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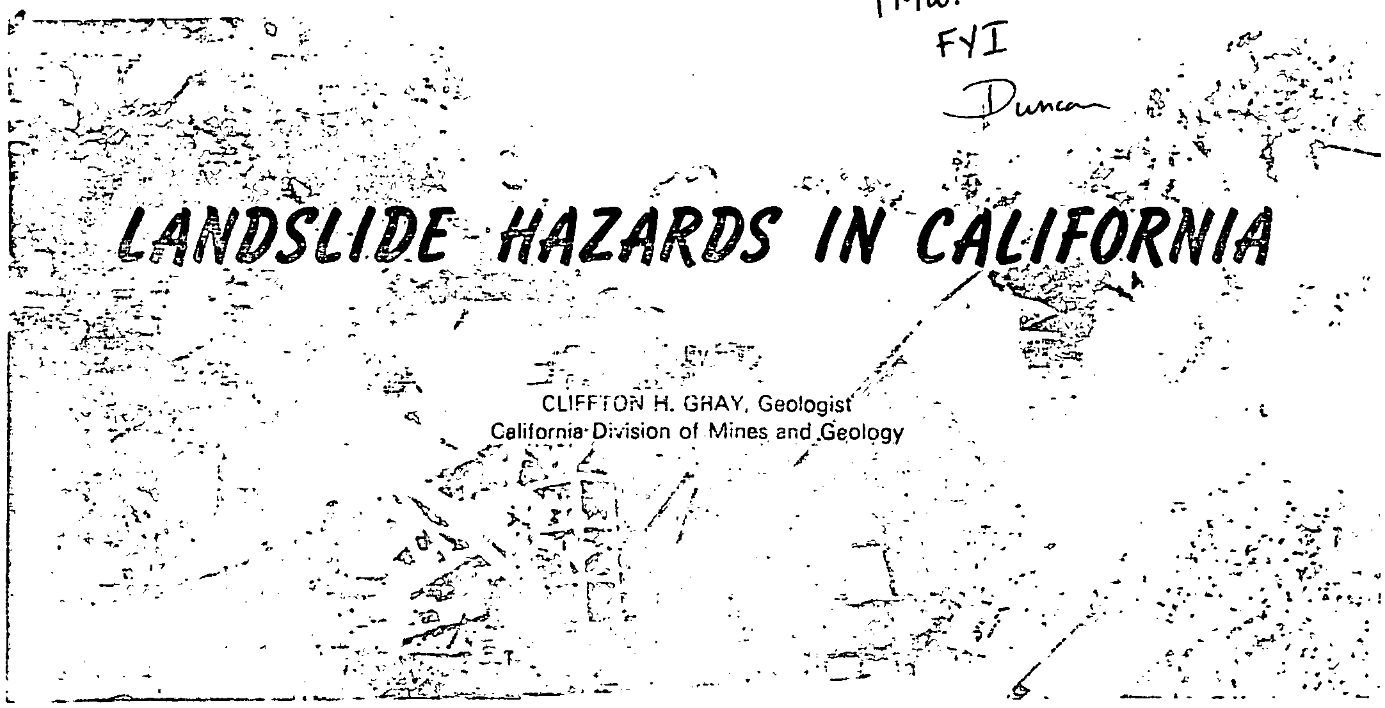
PMW:
FYI
Duncan

LANDSLIDE HAZARDS IN CALIFORNIA



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INTRODUCTION

Each year thousands of individual landslides occur as a result of natural, ongoing erosional processes. Landslides activated by natural processes are common in many areas of California, especially along the coastal region. The areal size of a landslide can range from several square feet to several square miles. Slide thicknesses may range from less than a foot to several hundred feet. Landslides vary both in type and rate of movement. The movement of landslide material may be rapid or so slow that a change can be noted only over a period of weeks, months, or years. Specific factors that can cause or contribute to the failure of rock or soil on slopes are (1) weakness of the slope material, (2) steep or undermined slopes, (3) unfavorable geologic structural conditions, (4) prolonged precipitation, (5) absence or sparsity of vegetative cover, and (6) ground shaking, usually from earthquakes but occasionally from blasting and construction work.

When man's activities are superimposed on natural conditions without regard for their impact, severe property damage, sometimes with loss of life or injuries, is the result. For example, landslide losses in the state during the 1968-69 rain season were conservatively estimated to be approximately $32 million. Damage from the 1978 storms within the city of Los Angeles alone has been estimated at about $50 million.

Actual figures for total economic cost of landsliding in California for any particular year or group of years are not available. However, as an example of the magnitude of the problem in one rapidly urbanizing southern California county—Orange County—available information shows that over 40 major bedrock landslides have occurred in urbanized areas within the county between 1966 and 1983. Each had an ultimate economic cost of over $200,000, and the total economic loss was over $40 million. Included within this is the Bluebird Canyon landslide which accounted for $12 to $15 million of this total. The only fatal landslide that occurred in Orange County was a mudflow-debris flow in Silverado Canyon in 1969 which took five lives. Altogether more than 1,200 massive landslides have been mapped in the hillsides and bluffs of Orange County and an additional 1,000+ possible landslides have been identified.

The most recent landslides, an indication of the continuing and costly landslide problem in California, include the Devil's Slide area in San Francisco/San Mateo counties, the Highway 50 landslide in El Dorado County, the recently reactivated Big Rock Mesa landslide at Malibu Beach in Los Angeles County, the Love Creek landslide in Santa Cruz County, and Verde Canyon landslide in Orange County.

CDMG LANDSLIDE STUDIES

The primary mission of the Geologic Hazards Program of the Department of Conservation, Division of Mines and Geology (CDMG) is to provide basic geology information to the public and to local agencies so that they will be better informed of geologic conditions within their jurisdiction. As a result of cooperative programs with cities and counties, CDMG has prepared basic geologic and special slope stability maps for use by local environmental and engineering departments, many of which have no geologists on their staffs. CDMG's landslide information has been incorporated in General Plan elements and ordinances to determine if geologic reports are needed for particular developments and to guide city or county geologists in the preparation of geologic reports.

CDMG began "landslide mapping" in 1960 in the Palos Verdes Hills of Los Angeles County. This modest effort was the first project of many cooperative matching-fund agreements with local government.

In 1962 a program was begun to study the south front of the San Gabriel Mountains from San Bernardino County on the east to the area of Mt. Wilson on the west. This investigation was a cooperative effort of CDMG with the Department of County Engineer, Los Angeles County, and the Los Angeles County Flood Control District.

The passage of legislation (SB 703) in 1965 enabled the Division to increase emphasis on investigations of geologic hazards, such as earthquakes and landslides, by allowing CDMG to establish cost-sharing and cooperative agreements with local governmental agencies, other state agencies, and Federal agencies.

