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LIQUID WASTE DISPOSAL PROBLEMS IN UTAH: A GEOLOGIC PERSPECTIVE

By WILLIAM R. LUND

Introduction

The past decade has seen a rapid increase in Utah's population and continued development of the state's natural resources. Accompanying that growth and development has been the production of increasing quantities of liquid wastes. The safe and adequate disposal of those wastes is a major problem for both state and local authorities. The primary concern being the protection of shallow ground- and surface-water resources which, once polluted, are difficult to restore to their former quality.

Three types of liquid waste are commonly associated with disposal problems in Utah. These are: 1) brackish oil- and gas-well production waters, 2) agricultural waste converted to liquid form, and 3) sewage effluent from septic tank and soil absorption systems. The UGMS has investigated a number of occurrences where the disposal of these types of waste has become a problem. In nearly every instance, the cause could be related to inadequate consideration of geologic and hydrologic factors in the selection of disposal sites. The following examples selected from each of the three categories of waste are typical of the problems encountered, and illustrate the important role played by geology and hydrology in liquid waste disposal.

Oil and Gas Well Production Water

More than 102,000,000 barrels (13,500 acre feet) of water are produced annually from Utah oil and gas wells (oral communication, Utah Division of Oil, Gas and Mining personnel, 1982). About 7 percent of that total is reinjected into subsurface formations. The remainder, approximately 95,000,000 barrels (12,500 acre feet), is disposed at the ground surface. Some of the production water is fresh, and can be put to beneficial use. For example, fresh water from the Ashley Valley oil field in the Uinta Basin is used to irrigate cropland (Goode and Feltis, 1962). However, most of the water is polluted and contains such undesirable substances as petroleum residues, heavy metals, drilling fluids, and high concentrates of dissolved salts. The surface disposal of production water often takes place illegally, with the water dumped into the nearest convenient ravine or sprayed along a dirt road (Figure 1). Two recent cases of concentrated illegal dumping resulted in UGMS involvement in the location of alternative disposal sites.

In the first case, some 15 tanker truck loads of production water were being discharged each day into a county-operated sanitary landfill in Summit County. The dumping occurred with the permission of county officials who were not familiar with Utah Health Department regulations governing the disposal of such wastes. The landfill is located in an abandoned borrow pit on a mountain slope above the Weber River (Figure 2). The situation was eventually brought to

(see page 4)

Editor's Note:

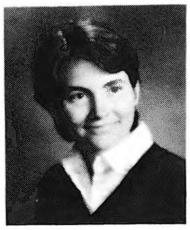
Survey Notes Get New Look

During the summer months the Utah Geological and Mineral Survey installed a WANG Computer and WANG Phototypesetting system. This is the first issue of the Survey Notes to be entirely typeset in the editorial department using computerized typesetting equipment.

The text for this issue, as well as all future UGMS publications, was typed and edited on the new system. After revision and final review, a "perfect" phototypeset copy is created via a photographic process whereby light passes through a film strip, accurately transferring character images onto light sensitive paper, called "galley." This galley is then developed and used in the printing process.

The new phototypesetter is very powerful and flexible, allowing virtually unlimited mixtures of type styles and sizes, as well as many special characters and symbols to be accurately reproduced. The typestyle used for the body of this issue is a 10 point Orleans, regular and bold face. As you can see, the result is **"purrfekt."** ■

IN THIS ISSUE



FROM THE DIRECTOR'S DESK

UGMS Site Investigation Section

The UGMS was established approximately 50 years ago to inventory Utah's mineral and ground water resources. Over time, its role has come to include the identification of Utah's geologic hazards as well. Today, approximately 25 percent of the UGMS investigations are concerned with "Applied Geology," the identification of hazard areas and the response to state and local agencies for requests for site investigations. This issue of *Survey Notes* contains several articles written about the activities of the UGMS Site Investigations Section, which consists of three geologists: William R. Lund, section chief; Gary E. Christenson; and Harold E. Gill.

The geologists in the Site Investigations Section act almost exclusively in response to requests from other state agencies, counties, or from municipalities. The state regularly seeks geologic input through the RDCC (Resource Development Coordinating Committee) which reviews all state projects receiving federal funds. Examples of the reviews solicited by this council include HUD developments guaranteed by the Federal Home Mortgage Insurance Fund, stabilization or removal of the Vitro tailings, and BLM plans for land use. The UGMS regularly advises the RDCC and these other agencies on the adequacy of the geotechnical work that has been performed for their projects and the advisability of further work.

The Site Investigations Section also responds to requests from the State's Real Estate Division. The UGMS reviews the geotechnical work performed by the contractor, and inspects the site for the Utah State Department of Health. With the slow down in the economy, requests for these inspections have diminished considerably. The UGMS also inspects, on a regular basis, construction excavations that might expose evidence of ground movement or deformation along the Wasatch Front.

In addition to performing these geologic reviews for the State of Utah, the Site Investigations Section acts as a geologic resource for counties and municipalities. These entities haven't the resources to retain geologists on their staffs. Instead, they can require that geologists be retained by the private sector for commercial, industrial, and residential developments . In addition, the legislature has mandated that the UGMS respond to requests from counties, state agencies and municipalities for site investigations of critical facilities. These critical facilities most generally are water tanks, water lines, fire stations, sewage treatment facilities, institutional facilities (e.g., jails), and facilities associated with utilities.

The services of the Site Investigations Section are requested by certain state agencies and counties more extensively than by others, even though UGMS services are available on an equal basis to entities throughout the state. These site investigations are similar to preventive health care: by helping select a site or by spotting problems early at an already-selected site, the UGMS has been responsible for saving millions of dollars on the construction of critical facilities, in addition to protecting the public safety and health.

Genevieve Atwood

NEW PUBLICATIONS

From UGMS:

- ***Geology, ore deposits and mineralogy of the Rocky Range, near Milford, Beaver County, Utah,*** by J. A. Whelan, UGMS Special Studies 57, November 1982, 35 p., 14 figs., 1 table; $7.50 over-the-counter.

- Map 51, ***Mining districts of Utah, 1980,*** by Kenneth C. Bullock, December 1982, scale 1:1,000,000 (20½ x 25 inches), multiple colors; $2.00 over-the-counter. Map 51 is a reprint of Plate 1, UGMS Bulletin 117.

Also available from UGMS:

- ***Atlas of Utah,*** edited by K. D. Gurgel, W. L. Wahlquist and H. A. Christy; photography by G. B. Peterson (D. C. Greer, project director), published by Weber State College and Brigham Young University Press, 1981, hardbound, 12 x 12½ inches, 300 p., approximately 400 maps, charts and diagrams in full color, numerous photographs and tables; place name gazeteer with 1200 entries, extensive bibliography, index; $49.95 over-the-counter.
  This book is a valuable reference work for anyone interested in Utah geology, geography, climate, and economy as well as the history and culture of its people.

- ***Scenes of the Plateau lands and how they came to be,*** by William Lee Stokes, published by Starstone Publishing Co., 1962, 66 p., numerous sketches; $1.50 over-the-counter.

Also of Interest:

- ***The Tintic mining district,*** by P. F. Notarianni, hardbound, 8½ x 11 inches, 200 p., 350 illustrations including maps and special historic photo essay by G. B. Peterson on towns, railroads, mines and people; endnotes and index; available by mail for $21.95 (Utah residents add 5% sales tax) from Basin Plateau Press, 3317 South 800 West, Bountiful, UT 84010.

Orders must be pre-paid. Postage rates: Orders less than $10.00, add $1.50; $10.00 - 24.99, add $3.00; $25.00 - $100.00, add $5.00; more than $100.00, add $10.00; add $1.50 for tube for rolled map (maximum of four map sheets per tube).

HOWARD R. RITZMA RESIGNS FROM UGMS

After almost sixteen years of dedicated service to the Utah Geological and Mineral Survey, Howard R. Ritzma leaves his Survey position, October 1, 1982, to return to active consulting. Mr. Ritzma has led a busy and a useful career in the geological sciences thus far, being a specialist in the geology of northeastern Utah (and adjoining parts of Colorado and Wyoming), Utah tar sands and oil shale, and general petroleum geology. His efforts on behalf of UGMS will be greatly missed.

Mr. Ritzma received his A. B. degree in geology from Miami University, Oxford, Ohio, in 1947 and went on to earn the Master of Arts degree in geology at the University of Wyoming in 1949. From 1949 to 1956 he worked for General Petroleum Corporation (Mobil) in areas of Wyoming, Colorado, Utah, and Nevada and as a district geologist in Denver, Colorado for Southern California Petroleum.

