Kirkham and Rogers, 1981; Mears, 1976; Soule, 1976; Soule, 1978). Some counties, such as Eagle (Vail-Locality 3), contracted with private consultant(s) to undertake hazards-mapping work (Robinson and Associates, 1975). Costa and Bilodeau (1982, p. 309–310) outline the

background of engineering-geologic practice in Colorado during that time and scientific, legal,, and administrative aspects of this law and its implementation are discussed in Shelton (1977). Based mostly on Colorado experiences, Soule (1980) discusses some of the technical problems and semantic pitfalls of engineering-geologic mapping of geologic hazards.

Colorado can be grossly divided into three physiographic provinces (Figure 1), each with characteristic geologic environment(s) and physical properties of its soils and rocks. These provinces are the high plains and piedmont east of the central Rocky Mountains front where Cretaceous and Cenozoic sedimentary rocks and a suite of late Tertiary to Holocene alluviums and eolian deposits predominate; the central Rocky Mountains themselves where Precambrian to Tertiary igneous and metamorphic rocks, Cretaceous to Tertiary sedimentary rocks, and their derived colluviums and alluviums are most common; and the table lands and plateaus of western Colorado where nearly flat-lying, but commonly deeply dissected, Cretaceous to Tertiary sedimentary rocks dominate the terrain. Alpine glacial deposits occur in the higher mountains and large scale mass wasting (landsliding) of many different kinds of materials occurred during the Neogene to late Pleistocene and/or Holocene on the side slopes of many mountains and plateaus.

Unstable slopes (landslides of all types and landslide-prone ground) and expansive soils and rock are probably Colorado's most widespread geologic hazards. Seismic risk in Colorado is low to moderate and is not a major factor in many land-use decisions. However it needs to be evaluated for certain localities and for all critical facilities. According to our statutes, snow avalanching is a geologic hazard, but clear-water flooding is not; both occur in well defined places. Soil settlement and compaction, corrosivity, and erodibility are geologic hazards as is subsidence, either natural or man-caused. Hazardous-material-contamination

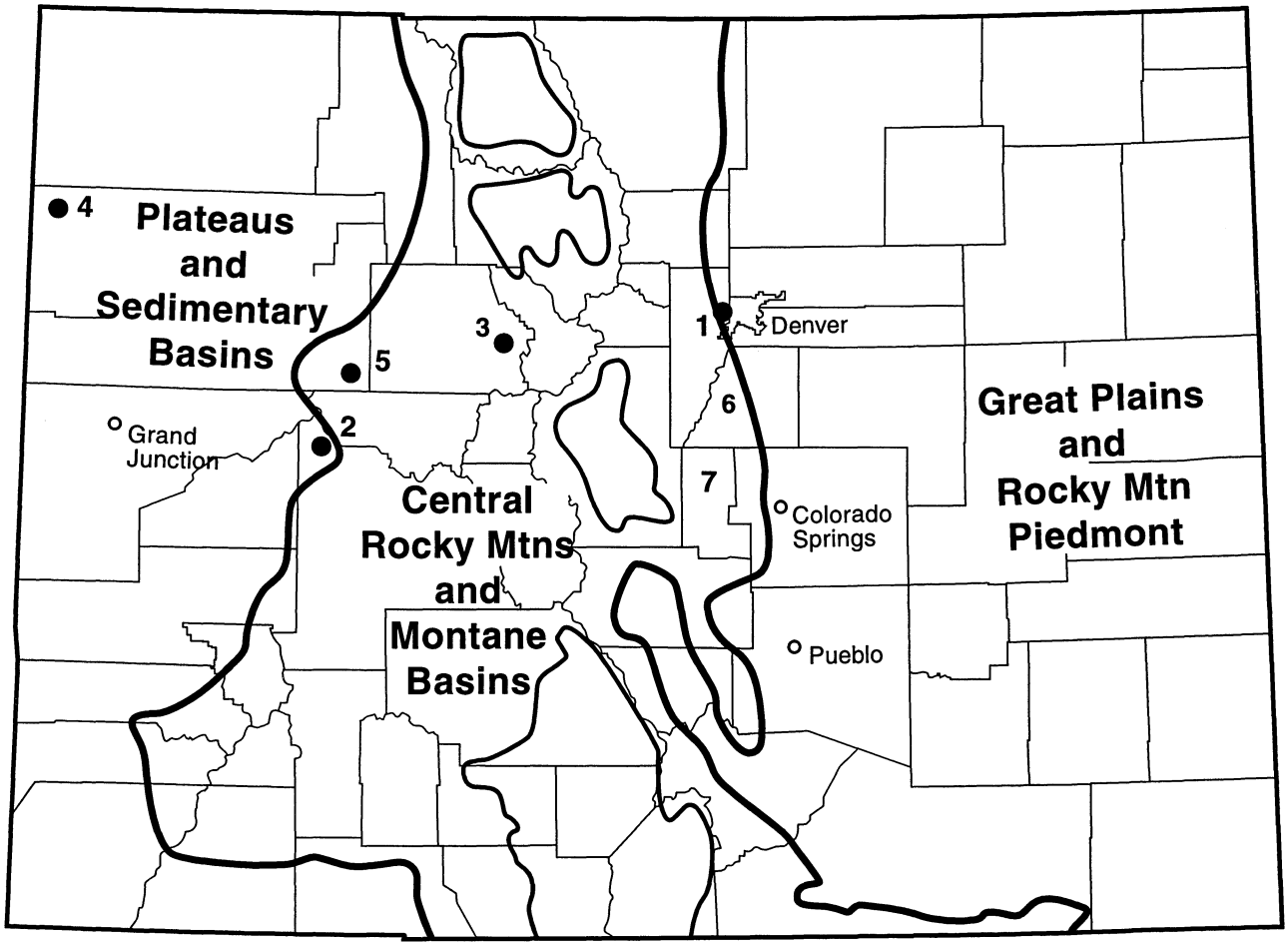


Figure 1. Map of Colorado showing county boundaries, major physiographic regions, and localities.

and environmental issues have been addressed in our reviews in recent years as dictated by the geologic aspects of Federal and State laws and policies. As indicated below, interaction(s) between human activities and geologic conditions or environments, and how they are addressed in reports have become the primary focuses of geotechnical-investigation evaluations made in our reviews.

INVESTIGATIONS OF GEOLOGIC HAZARDS IN SUBDIVISIONS AND CGS-REVIEW EXPERIENCES

Landslides

The fundamental issues which must be addressed in evaluation of landslides of all types and their potential for occurrence in subdivided land are:

1) Have landslides occurred in the subdivision area in the past?
2) Are landslides occurring now and, if so, under what conditions?
3) Are there materials present that could be caused to fail as a result of subdividing and developing this land?

During the process of grading subdivision land and installing improvements, earth is moved, drainage is usually changed, and fills are placed. Structural loads combined with changed ground-moisture conditions resulting from septic-system leach fields and altered water-runoff patterns can render formerly stable to metastable ground, unstable causing damages ranging from minor foundation, utility, and road disturbance to complete structural and facility losses. A geotechnical consultant should determine, after initial field examination of the site, study of the developer's plans, and, if warranted, materials testing and risk modeling, the likelihood of consequent slope-failure problems in the subdivision. Data obtained, its interpretation, and recommended remedial work, if any, should be reported. Frequently, and depending on his technical qualifications, the same consultant may then be the best qualified professional to supervise construction work for a well planned and engineered site. In most cases, long-term maintenance plans, especially for slowing or stopping active landslides, should be provided in the geotechnical report.

Expansive (Swelling) Soils and Rock

From our Colorado experiences, occurrences of expansive soils and rock are nearly always coextensive with outcrops or exposures of bedrock units with certain lithologies, especially montmorillonitic shales and their derived residuum, colluvium, and occasionally, alluvium. The expansion potential of weathered, in-place bedrock depends on many factors, according to recent CGS research by David C. Noe, of the CGS and others (see "Working with Counties..."in this booklet) These factors include the primary composition, thickness, and geometry of different bedrock layers, bedding dip (angle of bedding inclination), degree of overconsolidation, thickness of overburden soil deposits over bedrock, water table depth, and the amount and vectoring of surface water infiltrating the bedrock. Thus, where medium- to large-scale bedrock- and/or surficial-geologic mapping or, ideally, maps of expansive-soil areas such as those by Hart (1986) are available, a consultant can usually make a good first approximation of resulting problems for building tracts with expansive-soils conditions simply by transferring the map data to a larger-scale subdivision sketch plan. Where such mapping is not available, a quick field check, including inspection of nearby roads, road cuts, and (damaged) buildings, especially in places with drainage problems, often can be helpful.

Following the reconnaissance the site investigation should be much more site specific. The typical, standardized soils and foundation investigation, especially for "lightly loaded residential structures" has merit, but too often consists of a few, too widely spaced and generally logged drill holes. The material(s) from these dril holes then may be subjected to uniform and simple laboratory tests. These data typically support a "cookbook" commentary about foundation design(s) and maintenance. Few home builders retain a geotechnical engineer to inspect foundation excavations and caisson (drilled-shaft or drilled-pier) holes and/or to ensure quality assurance of foundation construction, as is common practice for commercial and industrial work. Probably because of cost, most home builders have been unwilling to invest in more than an overly simplified soils and foundation investigation. CGS has noticed a fortunate trend away from this attitude in the nineties. In the past, standardized foundation and other structural-concrete designs, the incentive in the marketplace to minimize per-square-foot construction costs,

the practice of emphasizing house size over construction quality in real-estate appraisals, and the non-existence (in Colorado) of concrete-flatwork structural-performance guarantees almost assure faster home deterioration and greater long-term maintenance and repair costs for homeowners.

In the opinion of this report reviewer, the issues above should be better addressed and the likelihood of the large monetary losses by the public thus could be significantly reduced. The geotechnical-consulting industry should make a much stronger case to HUD, real-estate lenders and appraisers, local building departments, architects, and home builders for increasing the sophistication and improving the thoroughness of geotechnical work. Municipal building departments should be empowered to enforce compliance by home builders with recommendations made by geotechnical professionals, especially for relatively moderately priced residential construction. Another aspect of the communication problem which this consulting industry should address is public awareness of the seriousness and costs of repair of structural damages. To this end, CGS has produced publications about expansive soils since 1974; the laterst one (Noe and others, 1997) is a maintenance and landscaping guide for homebuyers and homeowners. About 150,000 copies of its original (Jochim, 1981) have been sold, mostly to home builders who are required by Colorado law (S.B. 13, 1984) to distribute them at sales closings. The later, updated and expanded version had sold about 37,000 copies by early 1998.

Seismicity

Colorado has a relatively short history of instrumentally recorded earthquakes but this is reinforced by felt earthquake reports which extends the period of record to about 140 years. Over 400 earthquakes have been felt or recorded in Colorado since 1867. The strongest earthquakes have been in the range of magnitude 5.5 to 6.5. In November 1882 an earthquake of magnitude 6.5 occurred in Colorado. The epicenter is now believed to have been in the mountains of Larimer County west of Loveland. It was felt throughout Colorado and parts of neighboring states.

Although no complete collapse of structures or deaths have resulted from a Colorado earthquake, numerous instances of minor and moderate damage have occurred. Cracked plaster, cracked walls, cracked and fallen chimneys, broken windows, dishes and other household goods, damaged roof tiles, and similar effects have been reported for many of Colorado's earthquakes.

The CGS characterizes the seismic risk as low-moderate. This should not pose a major problem for well constructed modern residential construction, but could pose serious problems for older or poorly constructed buildings, building contents, and infrastructure.

The seismic hazard is sufficient that planning for critical facilities, high occupancy buildings and historic preservation of old buidings should consider the seismic exposure. CGS favors a building-code approach to planning and mitigation of this hazard, but this has not yet been achieved.

Snow Avalanches

Snow avalanches (see "Avalanche Facts" in this booklet) occur frequently during the winter months in most of the alpine mountains of Colorado; in fact, Colorado has more areas susceptible to them than any other state. Delineation of avalanche starting zones and tracks is a relatively easy task based on well defined parameters as discussed in Mears (1976). Usually, starting zones and tracks do not present hazards for subdivisions as they are in places that are so rugged and steep that they are not developable. However, they can be an extreme hazard to winter-time recreational users of the back country and to persons and vehicles on high mountain roadways that traverse them. For subdivisions, the hazard-assessment problem is usually a determination of frequency of occurrence of events of a given magnitude and type and determination of the runout or "stopping" zone which is usually on lower valley sideslopes, and, in the case of many large events, valley floors. The scientific methods used to study snow movement and to predict when, and under what specific conditions, events of a given magnitude will occur have parallels with those for rapid mass movements of earth, e.g. debris flows.

For the geotechnical consultant, geologic-hazards assessment in these areas is a specialized applied science where competence in engineering and design of "defense" structures, an understanding of the rheology and movement dynamics of unstable snow pack and moving snow, and a knowledge of winter weather patterns in the specific

area being studied are absolutely critical to an adequate investigation.

Water Flooding

Although not a "geologic hazard" under Colorado law, some kinds of floods, especially "flash" floods in steep mountain drainages, "cloudburst" floods in arid areas, and those caused by extended rainfall and/or rapid snowmelt, occur coincidentally with landsliding and rapid erosion. Because of this, subdivisions that are in these kinds of flood-prone areas, even those in or near small ephemeral drainages, almost always need a drainage-control plan. Most of these areas are outside of a 100-year floodplain. This plan should always address the effects of the subdivision on drainage in nearby subdivisions and undeveloped property that might be developed in the foreseeable future.

Soil Settlement

Soil settlement is a common problem in Colorado where surficial materials are either low density clayey loess, poorly compacted eolian sand, soils containing soluble minerals (e.g., gypsum and halite), or some types of alluvial (stream-originated)and debris-flow deposits. These materials occur in many places in Colorado and are the subject of a topical 1997-1998 study by CGS. The loess, which can range upward to 30 ft or more in thickness, is especially problematical in higher density, urban, residential subdivisions because, after house construction is completed, residents commonly install landscaping irrigation. Soon, moderate to severe settlement can rapidly occur and pavements are damaged. Then, owing to its clay content, the loess may behave indefinitely as expansive soil. In cases where it is especially thick, it also presents expensive foundation-engineering problems as it can initially settle under structural load. Especially long caissons to bedrock are frequently necessary for successful drilled-pier and grade-beam foundations. Eolian sand has essentially the same attributes as the loess except that it is usually higher density and, after settlement, its movement usually stabilizes. In older subdivisions or in areas heavily irrigated for agriculture (which may have caused "pre"-compaction), a perched water table can develop on relatively impermeable materials immediately beneath sand and in some places, loess. If this contact is above normal foundation depth, and depending on the expansivity of the underlying materials, homeowners can experience problems ranging from extreme structural distress to flooded basements. Commonly these soils are also prone to piping (underground erosion) which results in voids which can collapse, sometimes without predictability as to when or where, and with severe consequences for structures built on them.

With appropriate modification to geotechnical-investigation techniques, most of the comments applying to consulting practice in expansive-soil areas also applies to places with soil-settlement conditions.

Corrosive Soils

Corrosive soils are fairly common in Colorado and are most commonly developed on rocks and their erosion products that contain evaporites. (soluable minerals). The usual problems are rapid deterioration of conventional concrete in contact with soil and corrosion of buried, bare metal pipes. In the places where these soils occur, they were poorly understood until relatively recently and older construction has thereby been seriously damaged if not entirely ruined.

In places where these soils are likely to occur, CGS expects that results of appropriate testing and concrete specifications be included in a consultant's subdivision report.

Erodible Soils and Rock

Although all soils and rocks are to some degree erodible, we have many experiences with two rock units which have accompanied many costly land-development problems in recent years. The deeply weathered Pikes Peak Granite of Douglas (Locality 6), Teller (Locality 7), and El Paso Counties (Colorado Springs) is very erosion-prone. In many places and especially on steeper slopes, it has a thin to absent pedogenic soil. Naturally, its "soil" and grus (a gravel-like weathering product) support a low-density coniferous forest with a fragile understory of easily damaged, high altitude grasses. This granitic terrane was the source area for the Dawson Formation which consists predominantly of friable arkosic grit with a poorly developed, clayey, residual soil. The Dawson has a widespread outcrop on the Rocky Mountain piedmont in Douglas and El Paso Counties. The surficial environment and erosion characteristics of the Dawson are similar to those of the Pikes Peak although in most places its plant communities are more varied and slopes on it are less steep.

Because of the rapid increase in higher-density subdivisions on the outcrops of these two formations, what was formerly ranch land and, in privatly owned mountain areas, summer camps and homes, is now becoming predominantly urban with "bedroom" communities for Denver and Colorado Springs. Prior to urban development, cattle grazing and other pasturing on the piedmont had severely damaged the range and an episode of rapid, ephemeral-stream downcutting (gullying) was well underway. Most of the trunk-stream beds had become choked with granular sediment which greatly changed their hydrology and riparian habitat. As geologic hazards, these man-accelerated processes have resulted in not only severe damage to much of the remaining raw land, but also have increased maintenance costs for roads and bridges, increased potential for landsliding and "muddy"-water flooding, and caused damages by deposition of large volumes of sediment in many residential subdivisions.