In March 1980, for the first time, CDMG was authorized, required, and funded by legislative act (AB 1571) to carry out a specific slope stability investigation. This now completed study was partly in the city of Los Angeles and partly in Los Angeles County in the Baldwin Hills area, including portions of the communities of Culver City, View Park, and Windsor Hills.

CDMG's Geologic Hazards program has resulted in major reports and publications. One study in 1973 resulted in the publication of the "Urban Geology Master Plan for California" as CDMG Bulletin 198. The purpose of this report was to determine the magnitude and costs of geologic hazards in California and make recommendations for their mitigation. One of the major findings of the study was that approximately $10 billion in landslide damage would occur in the state between 1970 and 2000 if the 1972 loss-prevention practices were to continue unchanged. At the same time CDMG projected that rigorous application of all measures available in 1972 could reduce this 30-year loss by 90 percent at an estimated cost of approximately $1 billion during the same period (Bulletin 198, p. 96-97).

These estimates are in 1972 dollars and are undoubtedly low in relation to today's standards. But, they illustrate two important points about the landslide hazard that are as true today as they were then: first, that the application of known mitigative measures can significantly reduce landslide losses; and second, that the amount saved in decreased property damage from landslides as a result of these mitigative measures will far exceed the cost of implementing mitigative measures.

CDMG responds to specific geologic events that involve public safety or that provide a "laboratory" to document the case history of a specific event. Examples include investigations of storm-related slope failures in the Los Angeles region in 1978, 1979, 1980; and emergency support services to seven counties and 10 cities in the San Francisco Bay region in January 1982.

Also, special studies or programs are conducted in cooperation with other state agencies. Most of the effort has been with the Department of Forestry in providing geologic expertise in the review of timber harvest plans where there are problems of erosion, slope stability, and landsliding. Several slope stability studies have been done for Department of Parks and Recreation.

AB 101 LANDSLIDE HAZARD IDENTIFICATION PROGRAM

Many legislative bills are introduced concerning land use and some of them touch on use of engineering or geoscience in land-use decisions. A bill of current interest is AB 101, signed into law by the Governor in summer 1983. Before AB 101, existing law provided that the State Geologist may conduct, with the assistance of Federal and local agencies, investigations to identify geologic hazards in and adjacent to metropolitan areas. Now, AB 101 requires the Director of the Department of Conservation to establish within the Division of Mines and Geology a program to map landslide hazards. Such mapping is to be based on guidelines and priorities adopted by the State Mining and Geology Board. Priorities adopted by the Board shall reflect the severity of the landslide hazard, the willingness of agencies to share the cost of mapping within their jurisdictions, the availability of existing information, and the need to supplement information used in existing landslide hazard abatement or prevention programs.

Information developed by this program will be provided to local government for use in planning and decision making that affects building, grading, and development permits. The geologic information developed by the Department of Conservation to be properly utilized where land-use decisions are involved requires the local engineers and building officials to have a vital role in mitigation of landslide problems.

EFFECTIVE MITIGATION

The key to the successful mitigation of the landslide hazard potential lies in the enactment of adequate building and grading codes based on sound geologic information with adequate enforcement by local government. The state's role is to provide basic data surveys and overview of the region, but not a lot-by-lot assessment. The state may provide, for example, studies of geologic formations known to be landslide prone; maps that identify old landslide areas; and maps showing landslide propensity as derived from basic geologic studies, slope angle, and other factors. These studies are helpful from a statewide, regional, or area perspective but leave specific site evaluation to the landowners and their consultants, and those local agencies closest to the problem. The actual site development studies and plans should be done by the private sector with the local agency reviewing and inspecting the work.

The number of damaging landslides can be significantly reduced by three general preventive actions. These actions include:

1. Delineation of landslide localities—basic data surveys to identify existing and potential landslide problems, and special studies of key factors of slope stability such as problems in a particular geologic formation, vegetation, rainfall, and slope. These studies are done by technical agencies such as the California Division of Mines and Geology, the U.S. Geological Survey, some local agencies with geologic capability, and by contract with private geotechnical firms.

2. Commitment to strong planning and enforcement—general geotechnical planning, and rigorous building and grading code enforcement by local government. This activity is generally done through the County Engineer Department. In providing for public safety from geologic hazards, there is no substitute for ordinances or regulations based on good geologic information that are well written and carefully enforced. The Department's geologic mapping programs have helped to provide this basic geologic information to support local agency planning and enforcement programs.

3. Implementation of the geologic knowledge and grading codes at each building site. Multistaged site-specific geotechnical investigations by private consultants before and during construction.

SUMMARY

Landslides and related slope failures in California are responsible for extensive economic losses due to damage and destruction of property, as well as exacting a tragic human toll in injury or death. As urban development further encroaches upon hillside and mountainous terrain, the losses due to slope failure will inevitably mount unless specific action is directed toward identifying hazardous terrain prior to development, and mitigating measures are provided for unstable slopes.

In the future, mitigation of the landslide problem will call for detailed geotechnical evaluation of both potential and existing landslides. Local agencies and private consultants will use this information to solve specific problems. ⚒

13 Aug 84

to Rex Bronson →

1. Just started to read three
   Coraync + Ralph + Rex --
   Coraync be there tomorrow

2. Has trouble w/ amounts
   this year vs next year

   has trouble w/ costs vs accomplishments

3. Is in trailer between two bldgs
   in west end Southern trailer

22 Aug 86

Meeting with <u>CEM</u>

Lorayne Fayest, Rex Bronson, Rolph Finley (?)

SHW, DF, Paw -

Key question SHW - does it make sense to expand instrumentation

<u>Rex</u> - wants to identify in state landslide hazards --

- explore sites further to find geologic reasons for slides - high water table, slope, soil, etc.
- then correct current probs -
- have been planning private help - CEM/Colorado to assess state

FEMA will prob get legislat to cost share slide mitigation 50-50.

States role is identify g areas, specifying corrective action, specifying contractors also can help

<u>Rolph</u> -

- is looking @ slides along W Front that might be triggered by EQs -
- stresses money needed for long-term monitoring -

FEMA is in business of recognizing hazards to "lifelines" -

If its a research thing, its a USGS thing -
FEMA - no research $ -

Hazards Reduct Act 1977
USGS gets lion's share, to go to research
FEMA gets only a bit for mitigation -

FEMA - limited to public facilities and loss of life -

Surplus State $ - Loraine
- will address flood stuff - this year may change
- she is talking w/ her boss
- would entertain a proposal from us -- would want it this way
- is worried about our coord of USGMS -

Rec -
Research - wants product to hand to people to specify these are probs, these are mitig other measures -

Natural Disaster Act 1974
Hazard Reduction Ac 1977 - Earthquake

- Lorayne
  - couple of weeks to pull proposal together –
  - assessment reports needed –
  - worried about 10 sites –

Ralph – they are more interested in monitoring dams than slides
  – 28K people would have to be evacuated in Provo if Deer Creek went –

– feel 10 is a good number.