From 1957 through 1966 he was a consultant and independent in Denver. One consulting project was a compilation of information on tar sand deposits in the U. S. which was published as U. S. Bureau of Mines Monograph 12.

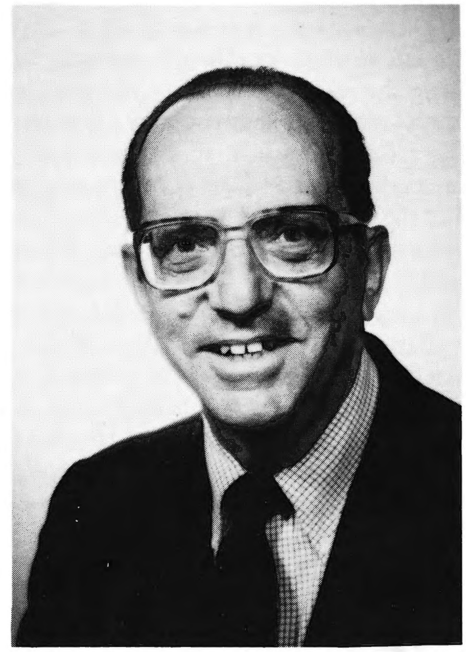
Howard began his career for UGMS In January 1967 being hired by former director, William P. Hewitt, as the chief petroleum geologist. His talents for Utah geology had already been discovered by the Survey's first director, Arthur L. Crawford, at a much earlier date. Mr. Crawford invited Howard to author the "Geologic Atlas of Utah, Daggett County," which was completed in September of 1959. In the foreword of that bulletin (UGMS Bulletin 66), Mr. Crawford recognized Mr. Ritzma as a unique talent:

> The profound impression made by Ritzma at the Wyoming field conference was deepened and further expanded when, later in 1955, as editor of the "Guidebook to the Geology of Northwest Colorado," sponsored jointly by the Rocky Mountain Association of Geologists and the Intermountain Association of Petroleum Geologists, he guided this field conference through the eastern Uinta Mountains of northwestern Colorado ...
>
> His background and scholarship marked him as the logical choice to author the Daggett County bulletin for our GEOLOGIC ATLAS OF UTAH series. Two years were spent in trying to get Ritzma to accept the assignment. The multiplicity of his other commitments as a consulting geologist made him hesitate. Finally he undertook the task. Since that time the Utah Geological and Mineralogical Survey has known that Daggett County "was in good hands" and that when completed this bulletin would be a highlight in our Atlas series concerning which we would all be proud.

Howard has been a tireless worker for UGMS from the very beginning. His first paper appeared in the UGMS Quarterly Review, scarcely one month after his arrival. To date he has authored more than 50 publications, maps and articles. He recently completed the compilation of UGMS Map 67, "Geology between Asphalt Ridge and Raven Ridge, Uintah County, Utah;" his final paper with UGMS will be released as Special Studies 56 ("Igneous dikes of the eastern Uinta Mountains, Utah and Colorado") and helps define his wide areas of expertise.

During his career with UGMS, Howard has acted on many state and federal committees concerning natural resources, tar sand, and oil shale development. He was the chairman of the Utah Committee on Environmental Problems of Oil Shale from 1970 to 1974, and received a commendation by the Secretary of the Interior for his work on prototype oil shale leasing in 1973. At the time of his resignation, he is a member of the Interstate Oil Compact Commission, Tar Sand Subcommittee, and the Utah State Committee on Geographic Names.

Ritzma worked hard for the State's interests being able to clearly explain to non-geologists, laymen, governmental planners, and the public the geologic problems and peculiarities of Utah petroleum geology. He was keenly loyal to the State's interest and acted as an expert witness in its battle for Great Salt Lake and the acquisition of Antelope Island. He was always and continues to be "on top" of what is going on in the petroleum industry and what is going on concerning tar sand and oil shale development and production, and this data



was always available when needed. Howard was advanced to Assistant Director in 1974 and has acted administratively for UGMS as well. His integrity and love for Utah's geology has been infectious and he has been instrumental in furthering the careers of many Survey workers.

While active with the Survey, Ritzma maintained rapport with the geological community of Utah and the nation as well. He maintains memberships in the Geological Society of America, American Association of Petroleum Geologists, Rocky Mountain Association of Geologists, Wyoming Geological Association and the Utah Geological Association. He was the latter's first president after its formation from the merger of the Intermountain Association of Geologists and the Utah Geological Society. He served on numerous field trip committees and has been a consistent contributor to the guidebooks and on the field trip stops. Howard was called to be an adjunct professor with the Department of Fuels Engineering at the University of Utah in 1980 and still holds this appointment. He has always been an effective wearer of many hats.

Howard R. Ritzma has been a great asset to UGMS. His leaving will create a "hard-to-fill" void in our ranks and we shall miss him. We wish him success and the very best in his new enterprises. ■

("Liquid Waste" cont'd. from page 1)
the attention of local health authorities by property owners along the river who had become concerned about possible effects of the dumping on their irrigation and domestic wells. The UGMS investigation showed that the landfill was excavated in Tertiary-age conglomerate and claystone strata that dip about 20-25 degrees toward an intermittent stream tributary to the Weber River. Faulting in the vicinity of the landfill produces a variety of local dips of the strata although the rock is not highly fractured. It was apparent that water migrating from the landfill through coarse-grained strata or along bedding planes could infiltrate into alluvial deposits along the tributary and from there reach the Weber River. There was also concern about the possible effects of faults and joints which could transmit water directly toward the Weber River and the wells located along it.

Figure 1. Tanker truck spraying oil well production water along a dirt road.

The local health department stopped the disposal of brines in the landfill and asked UGMS to examine a nearby abandoned clay pit as a possible alternative disposal site. Available data indicated that the pit was probably suitable from a geologic standpoint, but public sentiment against production water disposal anywhere in the area was so strong that the clay pit was not used. UGMS was then asked to investigate two additional sites several miles to the southeast. A preliminary reconnaissance indicated that both sites were underlain by shale bedrock, that depth to ground water was probably greater than 100 feet, and that faulting was absent. It was concluded that both were potentially suitable and worthy of further detailed study. At the present time, disposal is being permitted at one of these sites even though the necessary drilling and ground-water investigations required to prove the site's suitability have not yet been conducted by the county.

In the second case, the dumping of large quantities of production water in an abandoned gravel pit led to a lawsuit by landowners located downslope. It was their contention that the production brines had polluted water wells which were approximately 800 feet from the pit. The judge ruled in the

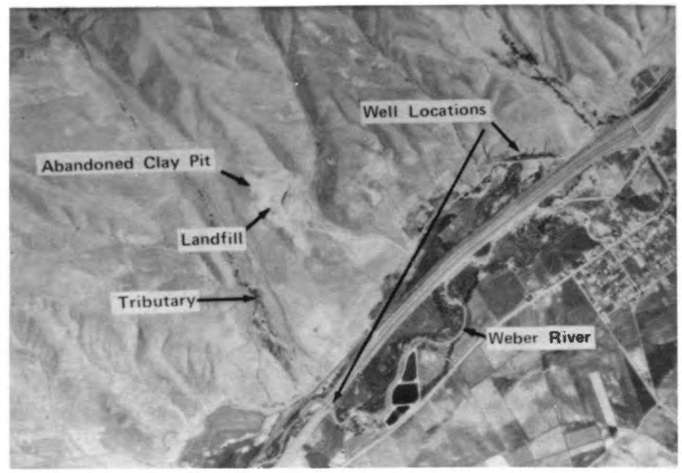


Figure 2. Aerial photograph showing sanitary landfill where dumping of production water brines occurred on hillside above the Weber River.

landowner's favor and ordered the commercial water hauler to locate a site and construct a facility where production water could be safely disposed. A site was selected and the State Health Department requested that UGMS make a prelicensing investigation of the property. Expecting to find an unoccupied site, Survey geologists were surprised to discover a disposal facility already constructed and operating at the time of their visit. Three ponds had been built using residual soils developed on the Duchesne River Formation (Figure 3). The soils were clayey, and a small mesa north of the site exposed gently dipping shale and sandstone strata. Normally, the clay soils and shale bedrock in the area could be expected to provide adequate materials for constructing an impermeable holding pond. However, at this location a four- to six-foot thick, coarse sandstone horizon cropped out on the property and was exposed by excavation equipment in the floor of the largest pond. Portions of the sandstone outcrop were also incorporated in the pond embankment (Figure 3). Concerns were raised that brines might infiltrate the

Figure 3. Holding ponds constructed at wastewater disposal facility prior to UGMS inspection. Note sandstone outcrops incorporated into pond embankment.