Addressing and designing mitigation of these adverse effects on residential subdivisions can present difficult challenges for the geotechnical professional. Development plans must be combined with very carefully designed drainage control for roads and runoff from impervious cover(s). (Re)establishment of vegetation that will help reduce sheet flooding and gullying is difficult to do and usually justifies collaboration with botanists and landscape architects. Slope instability can be greatly increased in places adjacent to undercutting streams and debris avalanches and flows can be the direct result of slope denudation during and after construction.

Ground Subsidence

Colorado ground-subsidence hazards are caused by: collapse of abandoned-underground-mine openings, collapse of solution voids in rock units containing evaporites and limestones, and hydrocompaction of soils and surficial materials caused by dissolution of soluble minerals. Ground subsidence can, for soils, be considered an exterme case of "soil settlement" as discussed above. Mining subsidence is by far the most widespread, and for that reason, the most type of serious subsidence hazard in Colorado. Localized areas, primarily in Eagle and Garfield Counties (Locality 5), have experienced serious property losses caused by subsidence and hydrocompaction over the outcrop of the Eagle Valley Evaporite. Paleokarst-void collapse in Mississippian limestones has been reported but has not resulted in serious damages to date.

Colorado's mining history extends back to 1859 when placer gold was discovered in Douglas County. Placer and lode mining of gold and soon thereafter, silver mining, supported many, now famous mining camps, the majority of which still exist as established communities, albeit most with different economies. Very soon after the inception of this mining boom, numerous mountain areas experienced a shortage of wood; what had been there was exploited for construction materials, fuel, and mine timbers. This situation, combined with railroad development and presence of exploitable coal, especially on the Front Range piedmont and in a few mountain areas, rapidly gave rise to an underground-coal-mining industry which supplied not only the mining camps and railroads, but also the nearby residential- and commercial-fuel markets and many smelters including, eventually, the Colorado Fuel and Iron Corporation steel mills at Pueblo. A legacy of all this mining is that most of these same areas of the State have mine subsidence and related problems. Somewhat ironically, far more land was impacted by coal mining than metal mining, the resulting surface hazards are usually potentially more severe over abandoned coal mines, and much of this affected land is now in populous areas.

It is not possible in this paper to discuss all of the conditions and parameters that should be addressed in a mine-subsidence-hazard investigation for land subdivisions. From our experiences (largely based on arguments and counterarguments about the validity of conclusions presented in subsidence-hazard investigations), the following considerations appear to be the most relevant:

1) What is the present status of mine collapse? Has the mine collapse gone to completion, and if so, have all of the potentially adverse surface effects taken place?
2) Was the mining deep enough or is the roof rock and overburden competent enough and/or was/is the remaining mine void so small that, regardless of the status of mine collapse, the mining will never have significant adverse effects on the surface (or subdivision)?
3) Is the record (mine mapping) of mining accurate?

How much of a safety (hazard) zone should be delineated to compensate for possible inaccuracies in mine mapping? How far beyond the actual extent of mining might the surface effects extend, i.e. determination of "angle of draw" How does mining method, e.g. room-and-pillar versus long-wall (for coal mining), influence surface-subsidence timing and patterns.

4) If applicable, was there enough subsurface work, e.g. drilling and geophysics, done in the investigation (and provided in the report) and is it interpreted competently and reasonably?
5) Are shafts, adits, and dumps and spoils (especially if they have been regraded and/or used for fills) shown accurately on a map of the surface. If they have been back filled or otherwise "reclaimed", have shafts and adits been correctly plugged or sealed off to render their associated hazards minimal?
6) Are the subsidence-hazard-area delineation(s), surface improvements, and cultural features accurately rectified to the subdivision plat?

Much of the commentary about mine-subsidence investigations also applies to investigation of solution-collapse hazards. Perhaps the most important differences are that there is rarely any relevant subsurface mapping available and that movement and location of ground water, both before and after subdivision development, must be considered. We usually recommend that a consultant map known sinkholes and related features, investigate the subsurface with drilling and shallow geophysical surveys, and determine the hydrologic effects of the subdivision on natural ground-water conditions.

Hydrocompactive materials in Colorado are usually rapidly deposited, low density alluvial-fan and and/or sheet-flood deposits derived from rocks containing soluble minerals. The significant difference between them and settling soils as a geologic hazard is that the subsidence can be much greater (upwards to 15 ft in places) and can occur rapidly in a few hours. The most common cause of these movements are drainage changes which divert water onto these deposits, especially relocation of irrigation ditches by unsuspecting farmers and ranchers. For subdivisions and roadways, the most advisable mitigation measure is prewetting and compaction followed by regrading.

As for expansive soils, CGS has published a public-information guide to mine-subsidence hazards (Turney, 1985).

'Environmental' Hazards

Although they are not included strictly in Colorado subdivision laws, the kinds of investigations required by the various "environmental cleanup" regulations have made their way into geologic-hazards studies and subdivision reviews. These two examples have been seen often enough Colorado in subdivisions to warrant comment here:

1) Fills of unknown composition and structural characteristics commonly are found in (re)developing urban and urban-fringe areas, in or near transportation corridors, in mining areas, and on land which has been used for many different kinds of refuse dumps. One of the most tragic and difficult to mitigate circumstances is the widespread past use for common fill, especially in the Grand Junction area, of radioactive uranium mill tailings.
2) Leaking underground storage tanks (UST's) and other sources of soil contamination by hazardous materials, including petroleum products and agricultural and industrial chemicals, have been located in both urban and rural subdivisions and, in two cases we have reviewed, one industrial and one residential, the environmental clean-up costs exceeded the value of the undeveloped property.

For the geotechnical professional who is preparing a subdivision report for a private client, extreme care should be taken when discussing possible environmental degradation. We have seen several cases where engineering geologists have disclaimed responsibility for any part of their investigation that might relate to "environmental" matters; others have recommended environmental assessments by specialist firms. The discussions by Gerla and Jehn-Dellaport (1989) are probably as relevant to residential real-estate transfers (i.e.,building-lot sales) as commercial ones.

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AVALANCHE FACTS

BY THE COLORADO AVALANCHE INFORMATION CENTER

HOW SEVERE IS THE AVALANCHE PROBLEM IN COLORADO?

We estimate that 20,000 avalanches fall in the Colorado mountains in an average winter. Most of these cause no harm whatsoever. However, since 1980, avalanches annually cause on average five deaths, five severe injuries, more than $100,000 in direct property damage, and more than $1 million in economic losses. Additionally, avalanches block highways 100–200 times per winter.

WHICH COUNTIES HAVE AVALANCHE PROBLEMS?

Since 1950, 21 counties have had at least one avalanche death (see Figure 1).

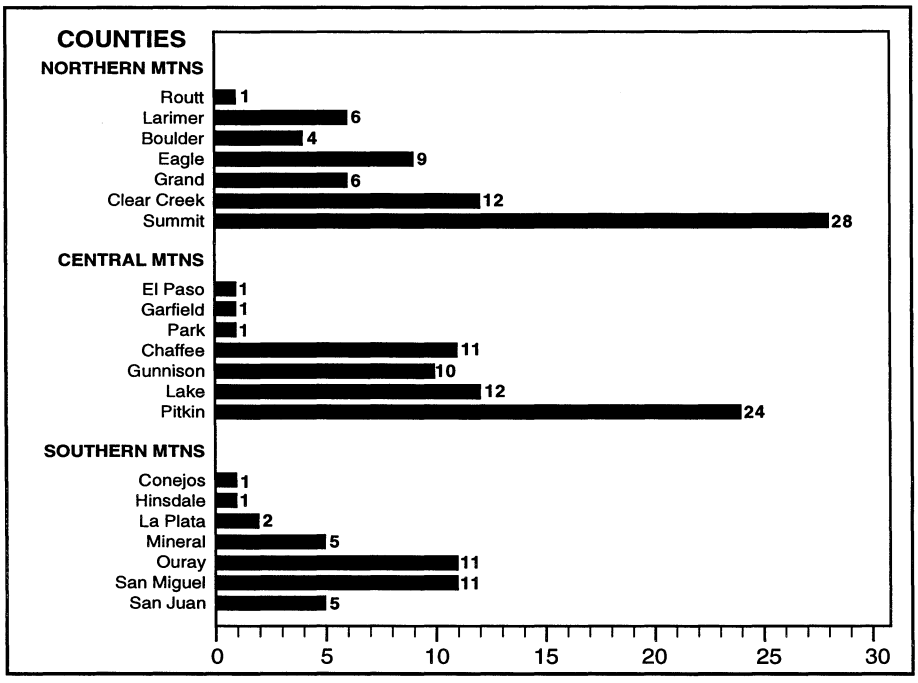

Figure 1. Avalanche fatalities in Colorado since 1950.

WHAT CAN BE DONE ABOUT AVALANCHES?

Avalanches are forces of nature and cannot be eliminated. However, much can be done to mitigate avalanche hazards and reduce avalanche accidents. In developed areas, avalanches can be controlled— either actively by explosives, or passively by permanent retaining or diverting structures. In backcountry areas, forecasting avalanche dangers and educating recreationalists can reduce accidents.

WHAT IS THE COLORADO AVALANCHE INFORMATION CENTER?

Founded in 1983, the CAIC is a program in the Colorado Geological Survey. Its mission is to promote safety by reducing the impact of avalanches on recreation, industry, and transportation in Colorado.

HOW IS THE CAIC FUNDED?

The CAIC is entirely cash and federally funded. Grants and donations come from the Colorado Department of Transportation, U.S. Forest Service, local governments including counties and towns, ski industry, hut and trail associations, and foundations. In 1996–97, revenues were approximately $350,000.

WHAT DOES THE CAIC DO?

The CAIC has a staff of 10 avalanche experts to carry out a program of forecasting, training, and consulting.

Forecasting

The CAIC uses a network of 35 observers to provide daily data on weather, snowpack, and avalanches. We provide this information and a forecast to the public via seven hotlines and a computer bulletinboard. Last year there were 126,000 calls to the hotlines, bulletin board, and home page for this information. Additionally, 11 mountain radio stations broadcast our hotlines messages daily.

Training

The CAIC offers avalanche classes that range from a 2-hour lecture to multi-day field courses.

Last year we presented 84 classes to 3,800 people. Additionally, we have produced two educational videos.

Consulting

The CAIC provides avalanche consulting services to the ski industry and CDOT.

WHAT SERVICES CAN THE CAIC PROVIDE COLORADO COUNTIES?

The CAIC can provide the following services:

- Mountain weather forecasts and backcountry avalanche danger ratings for use by the public and by county road maintenance personnel.
- Weather and avalanche forecasts to sheriffs and search-and-rescue teams during rescue missions.
- Avalanche education programs and materials.
- Consultation on avoiding, controlling, or otherwise managing specific avalanche problems.

AVALANCHE HOTLINES

Current information on mountain weather, snow, and avalanche conditions are updated daily.

Denver/Boulder	(303) 275-5360
Colorado Springs	(719) 520-0020
Fort Collins	(970) 482-0457
Summit County	(970) 668-0600
Durango	(970) 247-8187
Vail	(970) 827-5687
Aspen	(970) 920-1664

FOR MORE INFORMATION CONTACT

Knox Williams, Director
Colorado Avalanche Information Center
10230 Smith Road
Denver, CO 80239
(303) 371-1080

COALBED METHANE— A POTENTIAL GEOLOGIC HAZARD

BY CAROL M. TREMAIN

METHANE OCCURRENCES

Gas seeps in the Pine River, ponds, and some water wells in the Pine River Ranches subdivision (Sec. 14, T. 35 N., R. 7 W.) led La Plata County and Amoco personnel to test 66 homes near the outcrop of the coal-bearing Fruitland Formation for methane gas. Sixteen of the tested homes had detectable levels of methane.

The methane (natural gas believed to have emanated from underlying coal seams) reached explosive levels outside one house in the subdivision (Amoco Pine River Fruitland Outcrop Investigation, Sept. 15, 1994). Methane seeps were mapped by an Amoco subcontractor in portions of a 500 ft wide area in the Pine River Valley directly underlain by the Fruitland Formation (Amoco, 1994).

La Plata County officials reported that another house near a very active historical gas seep in South Texas Creek (a tributary of the Pine River) had explosive levels of probable coal-derived methane in the crawl space and under the kitchen sink (Durango Herald, Sept. 15, 1994).

Historically active gas seeps have been observed in other localities in the County including the Animas River near Durango and the Soda Springs area near Red Mesa. Twenty affidavits attesting to gas seeps which have been active for decades are also on file with La Plata County District Court. Many of these gas seeps occur where the coal-bearing Fruitland or Menefee Formations are exposed (outcrop) or directly underlie surface soils or gravels (subcrop).

Approximately one-third of Colorado is underlain by coal (Figure 1). Much of the coal is deeply buried and natural gas generated during the coalification process is trapped in the micropores of the coal at depth. However, coalbed methane gas does escape from shallow coal seams and this gas could present a hazard if trapped in a surface structure. This is particularly true in areas where mines were historically gassy (see Fender and Murray, 1978).

Gas has been reported in abandoned coal mines in Las Animas County and was responsible for a mine explosion in an active mine as recently as 1991 (Denver Post, Oct. 1, 1994). Gas is being vented as part of the mining process from operating mines in Rio Blanco, Gunnison, La Plata, Mesa, and Routt Counties. Coalbed methane is being produced from gas wells in Garfield, La Plata, Rio Blanco, and Las Animas Counties, and has been produced to a minor extent in Archuleta and Huerfano Counties (Tremain, 1990).

Although methane gas is colorless, odorless, and non-toxic, it *is* explosive at 5 to 15 percent mixtures in air. Numerous injuries and fatalities in the state's underground coal mines have been attributed to ignition of methane released during mining. Methane can also saturate the ground and deprive plant roots of oxygen and the ability to absorb needed nutrients from the soil.

Although CGS geologists are unaware of any above-ground losses of lives or structures due to coalbed-methane explosions or emissions, the gas occurrences in La Plata County investigated by the Pine River Fruitland Outcrop Investigative Team and the increase in housing development and water-well drilling around the state have prompted the CGS to add coalbed methane to our list of potential geologic hazards (see addendum).

The CGS began accumulating data about the methane potential of Colorado coals in 1975 with a U.S. Bureau of Mines grant, and has continued this research to the present. Research objectives are to increase mine safety and productivity, and to aid in the development and conservation of this new source of pipeline-quality natural gas.

In 1978, our earliest coalbed methane publication reported mine-gas emissions and explosions around the state (Fender and Murray, 1978). Subsequent gas-content measurements of coal core samples (Tremain and Toomey, 1983) and coal-basin

geologic studies (see CGS Publications section) revealed that Colorado contained an in-place coalbed methane gas resource in excess of 100 trillion cubic feet. In 1995, 43 percent of the natural gas produced in Colorado was coalbed methane (Colorado Oil and Gas Conservation Commission).

Oil and gas seep naturally to the surface and such seeps led to the discovery of many of the state's oldest oil and gas fields (New Mexico et al., 1993). Where gas is escaping from coals, seeps may be observed in standing or flowing water or in water wells. Proposed construction sites directly overlying coal seams in the Raton and Vermejo Formations in the Raton Coal Region, the Fruitland and Menefee Formations in the San Juan River Region, and the Mesaverde Group in the Uinta and Green River Regions should be checked for visible gas occurrences particularly where the coal is at or very near the surface and not covered by an aquitard.

However, gas seeps may vary seasonally or at much longer climatic cycles; a lack of seeps in the present does not preclude their occurrence in the future. Long-time rural residents, coal miners, water well drillers, or fire safety personnel may provide additional information on the occurrence of methane in an area. Methane concentrations in suspect locations can be measured with combustible gas detectors or alarms; Amoco has provided a number of these to concerned residents in La Plata County (Amoco, 1994). La Plata County will arrange for methane testing when contacted by residents (La Plata County methane health and safety brochure, 1993).