– matching County funds – would want a product for their area

FEMA – always wants local $ to match – there is little $
  – have a better chance w/ FEMA as USGS than CEM does –
  FEMA has Hazard Mitigation Projects – can be big bucks –
– contact on this stuff – Lorayne can give name –

– we might hear on CEM funding after Special session
  – after Labor Day –
  – She wants her boss, or gov – w/ Sen Fowlappen –

- 9:00 Friday

- budget broken out in detail
need backing for all of budget

— 380K not scary if we can justify it.

---

meeting w/ Doug Stan, after, etc.

1. Budget
   - Dale - Drew
   - McCarter - come up this afternoon
   - Dunc. -

2. Text - critique text
Wright, Dennis, Stan, McCarter, Green

3. Writing assignments -
   - Instruments - Green, McCarter
   - Overall - Foley
   - Respondents - Ward

Call Dee Hansen's
office

Any all in charge
of inspecting <u>dams</u>

Call the Branch

office

Give all the charges

of computing items

McCarter's Suggestions 27 July 84

1. Cost of installation, monitoring etc could go sky high if area is difficult to get to. Foot, helicopter, etc
   -- put contingency in
   say "up to 10 sites" —
2. Say we will endure as many sites as possible
   -- don't promise 10.
3. It's a big project -- Kim's afraid it will not all come off given the time frame —

4. UGMS proposal - to state
   - mobile van w/ instruments to respond to emergencies
   receiver in van.

5. Kim suggests we chase dams -- maybe rather than slides —

6. Weakest part is relationship between physical event and its cause
   pore pressure - piezometer
   precip
   ground temp
   infiltration (wanted)

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DELINEATION OF LANDSLIDE, FLASH FLOOD, AND DEBRIS FLOW HAZARDS IN UTAH

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Landslide Proposal

1. Revised Strategy

(a) instrument up to 10 slide areas, weather permitting and early availability of funds

(b) do brief geologic assessment of each slide area 1-2 field days to assist in placing of monitor devices

(c) Select ~~[illegible]~~ 1 or 2 slide areas for more intensive research that show movement or incipient movement as well as 1 or 2 slide areas that do not move -- a comparative study.

(d) Develop geophysical monitoring techniques, specifically ~~sev~~ electrical resistivity and self potential. Instrument 1 or 2 slides with these methods, selected from among those slides with greatest likelihood of mass movement.

(e) more ~~intensive~~ research work to consist of
   (1) detailed geologic mapping, placed in regional context
   (2) pitting and or drilling for sampling
   (3) ~~[illegible]~~ clay and similar studies
   (4) ~~sever~~ periodic airflights for air photo coverage, where applicable, to monitor movement and to help detail the nature of that movement
   (5) ~~also~~ periodic resistivity, SP or other geophysical surveys to ~~[illegible]~~ help map slide morphology and/or water content
   (6) chemistry of waters saturating slide may be important, should be included.

Note: Have a section in the proposal, pointing out that, with the fact that the monitoring equipment is already developed and that the State would commit to retain no shops to the equipment through this project.

(F) Emphasize that if $ are not available quickly, there will be no time to ~~depl~~ deploy sensors prior to snowfall.

(~~G~~)

2. On Budget, hound Dale and Steve for realistic costs. Emphasize at Friday's meeting w/ CEM that budget is tentative but will be firmed up over the week

3. ~~At~~ Friday meeting w/ CEM (a) ask for specific criticisms on justification, i.e. how can proposal be improved to help Lorayne sell it to the Gov + Legis better?
(b) talk about the state-wide assessment, and tell them this will be the topic of a subsequent proposal -
(c) ask again about dam monitoring - what would do them substantial good? Do they want a separate proposal -- (we would have to do significant background work on this).

DEVELOPMENT OF A LANDSLIDE MONITORING SYSTEM FOR UTAH

a

PROPOSAL

to

Comprehensive Emergency Management Agency
State of Utah

by

Landslide proposal, pre-preliminary rough draft #1, 19 July, 1984

Table of contents:

Table contents need

EXECUTIVE SUMMARY

The Earth Science Laboratory/Univerisity of Utah Research Institute, in conjunction with the Department of Mining Engineering of the Univeristy of Utah, proposes a program to instrument and remotely monitor selected high risk landslide areas of Utah. Data on the rate of movement of the land will be provided to local emergency response personnel on a real time basis, and used later by researchers to further understanding of the nature of mass movement in Utah.

The landslide monitoring system will consist of three major parts. The first will be the instrumentation of the slide. Extensometers, to measure the amount and rate of offset across the upper portion of a slide, and inclinometers, to measure changes in slope angle, will be emplaced at the slide sites. The second part of the monitoring system will be a telemetry network, to radio data from remote landslide sites to appropriate local facilities. The third part of the monitoring system will be the receiving and data storage equipment, which will probably be placed in a local police station.

Data from the slide areas will be used in both a hazard warning system and for research. Telemetered data will be automatically monitored, to identify landslide events. The data then will also be stored on computer, and will be able to be accessed for studies of ground motions prior to and during the slide event. Additional research tasks will be directed toward questions of the geology of slide areas, to identify further areas of likely slippage, and to assess the possibility of mitigation strategies.

Work under this proposal will be carried out in two phases. The first will be a limited instrumentation program, with the goal of monitoring a few selected sites by the spring 1985 slide season. A second phase, to be carried out in 1985, will be the instrumentation of further sites, in time for the 1986 slide season. It is estimated that the first phase will cost approximately $??,000, and the second phase about $???,000.

INTRODUCTION AND STATEMENT OF PROBLEM

Landslides and debris flows in Utah have caused much disruption of communities and commerce during 1983 and 1984. Although the events of these two years have made national news, the effects of mass movements have been noted in Utah since early geological studies. The present wet climatic cycle has aggrevated the problem, but major movements, such as the Manti Canyon slide during the mid-1970s, have occurred during relatively dry years. Expansion of Wasatch Front urbanization into range front slope areas and alluvial fans has placed more people at peril from these geologic hazards.

Geologic studies of the nature of slides, and monitoring slides to provide needed data to emergency personnel, are two important aspects of hazard mitigation. The basic nature of landslides and debris flows needs to be better understood, and the technology for monitoring remote sites that may be hazardous needs to be improved. The work proposed herein will allow the development of approximately 10 remote telemetry slide monitoring systems, installation of these systems in areas with identified high hazards, operation of these systems through a season, and geoscientific research into the nature of landslide problems.