Figure 4. Shallow perched water table in test pit located downslope from production water holding ponds.

Figure 5. Salt encrustation resulting from evaporation of brines from the shallow perched water table developed downslope from wastewater ponds. Note moisture in stream bed.

sandstone, especially where it had been fractured by construction equipment, and then migrate down dip to the north. It was also thought that leakage might occur through the pond embankment along the contact between the sandstone and the fill. The UGMS recommended that the ponds be lined with clay in those areas where sandstone was exposed and that monitoring wells be installed in the unconsolidated deposits downslope from the ponds and in the sandstone horizon upslope, but down dip, from the disposal facility. Neither recommendation was implemented, and within a year water could be observed seeping through the embankments. A shallow perched water table has developed in the formerly dry soils downslope from the ponds and previously dry streambeds now remain moist during even the warmest summer months (Figure 4). The ground surface over the perched water table is encrusted with salt left behind as the brine evaporates from the soil (Figure 5). The nearest water wells which might be affected by the brines are located about a half mile from the ponds (Figure 6). The situation has been reported to the health department, but brine disposal continues at the facility.

Agricultural Waste

The second major category of liquid waste is agricultural waste converted to liquid form. In recent years many agricultural operations have implemented improved methods of livestock waste management. Much of the impetus for the new technology has come from Section 208 of the Clean Water Act which regulates point and nonpoint sources of water polution. A method of waste control favored by an increasing number of Utah dairies is the conversion of livestock waste to liquid form. The liquid is then applied to fields as fertilizer through conventional sprinkler irrigation systems. The holding ponds required for such systems represent a concentrated source of pollutants that include fecal coliform bacteria, nitrates, phosphorous, and heavy metals (Figure 7).

The Utah Geological and Mineral Survey received a request to evaluate the site of a holding pond being constructed at a dairy in Wasatch County. The pond was located less than 450 feet upslope from a spring supplying culinary water to a town with over 4,000 inhabitants (Figure 8). Current Health Department regulations call for a 1500-foot protection zone around a spring used as a source of culinary water. However, both the dairy and the spring predate the regulation and are not subject to its provisions. Water-quality data compiled for the spring during the years prior to construction of the holding pond showed an average bacteria count of 16 bacteria/100 ml of sample. The water system is equipped with a chlorinator to remove the bacteria. State health regulations require complete water treatment if bacteria counts exceed 50 bacteria/100 ml of sample on a regular basis. The city was not anxious to construct an expensive water treat-

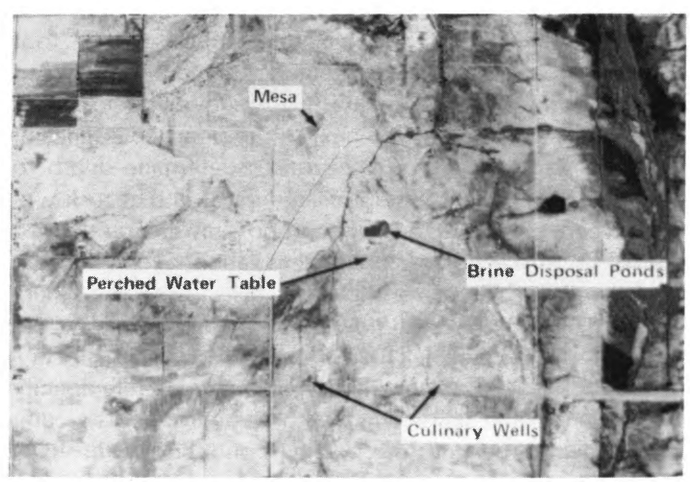


Figure 6. Aerial photograph showing the location of production water holding ponds in relation to threatened water wells.

ment facility, and although unhappy about having a dairy next to its spring, opposed any change in the status quo for fear of increasing the bacteria count. The situation was further complicated by the presence of three homes within 250 feet of the spring which rely on septic tank and soil absorption systems to dispose of domestic wastes.

The investigation showed that the dairy, septic tanks, and holding pond (which was under construction) were all located on a low limestone ridge (Figure 8). The spring discharges from joints in the limestone, and the collection box for the spring is in a small swale at the base of the ridge. The same limestone bedrock is exposed on top of the ridge in the corral areas, and near the milking barns. A hand-dug well located next to the home closest to the holding pond encountered bedrock immediately below the ground surface and depth to water in the well was measured as 25 feet.

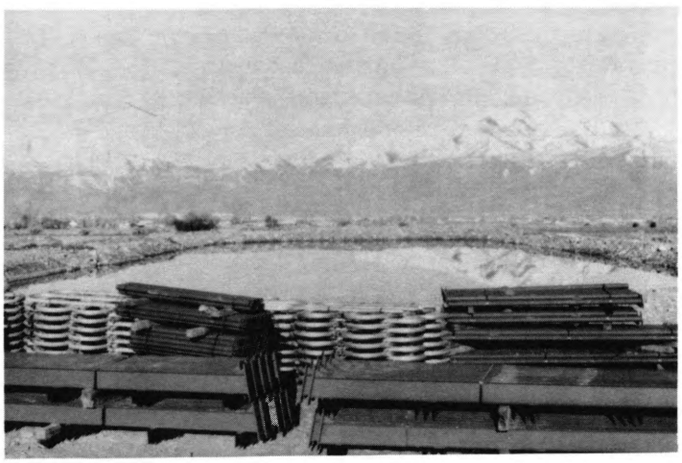


Figure 7. Typical dairy liquid waste holding pond.

The holding pond was excavated to a depth of 7.5 feet without encountering rock (Figure 9). Materials exposed in the pond consisted of 3 feet of clayey and sandy silt underlain by 4.5 feet of gravelly, clayey sand containing numerous cobbles and boulders. A strongly-developed, 3 to 4 foot thick caliche horizon was found along the contact between the silt and the underlying sand. The landowner denied permission to excavate test pits next to the pond, so a series of seimsic refraction profiles were run to determine depth to bedrock. The results of the profiling indicated that rock was everywhere greater than 8 feet and possibly greater than 20 feet beneath the holding pond. Percolation tests run in the gravelly, clayey sand unit showed rates ranging from 2.5 x 10^{-4} to 5.5 x 10^{-5} cm/sec; slow but not slow enough to be considered impermeable (10^{-7} cm/sec).

It was obvious that more data were needed before definite conclusions could be drawn. Depth to bedrock was greater than expected beneath the holding pond, but permeability of the gravelly, clayey sand unit was not sufficiently low for the pond to be considered water tight. The depth to the water table was not known with certainity, but considering

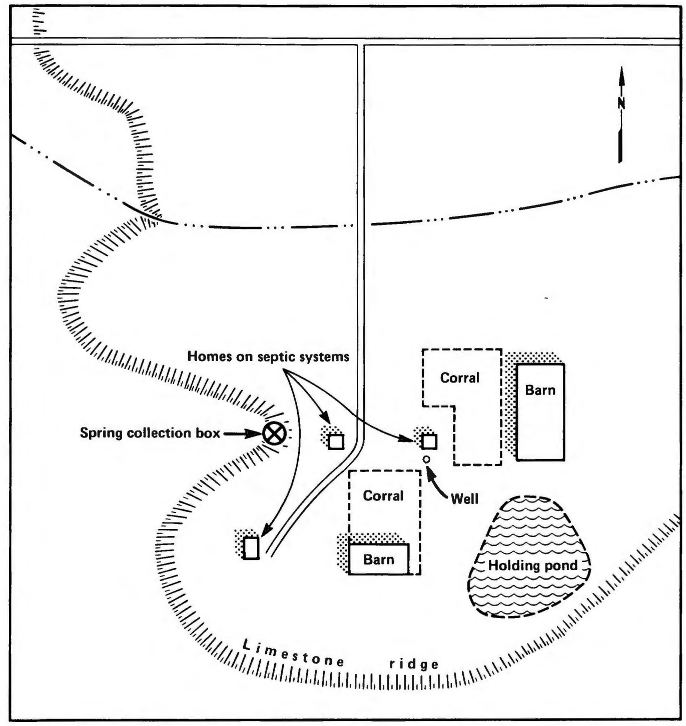


Figure 8. Schematic diagram of dairy showing spring, liquid waste holding pond, and homes utilizing septic tank and soil adsorption waste disposal systems.

the elevation difference between the pond and the hand-dug well, it was thought to be something less than 20 feet. Percolation through this thickness of clayey sand might improve the quality of any effluent seeping from the pond, but no data were available to indicate that the gravelly, clayey sand unit extended to the water table. If a more permeable sand or gravel unit were to exist in the subsurface, untreated waste water might reach the town's water supply.