The CGS recommends that jurisdictions that have past or ongoing coal mining (Figure 2) consult with CGS geologists regarding the potential for

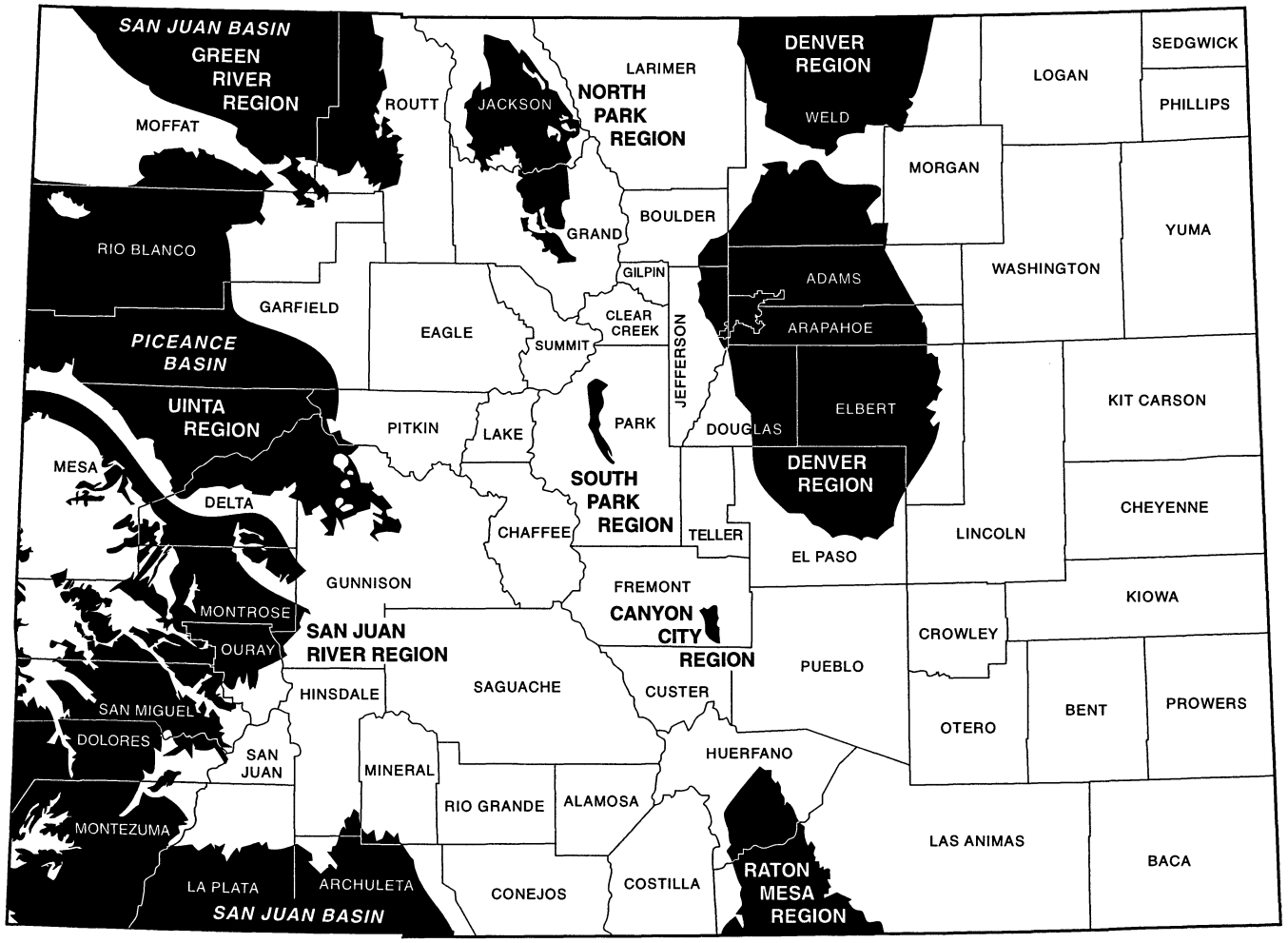

Figure 1. Coal regions and basins of Colorado.

methane seeps. For land-use-change proposals, such as housing subdivisions, methane occurrences may need to be addressed as geologic hazards as indicated in S.B. 35 (1972) and H.B. 1041 (1974). Measures to mitigate and monitor methane-related hazards in existing structures (e.g., ventilation of crawl spaces and water wells) do exist (see Amoco, 1994). However, prudence dictates site evaluation for potential coalbed-methane hazards prior to construction in coal outcrop and subcrop areas. Published geologic maps and reports on coal and coalbed methane geology should provide developers with general geologic information on proposed development areas. In areas where coals are near surface and historically gassy, a detailed geologic review and possibly soil, structure, or water well testing may be necessary. Due to the relatively recent recognition of this potential hazard, building standards and testing procedures still must be formulated in cooperation with local government authorities.

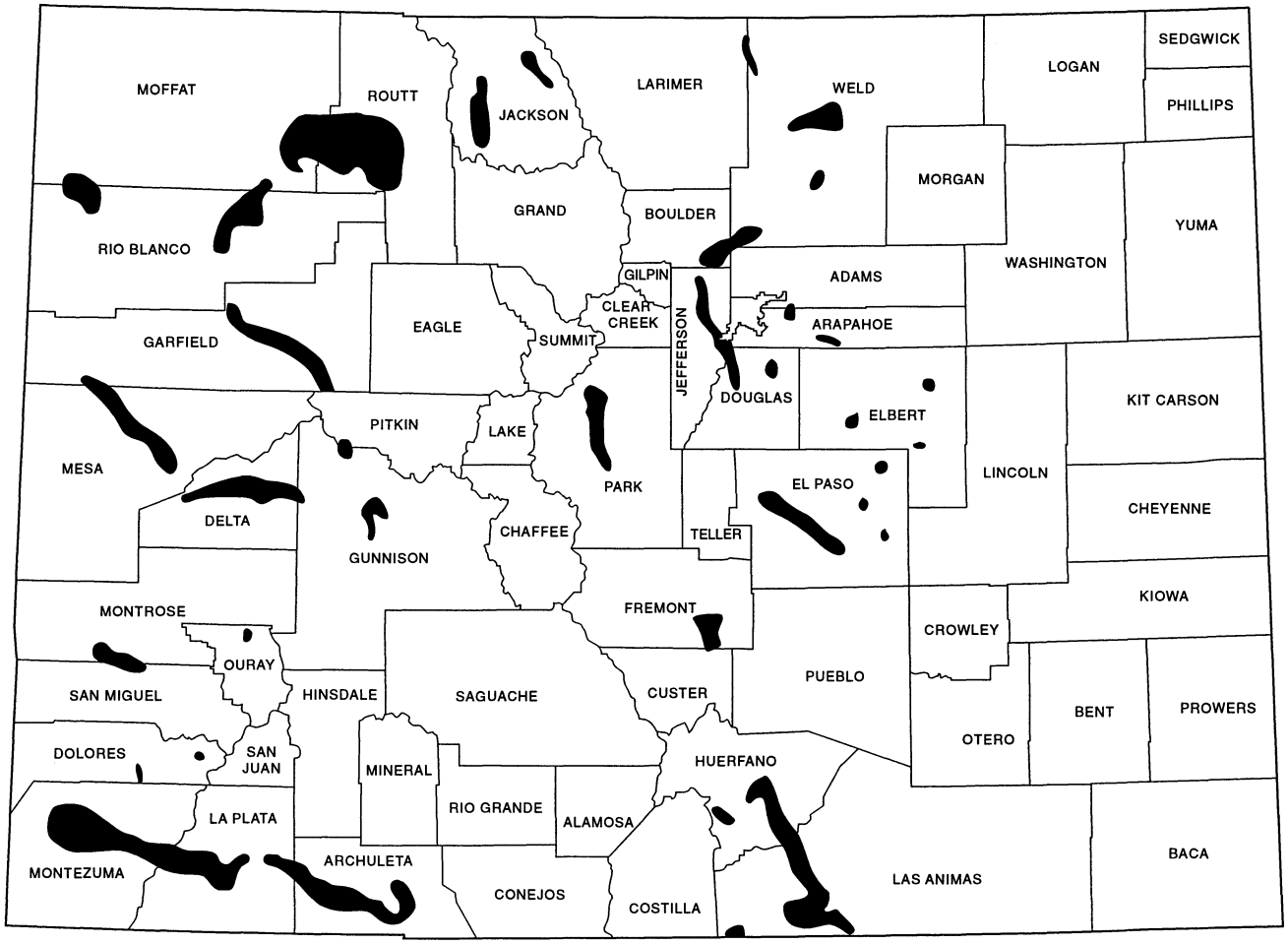

Figure 2. General locations of active and inactive coal mines in Colorado.

GEOLOGIC HAZARD REVIEWS PERFORMED BY THE COLORADO GEOLOGICAL SURVEY

BY JAMES M. SOULE

REVIEWS

To review is to make a constructive critique and, necessarily in this instance, usually means an assessment of the adequacy and appropriateness of (geo)technical investigations and/or applications of geologic principles made by others, mostly professional geotechnical engineers and consulting engineering geologists. This also means that CGS does not offer designs or actually do the work unless specifically requested to do so and it is within the purview of CGS expertise and it is permitted by the Colorado statutes and regulations that govern CGS' relationships with private consulting practice. CGS reviewers make decisions about whether enough meaningful work was done, if the resulting report proposes reasonable solutions to problems related to the geology of the site, and if it offers a technically competent analysis of natural geologic conditions and their potential impacts on a proposed activity.

The CGS reviews land-use or land-use-change proposals, as required by statute, regulation, or when voluntarily requested by public or quasi-public entities as follows:

REVIEW TYPES

- Subdivision reviews required by S.B. 35 submitted by county planning departments
- Subdivision reviews voluntarily requested by cities and towns
- School-site reviews required by H.B. 1045 (1984) submitted by School Districts (see addendum at the end of this section)
- Water-quality reviews submitted by engineering firms or other representatives of water and sanitation districts, local governments, and/or various health and sanitation authorities.
- Miscellaneous reviews of:
  - — landfill proposals
  - — utility alignments
  - — transportation alignments
  - — building-lot construction suitability
  - — public-facility construction
  - — major development impacts (e.g., mines, ski areas)
  - — airport sites and improvements

Some counties also request reviews based on the "matters of state interest" provisions of H.B. 1041 (1974) which they have incorporated into their local land-use regulations.

REVIEW PROCESS

The review geologist reads and interprets submitted review materials, does background research and analysis based on file and library materials, and makes a site (field) investigation of the location and/or parcel that is the subject of the review. The reviewer then prepares a letter report to the submitter which discusses the accuracy and adequacy of materials prepared by or for the land-use-change proponent (e.g., land developer or land subdivider) and whether additional and/or more technical or detailed geotechnical work should be done. The reviewer offers advice to the submitter and proponent regarding possible changes in the proposal which might make it more compatible with geologic conditions and geology-related constraints. In extreme (usually infrequent) cases where an activity might become life or property threatening, the reviewer might recommend (rarely) outright denial of a proposal or its major revision. If deemed necessary, the review geologist, planner or other local government official (as appropriate), proponent, and the proponent's geotechnical consultant and, sometimes, his attorney meet or otherwise collaborate to resolve any differences about the geological feasibility of a proposal. The ultimate decision about acceptance of the final proposal is made by local-government officials, most commonly the Board of County Commissioners or other local legal, planning, or regulatory authority.

HAZARDS REVIEWED

The most significant and/or widespread geologic hazards in

Colorado, insofar as they threaten public safety and well being or cause economic losses, are as follows. They cannot be ranked by severity unless a specific land use or human activity in a defined (mapped) susceptible area is specified.

- Snow avalanches
- Landslides (N.B. There are many types of such ground movements and they are frequently transitional to one another.)
  - — rockfalls
  - — mud and debris flows
  - — slumps
  - — rockslides
  - — rock and debris avalanches
  - — earthflows
  - — settlement, subsidence, and lateral spreading (soil collapse)
  - — man-induced ground failure (which may simulate any of the natural types indicated)
- Seismic (ground-shaking/ earthquake) events, bedrock movements, and their effects
- Ground subsidence caused by underground mining, fluid withdrawal, or rock dissolution
- Nuclear radiation (natural and man-caused)
- Soil and rock properties (expansivity, chemistry (corrosivity), and bearing capacity and strength)
- Radioactive and explosive soil and rock gases (radon and methane)
- Hazardous- and deleterious-material contamination of rocks, soils, and water
- Soil- and rock-erosion potential

Note: Clear-water (overbank) flooding and fill failures of dams and canal banks are not legally defined in Colorado as geologic hazards. They are not addressed in geologic-hazards reviews unless they are related to or can be caused by the geologic hazards indicated above..

SCHOOL SITE REVIEWS PERFORMED BY THE COLORADO GEOLOGICAL SURVEY

BY JAMES M. SOULE

Introduction

The Colorado Geological Survey (CGS) has reviewed proposals and plans for all new real-estate acquisitions and facility construction for all Colorado K-12 school districts since enactment of H.B. 1045 (1984) (C.R.S. 22-32-124 et seq.). This act provided that the *"Board of Education..."*, is directed to consult with CGS about *"...geologic hazards..."* (e.g., expansive soils, slope instability) *"... prior to the acquisition of land for school building sites or construction of any buildings thereon...and to determine the geologic suitability of the site for its proposed use."* Boards of Education were also instructed to participate in local land-use-planning processes and to conform with construction, fire, and safety codes.

Undeveloped (Raw) Land

The District is considering a land purchase, trade, or dedication—

- School districts usually acquire land by dedication, trade, or outright purchase. There is a tendency of owners to offer land which is marginally suitable for other development purposes. The reviewer assesses the relevant geologic and geology-related conditions for the planned use of the site.
- School districts can thus avoid involvement with real-estate sales resulting from acquisition of land which they cannot use without surmounting serious geology-related development problems.
- Almost all school campuses are a permitted non-conforming use in R-1 or R-2 zones. Unless a district plans to use a site in the foreseeable future for a school, the reviewer considers whether it is more suitable for residential or open-space land use.

New Construction, Reconstruction, and Additions

The District is going to build on a new site or modify or add to an existing facility—

- Geotechnical and drainage studies must be relevant to plans and proposed designs. The reviewer evaluates the adequacy of these and indicates to district officials and architects whether additional work is justified.
- A forensic inspection of existing facilities is made to assess their condition and to relate damages or deterioration, if any, to geologic and geology-related (e.g., soils and drainage) conditions. The resulting conclusions are used to support recommendations about possible modifications of site drainage control, repairs to existing facilities, and changes in construction plans to reduce the possibility of similar damages to new construction, rebuilding, and additions as applicable.
- Specific siting of new construction and its appurtenances can greatly affect its long-term servicibility and overall maintenance and repair costs. The reviewer may recommend changes in site plans to avoid problem areas and to avoid places that may be hazardous to pupils (e.g., drainage and irrigation ditches).

Existing Facilities

The District is Considering Acquisition of Developed Property—

- All of the appropriate considerations made for undeveloped land and construction apply and are considered by the reviewer.

COLORADO GEOLOGICAL SURVEY STANDARD FEE SCHEDULE FOR MOST COMMONLY USED SERVICES

EFFECTIVE JULY 1, 1994

CGS FEE SCHEDULE

1. SMALL SUBDIVISION REVIEW

(Those with lots for ten or fewer dwelling units), also major replats of *existing approved subdivisions*, rezonings or sketch plans for twenty acres or less, major activity notice reviews, and water quality application reviews:

Cost = $485.00 prepaid
$510.00 not prepaid

2. MEDIUM AND LARGE SUBDIVISION REVIEW

(Those with lots for more than ten dwelling units), rezonings or sketch plans for more than twenty acres:

Cost = $595.00 prepaid
$620 not prepaid

Although most reviews listed in **1** and **2** above will fall within the estimated time and costs built into the listed standard charges, it is necessary, in fairness to all users, to provide for those cases that will incur excess revew costs. The CGS will contact the local planner if it is evident that additional review costs will be requested (See discussion in **3** below).

3. VERY LARGE OR COMPLEX SUBDIVISON, GEOLOGICAL HAZARD REVIEW, MASTER PLAN, OR PUD

These reviews generally require field observation and much more review time. Consequently, cost varies considerably and may exceed $1,200.00 based upon standard fee plus additional review time and travel cost.

Excess time or travel charges

Will be made for those expenditures in excesss of the normal range of review time (maximum 6.75 hours on small reviews or 8.75 hours for large reviews), or for extensive travel related to a particular case:

Extra review time: at hourly fee rate of CGS reviewer
Travel at current state rates:
Per diem: current state rates
Vehicle mileage :
$0.20/mile;
$0.24/mile 4WD
Other travel at actual cost
(e.g., auto rental, plane fare, etc.).

4. SCHOOL SITE REVIEW

Single school site: **$855.00**. Multiple submittals from the same district, *submitted at the same time*: (Not to exceed the number of sites that can be reasonably visited in one day.) **$855.00** for the first one, and **$700.00** for each additional one (includes $155.00 reduction for travel.)

5. WRITTEN MINE SUBSIDENCE HAZARD OPINION ON A RESIDENTIAL LOT FOR REAL ESTATE TRANSACTION

These will be done as quickly as possible, but *five to ten days* lead time is needed in most cases. **$135.00** prepaid, **$150.00** otherwise.