The proposers designed, developed, installed and operated a remote telemetry system at Rudd Canyon during the 1984 slide season. Many other sites with high hazard exist; instrumentation of about ten will allow further development of monitoring techniques. The ten sites will be selected in consultation with both public and private sector personnel familiar with slide hazards, through convening a workshop. Once the sites are selected and the instruments are constructed, operation will be coordinated through local and state emergency personnel. Research into basic slide processes will accompany the monitoring effort.

Although professionals from individual scientific disciplines can study geologic hazards, practical applications of these studies are best made in an interdisciplinary environment, where the translation of scientific data to the needs of community planners and emergency response personnel can be easily accomplished. The disciplines involved in this proposal include geologists, to study the basic nature of the slides and the surrounding geology; geotechnical engineers, to develop sensitive instruments for monitoring potential slide areas; electrical engineers, to develop data telemetry systems for real-time monitoring of the slides at remote locations; and emergency management personnel, to insure that the data are presented in a usable manner.

Although management of a program needs to be centralized in one organization, success of a study such as the one proposed herein can only be achieved by involving many organizations. Overall management of the proposed work will be by the Earth Science Laboratory/University of Utah Research Institute. ESL/UURI personnel will also perform geological and electrical engineering aspects of the study. Active participation in the proposal will also be made by the Department of Mining Engineering, University of Utah, who will provide geotechnical engineering expertise. Other Univeristy of Utah personnel will be involved as appropriate through the Engineering Experiment Station on campus. Personnel from agencies of the State of Utah will be involved in the program. These agencies include the Utah Geological and Mineral Survey, who will aid in site selection for monitoring and coordination with local communitites, and the Utah Division of Comprehensive Emergency Management, who will assist in coordination with local emergency response agencies. Limited participation will also be sought from other appropriate groups such as the U.S. Geological Survey.

Formation of a multidisciplinary, multiorganization team to instrument and study landslide and debris flow hazards along the central and northern Wasatch front will aid in mitigating damage to communitites along the front. The work proposed herein will support development of a warning system for some of the most hazardous areas, and research into some of the basic scientific phenomena associated with slides.

Landslides in Utah

Early studies in the geology of Utah identified many areas of landslide activity (   ). No geologic province of the state is free from slide activity (Schroder, 1971). The low population in the early history of the state meant that hazards from any particular event were limited. As the population of the state has increased, however, people are living in more geologically hazardous sites, and there therefore has been a resultant increase in damage from and awareness of landslide and debris flow activity. In particular, the Thistle slide in 1983, and the Farmington debris flow in 1983 have created a great public awareness of the problem. Damage from landslide and debris flow activity in 1984 and 1984 has been estimated to be approximately ?? million dollars. Two governors conferences on geological hazards and one speciality conference have noted the problems of landslides (Goode, 1970; Atwood and Mabey, 1983).

High hazards from landslides exist in many parts of the state, while the highest hazard from debris flows is presently found along the highly populated area of the Wasatch Front. Hazards exist in the form of many partially detached starting zones (Wieczorek et al., 1983).

The increase in hazards from mass movements implies that at least two strong areas of research are needed: development of monitoring and warning systems, and geological studies of the nature of slides. The work proposed herein is directed toward these two goals.

Monitoring system (this description of the existing system should be written by McCarter and Green)

System on slide - design, location, numbers, etc.
- extensometers
- inclinometers
- other non-telemetered data collection

Telemetry
- data compilation
- data transmission

Receiving station
- data collection
- data storage

Use of data in warning

Geology

Geological studies of landslides that will be carried out in the first areas selected include regional stratigraphic studies and evaluation of the mineralogy of starting areas. Although it has often been reported that selected geologic units are most prone to sliding along the Wasatch Front (e.g. the Arapeen Formation and the Farmington Canyon Complex), detailed studies of the stratigraphy of these units, to identify the most slide prone aspects of their stratigraphy, have not yet been carried out. This is particularily true for the Farmington Canyon Complex, which has been treated by landslide investigators as a homogenious mass of rock. Identification of stratigraphy in much of the area of the Farmington Canyon Complex has been hampered by deep weathering and extensive vegetative cover; there is no reason to expect, however, that the rock unit is any less diverse in starting zones of slides than in areas where it is better exposed. Stratigraphic controls are probably important in determining which portions of the range front are likely to slide, but these controls are not yet presently known. Geologic structures within these rocks are also extensive and diverse. It is entirely possible that unrecognized controls, such as traces of the Wasatch Fault or older faults, may localize slide activity. Such controls have been noted in other studies ( ).

The second aspect of geologic studies that will be investigated will be the mineralogy of slide areas, particularily the clay assemblage in starting zones. The deep weathering profile of the rocks suggests that types of clay minerals that have formed from the weathering of the underlying bedrock may be important in controlling slodes. To date, no studies of these minerals have been done. Once the mineralogy of the slides is identified, these data may be able to be used to select chemical treatments to stabilize slides that present particularily high hazards (Arora and Scott, 1974).

Mitigation

The three major aspects of hazard mitigation are: operating a warning system during the hazardous event;

engineering or non-structural preparation for handling the occurrence of a hazard; and preventing the hazard from occurring. Data compiled and collected during the course of this study will be applied to all three of these aspects.

Mitigation techniques need to be cost effective. The establishment of the warning system is part of this proposal. Other mitigation stratigies will involve a thorough assessment of their costs, an evaluation of the level of the accecptable risk from the landslide at a particular site, and a concensus of community representatives, emergency planners, and funding agencies that such mitigation stratigies are appropriate. Evaluation of costs and achieving such a concensus are beyond the scope of this proposal.

The warning system developed in this work will be useful in giving very short term forecasts of when a debris flow is likely to enter a town or when a landslide is moving at a fast rate. Such warnings, particularily if they can be given at a time of heightened awareness of the potential for problems, may be useful to local police departments for warning and action activities. Although the time of warning at Rudd Canyon was only about 12 minutes, this was enough to be useful to the local police.

Engineering preparation for debris flow hazards in Utah has included such measures as channelization and construction of debris basins. These are costly measures, and take much time for execution. Non-structural approaches, such as zoning regulations and land use planning, take much time also.

Prevention of the occurrence of a natural hazard is highly dependant upon site specific conditions of that hazard. It may be possible, using the data on clay mineralogy of these slides, to design chemical techniques for stabilization. This could be particularily important where small slides threaten a large number of homes.

PROPOSED STRATEGY

The components of this proposal are to design and construct equipment to measure and monitor surface displacement of potential landslide and debris flow zones; to emplace these instruments in crutial locations; to remotely monitor land displacement through development and installation of a telemetery system; to operate the system through a time of high hazard; and to preform needed research in basic conditions of land instability.