Based on existing information, and remembering that the spring represented the principal source of culinary water for 4,000 people, it was recommended that the pond either be

Figure 9. Holding pond excavation. Note strongly-developed caliche horizon at the contact between the overlying clayey/sandy silt and underlying clayey sand horizons exposed in the sides of the pond.

lined, or moved to a more favorable location. Neither recommendation was implemented. The holding pond was put into service and the State Health Department ordered the city to change from a monthly to a weekly water-quality monitoring program (Figure 10). No increase in bacteria counts has been detected at the spring to date.

Figure 10. Unlined liquid waste holding pond in use approximately 450 feet upslope from culinary spring.

Individual Wastewater Disposal Systems

The final category of liquid waste to be discussed is domestic waste-water disposed of in individual wastewater disposal systems. There are over 56,000 year-round housing units in Utah that rely on septic tanks or cess-pools for sewage disposal (U. S. Census Data 1980). A survey conducted in 1981 by the Utah Health Department indicated that approximately 3,500 new septic tank and soil absorption systems are installed in the state each year. Assuming that half that number are year-round units producing an average of 400 gallons of waste water per day per unit, the new systems alone account for more than 25,500,000 gallons (784 acre feet) of waste water each year. Contaminants found in domestic sewage include fecal coliform bacteria, nitrate, phosphate, heavy metals, viruses and other micro-organisms.

Figure 11. Raw sewage surfacing on hillside below home where septic tank and soil absorption system has failed.

According to the Utah State Health Department (1981), approximately 150 septic tank and soil absorption system failures are reported in Utah each year (Figure 11). It is estimated that at least that many additional failures go unreported for the same time period. Many of the problems experienced by individual wastewater disposal systems are directly related to unsuitable site conditions. Factors such as excessively permeable or impermeable soil, shallow ground water, shallow bedrock, steep slopes, and flooding can all lead to absorption system failure.

The following example illustrates the problems which may occur when development plans fail to consider site conditions for septic tank and soil absorption system installation. In this instance, a subdivision in Washington County was approved, plotted, lots sold, and building permits issued before the feasibility of individual wastewater disposal systems was addressed. Test pit excavations examined by UGMS encountered the top of a strongly-developed, dense, hard, impermeable caliche horizon at 1 to 3 feet below the ground surface (Figure 12). The caliche was frequently so

Figure 12. Strong caliche development in soils beneath subdivision intending to use septic tank and soil absorption systems for liquid waste disposal.

hard that even a large track-mounted backhoe could not penetrate it and blasting was required. Below the caliche, which was normally 6 to 8 feet thick, were either basalt cinders or a yellow-brown, sandy silt. The log of a water well on the property indicated that the aquifer supplying water for the development was in the cinders. The local health department, on the advice of UGMS, would not issue permits for septic tank and soil absorption systems in either the caliche or the cinders. The caliche was considered too impermeable to allow the systems to function properly, and the cinders so permeable that effluent might reach the water table and pollute the well. Only the sandy silt layer showed any promise for use in an absorption system. By that time a number of homes had been completed and the owners were threatening to sue the health department if permits for septic tanks weren't issued. It was decided to deepen the test pits where the sandy silt layers had been encountered to determine if enough suitable material was present to install deep disposal systems. The distribution of the soil was found to be irregular so a 60-foot test trench was excavated to investigate the soil's lateral continuity. Cinders were uncovered at various locations in the trench, indicating that the surface of the volcanic horizon is undulatory and that suitable soils may occur only in isolated pockets. For the present, the local health department is continuing to withhold approval for most septic tank systems, and property owners, many of whom have built homes they cannot occupy, are investigating the feasibility of alternative disposal systems such as holding tanks, lagoons, or a community absorption system.

Conclusions

The safe disposal of liquid wastes, whether from an oil well or a single family residence, is largely dependent on the geologic and hydrologic conditions that exist at the disposal site. Many of the liquid-waste problems investigated by UGMS could have been avoided if adequate pre-disposal site investigations had been performed. The UGMS is working with both the state and local health departments not only in investigating existing problems, but also by providing the pre-disposal investigations and consultation necessary to avoid future problems. These investigations range in size from individual site inspections to watershed analyses and area-wide studies involving tens of square miles. The benefits to be derived from such investigations, both technically by avoiding costly problems, and politically by gaining public acceptance for disposal sites are being increasingly recognized by industry and government alike. The Utah Geological and Mineral Survey is actively working to see that realistic site investigation criteria are included in Utah's liquid waste disposal regulations.

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DAMS AND RESERVOIRS

By BRUCE N. KALISER*

Municipal and industrial water needs in Utah are accelerating as immigration and growth of population and industry increase. Though ground water is being increasingly regarded as an additional water source, reserviors remain a significant source of water for agricultural, industrial and municipal uses. Reservoirs may also prove valuable for generation of power, and for flood control, irrigation and recreation.

For the most part dams have already been built upon the best sites, especially near the larger communities in the state. Remaining sites are more than likely to have complex geologic, topographic, and hydrologic conditions. As a result the role played by geologists in evaluating these sites is an ever more important one. The geologist must assess, or at least participate in the assessment, of a number of critical factors, including: (1) geotechnical suitability of the dam site, (2) seismotectonic regime and related earthquake hazards, (3) hydrogeologic regime relative to the ground-water resources in the reservoir vicinity and relative to other facilities such as underground openings, (4) economic geology of the project area, (5) environmental geochemistry of the reservoir vicinity, and (6) rate of sedimentation of the reservoir basin.

Geotechnical suitability requires sound rock at depths that are economic for the particular dam construction. To establish the site suitability, geologic field mapping is a primary function. From the resulting surface geologic map, subsurface projections must be made to reconstruct the geometry of both unconsolidated ("soil") and consolidated ("bedrock") subsurface materials. Many other exploration tools are also employed to interpret the subsurface. Drill holes are indispensible for probing to any depth necessary and to obtain samples of subsurface rock for laboratory strength testing. In addition, many geophysical techniques are available for determining subsurface structure or composition. Trenching may be required to inspect shallow subsurface conditions at first hand. All of these methods of exploration are intended to answer such questions as depth of the cut-off trench required across the foundation, zones of weakness, underground voids, requirements for grouting, and potential seepage paths.

Sights on Public Facility Sites
Ninth article in a continuing series

The possibility of earthquake hazards must be addressed to some extent at least at any potential reservoir site in Utah. The degree of hazard varies across the state but in the vicinity of the majority of the state's population centers the hazard and the risk may both be great. Seismotectonic studies in some detail may be required in the project vicinity in order to establish the design earthquake and design ground displacement. Attention must also be paid to the mapping of Quaternary sediments so that dating of relatively recent seismic events can be attempted. Use of geomorphology, age dating, remote sensing, Quaternary stratigraphy and shallow exploration invariably come into play in any detailed study. The possibility of reservoir-induced seismicity must be considered with large or deep reservoirs in Utah. When judged to be of serious concern, microseismic monitoring may be necessary for a period of time prior to their construction.

A very important earthquake hazard is that of slope instability on existing landslide and reservoir slopes. Sudden failure of a mass of soil or rock into a full reservoir can be catastrophic. Understanding the nature of the reservoir rocks, their underlying geometry and discontinuities is critical in assessing the groundwater effects of the reservoir. In addition, a rise in the water table in the vicinity of the reservoir may affect land use over a considerable area. Springs and seepage zones may arise in new locations and mine workings and other underground openings may be flooded.

Earth resources in the project vicinity, including working and nonworking mines and quarries, and mineralized rock must be inventoried for conservation purposes, whether they are of current economic value or not. Future demand and technology changes may make an economic deposit out of today's subeconomic or uneconomic one. Underground openings and passageways, even if collapsed, affect the ground-water flow pattern. It is possible that the potential for ground surface subsidence may also have to be evaluated, whether due to natural or man-made cause.

With surface as well as underground flow of water toward the reservoir, the possibility may exist for the transport of substances in suspension or solution which can degrade the quality of the impounded waters in a proposed reservoir. Sewage from a breached lagoon or effluent from a waste disposal facility in the watershed may reach a reservoir intended to hold potable water. An additional consideration is that the reservoir will be subject to sedimentation at some rate which must be established prior to design.