As stipulated in C.R.S. 30-28-136, it is the responsibility of the county commissioners, or their representatives, to submit copies of subdivision plans to the CGS. It should also be noted that the statute has been amended, and now states that reviewing agencies shall make recommendations within twenty-one (21) working days after the mailing by the county, or its representatives. However, reviews are performed as quickly as possible.

ADDITIONAL SERVICES BY CGS REQUIRING AN AGREEMENT AND PRICE ESTIMATE

Price ranges shown here are only suggested for general information. Actual prices will vary according to specific needs, size and complexity of the individual project, staff assignment by us, and amount of travel and follow-up work required. Please contact **Jim Soule (866-2611)** to discuss details of review or other project needs. In come cases, a fixed cost may be practical. In others, it will be more practical to use hourly fees plus other direct costs attributable to the work.

PH: (303) 866-2611
FAX: (303) 866-2461

TABLE OF SERVICES AND COSTS

DESCRIPTION OF SERVICE	ESTIMATED COST OR RANGE	COMMENTS
Solid waste disposal application review	Basic review, $1500 to $3500, extra for testimony and travel, if needed	Basis: 30–40 hours professional time
Hydrogeological/water quality problems • Septic tank failures • Brine pit contamination • Old landfill • Methane, radon or other contaminants in water wells • Hydrocarbon leakage from storage facilities		Highly variable—individual project estimate required
Water quality application reviews	Standard fee no.1 $485 if prepaid, otherwise $510	Possible extra charges in some cases
Geological review of new local environmental health regulation	$300 to $700 in most cases	Variable, depending on complexity
Geological hazard studies and reviews Review of detailed geologic hazard reports: mine subsidence, slope instability, dam site and/or active fault studies, mudflow/debris flow mitigation, etc.	Basic reviews $500 to $3,000 plus travel	Recommended individual project estimate
Expert testimony in local goverment of other administrative or judicial forums	Minimum approx. $500 for one day, possibly less if minimal travel	Cost highly variable, includes preparation time, testimony and travel
Geological assistance with planning area studies	Highly variable, depending on time and travel	Based on actual hours
Geological hazard or mineral resource conservation map	Highly variable, depending on size and complexity	Recommend individual project estimate
Site reconnaissance for facilities (sewage treatment plants, public buildings, etc.)	Typical $450 to $650, plus travel	May be more for large project or extensive travel
Mineral resource and/or conservation reviews Master extraction plan for sand, gravel or quarry aggregate	Typical cost: $450 to $800	May be more if issues of complex
Specific mineral resource area evaluation	Typical cost: $450 to $800	May be more if issues of complex
Major quarry aggregate application review, local rezoning, local mining permit, etc.	Typical cost: $1,500 to $3,500	Depends on size and complexity
Small gravel pit or borrow pit application	Standard fee no. 1: $485, if prepaid, $520 otherwise	

Information regarding other services consistent with our statutory duties on request

Additions:
1. Fee for bad checks: $25.00
2. Fee for retrieval of archived documents: $25.00 per file
3. Invoices for services will be directed to the submitting local government unless another address is provided.

CGS PUBLICATIONS

COLORADO GEOLOGICAL SURVEY SELECTED PUBLICATIONS

See our Publication List with search engine on our Website:
www.dnr.state.co.us/geosurvey

CITIZENS' RESOURCES

Avalanches

IS 38 **Avalanche Rescue Beacons: A Race Against Time.** D. Atkins, 1995, 38 min. VHS video. Teaches proper use of avalanche rescue beacons, search techniques, and how to search for someone who is not wearing a beacon; uses live action and computer animation. **$25.00**

IS 43 **Snow & Avalanche: Annual Report 1996–97, Colorado Avalanche Information Center.** Colorado Geological Survey, 1997, 32 p., 3 figs, 6 tables. Funding and budget; operations; weather and avalanche synopsis; detailed winter summary; information acquisition; dissemination of forecasts, public education; forecasting for highways. **$5.00**

IS 46 **Snow & Avalanche: Annual Report 1997–98, Colo. Avalanche Information Center.** Colorado Geological Survey, 1998, 36 p., 3 figs, 6 tables. Funding and budget; operations; weather and avalanche synopsis; detailed winter summary; information acquisition; dissemination of forecasts, public education; forecasting for highways. **$5.00**

MI 30 **The Avalanche Book.** B. Armstrong and K. Williams, 1992, rev. ed., 256 p., illustrations, Fulcrum Publishing. History, causes, terrains, weather, safety, survival, rescue, control techniques, law, studies, additional reading. **$17.00**

MI 56 **The Snow Booklet: A Guide to the Science, Climatology and Measurement of Snow in the United States.** N. Doesken and A. Judson, 1996, 85 p., illustrations, Climate patterns, science of snow formation, snowpack delvelopment and melting; impact of snow on environment, transportation, and everyday lives. **$15.00**

SP 39 **The Snowy Torrents—Avalanche Accidents in the U.S., 1980–86.** N. Logan and D. Atkins, 1996, 268 p., 43 figs., tables. Accounts and evaluations of 146 accidents; classification; accident reporting form; statistics of avalanche burials; evaluation of risk and how to avoid and survive avalanches; table of accidents in all four volumes of *The Snowy Torrents*; glossary. **$16.00**

Earthquakes

B 43 **Earthquake Potential in Colorado, A Preliminary Evaluation.** R.M. Kirkham and W.P. Rogers, 1981, 175 p., 3 pl. (1:500,000, 1:1,000,000, & 1:62,500). Description of potentially active faults, discussion of historic seismicity, geologic evidence for Quaternary tectonism and land use implications; detailed bibliography. **$7.50**

IS 23 **Results of a Search for Felt Reports for Selected Colorado Earthquakes.** S. Oaks and R.M. Kirkham, 1986, 89 p. New felt reports for several widely reported earthquakes in the pre-instrumental. Primary documentation emphasized; newspapers also checked for time hear events and possible aftershock. **$6.00**

Geologic Hazards

EG 7 **Potentially Swelling Soil and Rock in the Front Range Urban Corridor, Colorado.** S.S. Hart, 1974, 23 p., 13 figs., 1 table, 4 pls. (1:100,000). Explanation and recognition of swelling soil, extensive bibliography, glossary, estimate of swell potential. Colored maps covering Front Range area from Ft. Collins to Pueblo. **$15.00**

IS 24 **Radon: Issues and Answers.** L.R. Ladwig, 1986, 11 p. General discussion of radon: its sources, movement and testing; state concerns; current list of testing firms. **$1.00**

IS 47 **Geologic Hazards Avoidance or Mitigation: A Comprehensive Guide to State Statutes, Land Use Issues, and Professional Practice in Colorado.** E.J. Johnson and J.W. Himmelreich, Jr., 1998, 43 p., figures, 8 appendices. Award winning reference tool for professions in the land development and construction industries. Includes Colorado land-use and planning regulations, local government authority and requirements, consumer protection legislation, additional statutory requirements addressing natural hazards, responsibilities of practitioners and professional associations, role of the Colo. Geological Survey. **$25.00**

MI 26 **Hazardous Waste Issues and Answers.** Am. Inst. of Professional Geologists, 1984, 24 p., illustrations. Locations, regulations, disposal issues, planning, AIPG policy, glossary. **$5.00**

MI 57 **The Citizen's Guide to Geologic Hazards.** E.B. Nuhfer and others, 1996, 134 p., 100 color illustrations, AIPG publication. Comprehensive tour of hazards presented by earthquakes, volcanoes, landslides, ground subsidence, floods, tsunamis, and coastal storm surges; discussion of controversial radon gas and asbestos hazards; geologist's role in preventing losses and sources of help. **$20.00**

MI 58 **Homebuyers' Guide to Geologic Hazards: an AIPG Issues and Answers Publication.** W.B. Creath, 1996, 30 p., color illustrations. Covers expansive soils, heav-

ing bedrock, flooding, subsidence, landslides, rockfalls, avalanches, earthquakes, coastal erosion, and radon; maps show areas in U.S. subject to each hazard; sources of information. **$9.00**

MS 32 Map of Areas Susceptible to Differntial Heaving in Steeply Dipping Bedrock, City of Colorado Springs, Colorado. J.W. Himmelreich, Jr. and D.C. Noe, 1998, 1 pl. (1:24,000). Color overlay map of areas within the City of Colorado Springs where heaving bedrock hazards may be encountered. Map text includes description of geology and considerations for existing and future development. **AVAILABLE SOON**

SP 12 Nature's Building Codes—Geology and Construction in Colorado. D.C. Shelton and Dick Prouty, 1979, 72 p., figs. Handbook on the relationship of geology to construction—particularly single family or small multifamily units; homebuyer's guide and geologic report guidelines; for planners and general public. **$4.00**

SP 42 Heaving Bedrock Hazards Associated with Expansive, Steeply Dipping Bedrock, Douglas County, Colorado. D.C. Noe, 1998, __ p., 18 figs, 2 pl. (1:24,000). Report describing bedrock as a distinctive geological hazard, its occurrence in Douglas County, and considerations for existing and future development. Includes overlay map and heaving bedrock hazards map in color. **AVAILABLE SOON**

SP 43 A Guide to Swelling Soils for Colorado Homebuyers and Homeowners. D.C. Noe, C.L. Jochim, and W.P Rogers, 1997, 76 p., 45 figures. Written to assist homeowners in reducing damage caused by swelling soils. Latest information on: geology, construction, landscaping, home maintenance, and homeowner risk; property check list, reading sources, information sources. (Replaces SP 14 and SP 11) **$7.00**

SP 45 Heaving Bedrock Hazards Mitigation and Land-Use Policy: Front Range Piedmont, Colorado. D.C. Noe, 1996, 11 p., illustrations. A reprinted article from *Environmental Geosciences* which defines heaving bedrock as a distinct geologic hazard and describes the technical and policy advances made in recent years to promote the understanding and effective mitigation of the problem. **$4.00**

Minerals

IS 44 Colorado Mineral and Mineral Fuel Activity, 1996. J.A. Cappa, C.M. Tremain, and H.T. Hemborg, 1997, 29 p., 34 figs, 6 tables. Production, prices, drilling activity, and reserves of oil and gas, coal, molybdenum, precious metals, construction materials and industrial minerals; exploration activities; maps of oil and gas wildcats, current coal mines and power plants, and major minerals producers and prospects; production graphs and photographs. **$4.00**

MI 7 Mineral and Water Resources of Colorado. USGS, 1968, 302 p., 49 figs., 44 tables, (90th Cong., 2nd Sess., Sen. Doc. 115). General stratigraphy, structure, and economic geology. Occurrence, production, and resources of mineral fuels, metals, nonmetals. **$10.00**

SP 5B Atlas of Sand, Gravel, and Quarry Aggregate Resources, Colorado Front Range Counties. S.D. Schwochow, R.R. Shroba, and P.C. Wicklein, 1975, 215 figs. Page-size reductions of 1:24,000-scale basic-data maps (1:75,000). (See OF 74-1 for full size maps.) **$15.00**

SP 47 An Introduction to Mining and Minerals in Colorado. Colorado Geological Survey, 1998, CD-ROM. An interactive CD-ROM developed under the Colorado Minerals Education Program which contains a geologic map of Colorado with information about minerals, mines, the uses of mineral commodities and their economic impact. Covers reclamation and environmental restoration of mines and quarries. Colorado teachers of middle or high school classes contact CGS for free copies. **$10.00**

MI 61 Minerals of Colorado. E.B. Eckel et al., 1997, 665 p., 119 color and 26 b&w photographs, 8 index maps, hardcover, Fulcrum Publishing. A 140-year record that is result of two decades of work and provides most complete documentation of Colorado mineralogy ever compiled. Revised and updated from 1961 edition. Includes 774 different mineral species. Not a field guide but includes comprehensive locality information; extensive bibliography. (hardcover) **$150.00**

RECREATIONAL GEOLOGY

Water & Geothermal Resources

MI 20 Ground Water Issues and Answers. Am. Inst. of Professional Geologists, 1983, 24 p., illustrations. Resources, uses, development, management, and protection; glossary. **$5.00**

SP 18 Groundwater Heat Pumps in Colorado: An Efficient and Cost-Effective Way to Heat and Cool Your Home. K.L. Garing and F.R. Connor, Coury and Associates, Inc., 1981, 32 p., 5 figs., 8 tables. Operating cycle, well permits, groundwater, system design, economic comparison, manufacturers. **$1.00**

Dinosaurs

MI 28 Pathway to the Dinosaurs. Dino Productions, 1987, 1 pl. (1:2,000,000). Generalized geologic map of Wyoming, Utah and Colorado: Mesozoic Era formations highlighted, major faults and points of interest, historical collecting areas, highways. Family tree, historical collecting site descriptions, basic dinosaur groups, stratigraphic chart. **$5.00**

MI 41 A Field Guide to Dinosaur Ridge. M. Lockley, 1990, 29 p., illustrated, Friends of Dinosaur Ridge. Historic quarries; geology; tracks; depositional environment; fossils. **$7.00**

MI 42 Fossil Footprints of the Dinosaur Ridge Area. Martin Lockley and Adrian Hunt, 1994, 53 p., 31 figs., Friends of Dinosaur Ridge. Identification; biologic and geologic indicators; oldest prints; tracks through the three geologic periods. **$7.00**

MI 44 Archaeology of the Dinosaur Ridge Area. K.D. Black, 1994, 37 p., illustrations, Friends of Dinosaur Ridge. Four time periods and lifeways at the Ridge; results of survey of ancient, recent, and paleontological sites; glossary. **$7.00**

MI 47 Dinosaur Coloring Book of Garden Park. Fifth and Sixth grades of Skyline Elementary, Canon City, Colo., 24 p., School District Fremont County Re-1. Information and history of Garden Park paleontological site with drawings for coloring. **$3.00**

MI 55 Where Dinosaurs Still Rule. Debbie Tewell with G.C. Shirley, 1993, 48 p., color illustrations, Falcon Press. Information and descriptive passages on 9 special sites and 17 museums in western North America where dinosaur bones were found or are displayed; answers to basic dinosaur questions; map; paintings; dinosaur index and pronunciation; for ages 8 and older. **$7.00**

SP 35 Colorado's Dinosaurs. J. T. Jenkins and J. L. Jenkins, 1993, 74 p., 84 figs., full color. History of dinosaur collecting in Colorado; process of fossilization; geologic time scale, rock formations that yield dinosaurs; dinosaur types; story of three geologic periods when dinosaurs lived; current excavations; guide to tours and museums; sources. **$15.00**

SP 40 Dinosaur Lake—The Story of the Purgatoire Valley Dinosaur Tracksite Area. M. G. Lockley, B.J. Fillmore, L. Marquardt, 1997, 64 p., 73 figures, full color. Latest research on the largest tracksite in North America located in remote area near La Junta. Summarizes natural and social history of region; identifies trackmakers and their social behavior; tracks as biologic and geologic indicators; erosion and other problems of the site. **$12.00**

Gems & Minerals

MI 37 Gems and Minerals, A Guide to Colorado's Native Gemstones. L. McKinney and D.T. McKinney, 1987, 48 p., color illustrations, Renaissance House. A guide for the amateur collector; detailed descriptions of gemstones and their major collecting locations. **$5.00**

MI 43 Gem Trails of Colorado. J.R. Mitchell, 1992, 125 p., illustrations, Gem Guides Book Co. Mineral descriptions; directions to and description of mine sites; local rock shops; extraction information; maps to sites. **$10.00**

MI 45 Colorado Rockhounding. S.M. Voynick, 371 p., illustrations, Mountain Press Publishing Co. Guide to minerals, gemstones, and fossils. Geology of Colorado; history of mining, digging, and collecting; collecting legality and safety; collecting localities and related sites of interest by county; mineral guide. **$18.00**

MI 46 Colorado Gem Trails. R.M. Pearl, 1972, 222 p., illustrations, Swallow Press. Outline of Colo. geology; sketch maps; museums; land ownership; local transportation and collecting conditions; mileage logs; localities arranged along main highways. **$17.00**

MI 52 Rockhounding Colorado. W.A. Kappele, 1998, 203 p., illustrations, Falcon Press..78 sites include: minerals, fossils, gems; 12 trips, glossary, map sources, mine and mountain safety, trespassing,maps to each site and photos, index. **$13.00**

MI 61 Minerals of Colorado. E.B. Eckel et al., 1997, 665 p., 119 color and 26 b&w photographs, 8 index maps, Fulcrum Publishing. A 140-year record that is result of two decades of work and provides most complete documentation of Colorado mineralogy ever compiled. Revised and updated from 1961 edition. Includes 774 different mineral species. Not a field guide but includes comprehensive locality information; extensive bibliography. hardcover **$150.00**

RS 11 Rare-Earth Pegmatites of the South Platte District, Colorado. W.B. Simmons, Jr. and E.W. Heinrich, 1980, 131 p., 45 figs., 8 tables. Location, maps, zonation, and mineral constituents of rare-earth rich pegmatites of the South Platte District, Jefferson County, Colorado. **$4.00**