(Kim McCarter should write text on design and emplacement of instruments)

(Dale and Steve should write text on the telemetry system)

The selection of sites to be monitored will be very important. The sites will need to be in high hazard zones, likely to move, and have reasonable access. Selection of the sites will need to be performed in conjunction with the Utah Geological and Mineral Survey, the Utah Division of Comprehensive Emergency Management, the U.S. Geological Survey, affected local governments, and perhaps other federal, state, and local agencies. Input will be sought from private sector companies, particularily utilities, to seek additional sites for monitoring.

Day-to-day operation of the receiving station will be the responsibility of the local government unit, with assistance from the state CEM. Insuring that the monitoring and telemetry equipment are operating, however, will be the responsibility of the proposers.

The applied research component, which has been described above, will be the responsibility of the proposers. This research will include studies connected to design of monitoring equipment, studies of electronic components required for the telemetery system, and geological investigations of landslide sites.

STATEMENT OF WORK
to be devised

PROJECT MANAGEMENT

Overall management of this project will be with the Earth Science Laboratory/Univeristy of Utah Research Institute. Consultants will be retained as discussed below, to augment the expertise of ESL/UURI professionals. The overall structure of the program is indicated on figure X.

(insert general ESL management and capabilities text)

PROPOSED BUDGET

This will be written with all funding coming through ESL, with other U of U participants shown as consultants (except McCarter students?). Two phases will be reflected: the first to do two sites during fall 1984, and the second to do at least 8 more sites during the summer of 1985.

REFERENCES

Arora, H.S., and Scott, J.B., 1974, Chemical stabilization of landslides by ion exchange: California Geology, vol. 27, pp. 99-107

Atwood, G., and Mabey, D.R., eds., 1983, Governor's conference on geologic hazards: Ut. Geol. Min. Surv., Circular 74, 99 p.

Goode, H.D., 1970, Landslides as geologic hazards in Utah, in, Governor's conference on geologic hazards in Utah: Ut. Geol. Min. Surv., Spec. Stud. 32, p. 21

Schroder, J.F., 1971, Landslides of Utah: Ut. Geol. Min. Surv., Bull. 90, 51 p.

Wieczorek, G.F., Ellen, S., Lips, E.W., Cannon, S.H., and Short, D.N., 1983, Potential for debris flow and debris flood along the Wasatch Front between Salt Lake City and Willard, Utah, and measures for their mitigation: U.S. Geol. Surv. Open-File Report 83-635, 76 p.

Salaries and Wages

	days			
Wright	40			
Nielson	10			
Foley	40			
~~Sibbett~~	100			
Green	100			
Olsen	40			
			50,460	
Tech	140	@ 100		
Student	140	@ 50		
Sec.	20	@ 55		
Draft	15	@ 70		
Adm Asst.	15	@ 110		
			24,800	72,260
			burden @ 41%	30857
				106,120

Consultants (McCarter, etc)
25 days @ $350 McCarter
10 days @ $350 other | 12,250

Travel:	25,000
Instrumentation & Equip: #7000x10	70,000
Supplies:	2000
Imagery:	1000
Computer Time	1000
x-ray & chem	5000
Total Direct	222,370
Indirect @ 43%	95,620
G&A @ 13.5%	30,020
	348,010
Fee @ 5.5	19,140
	367,150

LANDSLIDE BUDGET

1. To build instruments:

Dale: 15 days initially + 3 days/instrument = 45
Steve: 5 days " + 1 day 25
Tech: 20 + 7 90
MCC: 5 + 1 15
Stud: 15 + 2 35
Parts: ~~$6,000~~ $3000 /installation x ~~10~~ 8
~~+ Sensors~~

2. To install equipment (each install)

Dale: 5 50
Steve: 2 20
Tech: 5 50
MCC: 1 10
Stud: 5 50

3. To ~~monitor~~ maintain equip results

Dale: 2 day/mo
Tech: 1 day/week
~~Stud: 1 day/week~~

4. To track results

Student: 1 day/week
ESL Tech: 1 day/week

5. Research:

	days
Geol Mapping / Sampling	
initial: 1 week / area in field + 1 week other	100
Clay Studies – 20 samples / area + 1 week area geol interp	50
Resistivity Monitoring / Surveys	
10 days / area	100
+ $1000 / area equip	$10,000
Proj Management	
Imagery Interp — 1 day / week for 10 mo	40

PROPOSED PROJECT

ELEMENTS OF PROJECT

1. Deployment of an early warning system in, say, 10 high risk areas in Utah by 1985 snowmelt season.
2. Provision of warning data to state agencies (mainly CEMA and UGMS) and to affected industries, utilities, communities, etc.
3. Research into monitoring of landslide phenomena.

SCOPE OF WORK

Year 1. $5K

1. Site Selection - with state agencies, industry, utilities, communities, etc.
2. Instrument manufacture and deployment $12 @ 6K = 72 ⇒
3. Data collection and analysis - provision of data to pertinent parties.
4. Begin research 1 mo ME, 2 mo Elect, 6 mo geol, $100K

total $250K

Year 2.

1. Continuation of data collection.
2. Research--density and positioning of sensors, precursor signals of danger, predicting rapid and profound mass movement, use of remote sensing, etc.
3. Research reports, etc.--
4. Turn over some field operations as appropriate to CEMA.

PARTICIPANTS

1. UURI - Project management; instrumentation deployment and maintenance; selected research tasks
2. UU - Selected research tasks, consulting and advice
3. Utah CEMA - Dissemination of warning data, coordination and interface with state agencies.
4. UGMS - assistance in siting, selected research tasks

Year 3.