Because dams and the reservoirs they create are among the most critical of public facilities and because of the risk created by the impoundment of water, it is common for a technical review procedure to be undertaken by experts at the request of either the dam building authority, the regulatory authority, or both. This review may be performed by a consulting team of experts on engineering geology, seismology, geotechnical engineering, dam design, and dam construction.

The one objective that must never be lost sight of throughout the planning, design, and construction phases of dam building is public safety. The geologist has a critical role as a member of the team to insure that the facility performs satisfactorily over its intended lifetime with minimal risks to downstream residents. ■

*Editor's Note: UGMS has agreements with the Utah Division of Water Rights (State Engineer's Office of Dam Safety) and the Utah Division of Water Resources to provide technical expertise in the siting, design, and construction of dams; the Hazards Section, of which Bruce N. Kaliser is section chief, fulfills this function.

UTAH SYNFUELS UPDATE

By MARTHA RYDER SMITH

Utah's synfuel industry is still moving ahead, in spite of the recession and lowered energy demands. A number of companies were disappointed when the United States Synthetic Fuels Corporation (SFC) rejected their first requests for loan and price guarantees to start commercial construction and production. Several companies are still doing research and development; others have completed this stage and plan to continue without federal funds. The major synfuel projects are:

Oil Shale Projects

Geokinetics Inc. of Salt Lake City has nearly completed the research and development stage of its *in situ* burn process at Camp Kerogen, near Vernal in Uintah County, and has produced 50,000 barrels of shale oil since 1975. Geokinetics expects to start construction of a commercial project next year on its state lease of 1,200 acres at Wolf Den, to produce 3,500 barrels of oil per day from ten retorts.

Geokinetics is also planning to construct a room-and-pillar mining operation at its 17,000 acre Agency Draw property, where it will use surface retorts to produce 16,000 barrels of oil per day. The oil will be upgraded by hydrotreating. Construction is to begin in 1984

In late 1982 Geokinetics announced that it had received a contract from the Department of Defense for crude shale oil, to be tested as a source of jet fuel of the Caribou Four Corners refinery near Salt Lake City.

Magic Circle Energy Corporation is proposing to use surface retorts and underground mining to produce 33,000 barrels of oil per day, with production beginning in 1987 from its property in Cottonwood Wash, Uintah County.

Paraho Development Corporation, plans to use the Paraho surface retort system and undergound mining to produce nearly 40,000 barrels of oil per day from the Paraho-Ute project at P. R. Springs, about 50 miles southeast of Vernal in Uintah County. Construction is to commence next year and production is to begin in 1985.

TOSCO (The Oil Shale Corporation) is conducting feasibility studies and tests at its Sand Wash project, in Uintah County. It plans to use a surface retort and underground mining and expects to begin production in 1988.

The White River Oil Shale Corp. has finally received a court decision on the ownership of the land leases (the federal government) and will begin development on its federal prototype leases U-1 and U-2 in Uintah County, near Vernal. It plans to use surface retorts and underground mining to produce 15,000 barrels-per-day by 1985.

Syntana, Utah plans to go ahead with a feasibility study at its property near Bonanza, using a surface retort and an underground mine.

Ramex Synfuels International, Inc. demonstrated its process for recovering shale oil at its Avantiquin canyon site 30 miles SW of Duchesne. Ramex is a joint venture with a Brazilian company, Karma, engaged in similar research.

Plateau, Inc. is considering modifying its refinery near Roosevelt, in Duchesne County, to process shale oil.

Chevron Research Company is building a 350 ton-per-day shale oil demonstration plant in North Salt Lake City, to be in operation in early 1983. The plant has successfully tested a variety of oil shales, with a "staged turbulant bed" process using superheated gases and fluids on finely ground ore. Plans are to build a full-scale refinery to process 100,000 barrels-per-day by the year 2,000.

Tar Sand Projects

The Great National Energy Corp. at its Sunnyside project in Carbon County plans to mine the sand and treat it in a surface retort to produce nearly 35,000 barrels of oil per day by late 1986.

C & A Companies, Incorporated and ***Mineral Research Ltd.,*** are proposing a 20,000-barrel-per-day project at the P. R. Springs deposit in Garfield County. They now have a small demonstration plant using the Minerals Research, Ltd. solvent extraction process. The first of five 4,000-barrels-per-day modules is to begin production in 1985.

The International Hydrocarbons Project, in Grand and Carbon counties, has plans for a 60,000-barrel-per-day plant at Sunnyside to recover tar and for a coal gassification project. Waste heat from the coal gassification is to be used to recover the tar.

The Sohio Oil Shale Company is building a 24-barrel-per-day pilot project using surface mining and a solvent extraction process, at its Asphalt Ridge deposit in Uintah County.

Western Tar Sands, Inc. is nearing completion of a demonstration plant on Raven Ridge, Uintah County.

Amoco (Standard Oil of Indiana) has an extensive exploration program at Sunnyside in Carbon County.

The Laramie Energy Technology Center, Department of Energy, terminated its *in situ* testing at Asphalt Ridge near Vernal. It made two reverse-burn fire flood and one steam flood test, and is now analyzing the data. It is continuing drilling on its P. R. Springs project.

Enercor tested its tar sand extraction process in late 1981, developed by the University of Utah. The alkali-assisted hot water process is followed by air flotation and a second hot-water separation. The 125 ton-per-day plant produces from 50 to 100 barrels of crude bitumen.

Kirkwood Oil and Gas Corp. has drilled the Tar Sand Triangle area in Wayne and Garfield counties, but has released no information.

Altex Oil Corp. has drilled a well yielding asphalt-grade crude in the Tar Sand Triangle, on Wayne and Garfield counties.

Santa Fe Energy is planning an *in situ* forward combustion hot water extraction digest and flotation process in the Gordon flats unit in the Tar Sand Triangle.

(see page 15)

Paradox Basin Quaternary Study

As part of the UGMS review of geotechnical work done by Department of Energy (DOE) contractors to select a nuclear waste repository site in the Paradox Basin, Gary E. Christenson of the Site Investigations Section made a study of the Quaternary history of Montezuma and lower Recapture creeks. These creeks flow from the Abajo Mountains in the Blanding/Monticello area southward to the San Juan River. The area was chosen because geologic conditions are similar to those in the Gibson Dome area and because little previous work had been done here. The purpose of the study was to reconstruct the Quaternary history of the area, particularly with regard to erosion rates, and evaluate the long-term erosional stability of this part of the Paradox Basin.

Quaternary deposits found in the study area are similar to those over much of the Colorado Plateau. The canyons of Montezuma and Recapture creeks contain a series of gravel-capped, rock-cut terraces at many levels above the modern channel. Studies of soil profile development in the gravels indicate that most are Middle to Late Pleistocene in age. Pleistocene time was characterized by over 1000 feet of total downcutting by Montezuma Creek. During Holocene time, streams aggraded and partially filled previously cut channels with over 50 feet of fine-grained alluvium (sand, silt, clay). These deposits are cut by an arroyo 20-40 feet deep which began forming around the turn of the century. A previous cycle of downcutting and alluviation preceded the present arroyo-cutting episode, and radiocarbon dates indicate that alluviation of the channel cut during this previous cycle began around 1200-1500 years ago.

The results of this study generally concur with conclusions drawn by DOE contractors regarding the Quaternary history of the Paradox Basin. Rates of stream downcutting and cliff retreat are of the same order of magnitude as those calculated elsewhere on the Colorado Plateau. The complete study will be published by UGMS in early 1983. ■

Study of Railroad Access Routes Proposed Gibson Dome Nuclear Waste Repository

William R. Lund, Chief of the Site Investigations Section, has recently completed a review of geologic conditions along possible railroad access routes to the proposed Gibson Dome nuclear waste repository. Railroad transport is considered the best means of delivering waste to the proposed repository, and three possible routes have been identified by the Department of Energy. The proposed railroad routes extend from Moab, the present terminus of the Denver and Rio Grande Western Railroad, to the Davis and Lavender Canyon sites. Because of the rugged topography in the area, the rail access routes involve construction several tunnels and bridges. Also, railroad beds on steep hillsides will be required.