General & Roadside Geology

MI 16 Geologic Map of Colorado. USGS, Ogden Tweto, 1979, 1 pl. (1:500,000). Color state geologic map and explanation sheet. Folded **$15.00**
If mailed rolled, add map tube charge **$2.00**

MI 17 Roadside Geology of Colorado. H. Chronic, 1980, 322 p., illustrations, Mountain Press Publishing Co. Specifically designed to help the traveler discover Colorado. Explains geologic features, rocks, minerals, and fossils along highways. Photographs, maps, cross sections, and stratigraphic charts. **$14.00**

MI 27 Aspen High Country. D. Laing and N. Lampiris, 1980, 132 p., colored illustrations, 1 pl. (1:250,000), Thunder River Press. Geologic guidebook to roads and trails; geologic setting and chronological record; road and trail logs and maps; glossary; colored geologic map. **$10.00**

MI 38 Colorado Geologic Highway Map. Western Geographics, R.D. Christianson, Revised Edition, 1991, 1 pl. (1:1,000,000). Geology adapted and generalized from USGS Geologic Map of Colorado. Diagrammatic section; shaded relief map (1:1,000,000 on reverse side); information on Colorado's geologic history, water resources, energy and mineral resources, rock collecting, and prospecting. **$7.00**

MI 48 The Geologic Story of the Great Plains. D.E. Trimble, 54 p., 30 figs, color. Theodore Roosevelt Nature and History Assoc., reprint of USGS Bulletin 1493. Nontechnical description of the origin and evolution of the landscape of the Great Plains; history; landforms. **$7.00**

MI 49 Geology of Colorado Post Card, 1995, 5x7 postcard in color, CGS and RMAG. Shows distribution of rocks of differenct ages, geology is superimposed over shaded relief of Colorado topography showing mountains valleys, rivers and some cities.
Up to 20 postcards will be shipped free; order of more than 20 will be charged $3.50 per $10 order for S&H **$1.00 for 2 cards**

MI 50 Lighting the Frontier: the Story of Colorado's Florence Oil Field. RMAG; 1995, VHS video, 28.5 min. Dramatic story of the people and events that led to the discovery of Colorado's first oil field in 1860. Documents field's important role in establishing Colorado as a significant oil and gas producing state, geologic factors contributing to the formation of this oil field in

and highlights Colorado's numerous other natural resources incl. coal, gold, and dinosaur fossils. For Jr. and Sr. High School. **$19.95**

MI 51 Rocky Mountain Splendor, A Mile by Mile© Guide for Rocky Mountain National Park. D.B. Osterwald, 1989, 271 p., illustrations (incl, color), Western Guideways. Mile by mile guide of all roads (scenic viewpoints, points of interest, plants, wildlife, geology, history), sections on history, geology, nature; glossary, index; award winning guidebook for one of the nation's premier national parks by an outstanding geologist, writer and educator. **$14.00**

MI 53 Geology Tour of Denver's Buildings and Monuments. J. A. Murphy, 1995, 96 p., illustrations, Historic Denver. Regional geology, Colorado's building stone industry, and descriptions of building stones on the tour. **$9.00**

MI 54 It Happened in Colorado. J.A. Crutchfield, 1993, 137 p., illustrations, Falcon Press. Easy to read famous short stories from Colorado history—an ancient buffalo hunt and other Native American tales; early settlements, expeditions, and trails; Pikes Peak gold rush; J.W. Powell's Rocky Mtn. expedition; Leadville, the silver capitol; and legendary characters. **$9.00**

MI 59 Geology along Trail Ridge Road (Rocky Mountain National Park): A Self-Guided Tour for Motorists. O.B. Raup, 1996, 73 p., color illustrations. Geology overview; 17 stops with color photo views and close-ups of rocks; rock types; oblique-view foldout map; glossary. **$11.00**

MI 62 This Dynamic Earth: the Story of Plate Tectonics. W.J. Kious and R.I. Tilling, (1996), 77 p., full color illustrations, USGS publication. Historical perspectives; developing the theory; mapping the ocean floor; understanding plate motions; hotspots—mantle thermal plumes; unanwered questions; plate tectonics and people. Also role of the key scientists; exploring the ocean floor. Written for general public and students (HS & JHS); heavily illustrated with photos, maps and diagrams **$6.00**

SP 27 Scenic Trips into Colorado Geology: Uncompahgre Plateau—Montrose, Ridgway, Norwood, Naturita, Uravan, Gateway, Delta. D.B. Collins, 1985, 1 pl. (1:250,000). Geologic tour guide to mountain ranges, canyon mazes, high country deserts, and river valleys around the Uncompahgre Plateau in southwestern Colo.; a scenic and geologically exciting area and some of the most rugged country easily accessible to motorists; road log, points of interest, and color photos, with colored geologic map, stratigraphic column, and cross section. **$2.00**

SP 44 Geologic Excursions to the Rocky Mountains and Beyond, Field Trip Guidebook for the 1996 Annual Meeting, GSA, Denver. R.A. Thompson, M.R. Hudson, and C.L. Pillmore, eds., 1996, 683 p., illustrated. CD-ROM guide with 28 field trips to parts of Colorado and surrounding states; includes Adobe™ Acrobat™ Reader and accessible on DOS, Windows 3.1 and 95, MacIntosh, and Unix systems. **$25.00**

OF 96-4 Geologic Excursions to the Rocky Mountains and Beyond Field Trip Guidebook, Individual Field Trips. 1996. Order by individual numbers

8. **Geology and Geologic Hazards of the Glenwood Sprngs Area, Central Colorado** by Kirkham et al., 38 p. **$6.00**
9. **Geology of the Western San Juan Mountains and a Tour of the San Juan Skyway, Southwestern Colorado** by Blair, 8 p.. **$5.00**
10. **Sequence Stratigraphy of the Muddy Sandstone and Equivalent Rocks from North-Central Colorado to Northeastern New Mexico** by Hollbrook and Ethridge, 43 p. **$7.00**
11. **Kinematics of the Slumgullion Landslide, Lake City, Colorado** by Fleming et al., 21 p. **$5.00**
20. **History, Geology, Hydrogeology, Summitville Mine and Downstream Effects, and Other Nearby Mines of the San Luis Valley, Colorado** in 27 parts, 184 p. **$15.00**
21. **Jemez Volcanic Field and Valles Caldera-Middle Rio Grande Rift** by Sawyer et al., 16 p. **$5.00**
23. **Depositional Environments of Codell-Juana Lopez Sandstones and Regional Structure and Stratigraphy of Canon City and Huerfano Areas and Northern Raton Basin, South-Central Colorado** by Krutak and Neuhauser, 67 p. **$8.00**
24. **Geology of the Gold Belt Backcountry Byway, So.-Central Colorado** by Henry et al., 48 p. **$7.00**
25. **Oblique Laramide Convergence in the Northeastern Front Range: Regional Implications for the Analysis of Minor Faults** by Erslev and Gregson, 11 p. **$5.00**
27. **Soil-Geomorphic Relationships Near Rocky Flats, Boulder and Golden, Colo. Area with a Stop at the Pre-Fountain Formation Paleosol of Wahlstrom (1948)** by Birkeland et al., 13 p. **$5.00**
28. **Tertiary Igneous Rocks and Laramide Structure and Stratigraphy of the Spanish Peaks Region, South-Central Colorado: Road Log and Descriptions from Walsenburg to La Veta (First Day) and La Veta to Aquilar (Second Day)** by Penn and Lindsey, 21 p. **$5.00**

Gold

IS 33 Gold Panning and Placering in Colorado—How and Where. B.H. Parker, Jr., 1992, 83 p., 55 figs, 3 tables. How to pan, recovery devices, placer mining methods used in Colorado, history of placering, geology of placers, and an extensive section with maps on where to pan. **$12.00**

RS 28 Gold Occurrences of Colorado. M.W. Davis and R.K. Streufert, 1990, 101 p. 49 figs., 2 tables, 2 pl. Classification of gold occurrences; discussion of important gold districts by age; table of occurrences showing map no., type, location, ore/mineral, host, control, and references; extensive selected references; Plate 1: (1:500,000) Gold Districts and Placers; Plate 2: (1:2 mil.) Late Cenozoic, Middle Tertiary, and Laramide Igneous Rocks and Tectonic Elements. **$14.00**
Plate 1 only, rolled **$5.00** plus tube charge **$2.00**

ENVIRONMENTAL AND LAND-USE REPORTS

Land-Use Planning Guidelines

B 48 **Colorado Landslide Hazard Mitigation Plan.** C.L. Jochim, W.P. Rogers, J.O. Truby, R.L. Wold, Jr., George Weber, and S.P. Brown, 1988, 149 p., 37 figs., 15 tables. Landslide types, definitions, triggering mechanisms, societal and economic impacts, and consequences, and multiple-hazard concept. Identification of hazardous areas and analysis of governments' roles and capabilities. Methods of landslide analysis, land-use regulations and policies, and physical mitigation methods. **$15.00**

B 49 **Snow-Avalanche Hazard Analysis for Land-Use Planning and Engineering.** A.I. Mears, 1992, 55 p., 34 figs, 12 tables. Terrain, release and motion of avalanches; avalanche design periods, magnitude and encounter probability, identification of design-avalanche terrain, calculation of avalanche runout and velocity; zoning definitions and plans; land-use controls; structural protection and mitigation methods. **$12.00**

IS 47 **Geologic Hazards Avoidance or Mitigation: A Comprehensive Guide to State Statutes, Land Use Issues, and Professional Practice in Colorado.** E.J. Johnson and J.W. Himmelreich, Jr., 1998, 43 p., figures, 8 appendices. Award winning reference tool for professions in the land development and construction industries. Includes Colorado land-use and planning regulations, local government authority and requirements, consumer protection legislation, additional statutory requirements addressing natural hazards, responsibilities of practitioners and professional associations, role of the Colo. Geological Survey. **$25.00**

SP 1 **The Governor's First Conference on Environmental Geology, (Proceedings, 1969).** AEG and AIPG, 1970, 78 p., figures. Thirteen papers dealing with application of geology to urban growth and planning, mineral conservation, and engineering problems. **$1.00**

SP 6 **Guidelines and Criteria for Identification and Land-Use Controls of Geologic Hazard and Mineral Resource Areas.** W.P. Rogers and others, 1974, 146 p., 32 figs., 7 tables. Land-use planning guide for H.B. 1041. Definition, identification, and mitigation for all geologic hazards listed in H.B. 1041. Identification and classification of mineral resource areas. Glossary and model geologic hazard-area regulations. **$6.00**

SP 7 **Colorado Avalanche Area Studies and Guidelines for Avalanche-Hazard Planning.** A.I. Mears, 1979, 124 p., 27 figs. 15 maps showing avalanche zones and hazards of critical areas in the state; descriptions of individual paths, statistics and guidelines for land-use planning in avalanche hazard areas. **$8.00**

SP 22 **Proceedings of the 33rd Annual Highway Geology Symposium—Engineering Geology and Environmental Constraints in Vail, Colorado, 1982.** J.L. Hynes, ed., 1983, 286 p., figures. 16 papers given at national symposium address geologic problems and solutions related to road construction and maintenance in mountain environments: swelling and hydrocompacting soils, narrow canyon construction, detection of underground voids, landslides, retaining walls, reinforced earth techniques, and computer applications in corridor selection. **$7.00**

SP 33 **Landslide Loss Reduction: A Guide for State and Local Government.** R.L. Wold, Jr. and C.L. Jochim, 1989, 50 p., 28 figs., 7 tables. Types, causes and losses of landslides; benefits of mitigation, hazard identification, assessment and mapping; use of communication; loss-reduction techniques; plan preparation and review; overcoming anticipated problems. **$3.00**

Geologic Hazards & Land-Use

B 43 **Earthquake Potential in Colorado, A Preliminary Evaluation.** R.M. Kirkham and W.P. Rogers, 1981, 175 p., 3 pl. (1:500,000, 1:1,000,000, & 1:62,500). Description of potentially active faults, discussion of historic seismicity, geologic evidence for Quaternary tectonism and land use implications; detailed bibliography. **$7.50**

B 50 **Debris-Flow Origin of High-Level Sloping Surfaces on the Northern Flanks of Battlement Mesa, and Surficial Geology of Parts of the North Mamm Peak, Rifle, and Rulison Quadrangles, Garfield County, Colorado.** B. K. Stover, 1993, 34 p. 22 figs., 2 tables, 1 pl. (1:50,000). Detailed surficial-geologic mapping and related stratigraphic and geomorphic analysis; new interpretation of origin of high-level sloping surfaces. **$12.00**

EG 6 **Environmental and Engineering Geology of the Windsor Study Area, Larimer and Weld Counties, Colorado.** D.C. Shelton and W.P. Rogers, 1987, 11 pls. (1:48,000 & 1:96,000). Engineering and environmental geology of an area covering eight 7.5-minute quadrangles and including the cities of Ft. Collins, Loveland, Greeley, and Windsor. Model geologic baseline-data study for a rapidly urbanizing area. **$15.00**

EG 8 **Roaring Fork and Crystal Valleys—An Environmental and Engineering Geology Study: Eagle, Garfield, Gunnison, and Pitkin Counties, Colorado.** F.M. Fox and Assoc., 1974, 64 p., 3 figs., 3 pls. (1:48,000). Description of stratigraphic units and their engineering-geologic characteristics; ground-water and mineral-resources summary. Glossary; water-well data; colored geologic, geologic- constraints, and ground-water/geologic resources maps. **$4.00**

EG 9 **Coal Mine Subsidence and Land Use in the Boulder-Weld Coalfield: Boulder and Weld Counties, Colorado.** Amuedo and Ivey, 1975, 92 p., 32 figs., 6 pls. (1:24,000). Basic subsidence-related problems; practical approaches to land development; extent of mining. Plates: 1) Extent of Mining, 2) Depth of Cover, 3) Mine Pillars, 4) Probable Thickness of Extracted Coal, 5) Subsidence Inventory, 6) Subsidence Hazards.
Text only **$4.00**
Blackline prints of each plate **$4.00**
Set of text and six plates **$25.00**

IS 8 **Debris-Flow-Hazard Analysis and Mitigation—An Example from Glenwood Springs, Colorado.** A.I.

Mears, 1977, 45 p., 8 figs. Characteristics, dynamics, and probability of debris flows; measures for protecting structures from debris flows. **$7.00**

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MS 29 Map Showing Potential Metal-Mine Drainage Hazards in Colorado, Based on Mineral-Deposit Geology. G.S. Plumlee, and others, 1995, 1 plate, color (1:750,000). (USGS OFR 95-26) Mining districts, deposit types likely to generate acidic or near neutral and metal rich or metal poor waters, occurrences, drainage basins, rivers, mineralized areas, precipitation contours, four federal agency land ownership, text, references. **$15.00**

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MI 29 Geology of Boulder, Colorado, U.S.A. S.W. Bilodeau, D. Van Buskirk, W.L. Bilodeau, 1988, 37 p., 23 figs., reprinted from the Bull. of the Assoc. of Engineering Geologists. Geologic setting, geotechnical characteristics, economic deposits, geologic constraints, environmental concerns. **$10.00**

MI 39 Colorado Rockfall Simulation Program. R.D. Andrews, 1988, rev. 1993 40 p., 11 figs., 9 tables. Manual and software which models rockfall behavior; data given includes: rock bounce height, rock velocity and kinetic energy values. Model takes into account slope profile, rebound and friction characteristics, and the rotational velocity of the rock; includes source code and 3.5 in. HD DOS diskette. **$15.00**

SP 30 Debris-Flow Hazard in the Immediate Vicinity of Ouray, Colorado. C.L. Jochim, 1986, 69 p., 38 figs., 1 table, 1 pl. (1:24,000). Study of a small mountain city with a long history of destructive debris flows; description of past events, local geology, hydrology, damage incurred, and mitigation attempts and costs; map of hazard zones. **$6.00**

SP 31 Proceedings of a Conference on Coal Mine Subsidence in the Rocky Mountain West. J.L. Hynes, ed., 1986, 315 p., figures. Papers presented at the conference on subsidence held in Colorado Springs, Colorado in October, 1985; geologic road log. **$8.00**

SP 37 Highway Rockfall Research Report. B. K. Stover, 1992, 27 p., 1 fig. The pilot study that developed the methodology for evaluating and prioritizing slopes for rockfall hazards along Colorado's highways. Incorporates accident data, maintenance input and geologic characteristics into the rating. **$5.00**

SP 38 Proceedings: Summitville Forum '95. H.H. Posey, J.A. Pendleton, and D. Van Zyl, eds., 1995, 375 p., figures. 46 papers and abstracts studying the Summitville Superfund mine site in Colorado. Topics include water chemistry, metal uptake by environment, ore deposits geology, sediment-water metal flux, mine engineering, groundwater hydrology, water treatment technologies, legal assessments of Superfund process. By USGS, EPA, Colo. State Univ., and other authors. May serve as college text or case study in environmental science; useful to earth scientists, mining engineers, attorneys, and public policy analysts.