1. continuing collection of data
2. Research and publication of results
3. Application to other areas / problems
   - California
   - avalanches

DEVELOPMENT OF AN EARLY WARNING SYSTEM
FOR
MONITORING OF LANDSLIDE HAZARDS IN UTAH

1.0 INTRODUCTION AND SUMMARY

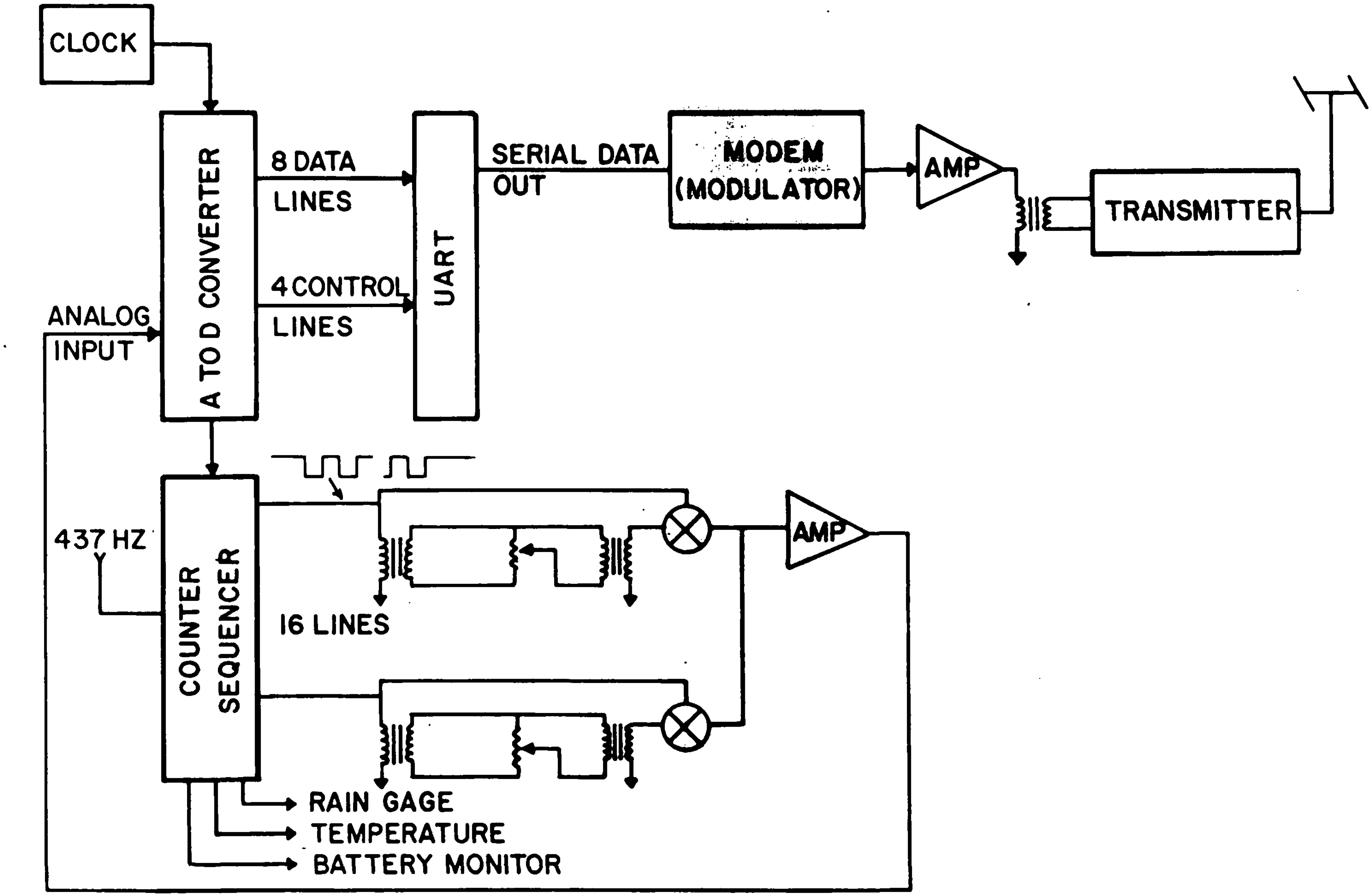
2.0 LANDSLIDE HAZARDS IN UTAH
Location of Recent Slides, Extent of Recent Damage; Location of Major Historic slide areas; Potential for Future Slides.

3.0 EARLY WARNING AND MONITORING INSTRUMENTATION
- 3.1 Description - extensiometers, tiltmeters, telemetering
- 3.2 Deployment - location and density in slide areas
- 3.3 Data Evaluation

4.0 PROPOSED PROJECT
- 4.1 Summary of Project
- 4.2 Selection of Sites
- 4.3 Installation of Equipment and Data Acquisition
- 4.4 Dissemination of Data

5.0 MANAGEMENT
Participants, Interfacing of State Agencies

6.0 BUDGET AND SCHEDULE



RUDD CANYON MULTIPLEXER/TRANSMITTER

meeting w/ Dennis, Dave. 27 June 84

1. Potential of Monitoring Equip
2. Landslide Monitoring and Research Coalition
3. Geologic Hazards Institute

---

17 July 84

1. Go w/ proposal to State then Brophy @ State
   Science Advisory Board -
   - Second line - go to FEMA -
   - Third line - Soil Conservation Service -
   - Talk w/ communities - SK ea. - get state to match
     Then get Feds to match this - partly into $200K
     easy -
   - Div Community & Econ Devlp - Disaster Relief Board -
   - State Agriculture Dept. -
   - USFS - they have landslide $ -

   - Go to utilities + communities -

2. For Brophy - could we get $250K only from
   State?
   - if not, get 1/2 state, 1/2 FEMA
   - if not, Cos + comms @ $5-10K each, w/ matching state
   - also ask Brophy what he found out about USGS proposal
   - get in touch w/ Utah State -

3. Wright to call Pope

13 June 84   LANDSLIDES —
w/ Ken McCarter, Gordon Jensen

actually $ FEMA thru CEMA -- surplus $ from debris basin, Big Cottonwood out of gov's emergency funds

1. Players
- CEMA — Bob ~~[illegible]~~ Kestner — got $, coordinated w/ city of Farmington
- UGMS — got involved even before CEMA -- Gordon J. & Ken talked to them
  - role — Bruce Kaliser — identified slide areas, there for installation —
  - feels we won't have much luck doing this work w/out UGMS — state has designated them for geol hazards —
  - no probs working w/ them
- Utah Dep Sfa
- Dept Nat Eng
- UURI
- Wasatch Nat Forest — very helpful — helicopter, trail crew — Jim Cook
- USFS —
- SLC Water Dept — Don Schenk — provided snow thickness data
- SL County Flood Control & Water Quality — they handled $ from gov's emerg fund -- reporting agency

2. Stan – explained our funding strategy
- not go thru USGS -- Gen. would not like it, even though theirs is higher –

- Potential USGS role –
as a Univ, we could not be in position of providing warning data –

Kim — what we are suggesting has been done by Utah State
- USU/UGS/ Ford Bocany Davis –
- Kim has been asked to play a role, too –

- They are interested in a hydrologic investigation
- Piezometer array on landslides – build a model of landslide movement vs water content

- How many sites could be instrumented? Kim has no good idea –

Kim — site selection – must ask "to what use will data be put?"
- Utah Fuel, UP&L, communities, UDOT

- USU wants to develop hydrologic model
- not a 3D finite element failure model

Installations 10-25 (Kim)
would not want to help track of [illegible]

- Kim suggests go to UGMS before CEMA.
  UGMS, CEMA, USU
- then get proposal put together
  - we would designate project leader -
  - Kim wants PI on his research -, not proj leader -

- Kim will be gone 21 June -- so meet w/ UGMS before this -

meeting CGMS — 20 June 84

[Gordon Jensen, Don Mobley, Bruce Kaliser, Genevieve Atwood, Jim Brophy, Duane Foley, Ken McCarter

Genevieve
1. Their charter
   - inventory resources
   - assess ~~hazards~~ hazards
   - dissem info
   - advise state agencies
   So in ~~Hazards~~, they are in business to advise state agencies & inventory and assess
2. - they are studying specific hazards
   - they are talking about red-flag map of hazards generalized zones of hazards
   - Earthquake 3 yr USGS program is exciting
3. See needs for
   research
   mapping
   processes - univ-type research
   - plenty of room for more work
   - UGMS may not have a role in what ~~they~~ we want to do
   - is excited about what has been done w/ CCIM, etc.