Based on literature and field studies, the major geologic considerations important to siting of the railroad were identified and include flooding, slope stability, faulting and seismicity, expansive soil and rock, collapsible soil, erosion and sedimentation, and ground water. To evaluate the three rail access alternatives, a qualitative assessment was made of the signficance of each of these considerations along each route. Geologic problems that would eliminate any of the routes from further consideration were not encountered, although variations in conditions would result in differences in costs for both construction and maintenance between alternatives. The study is available as UGMS Report of Investigation No. 177. ■

Engineering Geology of the St. George Area

The St. George area of southwestern Utah has grown dramatically in population during the past decade and by all indications will continue to grow in years to come. Careful planning will be required to insure that construction accompanying this growth proceeds in an efficient and safe manner, taking into account geological considerations. In order to provide planners with geologic information necessary to make decisions regarding development, UGMS initiated a study of the engineering geology of the St. George area. The area covered by the study includes the cities/towns of St. George, Santa Clara, Ivins, Middleton, Washington, and Bloomington.

Geologic conditions in the St. George area of importance to long-range planning include slope stability, flooding, foundation conditions, faulting and seismicity, availability of construction materials, and suitability for soil absorption systems for domestic wastewater disposal. Probably the most troublesome geologic conditions in the area result from the presence of the Chinle Formation. This formation consists principally of bentonite shale which weathers rapidly to clay and is very unstable in slopes. Many ancient landslides and several modern ones are associated with this rock unit. In addition, the unit presents foundation problems even on flat ground due to the expansive properties of the clay. Similar problems, although less severe, are found in the Moenkopi Formation and in soils derived from both the Moenkopi and Chinle formations. Cracking of sidewalks, roads, and building foundations may result if these soils are subjected to alternate wetting and drying. Shallow ground water in St. George and in low-lying areas along the Virgin and Santa Clara rivers also presents a problem for building foundations.

The largest earthquake recorded in the St. George area occurred in 1902 with an estimated Richter magnitude of 6.3. Since then, events ranging in magnitude from 2 to 4 have been common with none larger than magnitude 5. Epicenters of some earthquakes were along the Washington fault, a Quaternary fault which passes north-south

(see page 15)

Utah Earthquake Activity, April - September 1982

By WILLIAM D. RICHINS[1]

The University of Utah Seismograph Stations records a 60-station seismic network designed for local earthquake monitoring within Utah, southeastern Idaho, and western Wyoming. Two time periods are covered in this report. During the first period, April to June 1982, 187 earthquakes were located within the Utah region (Figure 1a); 125 earthquakes were located in the same region during the second period, July to September 1982 (Figure 2). These earthquake data are subject to final revision. All magnitudes referred to herein are local magnitude, M_L.

The largest event during the first time period occurred on May 24, 1982 at 6:14 a.m. approximately 3 miles south-east of Richfield near Annabella (location: 38° 44.6′ N, 112° 02.1′ W), with a local magnitude of 4.0. Slight damage was reported in Annabella and Glenwood where the maximum intensity was VI (from USGS Preliminary Determination of Epicenters, June 15, 1982). The earthquake was also felt in Elsinore, Monroe, Richfield, and surrounding communities as well as Manti and Cedar City. Seismologists from the University of Utah operated ten portable seismographs for eight days in the epicentral region and collected detailed data for the accurate location of 250 aftershocks with magnitudes up to 2.7. The preliminary locations of these aftershocks shown in Figure 1b were made available by Dale R. Julander and Walter J. Arabasz.

Other significant earthquakes during that period include: 1) a magnitude 3.5 event on April 16, 1982 near Capitol Reef National Park, 90 km southeast of Richfield, that was not reported felt; 2) continued activity in the vicinity of the coal mines north and southwest of Price; 3) clustered small earthquakes west and southwest of Cedar City; 4) activity with magnitudes less than 2.0 near the southern end of the Wasatch fault zone south of Levan, 75 km north of Richfield; 5) several small events within Goshen Valley south of Utah Lake, 35 km southwest of Provo, in the vicinity of the May 1980 magnitude 4.4 Goshen Valley earthquake; 6) four small earthquakes west of Salt Lake City; 7) an isolated magnitude 2.6 earthquake on June 20, 1982, 75 km northwest of Ogden, beneath northwestern Great Salt Lake; and 8) continued activity with magnitudes less than 2.0 east and south of Logan beneath the Bear River Range.

The largest earthquake during the July - September report period occurred on August 23, 1982, 50 km east of St. George, Utah, with a magnitude 3.3. This earthquake was not reported

[1]Senior Staff Seismologist, University of Utah Seismograph Stations. Additional information on earthquake data within Utah is available by contacting the University of Utah Seismograph Stations, Salt Lake City, UT 84112.

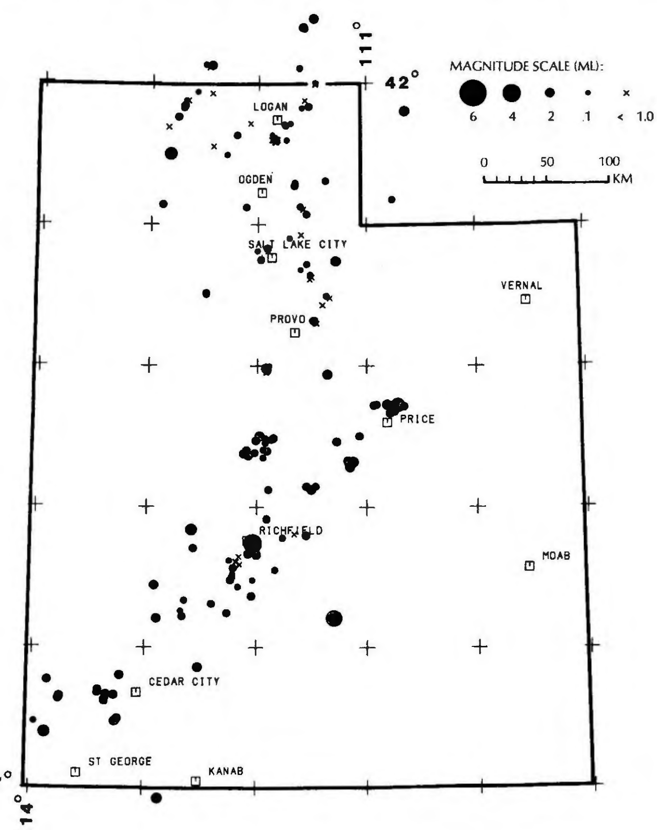


Figure 1a. Utah earthquakes: April - June 1982.

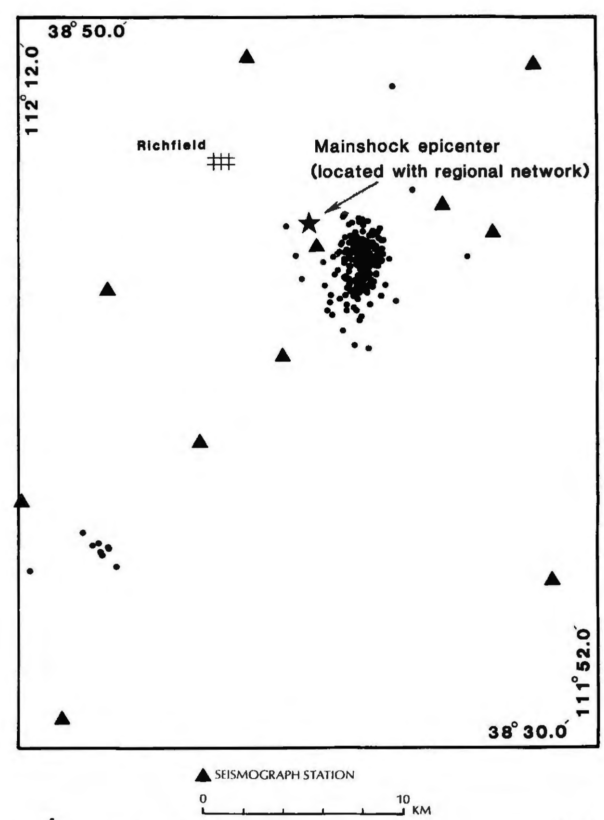
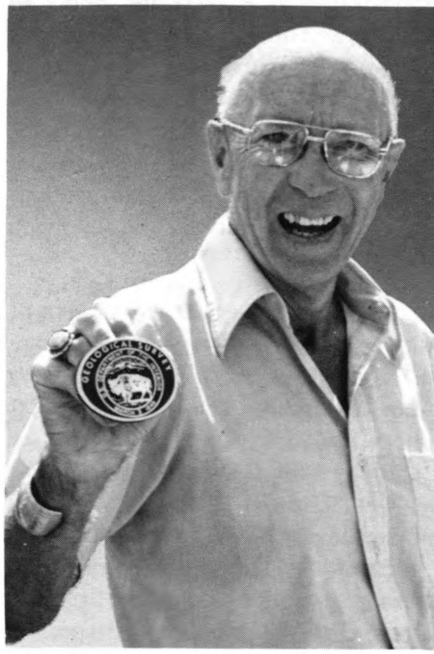


Figure 1b. Richfield aftershock sequence: May 24 - June 1, 1982.