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OF 85-1 Surficial Geology, Geomorphology, and General Engineering Geology of Parts of the Colorado River Valley, Roaring Fork River Valley, and Adjacent Areas, Garfield County, Colorado. J.M. Soule and B.K. Stover, 1985, 8 pls. (1:50,000), 2 explanation sheets. Surficial geology, geomorphology, geologic hazards, and areas of potential sand and gravel resources; engineering-geologic hazard matrix for land use. **$30.00**

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OF 87-1 Inspection Program for Low-Level Waste Disposal Facilities in Colorado. W.R. Junge, W. Eakins, W. Wright, D. Brown, and W. Jacobi, 1987, 15 p., 1 table. Describes the general requirements necessary for the establishment and execution of an inspection program for a low-level waste disposal facility in Colorado. **$5.00**

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OF 87-3 Tri-Towns Subsidence Investigation, Weld County, Colorado. J.L. Hynes, 1987, 52 p., 14 figs., 3 tables, 3 pls. (1:4,800). Community-wide approach to hazard evaluation and land use in undermined areas. Firestone, Frederick and Dacono. **$15.00**

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OF 91-4 Results of the 1987-88 EPA Supported Radon Study in Colorado with a Discussion on Geology. The Colorado Geological Survey, 1991, 51 p., 1 fig., 9 tables, Colorado results of the EPA funded 16-state Indoor Radon-Gas Survey. Some tabulations are by geologic formation, zip code, county, month tested, and different house constructions. **$10.00**

OF 95-4 Geologic Map of the Shoshone Quadrangle, Garfield County, Colorado. R.M. Kirkham, R.K. Streufert, J.A. Cappa, 1995, 1 plate (1:24,000), 16 p. Cross section, booklet of extended description of map units, rock analysis table, and references.
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OF 95-5 The Dipping Bedrock Overlay District (DBOB): An Area of Potential Heaving Bedrock Hazards Associated with Expansive, Steeply Dipping Bedrock in Douglas County, Colorado. D.C. Noe and

M.D. Dodson, 1995, 33 p. 3 figs., 2 tables., appendix "A Pierre Shale Primer", 1 plate (1:50,000). Preliminary report describing heaving bedrock as a distinctive geological hazard, a delineation of sedimentary formations that are prone to heaving; includes overlay map. **$8.00**

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RESOURCE REPORTS

Mineral Resources

(See Citizens' Resources: Minerals and Recreational Geology: Gold, Gems and Minerals)

IS 45 Active Permitted Mine Operations in Colorado, 1996-97. A. Lawson, 1998, 58 p., 1 pl. (1:1 mil.). Coal, metal, gemstone, building stone and non-metallic mines; sand and gravel operations located on a state map and listed in a directory by county with mine type and commodity. **$10.00**

IS 44 Colorado Mineral and Mineral Fuel Activity, 1996. *(See Citizens' Resources/Minerals section)*

MS 13 State Lands Status Map, Lands and Minerals Administered by Agencies of the Colorado Department of Natural Resources. Compiled by S.J. Soukup, 1979, 1 pl. (1:500,000). Lands owned by Division of Wildlife, Parks and Outdoor Recreation, and State Board of Land Commissioners. **$4.00**

MS 28 Location Map and Descriptions of Metal Occurrences in Colorado with Notes on Economic Potential. R.K. Streufert and J.A. Cappa, 1994, 1 pl. (1:500,000), descriptions, 34 p. Includes pertinent mineral species and discussion of uses. **$10.00**

OF 74-1 Atlas of Sand, Gravel, and Quarry Aggregate Resources, Colorado Front Range Counties. S.D. Schwochow, R.R. Shroba, and P.C. Wicklein, 1974, 213 pls., (1:24,000). USGS topographic maps with distribution of sand and gravel resource by type. (See SP 5B for full set reduced and bound in a book.) each **$5.00**

OF 80-8 The Effects of Mineral Conservation Legislation on Colorado's Aggregate Industry. S.D. Schwochow, 1980, 41 p., 8 figs. Discussion of legal and planning issues in relation to aggregate quarry proposals. **$5.00**

OF 97-6 Geologic Map of the Salida East Quadrangle, Chaffee and Fremont Counties, Colorado. C.A. Wallace, J.A. Cappa, and A.D. Lawson, 1997, 1 plate (1:24,000), 27 p. The quadrangle is located in the southern Mosquito Range in an area containing gold, base metal, industrial mineral, and construction material occurrences—Cleora tungsten district and parts of Turret gold district are on map. Includes cross section and booklet of extended descriptions of map units, previous studies, geologic setting, structure, mineral resources, industrial mineral occurrences, and references. Blackline copy **$6.00**

Mineral Fuel Resources

B 51 Guide to the Petroleum Geology and Laramide Orogeny, Denver Basin and Front Range, Colorado. R.J. Weimer, 1996, 127 p, illustrations. Two field trip guides: Part I—A Field Guide to the Denver Basin with Summary of Petroleum Geology (including petroleum system, sequence stratigraphy, wrench faulting and reservoir compartmentalization); Part II—A Field Guide: Laramide Orogeny and Early Cenozoic Erosional History, Front Range and Denver Basin. **$15.00**

IS 41 Active Permitted Mine Operations in Colorado, 1995–96. *(See Mineral Resource section)*

MS 26 Oil and Gas Fields Map of Colorado. J. R. Smith, C. M. Tremain, and C.A. Brchan, 1991, 1 pl., (1:500,000). Field names; producing horizons; water disposal wells, gas injection wells , storage projects; oil, gas, and products pipelines; refineries; gas processing plants; and basin outlines. Full color map current through 1991. Folded **$10.00**
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MS 30 Basement Structure Map of Colorado with Major Oil and Gas Fields. H.T. Hemborg, 1996, 1 pl. (1:1,000,000). Structure contours on top of Precambrian basement rock, selected wells drilled to Precambrian and Lower Paleozoic rocks, sedimentary basins, major oil and gas fields, Precambrian and Upper Cretaceous to Tertiary volcanic and intrusive rock outcrops; full color. **$10.00**

MI 40 Atlas of Major Rocky Mountain Gas Reservoirs. Prepared by: Colorado, New Mexico, Utah and Wyoming geological surveys, Barlow and Haun, Intera-Bergeson, and Methane Resources Group, 1993, 206 oversize pages, 700 figs, 102 tables, 10 pl. (1:2 mil. and 1: 1 mil.)., 3 3.5 in. HD DOS diskettes. Describes 66 gas plays containing 861 reservoirs that have each produced over 5 BCF. Includes sections on coalbed methane, low-BTU gases, engineering, and sequence stratigraphy. Computer database on all reservoirs and sequence stratigraphy reference.Price incl. S&H **$95.00**

RS 4 Proceedings of the Second Symposium on the Geology of Rocky Mountain Coal—1977. H.E. Hodgson, ed., 1978, 219 p., figures and tables. 14 papers on depositional environments, mine planning and development, geophysical and computer techniques, and coal petrography. **FREE**

RS 30 Geologic and Hydrologic Controls on Coalbed Methane: Sand Wash Basin, Colorado and Wyoming. W.R. Kaiser, A.R. Scott, D.S. Hamilton, R. Tyler, R.G. McMurry, N. Zhou, and C.M. Tremain, 1994, 151 p. Structural stratigraphic and hydrologic setting of Mesaverde and Fort Union coals; coalbed methane resources, producability, and possible traps. **$10.00**

RS 31 Coalbed Methane in the Upper Cretaceous Fruitland Formation, San Juan Basin, New Mexico and Colorado. W.B. Ayers, Jr., and W.R. Kaiser, editors, 1994, 216 p., 168 figs. Structural stratigraphic and hydrologic setting of Fruitland coals; coalbed methane reosources producability, pressure regimes, fracture patterns and gas composition. **$20.00**

RS 32 Directory and Statistics of Colorado Coal Mines with Distribution and Electric Generation Map, 1995–96. J.M. Zook and C.M. Tremain, 1997, 55 p., 18 figs., 1 pl., color (1:1,000,000). Directory includes mine information: location, index map, company, general and geologic information, coal quality and production, and sales data. Plate includes statistics on coal resources, mines, steam electric generation and consumption, electric utility coal consumption, hydroelectric power generation; and shows: mines, power plants, fields, coal regions, railroads, and amount and direction of coal movement. **$12.00**

RS 33 Spanish Peak Field, Las Animas County, Colorado: Geologic Setting and Early Development of a Coalbed Methane Reservoir in the Central Raton Basin. H.T. Hemborg, 1998, 34 p., 21 figs., 2 tables. Directory includes mine information: location, index map, company, general and geologic information, coal quality anshows: mines, power plants, fields, coal regions, railroads, and amount and direction of coal movement. **$12.00**

RS 34 Penetration Charts of Selected Colorado Oil and Gas Fields. C.M.T. Ambrose, 1998, 55 p., 4 pls. Directory includes mine information: location, index map, company, general and geologic information, coal quality as: mines, power plants, fields, coal regions, railroads, and amount and direction of coal movement. **$15.00**

SP 36 1990 Summary of Coal Resources in Colorado. C.M. Tremain et al., 1991, 33 p. 28 figs., 7 tables. Includes location, rank, analyses, geology, formation, structure, production, and resources in the 8 regions and 21 fields; stratigraphic column for each coal field. **$3.00**

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OF 77-1 Preliminary Investigation and Feasibility Study of Environmental Impact of Energy Resource Development in the Denver Basin. R.M. Kirkham and L.R. Ladwig, 1977, 30 p., 1 table, 1 pl. (1:500,000). Coal, lignite, uranium, oil and gas; extensive bibliography. **$7.50**

OF 97-5 Geologic Map and Coal Measures of the Axial Quadrangle, Moffat and Rio Blanco Counties, Colorado. J.K. Hardie and J. M. Zook, 1997, 3 plates: Plate 1.—Geologic Map (1:24,000), Plate 2.—Measured Coal Sections along the Northern Part of Danforth Hills in the Southern Part of the Axial Quadrangle, Plate 3.—Oil and Gas Well and Coal Exploration Test Holes along the Northern Part of Danforth Hills in the Southern Part of the Axial Quadrangle. Map area contains economically important thick coalbeds of the Williams Fork Formation and includes the Colowyo Mine. Blackline copy **$6.00**

OF 97-7 Stratigraphic and Structural Cross Sections of the Coal-Bearing Williams Fork Formation, Mesaverde Group, Colorado. R.G. McMurry and R. Tyler, 1997, 2 pl., color: Plate 1.—Stratigraphic Cross Section of the Coal-Bearing Williams Fork Formation, Piceance and Sand Wash Basins, Colorado, Plate 2.—Cross Section Indicating Missing and Duplicated Strata Due to Faulting (9S–91W Through 9S–89W) Piceance Basin Colorado. Uses genetic stratigraphy to correlate Williams Fork coal zones between Sand Wash and Piceance basins. Cross sections delineate major depositional systems and show rationale for coalbed methane target generation and resource estimates. **$15.00**

Water & Geothermal Resources

B 42 Water Resources of Boulder County, Colorado. D.C. Hall, D.C. Hillier, D.C. Cain, and E.L. Boyd, 1980, 97 p., 19 figs., 23 tables, 1 pl. (1:101,376). Occurrence, quality, and movement of ground and surface wate; general geology. **$4.00**

IS 6 Hydrogeochemical Data of Thermal Springs and Wells in Colorado. J.K. Barrett and R.H. Pearl, 1976, revised 1993, 124 p., 2 figs., 3 tables. Locations, physical measurements, chemical analyses, spectrographic analyses, radioactivity; location map of springs and wells. **$8.00**

IS 9 Geothermal Energy Development in Colorado: Processes, Promises and Problems. B.A. Coe, 1978, 52 p., 7 figs., 12 tables. Status of geothermal development in Colorado, potential for use and actions necessary for development. Conditions which constrain development and suggested remedies. **$4.00**

MS 16 Atlas of Ground Water Quality in Colorado. F.N. Repplier, F.C. Healy, D.B. Collins, and P.A. Longmire, 1981, 7 pl. (1:50,000). Hydrogeologic conditions of all aquifers less than 2,000 ft deep; cross-sections. **$12.00**

RS 6 **Colorado's Hydrothermal Resource Base—An Assessment.** R.H. Pearl, 1979, 144 p., 46 figs., 6 tables. Geology, hydrogeology, geothermometer reservoir temperature estimates, and estimates of potential resources. **$3.00**

OF 80-11 **Community Development of Geothermal Energy in Pagosa Springs, Colorado.** B.A. Coe, 1980, 58 p., 9 figs., 15 tables. Model study of community geothermal development. **$5.00**

OF 95-1 **1992–1993 Low Temperature Geothermal Assessment Program, Colorado.** J.A. Cappa, 1995, 20 p., 2 figs., 1 pl. (1:1,000.000), database on 3.5 in. HD DOS diskette. Sources of data; data format; .update of 1978 assessment in IS 6 and B 39: geochemical data, location, usage, and general information. **$15.00**

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Nature's Building Codes

Geology and Construction in Colorado

BY DAVID C. SHELTON AND DICK PROUTY

Colorado Department of Natural Resources
COLORADO GEOLOGICAL SURVEY
John W. Rold, Director

with assistance from the
COLORADO LAND USE COMMISSION

The preparation of this report was financed in part through a Comprehensive Planning grant from the Department of Housing and Urban Development, under the provisions of Section 701 of the Housing Act of 1954, as amended. The report was completed in August of 1979 and was administered through the Colorado Division of Planning. Additional assistance in funding of the report was provided by the Colorado Land Use Commission. The planning area involved covers the entire state of Colorado.

Table of Contents

Appendix C

Homebuyer's Guide

Introduction

Every house has imperfections, some of them serious. The purpose of this guide is to alert the buyer to basic geologic considerations affecting the value, serviceability and long term maintenance of a house or building. Structural flaws can have many causes. They may be of geologic, design, construction, or material origin, or a combination of them. A crack in concrete, for example, may be caused by geologic conditions, improper concrete mixing, lack of reinforcing steel or inadequate soil or base.

Basic lot locations relative to flood potential, unstable soils or other geologic hazards often can be checked with city, county or regional planning offices. In some instances maps of the hazard areas are available. In cases where examination of a structure indicates potential serious problems, experts can be retained to evaluate the situation. Such a consulting service can be inexpensive insurance for a major investment.

This guide is not intended to make all homebuyers into geotechnical experts. It can, however, be used by anyone to give a property a first screening.

Homebuyer's Geotechnical Inspection Guide

Look at OUTSIDE	Observation	Significance	Action
Onsite lot grading.	Lot slopes toward structure; water ponds next to foundation.	Roof runoff and precipitation will flow toward foundation adding water to subsoils which in turn cause wet basements, and aggravate potential swelling and collapsing soil problems which can cause foundation movement.	Regrade lot so the grade slopes away from the structure in all directions at least 6" in the first 10'.
	Lot has low areas with thick vegetation.	Possible high water table, surface drainage insufficient to remove runoff.	Determine if house is above water table or has functioning dewatering system.
	Steep slopes	Potential areas for rapid erosion and/or instability.	Control of surface drainage and do not overwater area. If severe, regrading may be required.
Landscaping	Vegetation planted close to structure and foundation.	Heavy irrigation may cause the same problem cited under "lot grading."	Control irrigation to prevent application of excess water; landscape and move vegetation.

Look at	Observation	Significance	Action
Water well and sewage disposal systems.	Close proximity of well and sewage disposal area (either on lot or adjacent lot).	Potential for contamination of water supply.	Have water quality checked by local health department.
	Well water tastes, looks or smells peculiarly.	Possibly poor water quality.	As above
	Well water yield unreliable.	Well may need maintenance or replacement. Some areas cannot yield sufficient water.	Repair or drill new well.
	Old septic-tank leach field-system. Sewage system backing up; effluent surfacing at leach field.	Malfunctioning system may cause surface or subsurface water contamination.	Septic tank may need to be pumped and/or leach field relocated.
Adjacent land	Surface water will drain onto property.	Could cause drainage problems such as ponding, erosion, or deposition on lot.	Create positive drainage control.
	Steep slopes	An unstable slope could generate rockfall, debris flow, landslide.	Investigate to determine if adverse effects are possible
	Low areas with heavy grass or other plant growth; standing water.	High groundwater table.	Investigate to determine if adverse effects are possible.
	Structure and lot close to drainageway.	It could mean part of the property is in flood prone area or susceptible to severe erosion; may be hazardous or just a maintenance nuisance.	If serious, check with local planning officials; initiate channelization measures.
Flat work (patio, driveway, sidewalks, garage floors).	Hairline cracks - no significant offset.	Minor settlement and/or shrinkage.	No problem - observe over long term.
	Cracks with offsets.	Major settlement or heaving unsightly but harmless.	If caused by poor drainage - drainage control may arrest process.
	Deteriorating concrete.	Old concrete or chemical deterioration due to sulfates in soil.	Replace with sulfate resistant concrete.