Bruce
- is interested in expansion into other slides, other forms of hazards

Mahey

WGNs position vis a vis applied vs research

- their position -

  mitigation + warning - state function + funding

  research - fed govt responsib + funding

- is in our interest to encourage fed funding but state funds best spent in reducing hazards -
- don't support research themselves
- would be interested in supporting research efforts -

Re Support from state, county, city agencies, etc

They have got virtually every form of support they have needed.

Re CEM role -

G. - they are interested, help bring in $ --

- have to be in loop
- they get $ from FEMA
- CEM is in a reactive mode -- they can't spend $ except in an emergency
- FEMA has matching funds for CEM -

  5% of mitigating moneys have to be pledged, then FEMA can match.

Dates

1. Disaster period close 1 July — consequence — those slides still moving may not be considered disaster.
2. Lorayne Tempest in CEM knows about this —

USGS Role — Mabey
- have had a close working relationship
  - have had people as part of UGMS staff
- keep UGMS informed of research activities —
- Contact — done in Branch headed by Bob Bushman, (serious) ~~but most Utah people~~
  - also contacts in Reston — Les Campbell — Hamilton, Peck —

G — So much to be done ~~that~~ there is room for everyone —

Utah State
- have inquired of UGMS on critical slides — this info is sensitive because public, mouth load, etc
- they want to get on a slide, etc
- USF proposal covered everything — instrumentation, research, etc
  for a Landslide Institute — was very broad, etc —

Brophy –

may be State Science Council is umbrella for a ~~Hazards~~ Institutes

G – wants to see a long-lasting facility. Has thus looked to USGS as critical mass of people, etc for this –

FEMA – ⇒ is a geologist

~~Art Seezel(?) is contact~~

Art Zeizel – WDC FEMA

Jerry Olsen – Denver – Den. people are in SLC frequently

– funding complex – pots of $ materialize, etc. –

Kim –

~~E~~mphasized the ongoing nature of interpreting data. and coord necessary w/ local entities –

→ we can't get too far afield; out of our eng

→ need to assess quality of info. and how valuable the info was (has not heard @ Farmington)

need to assess where monitoring will be valuable –

– Timing is critical –

– Debris flows may not be around in less wet years, but slope failures will always be around – –

utility involvement

- UGMS has interacted up then bee their functions affect public
- can't get info from Ultra Fuel & UPEL on line location
- Ultra Fuel has dealt w/ situation better than UPEL -

conclusions -- we will do

1. put together our outline of research
2. contact LEMA, then ~~FEMA~~ and try to ~~to~~ locate pots of $ -, then get back to UGMS -

proposal -

- what could we do that makes scientific sense
  KCM + DMW get together to define an outline for research

  class of slides
  tie in players — USGS - sites, warning -

- DMW call Boyce in FEMA
  structure
  what are they interested in
  5% money matching funds
  is ~~Zissel~~ person to talk w/

- Art Dennis again -

UGMS 6-20-84
Genevieve Atwood
Don Mabey

Other parameters
Other types of slides

involve local government agencies

working & coordinating CEM.

FEMA + State Matching Funds

Dates
Disaster period close July 1, 1984.
Laraine Tempest.

USGS
Bob Bachman – Denver.

FEMA
ART ZEIZEL WASH
JERRY OLSEN DENVER.

KIM – RESEARCH ONLY.
– LIABILITY A PROBLEM
– WARNING VS MONITORING.
– COORDINATION WITH LOCAL AGENCIES
– WHERE ~~IS~~ ARE IDEAL SITES.
– TIMING

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

KEY : [illegible]

- LONGEVITY OF PROBLEM

- [illegible] IS MONITORING

- COORDINATION WITH OTHER AGENCIES

- WHERE ARE [illegible]

- TIMING

DLN
6/12/84

Geologic characterization of Landslides

1. Formations involved
   - mineralogy (smectite)
   - hydrology

2. Contributing Geologic Factors
   - capping formation
   - ~~intersection~~ presence of structural zones
   - steep topography developed by erosion or faulting
   - presence of old slides / movement of old slides.

3. Precipitation / Elevation

- The purpose of this work is an initial screening which will identify areas susceptible to slides. It then identifies ~~areas for~~ target areas to be considered for instrumentation.

4. Seismic - induced slides

J. Foley

STATE LANDSLIDE/MUDFLOWS HAZARDS REDUCTION PROGRAM
Five-Year Plan FY 1984 - 88

DRAFT

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DRAFT

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- Task 1. Obtain Data on Significant Changes in the Physical Properties Preceding Failure
- Task 2. Why did Thistle Move?

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- Task 1. Conduct A Landslide/Mudflow Forecast Experiment in Davis/Weber Canyons.
- Task 2. Conduct a Landslide/Mudflow Forecast Experiment in Northern Utah
- Task 3. Conduct a Landslide/Mudflow Forecast Experiment in Central Utah

Objective 3. Land Use to Stabilize and Prevent Landslides and Mudflows
- Task 1. Did Terracing Help?
- Task 2. Evaluate Effects of Off-road Vehicles
- Task 3. What Types of Vegetation Help?
- Task 4. Relationship of Water Impoundments to Failures

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- Task 1. Manual for Monitoring Techniques and Practices
- Task 2. Identify Those Physical Factors to be Monitored
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- Task 4. Devices and Equipment for Monitoring and Transmission of Information.
- Task 5. Identification of Theshold Conditions
- Task 6. Experiments in Davis/Weber Canyons
- Task 7. Experiments in Central Utah
- Task 8. Experiments in Northern Utah

III. DESIGN AND ENGINEERING RESEARCH TO MITIGATE AGAINST LANDSLIDE/MUDFLOW DAMAGE

IV. PREPAREDNESS PLANNING AND HAZARD AWARENESS

Introduction
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- Task 1. State Preparedness Actions
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- Task 1. State Multihazard Preparedness Planning
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- Task 1. Utilization of Existing Educational Materials
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- Task 1. Develop Knowledge About the Socioeconomic Aspects of Hazard Mitigation
- Task 2. Increase the Base of Knowledge About Landslide/Mudflow Preparedness
- Task 3. Improve the Understanding of Disaster Impacts and Responses
- Task 4. Provide Ways to Improve the Dissemination of Hazards Information and Its Use by Decision makers, the Public, and the Private Sector
- 5. Desirability of legal prohibitions against structures in high risk areas

PROPOSED PROJECT

ELEMENTS OF PROJECT

1. Deployment of an early warning system in, say, 10 high risk areas in Utah by 1985 snowmelt season.
2. Provision of warning data to state agencies (mainly CEMA and UGMS) and to affected industries, utilities, communities, etc.
3. Research into monitoring of landslide phenomena.