Max D. Crittenden Jr.



Max D. Crittenden Jr. (1917-1982)

Max D. Crittenden Jr., one of the foremost authorities on Utah geology, died on November 25, 1982, of cancer. He was 65 and since 1942 had been a geologist with the U. S. Geological Survey. In 1956 he moved from Salt Lake City to Menlo Park, California.

Max received his bachelor of science degree from San Jose State and his doctorate from the University of California at Berkeley. Most of his geological work was done in Utah and most of his numerous publications dealt with the geology in Utah. His first scientific paper, in that regard, was a 1950 report on "Pre-Carboniferous stratigraphy and structure of the Uinta Basin." His next report, dated 1951, was the "Manganese deposits of western Utah." Later, his interest shifted to the Wasatch Mountains where he spent much of his career. His valuable contributions included mapping on the following 7.5′ quadrangles: Timpanogos Cave, Draper, Dromedary Peak, Brighton, Sugar House, Mount Aire, Park City West, Huntsville, North Ogden, Mantua, and Willard. Max's 1971 paper on the "Nomenclature and correlation of some upper Precambiran and basal Cambrian sequences in western Utah and southeastern Idaho" and his 1972 article on the "Willard Thrust and the Cache allochthon, Utah," were especially noteworthy.

Some of his last field work was done in the Promontory Mountains where he was mapping the structure and stratigraphy of the Precambrian and lower Paleozoic rocks. Max readily accepted the challenge of structurally complex regions. His maps presented logical interpretations of structure and stratigraphy in large areas that, beforehand, had been mainly question marks. We will miss him. ■

felt. Other significant aspects of earthquake activity shown in Figure 2 include: 1) continued activity with magnitudes less than 2.0 east and south of Logan beneath the Bear River Range; 2) on-going microseismicity with magnitudes less than 2.0, 50-75 km west of Logan within Hansel Valley, Pocatello Valley and surrounding areas; 3) a magnitude 2.7 earthquake 20 km northeast of Salt Lake City on August 29, 1982 that was felt by some residents near the mouth of Emigration Canyon and in Salt Lake City's east-bench area; 4) clustered small-magnitude earthquakes (magnitude less than 1.5) located 20 km northwest of Provo near American Fork; 5) a magnitude 2.5 shock 20 km northeast of Provo near Wallsburg, Utah, on August 28, 1982; 6) activity with magnitudes less than 2.6 near the southern end of the Wasatch fault zone about 40 to 80 km north of Richfield; 7) continued activity in the vicinity of active coal mining, north and southwest of Price; and 8) four small earthquakes (magnitude less than 2.0) near Richfield close to the epicenter of a magnitude 4.0 shock on May 24, 1982. ■

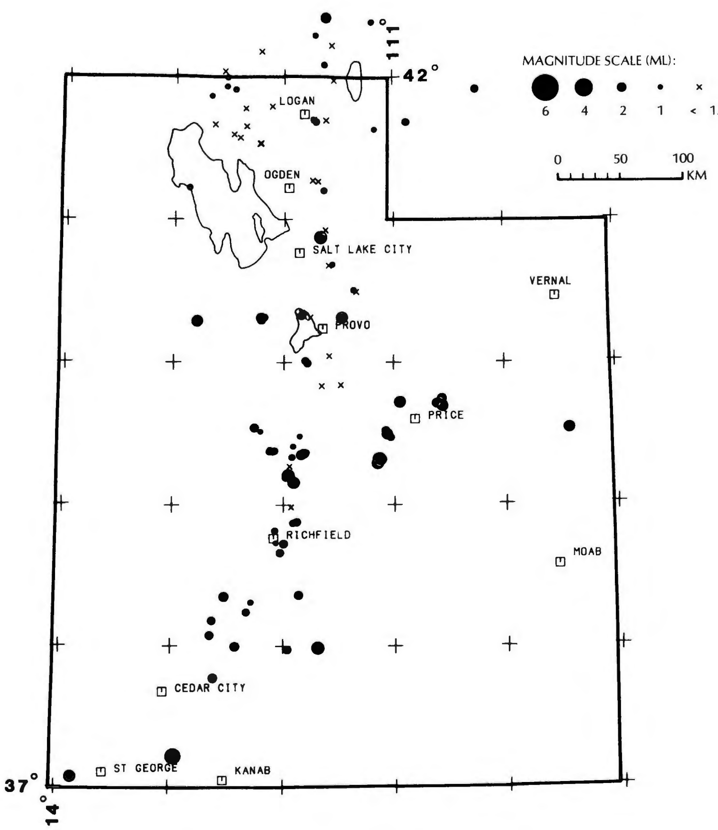


Figure 2. Utah earthquakes: July - September 1982.

Engineering Geology Study of Park City, Utah

During the Winter of 1982-83, two Utah Geological and Mineral Survey geologists, Harold E. Gill and William R. Lund, will begin work on an extensive engineering geology study of Park City, Utah. The study is being entered into under a cooperative agreement with the town and is intended to provide planners with a series of maps and accompanying texts, covering such topics as: geology, soils, surface hydrology and ground water, depth to bedrock, slope stability including avalanche hazard, and subsidence potential from abandoned mines.

Due to snow cover the initial investigation will be limited to compilation of reports, maps, old newspaper accounts of avalanches and other natural disasters, and examination of aerial photography covering the study area. Libraries, city and county files, and state and federal agencies will be utilized for the literature search and review.

Actual field activities will commence in the Spring of 1983. At that time, a drilling program will be initiated to compile information on depth to shallow unconfined ground water and bedrock. Boring logs will be utilized to check areas where possible problem soils are suspected. A final reconnaissance will entail field checking all prepared maps for accuracy.

Similar studies have been completed by the Site Investigations Section for the towns of Perry, Ballard, and Mt. Pleasant, Utah; another study concerning the engineering geology of St. George and its vicinity is nearing completion (see related story on p. 12). The results of these studies provide information for city planners and others to evaluate development proposals by identifying hazard areas. ■

The new UGMS List of Available Publications will become available February 15, 1983.

COAL PETROLOGY SHORT COURSE HELD

The first UGMS short course in the Foundations and Practice of Coal Petrology was conducted at the Survey for four days during December 13-16, 1982. The Survey has a primary interest in the characterization of Utah coals and the dissemination and utilization of petrological information and techniques relevant to those coals. The objective of the course was to instruct geologists, mining engineers, and management personnel in the foundations, terminology and procedures utilized in the petrological characterization of Utah coals. Further, the course served as a self-supporting vehicle for making this training available regionally to personnel of this area and providing Survey personnel additional training in coal petrology at no expense to the taxpayer.

"State of the Art" microscopic, photometric, and flourescence equipment was furnished to the course and demonstrated by E. Leitz, Inc. and Carl Zeiss, Inc. and utilized by the students in "hands-on" laboratory exercises. The instruction along with the laboratory exercises were most provided to students from as far away Calgary (Canada), Montana, Wyoming, Colorado and as close as Salt Lake City by the following instructors:

Dr. J. C. Crelling, assistant professor of geology in the Department of Geology and associate of the Coal Research Center at Southern Illinois University at Carbondale; Dr. R. R. Dutcher, professor of geology and department executive officer at Southern Illinois University at Carbondale; Dr. A. D. Cohen, professor of geology at The University of South Carolina, presently on leave to Los Alamos; Dr. L. R. Parker, associate professor of biology at The California Polytechnic State University in San Luis Obispo, currently associated with UGMS. ■

Hydrologic Investigation of Bay Area Refuse Disposal Site

The Bay Area Refuse Disposal (BARD) site is located 2 miles west of Centerville, Davis County, Utah. The property is adjacent to the Farmington Bay Wildlife Management Area (FBWMA) and there has been concern that leachate pollution from the landfill may contaminate the wildlife area.

Utah Geological and Mineral Survey geologist, Harold Gill, investigated the site for possible contamination hazards. Several monitoring wells were drilled to establish the direction of flow and the depth of the shallow unconfined aquifer in the area. Water quality samples were taken but results proved inconclusive due to a lack of a pre-landfill data base. However, the drilling program and field reconnaissance did establish several locations where potential contamination hazards exist.