Look at OUTSIDE/ INSIDE	Observation	Significance	Action
Foundation and basement walls.	Vertical or near-vertical cracks open at the top or bottom.	If clay soils, foundation movement caused by swelling soils. If silts and sands, settlement is the probable cause of movement. If severe, can cause damage to rest of structure.	Keep surface and subsurface water away from foundation. Investigate for structural damage.
	Cracks open on inside but not on outside.	Indicates inward movement of foundation or basement wall caused by external pressure. Could be minor backfill problem or major slope instability.	Determine cause and correct: remove and replace backfill or stabilize slope.
Exterior walls (Brick, block, stucco).	Cracks in masonry walls, along joints and across bricks and blocks. Windows and doors may not operate properly.	Probable foundation movement caused by swelling and settling soils.	As noted above for foundation movement.
(Wood)	Movement may only show around windows and doors due to flexibility of structure.		
Fireplace and chimney.	Cracks in masonry.	Differential settlement of foundation can cause openings in flue liner increasing fire hazard and/or pulling of chimney away from structure.	Check structural integrity for fire safety.
	Masonry intact but chimney pulling away from structure.	Fireplace foundation rotating away from structure and/or foundation.	Jack back into place or rebuild.
Look at INSIDE			
Basement floors	Cracks across slab or parallel to wall so floor shows upward movement. Check furnace duct work and interior partition walls for distress.	Swelling soils causing heave of slab. If basement is unfinished, may be only cosmetic problem unless furnace and utilities are affected. If basement is finished, problem may be serious causing major damage to walls, doors, and windows.	Determine if corrective or structural damage. Repair may be very costly.
Sumps, drains, sump pumps in basement and around foundation.	If these dewatering systems exist, look for evidence of past wet or flooded basement.	Indicates high or perched groundwater conditions are possible. Pumps require maintenance. Drains may plug. If malfunctioning, basement or crawl space may then become wet or flooded.	Check for proper operation and ascertain past history.
Interior walls, doors, and ceilings.	Cracks with offsets in plaster, drywall, wallpaper, often most noticeable around door and window panes.	May only indicate shrinkage or of wood frame. Can also indicate foundation or basement slab movement from swelling or collapsing soils.	Determine cause. May require structural repair or cosmetic attention.

Appendix D

How to Find Out About Geology and Land Use in Colorado

Several organizations exist to help the homebuyer, contractor, developer, banker, or other land user find out about the natural conditions prevailing at a particular location. Many Colorado cities and most counties have planning and building departments and some staff geologists particularly familiar with local situations. In some parts of Colorado several counties have banded together to form Councils of Governments (COG) to provide these services. Also, there are special districts in addition to state and federal agencies and professional organizations.

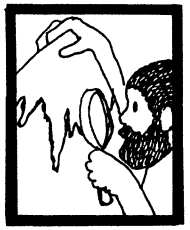
The organizations cited here are starting points and the list is by no means all inclusive. It is intended as a place to begin an inquiry into the fascinating interrelationships between man and nature in continuing wise use of the land.

Organizations	Types of Information
American Institute of Professional Geologists (AIPG) 622 Gardenia Street Golden, CO 80401 Phone: 279-0026	List of geologist members Monthly meetings Continuing education Professional ethics
Association of Engineering Geologists (AEG) 7391 W. 38th Avenue Wheat Ridge, CO 80033 Phone: 424-5564	List of engineering geologist members Monthly meetings Continuing education
Consulting Engineers of Colorado 1111 S. Colorado Blvd., Suite 305 Denver, CO 80222 Phone: 757-3379	List of member engineers Monthly meetings Professional ethics
Rocky Mountain Association of Geologists (RMAG) 1615 California Street, Suite 217 Denver, CO 80202 Phone: 573-8621	List of geologist members Weekly meetings Continuing education

Colorado State Agencies	Types of Information
Colorado Geological Survey 1313 Sherman Street Denver, CO 80203 Phone: 839-2611	General information on Colorado geology. Engineering and resources. Special mapping projects.
Colorado Health Department Water Pollution Control Commission 4210 E. 11th Avenue Denver, CO 80220 Phone: 320-8333	Regulatory agency for water pollution control.
Colorado Health Department Radiation and Hazardous Wastes Division 4210 E. 11th Avenue Denver, CO 80220 Phone: 320-8333	Regulatory agency for radioactive material management and disposal.
Colorado Land Use Commission 1313 Sherman Street Denver, CO 80203 Phone: 839-2778	Major land-use issues and information. Commission has investigative and regulatory powers.
Colorado Division of Planning 1313 Sherman Street Denver, CO 80203 Phone: 839-2351	Assistance for local planning and State planning.
Colorado Division of Mines 1313 Sherman Street Denver, CO 80203 Phone: 839-3401	Mine maps of coal mines and most other mines.
Colorado Water Conservation Board 1313 Sherman Street Denver, CO 80203 Phone: 839-3441	Flood plain information.
Colorado Division of Water Resources 1313 Sherman Street Denver, CO 80203 Phone: 839-3581	Administration of groundwater resources, dam safety.

United States Agencies	Types of Information
U.S. Geological Survey Box 25286 Denver Federal Center, Building 41 Denver, CO 80225 Phone: 234-3832	Map sales
U.S. Geological Survey Public Inquiries Office 1961 Stout Street, Room 169 Denver, CO 80294 Phone: 837-4169	Map and publication sales.
U.S. Bureau of Mines Mine Map Repository Denver Federal Center, Building 20 Denver, CO 80225 Phone: 234-4161	Microfilm collection of mine maps.

Other	Types of Information
Urban Drainage and Flood Control District 2480 W. 26th Avenue Denver, CO 80228 Phone: 455-6277	Flood control projects and flood plain maps for the Denver Metro area.



Appendix E

A Guide for the Preparation of Engineering Geology Reports in Colorado

An engineering geology report furnishes both technical and non-technical persons with information related to subdivision development, public works construction, mineral extraction, and other uses. It describes clearly all important geologic conditions, interprets correctly their impact on proposed development activities, and makes recommendations regarding the mitigation of adverse conditions or mineral resource conflicts. The report provides persons involved in the planning, design, construction, finance or review process with geologic information so that technical decisions can be made.

The guide is intended as a framework for many types of geotechnical investigations. However, it is designed specifically as a description of the type of geologic information and analysis that usually is included in engineering geology reports for residential and commercial subdivisions. The guide also lists geology-related investigations including flooding and water resources, that may be reviewed by governmental agencies other than the Colorado Geological Survey. These investigations usually are discussed as a part of the geotechnical report so that project feasibility can be evaluated in the early planning stages.

The size and geologic complexity of a project requiring engineering geology reports vary greatly. This variability necessitates reports different from one another in scope, length, and organization. Because of this wide variation, the geologic investigations and reports should be flexible and tailored to the specific geologic conditions and intended land-use. Additionally, certain geologic interpretations and report recommendations may not be firm or complete in the initial planning stages of a project and supplemental information or detailed reports may be necessary during later stages of development. Regardless of the project size, stage, or geologic complexity, all pertinent data, interpetations, and recommendations regarding geologic hazards, constraints, or resource conflicts should be presented clearly in the engineering geology report.

Geologic studies of hazardous or mineral resource areas are

required by certain Colorado Statutes. Senate Bill 35 (C.R.S. 1973, 30-28-101, 110(3)-(5), 133-137) and House Bills 1041 (C.R.S. 1973, 24-65.1-101, et seq.) and 1529 (C.R.S. 1973, 34-1-301, et seq.) require that geologic hazards and mineral resources be considered prior to development activities. Geologic hazard is defined in HB 1041 as "a geologic phenomenon which is so adverse to past, current, or foreseeable construction or land use as to constitute a significant hazard to public health and safety or to property." A mineral resource area is defined in this same bill as "an area in which minerals are located in in sufficient concentration in veins, deposits, bodies, beds, seams, fields, pools, or otherwise, as to be capable of economic recovery..." Local governments are empowered to regulate development in these hazard or resource areas by Senate Bill 35, House Bill 1041, and by House Bill 1034 (C.R.S. 1973, 29-20-101, et seq.). Regardless of the legal requirements it is in the best interest of the designer, developer and builder and financial institutions to obtain a report on the geologic conditions before a project is begun so that the results of a geologic investigation can be incorporated into the project planning. Geologic information can be used to save development and construction costs or, perhaps, liabilities and legal costs by acquainting the developer or contractor with adverse geologic conditions and their impact on the proposed project. Ultimately, the use of information contained in the report also could save local and state governments, and the taxpayers from excessive expense resulting from failure to recognize and cope with natural hazards. Private property owners benefit by preventing foreseeable devaluation of their holdings.

All engineering geology reports should be prepared and signed by a Professional Geologist as defined by Colorado law, House Bill 1574 (C.R.S. 1973, 34-1-20, et seq.). To prepare a complete and accurate report, the geologist must have special education and experience in the field of engineering and environmental geology. The geologist who does not have this general training and experience should refrain from doing engineering geology studies or should work under supervision of a geologist who is experienced in this field. The report should be prepared in accordance with the highest prevailing standards of the profession realizing that omissions of significant data are as serious an error as giving misinformation.

General Content of Engineering Geology Reports

Engineering geology reports generally contain three distinct and essential elements: 1) data, 2) interpretation of the data, and 3) conclusions and recommendations.

Data: Report data are facts used as the basis for interpretations, discussions, and conclusions. These facts are the cornerstone of the report and are obtained from published documents, surface and subsurface investigations, and field and laboratory tests. Surface studies generally include topographic surveys, geologic mapping, and the review of aerial photographs or other remote-sensing imagery. Subsurface investigations can include geophysical surveys, drill holes, test pits, and trenches. Field and laboratory tests may cover the analysis of various factors involving soils engineering, sewage leach fields, water quality, or mineral resources.

Geologic conditions which should be described in the report include bedrock units, surficial deposits, geomorphic features, structural features, surface drainage, ground-water conditions, and mineral resources. Description of the conditions will differ markedly in their degree of detail and specificity depending on the particular method or technique used in gathering data. The limitations of the method or techniques used and the quality of the data should be discussed. Where interpretations are added to the recording of direct observations, the basis for interpretations must be clearly stated.

Interpretation: After the geologic data has been presented, it is analyzed with regard to geologic hazards and geologic constraints, mineral resources, and water conditions. Geologic hazards are conditions that eventually will affect the safety of persons and property by instability of the ground surface or inundation of the surface by debris, mud, snow, or water. Instability or inundation may be caused by either natural or man-induced processes such as landslides, debris flows, mudflows, flooding, faulting, avalanches, rockfall, and subsidence over underground mines. Paramount in the analysis of geologic hazards and constraints is the recognition and evaluation of natural processes as well as an estimation of the recurrence interval for a specific size and kind of event. Colorado Geological Survey Special Publication 6 (Rogers and others, 1974) offers detailed descriptions of these processes. It defines the processes, gives the criteria for recognition, and anticipating the consequences of improper utilization. It also suggests mitigation procedures.

Geologic constraints are conditions that probably will not result in the loss of life but could cause significant added construction expense or property damage. These constraints may be controlled by by proper design and construction. The lack of proper design or construction could initiate or aggravate specific geologic processes and escalate construction and maintenance costs. These costs could determine project feasibility, especially if they are not

recognized and incorporated into project plans. Geologic constraints can affect road and foundation stability, sewage disposal feasibility, cut and fill stability, and other construction activities. These include factors such as potentially unstable slopes, expansive soils, hydrocompaction, high ground-water levels, ground subsidence, shallow bedrock, erosion, and soil creep.

Mineral resources usually do not affect safety of individuals or the stability of structures but they may impact the long-term economic well-being of citizens within the county and state. Mineral resources should be evaluated, administered, and protected to permit the wisest use of our limited resources. Mineral resources including occurrences of construction materials and industrial minerals at the surface and metallic and mineral fuel deposits within the subsurface, should be evaluated and described in the report.

These resources, such as oil, gas, coal, sand and gravel, uranium, and precious metals, should not only be economically evaluated but also should be evaluated with regard to multiple sequential land-use. This program considers the analysis of mineral extraction followed by use of the land for other activities. Colorado Geological Survey Special Publication 6 (Rogers and others, 1974) and Special Publication 8 (Shelton, 1977) should be consulted for detailed descriptions of mineral resources and resource factors.

Water resources, including surface and ground waters, are similar to mineral resources in that they usually do not adversely affect the safety of individuals or the stability of structures. However, water resources must be analyzed with regard to location, quality, and quantity so that possible pollution, recharge, or depletion can be determined.

The analysis of geologic hazards, geologic constraints, mineral resources, and water conditions constitutes the major part of an engineering geology report. The analysis, supported directly from geologic data and information, should identify and interpret adverse geologic processes and important mineral and water resources. It should evaluate (1) the effects of geologic processes or resources on the proposed construction and (2) the effect of the proposed project on the future geologic processes or resources in the area.

Conclusions and Recommendations: Report conclusions and recommendations vary greatly from report to report because of variable geologic conditions and different project criteria. Regardless of these variations, the data necessary for safe construction, long-term viability of the project, and adequate protection of mineral and water resources must be contained in the engineering geology report. It is equally important that this report be used in the planning process; e.g., the preparation of the preliminary plat. Geologic factors are incorporated most easily before submittal of the report to reviewing agencies.

Report conclusions and recommendations should be stated in ordinary and unambiguous language and should first identify the critical geologic aspects of all elements of the project. The geologic feasibility of the project should be determined and mitigation measures or design changes recommended to minimize or abate any adverse conditions. Further studies should be recommended if needed.

Engineering Geology Report Guidelines

The guidelines that follow are a general outline of the materials usually included in an engineering geology report. Items discussed in the outline were compiled from a variety of sources, especially the California Division of Mines and Geology, Ventura County and the City of San Jose, California, and from publications of the Association of Engineering Geologists. Specific references used in this compilation are cited at the end of this appendix and should be consulted for additional details.

These guidelines are not intended as a rigid framework of requirements, a specific format for all reports, or report procedures for all geotechnical investigations. Particular items or investigations listed may be deleted or may require emphasis because of local geologic conditions or type of project proposed. This outline should be considered as a general list of geotechnical information commonly evaluated and provided in an engineering geologic investigation.

I. BASIC INFORMATION

A. PROJECT DESCRIPTION

1. Describe present zoning, land-use proposed and structure(s) anticipated.

2. Indicate size and relationship of the project to the surrounding area.

B. LOCATION

1. Specify the project location in terms of section, township and

range, and county.

2. Depict the project location on an index map of appropriate scale, usually U.S. Geological Survey 7.5-minute quadrangle map.

C. PURPOSE

1. Clearly state the uses for which the report was prepared. Excluded uses also may be described.

2. Indicate the commissioning person or organization.

D. SCOPE

1. State the objective(s) and level of investigation for the study.

2. Cite previous published or unpublished geologic reports in the subject area and indicate the author(s), firm, and dates of each report.

3. List all the methods of investigation as well as professional firm(s) and individuals who participated.

4. If the level of investigation varies within the subject area, describe in the text and show on the maps areas of concentration or exclusion.

5. Indicate the approximate time spent in the field investigation and by whom.

II. BASIC DATA

A. REGIONAL SETTING

1. Describe the general physiographic setting of the project and its relationship to local topographic features.

2. Describe the general geologic setting of the project and indicate any lithologic, tectonic, geomorphic, or soils problems specific to the area.

3. Describe the general surface and ground water conditions and their relationship to the project area.

4. Describe the mineral resources in the general area.

B. SITE EVALUATION TECHNIQUES

1. State the extent and method of surface and subsurface geologic studies.

2. Topographic Mapping

   a. Indicate the type and accuracy of topographic maps in the area.

   b. State the date of the topographic survey and firm or individuals who conducted the survey.

3. Geologic Mapping

   a. Prepare geologic map(s) on the project topographic map to show important details commensurate with the purpose of the investigation.

   b. Show the abundance and distribution of earth materials and structural elements exposed or inferred in the subject area. Observed and inferred features or relationships should be so designated on the geologic map.

   c. Depict significant three dimensional relationships on appropriately positioned cross sections.

   d. Portray all geologic information at the same scale as the project plans. Use "tie-points" between the geologic map, topographic map, and project plans.

   e. Indicate the geologic base map used, date, and significant additions and modifications to previous work.