Refuse is presently being dumped directly into shallow ground water in open refuse storage cells along the northern perimeter of the landfill. Production of leachate will commence immediately under these conditions. During the winter the wildlife refuge is completely drained. At this time, leachate will flow from the refuse cells at the northern perimeter of the landfill into the wildlife refuge until a balance in the water levels between the two areas is attained. Data indicate that the shallow unconfined ground-water gradient is to the north-northwest. Therefore, any leachate produced may flow into the wildlife refuge.

The final report was sent to the Davis County Health Department and the landfill manager to assist them in determining the steps to be taken to mitigate the existing hazards. ■

("Utah Synfuels" cont'd. from page 10)

Coal Gassification

In addition to ***International Hydrocarbon's*** proposed coal gassification project, ***Mountain Fuel Supply Company,*** and ***Mono Power (Southern California Edison),*** are constructing a pilot plant at West Jordan, south of Salt Lake City. If the project is feasible, a large plant may be built in central Utah.

Geothermal

Phillips Petroleum and ***Utah Power and Light*** are developing geothermal resources at Roosevelt Hot Springs, near Milford, in Beaver County. The first geothermal electricity in Utah was produced in late 1981 from a well-head generator unit. Utah Power and Light is building a 20 megawatt generating plant to use the geothermal steam, and expects to be in production by 1984.

Phillips has found a new geothermal reservoir west of Delta in Millard County. The reservoir, about the size of Utah Lake, was delineated by shallow drilling; deep drilling is planned to test commercial potential

Sources

Howard R. Ritzma, UGMS, Geokinetics, Inc., and various issues of The Salt Lake Tribune, Deseret News, Logan, Harold, Vernal Express, Beaver County, and the Oil and Gas Journal. ■

("Engineering Geology" cont'd. from page 11)

through Washington along 200 East Street. It is important to recognize the potential for earthquakes along this fault and others nearby such as the Hurricane fault so that structures can be located and engineered to minimize risk.

The UGMS report on the engineering geology of the St. George area is complete and forthcoming as Special Studies 58 by Gary E. Christenson and Roy D. Deen. Two principal components of the report will be the geologic map and interpretive table listing generalized engineering geologic characteristics for each unit shown on the map. A preliminary assessment of conditions at a particular locality can be readily made by reference to the map and table. The remainder of the report discusses the general geology and hydrology of the area and outlines in more detail the specific geologic hazards. ■

GREAT SALT LAKE WATER LEVELS

By PAUL A. STURM

Due to the recent rise in the elevation of the Great Salt Lake, a significant amount of interest has been generated concerning the level of the lake. However, interest in the changing lake levels is not new.

The observations of the water level of the Great Salt Lake have been recorded in a variety of ways since the pioneers entered the Salt Lake Valley in 1847 (Figure 1). Some of these early records are contained as notes in diaries or in the form of verbal communications concerning the height of water on a particular sandbar or rock (Arnow, 1980). Today, continuous recording gaging stations of both the float and gas purge manometer types are monitoring the fluctuating levels of the Great Salt Lake.

The present lake level monitoring program is a cooperative project between the Salt Lake City office of the Water Resources Division of the U.S. Geological Survey, and the State Engineers office of the Utah State Division of Water Rights, Department of Natural Resources and Energy. The lake level readings are taken by the USGS on the first and fifteenth of each month from gaging stations which are positioned at the Great Salt Lake State Park - South Shore Marina. Soon thereafter, the lake level readings are made available to the public.

The historical high lake level of 4211.5 ft. occurred in 1873, while the historical low lake level of 4191.35 ft. occurred in 1963. The lake elevation as of December 15, 1982 is 4201.45 ft.

Reference

Arnow, Ted, 1980, Water Budget and Water Surface Fluctuations of Great Salt Lake *in* Great Salt Lake - A scientific, historical and economic overview: Utah Geological and Mineral Survey Bulletin 116, p. 255 - 263. ■

GREAT SALT LAKE LEVEL

Date (1982)	Boat Harbor South Arm (in feet)	Saline North Arm (in feet)
October 1	4200.20	4198.60
October 15	4200.50	4198.60
November 1	4200.70	4198.80
November 15	4200.90	4198.80
December 1	4201.10	4199.00
December 15	4201.45	4199.20

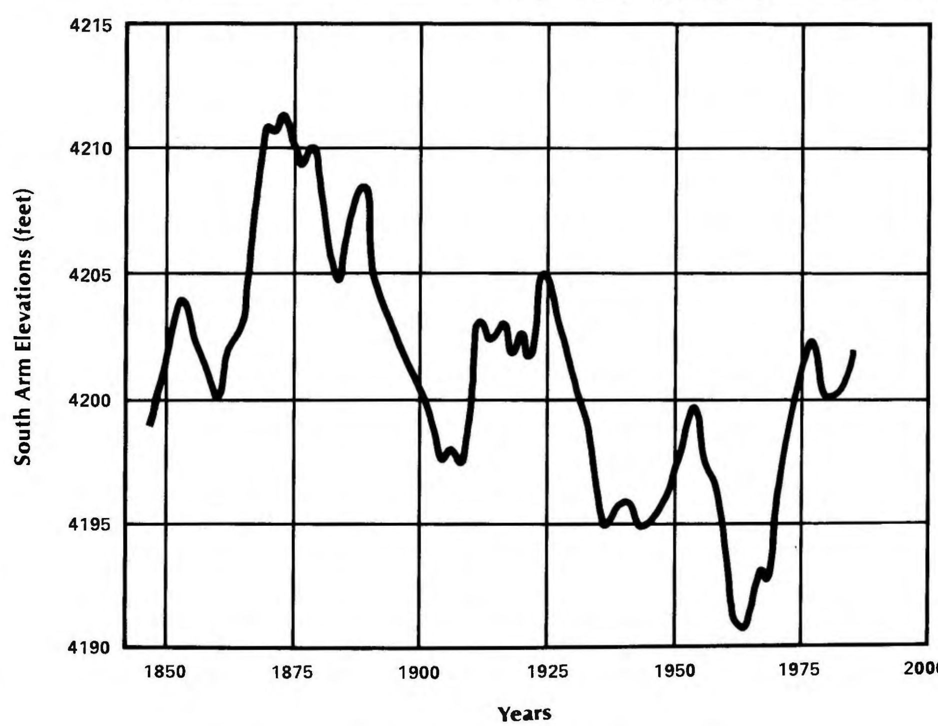


Figure 1. Generalized Great Salt Lake hydrograph, 1847 - 1982.

NEW UGMS STAFF

Don R. Mabey has joined the UGMS in October as senior geologist for applied geology after a distinguished career with the U. S. Geological Survey.

After graduating from the University of Utah with a B.S. in physics, Don joined the U.S.G.S. and over the next thirty years served as physicist/geophysicist, branch chief, deputy office chief, and from 1978 to 1982 managed the Geologic Division's Salt Lake City based projects including geophysical, geothermal, and mineral resource studies. He is the author or coauthor of about 100 technical publications including books, journal papers, geophysical maps, and is a member of the Geological Society of America, the American Geophysical Union, the Geothermal Resources Council, the Society of Exploration Geophysicists, and the Utah Geological Association.

As senior geologist Don Mabey manages the applied geology program of UGMS. The two sections involved in the program (Geologic Hazards and Site Investigations) conduct a diverse program of identifying and mapping geologic hazards in Utah and engineering geologic studies designed to protect the welfare of the residents of Utah. In addition, he will carry on a program of personal research directed toward the goals of the applied geology program.

With the U.S.G.S., Mr. Mabey was involved in a program applying techniques of geophysical exploration to the investigation of a wide range of geologic problems. These included mineral, geothermal, and petroleum resource studies, regional tectonic studies, and engineering geologic investigations. As chief of the Branch of Regional Geophysics, he was responsible for developing and managing major parts of the U.S.G.S. geophysical programs. He also coordinated several large multidiscipline programs of resource and regional geologic studies.

Walter M. Cox is the new computer geologist who is in charge of our WANG system; he also will be programming for the staff. Walter earned a B.S. from the Pennsylvania State University and has an M. S. degree from Northwestern University, both in geology. He has studied advanced math at other universities. His work experience has been in the oil industry, in a major research lab and in geological programming services for a major oil company. ■

UTAH GEOLOGICAL AND MINERAL SURVEY
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Address correction requested

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