4. Aerial Photographs and Remote-Sensing Imagery

   a. Describe type(s) of photographs or images including instrumentation, processing techniques, and final product.

   b. Indicate data and scale of photographs or imagery used in the investigation.

   c. Describe the source of photographs and photographic identification numbers.

   d. Indicate usefulness and general relationships observed on the images.

5. Geophysical Investigations

   a. State type and objectives of the geophysical investigation(s) (if any), quality of the data, and limitations of the geophysical techniques.

   b. Describe the information used to correlate the geophysical data and known geologic conditions.

   c. Display the geophysical data on the topographic/geologic maps and cross sections and show cultural features which affect the data.

6. Drill-Hole Data

   a. State the specific investigative methods, tests conducted, drilling equipment, and date

of investigation.

b. Show the location of all borings on the topographic or geologic map.

c. Show boring logs, geophysical logs, or profiles obtained in the investigation. This information generally includes location and type of samples; soil descriptions according to the unified soil classification; lithologic descriptions using standard geologic terminology; critical soil or geologic contacts; and groundwater levels.

7. Test Pits and Trenches

a. Describe the location and general dimensions of all pits and trenches and date of investigation.

b. Indicate the location of all excavations on the topographic/geologic map and profiles.

c. Provide a large scale descriptive log with sufficient detail commensurate with the features observed. Insets may be used if necessary.

d. Show sample locations if supplemental laboratory tests were conducted.

8. Field and Laboratory Tests

a. Describe the type and objectives of any tests conducted in the field or laboratory.

b. Describe the sample method and test procedures.

c. Show the test results on data work sheets or on summary tables.

9. Monitoring Programs

a. Describe the type, objectives, and location of all monitoring programs in the subject area.

b. State the monitoring period, the firm(s) or individuals responsible for the care and disposal of the installations.

III. GEOLOGIC DESCRIPTIONS

A. BEDROCK UNITS: sedimentary, igneous, and metamorphic rock types.

1. Rock type and bedding orientation.

2. Age of and correlation with recognized formations.

3. Dimensional characteristics such as thickness and extent.

4. Distribution and extent of the weathered zone.

5. Physical and chemical characteristics.

6. Distribution and extent of weathered zone.

7. Response of bedrock materials to natural processes.

8. Mineral occurrences.

B. SURFICIAL DEPOSITS: fluvial, colluvial, glacial, eolian, mass wasting, and man-made deposits

1. Distribution, occurrence, and age

2. Identification of material types and sources

3. Dimensional characteristics such as thickness and extent

4. Surface expression and relationships with present topography

5. Physical and chemical characteristics

6. Distribution and extent of altered zones

7. Response of surficial materials to natural processes

8. Mineral occurrences

C. GEOMORPHIC FEATURES: landslides, earthflows, debris flows, mudflows, rockfalls, debris avalanches, fault scarps, soil creep, erosion scarps, avalanche paths, and subsidence phenomenon.

1. Location and distribution

2. Dimensional characteristics

3. Age of feature and history of activity

4. Recurrence interval for geomorphic process

5. Physical characteristics including depth, flow velocities, and impact pressures

D. STRUCTURAL FEATURES: joints, faults, shear zones, folds, schistocity, and foliation

1. Occurrence, distribution, and proximity to site

2. Dimensional and displacement characteristics of faults

3. Orientation and changes in orientation

4. Physical characteristics such as brecciation, slickensides, gouge zones, sand boils, sag ponds, spring alignment, disrupted drainages, or ground-water barriers

5. Nature of offset(s) and timing of movement(s)

6. Absolute or relative age of latest movement

7. Location and magnitude of seismic events and their association with faults or fault systems

E. SURFACE DRAINAGE: rivers, streams, creeks, and draws

1. Distribution and occurrence

2. Relation to topography (drainage patterns)

3. Relation to geologic features

4. Source, permanence, and variation in amount of surface water

5. Evidence of earlier occurrence of water at localities now dry

6. Estimated peak flows and physiographic flood plain of drainages

7. Probable maximum or 100-year flood limits, including flash and debris floods

8. Water quality

9. Use of surface waters

F. GROUND WATER: confined and unconfined

1. Distribution and occurrence

2. Hydraulic gradients

3. Recharge areas for aquifers

4. Relation to topography

5. Relation to geologic features

6. Seasonal variations

7. Water quality

8. Use of ground waters

9. Aquifer characteristics

G. Mineral resources: metallics, mineral fuels, and non-metallics

1. Distribution and occurrence

2. Abundance and past production

3. Mineral rights and agreements

IV. GEOLOGIC INTERPRETATION

A. GEOLOGIC HAZARDS (landslides, avalanches, rockfall, mudflows, debris flows, radioactivity)

1. Geomorphic and structural features/processes present in the area

2. Man-induced features/processes

3. Age and activity of the features/processes

4. Natural conditions affecting the features/processes

5. Susceptibility to man-induced changes

6. Potential impact of hazard(s) and risk to project

7. Amenability of adverse conditions for adequate mitigation

8. Long-term lateral and vertical stability of earth materials

9. Impact of project on materials stability

B. GEOLOGIC CONSTRAINTS (expansive soil or rock, potentially unstable slopes, high ground-water levels, soil creep, hydro-compaction, shallow bedrock, erosion)

1. Soil, surface and ground water, and geomorphic conditions

2. Man-induced conditions

3. Activity of conditions

4. Effect of natural or man-induced changes

5. Potential impact of conditions and risk to project

6. Amenability of adverse conditions for adequate mitigation

7. Impact of project on long-term project stability

C. WATER RESOURCES

1. Quantity of surface or ground water available to project

2. Long-term water availability

3. Impact of waste disposal on water quality

4. Effect of project on ground water recharge

5. Potential for development of perched ground-water conditions

6. Impact of project, especially of on-site sewage disposal, on quality and quantity of water resources

D. MINERAL RESOURCES

1. Type of resource

2. Mineral economic parameters

3. Economic potential of the deposit(s)

4. Impact of the project on mineral resources

V. CONCLUSIONS

A. STATE WHETHER THE INTENDED USE OF THE LAND IS COMPATIBLE WITH

POTENTIAL GEOLOGIC HAZARDS, CONSTRAINTS, AND MINERAL RESOURCES AND IF MITIGATION MEASURES ARE NECESSARY.

B. DISCUSS THE CRITICAL PLANNING AND CONSTRUCTION ASPECTS INCLUDING SEWAGE OR SOLID WASTE DISPOSAL, THE STABILITY OF EARTH MATERIALS, GRADING PLANS, AVAILABILITY AND QUALITY OF SURFACE OR GROUND WATER, THE NEED FOR SELECTIVE LOCATION OF PROJECT FACILITIES, STATIC AND DYNAMIC PARAMETERS FOR THE DESIGN OF STRUCTURES, AND METALLIC AND NON-METALLIC MINERAL EXTRACTION.

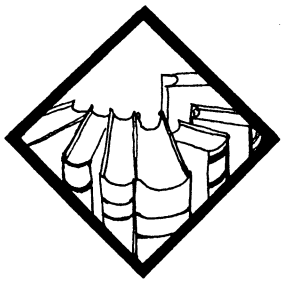
C. CLEARLY STATE THE GEOLOGIC BASIS FOR ALL CONCLUSIONS.

VI. RECOMMENDATIONS

A. DISCUSS THE DEVELOPMENT OF MITIGATION PROCEDURES OR DESIGN CHANGES NECESSARY TO MINIMIZE OR ABATE ANY ADVERSE CONDITIONS OR MINERAL RESOURCE CONFLICTS. EACH HAZARDOUS CONDITION OR MINERAL RESOURCE REQUIRES A RECOMMENDATION

B. STATE THE RECOMMENDATIONS IN ORDINARY AND UNAMBIGUOUS LANGUAGE, ESPECIALLY FOR NON-GEOTECHNICAL PERSONNEL. THE RECOMMENDATION SHOULD INSURE THE LONG-TERM STABILITY AND SAFETY OF THE PROPOSED PROJECT.

C. INCLUDE ANY SUGGESTIONS FOR ADDITIONAL GEOTECHNICAL STUDIES NEEDED TO DETERMINE THE IMPACT OF KNOWN OR INFERRED FEATURES IN THE SUBJECT AREA.



Appendix F

Suggested Readings for More Detailed Information

Proceedings of the Governor's First Conference on Environmental Geology, Association of Engineering Geologists and American Institute of Professional Geologists, 1970, Colorado Geological Survey Special Publication 1, 78 p., 13 papers dealing with application of geology to urban growth and planning, mineral conservation and engineering problems.

Guidelines and criteria for identification and land-use controls of geologic hazard and mineral resource areas, W.P. Rogers and others, 1974, Colorado Geological Survey Special Publication 6, Land use planning guide for H.B. 1041. Definition, identification and mitigation for avalanches, landslides and rockfalls. Identification and classification of mineral resource areas. Glossary and model geologic hazard area regulations.

Natural hazards, earthquake, landslide expansive soil loss models, John H. Wiggins, James E. Slosson, James P. Krohn; J.H. Wiggins Co., 1650 South Pacific Coast Highway, Redondo Beach, CA, 90277; December 1978.

Building losses from natural hazards: yesterday, today, and tomorrow, Daniel H. Baer; J.H. Wiggins Co., 1650 South Pacific Coast Highway, Redondo Beach, CA, 90277; December 1978.

Proceedings Governor's Third Conference on Environmental Geology--Geologic Factors in Land Use Planning, D.C. Shelton, editor, 1977, Colorado Geological Survey Special Publication 8, 17 papers dealing with geologic hazards, mineral resources: case studies in county planning, land use regulation and legal aspects.

Prairie, peak and plateau--a guide to the geology of Colorado, John and Halka Chronic, 1972, Colorado Geological Survey Bulletin 32. A layman's guide to the geology of Colorado.

Geological map of Colorado, U.S. Geological Survey, 1935: reprint Colorado Geological Survey, 1975. At present it is the only colored geologic map of the State of Colorado at a scale of 1:500,000. The U.S.G.S. has a revised version in

preparation.

Earth-science information in land-use planning--guidelines for earth scientists and planners, U.S. Geological Survey, 1976, U.S.G.S. Circular 721.

Geologic aspects of soil and related foundation problems Denver metropolitan area, Colorado, J.L. Hamilton and W. G. Owens, 1972, Colorado Geological Survey Environmental Geology 1. Bedrock and surface geology soil and stability problems, rock unit engineering characteristics, foundation design criteria. Includes engineering soils and geology/depth to bedrock maps.

"Nature to be commanded...," earth science maps applied to land and water management, G.D. Robinson and A.M. Spieker, editors, 1978, U.S. Geological Survey Professional Paper 950. Case histories of geology used in land and water management.

Flooding

Floodplain management, flood control and flood disaster programs--Manual for local governments, Colorado Water Conservation Board, June 1976. Discusses legislation, identification and regulation, control, and emergency and disaster programs.

Flood plain--Handle with care!, Department of the Army Corps. of Engineers, March 1975, EP1105-2-4. A case history approach to flood hazard mitigation.

Mountain Torrent-Flash Flood

Geologic hazards, geomorphic features and land-use implications in the area of the 1976 Big Thompson Flood, Larimer County, Colorado, J.M. Soule, W.P. Rogers, and D.C. Shelton, 1976. Colorado Geological Survey Environmental Geology 10. Present and potential geologic hazard areas, debris fans, landslides, rockfalls, unstable slopes, flood hazards, flood discharges, and descriptive text.

Debris/Mud Flow and Fan

Debris-flow hazard analysis and mitigation--an example from Glenwood Springs, A.I. Mears, 1977, Colorado Geological Survey Information Series 8. Characteristic dynamics, and probability debris flows; measures for protecting buildings from debris flow impact.

Ground Water

Bibliography of hydrogeologic reports in Colorado, R.H. Pearl, 1971. Colorado Geological Survey Bulletin 33. Compilation of published and unpublished reports on ground water conditions through 1970, with subject index.

Geologic control of supply and quality of water in the mountainous part of Jefferson County, Colorado, W.E. Hofstra and D.C. Hall, 1975. Colorado Geological Survey Bulletin 36. General geology, soils and water resources; chemical quality of surface and ground water; environmental factors influencing water quality; water-management problems and alternatives. Includes graphs and tables of water quality data.

Geology of ground water resources in Colorado--an introduction, R.H. Pearl, 1974. Colorado Geological Survey Special Publication 4. Occurrence, quality, and movement of ground water. Outline of resources in seven regions, stratigraphic chart showing water-bearing formations. Extensive bibliography.

Manual of Septic Tank Practice, U.S. Department of Health, Education, and Welfare, 1967. DHEW Publication #(HSM)72-10020.

National interim primary drinking water regulations, 1976, U.S. Environmental Protection Agency, Office of Water Supply, EPA-570/9-76-003. Maximum contaminent levels, monitoring and analytical requirements and background information.

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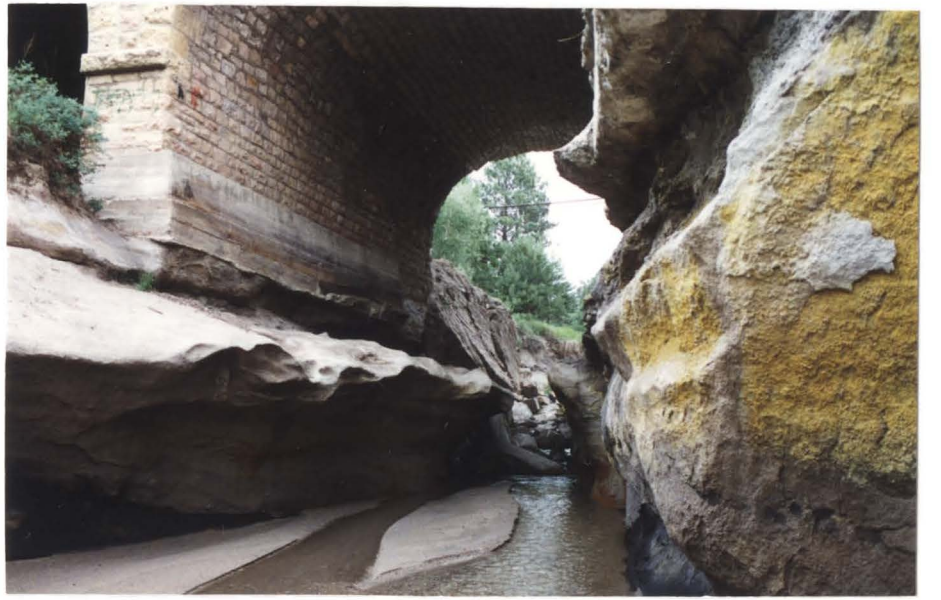
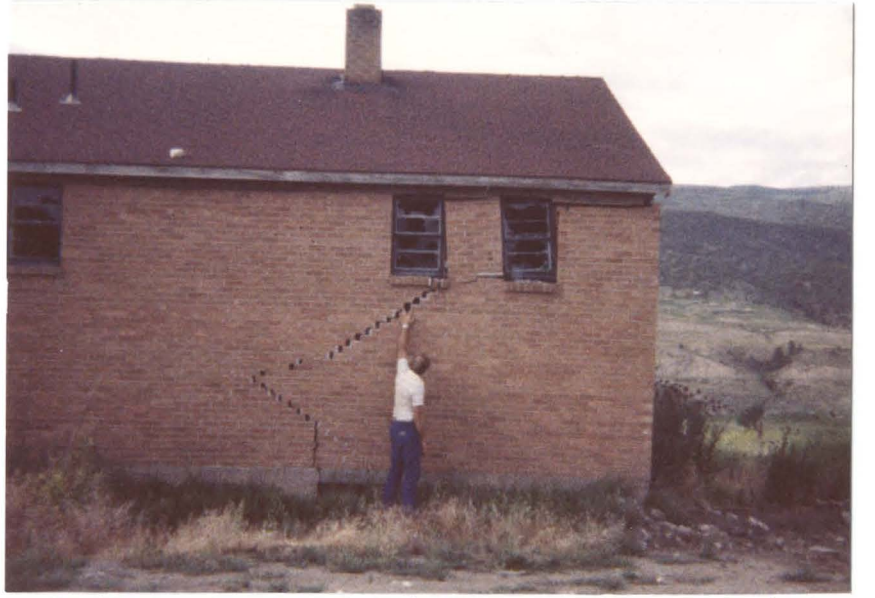
Shrinkage cracks form in expansive soils. Sulfate salts which are detrimental to concrete and metal leach out of corrosive soils.



Even foundations resting on solid bedrock are subject to undercutting by the erosive effects of water.

Several prominent linear heave features, which result from steeply dipping beds of expansive bedrock, cross a developed lot adjacent to an industrial development in Colorado Springs. All photos by John Himmelreich.



Soluble minerals in the Eagle Valley Evaporite formation are dissolved by groundwater. The resulting void sometimes causes subsidence at the surface. Subsidence (sink hole) resulted in this damage to a structure in Edwards, Colorado.