SCOPE OF WORK

Year 1.

1. Site Selection - with state agencies, industry, utilities, communities, etc.
2. Instrument manufacture and deployment
3. Data collection and analysis - provision of data to pertinent parties.
4. Begin research

Year 2.

1. Continuation of data collection.
2. Research--density and positioning of sensors, precursor signals of danger, predicting rapid and profound mass movement, use of remote sensing, etc.
3. Research reports, etc.--
4. Turn over some field operations as appropriate to CEMA.

PARTICIPANTS

1. UURI - Project management; instrumentation deployment and maintenance; selected research tasks
2. UU - Selected research tasks, consulting and advice
3. Utah CEMA - Dissemination of warning data, coordination and interface with state agencies.

DEVELOPMENT OF AN EARLY WARNING SYSTEM
FOR
MONITORING OF LANDSLIDE HAZARDS IN UTAH

1.0 INTRODUCTION AND SUMMARY

2.0 LANDSLIDE HAZARDS IN UTAH
Location of Recent Slides, Extent of Recent Damage; Location of Major Historic slide areas; Potential for Future Slides.

3.0 EARLY WARNING AND MONITORING INSTRUMENTATION
- 3.1 Description - extensiometers, tiltmeters, telemetering
- 3.2 Deployment - location and density in slide areas
- 3.3 Data Evaluation

4.0 PROPOSED PROJECT
- 4.1 Summary of Project
- 4.2 Selection of Sites
- 4.3 Installation of Equipment and Data Acquisition
- 4.4 Dissemination of Data

5.0 MANAGEMENT
Participants, Interfacing of State Agencies

6.0 BUDGET AND SCHEDULE

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Potential for debris flow and debris flood along the Wasatch Front between Salt Lake City and Willard, Utah, and measures for their mitigation

by

Gerald F. Wieczorek, Stephen Ellen, Elliott W. Lips, and Susan H. Cannon
U.S. Geological Survey
Menlo Park, California

and

Dan N. Short
Los Angeles County Flood Control District
Los Angeles, California

with assistance from personnel of the
U.S. Forest Service

Open-File Report 83-635
1983

two canyons from moderate to very high. Such fundamental information must be systematically incorporated into this method for it to yield reliable reconnaissance evaluations of the potential for these processes.

Such improvements form only the beginning of the research appropriate for careful evaluation of the potential for debris flow and debris flood. Studies needed for careful evaluation of potential should address the following questions:

1) Relations between rainfall (or snowmelt), ground-water levels, and landslide movement. Such relations would permit prediction of timing of debris flows. Real-time prediction and warnings could then be made based on telemetered rainfall, water-level, or ground-movement information.
2) Stability of the partly-detached landslides. Are these masses in fact significantly less stable than nearby hillslopes, and how long will they remain so? These questions should be approached through detailed site-specific studies including stability analyses of the landslides.
3) The process of transformation from landslide to debris flow. Understanding developed through such study could help evaluate the potential for debris flow of the partly-detached landslides.
4) Incorporation of channel materials by debris flow. Possible variations in materials available for incorporation is one of the major uncertainties of our analysis.
5) The transition from debris flow to debris flood. Understanding of this transition would permit more accurate prediction of the nature of flow from canyon mouths.
6) Factors that control debris-flow runout. Understanding of runout would help in prediction of areas likely to be affected beyond canyon mouths.
7) Recurrence of debris floods and debris flows at canyon mouths. Systematic

storm situations all three of these structures must be watched for undercutting.

The watercourse improvements shown in Figure 13 provide increased flow area and are appropriate in the steeper portions of the watershed (gradients of 6% to 7% or more). These methods by themselves are probably not sufficient in the more gently-sloping areas, but they may be incorporated along with flood-proofing measures shown in Figure 14.

Where diagonal crossings are encountered, flow in excess of channel capacity should be diverted to streets, allowing deposition to take place on public property. Appropriate street designs for this situation are those with inverted crowns and minimum 4-foot-wide concrete paving in the center. Depending on the slope, residents may have to flood-proof their property. An attractive way to accomplish this would be a concrete-block wall up to 3 feet high having removable timber stop logs, as shown in Figure 14. Block walls are also appropriate at rear and side yards where there are no alternate water paths. Berms of loose fill, like those now in place, are acceptable only in emergencies, as they are easily eroded by water not carrying its full capacity of sediment. Prior to making or increasing diversions into streets, the jurisdictional agency should evaluate local laws or ordinances and consult with their legal advisors with respect to future liabilities as a result of the diversions.

Mitigation measures are discussed below for each drainage area classified as having very high potential for debris flow (A) or debris flood (a).

Recommendations for further studies

The mitigation measures cited herein are primarily conceptual in nature. In most cases the recommended measures will not handle the full debris potential. These measures are based on estimated production rates and estimated bulking factors, determined from a limited amount of research, and they are presented only for canyons rated as having very high potential for debris flow or debris flood. Detailed research and engineering studies are appropriate for all the frontal canyons. These studies should determine the quantity of debris to be anticipated and methods for dealing with this material.

The flood plains and canyons of the Wasatch Front are under the jurisdiction of the U.S. Forest Service, three counties, and numerous cities and communities. None of these entities has exclusive control over a complete watershed and none has the staffing or financing to undertake studies of this nature. It is therefore recommended that a special district be formed, preferably by state charter, to coordinate watershed management and research and to oversee technical studies. This organization would also serve as the clearing house for all reports and data regarding these watersheds.

FEMA (Federal Emergency Management Agency) and FIA (Federal Insurance Agency) should be requested to review the hydrology of the area and to consider authorizing new studies to determine bulked flow rates, to quantify debris potential (both rate and volume), and to investigate the mechanics and locations of potential deposition. Programs should then be adopted to address these problems and to monitor the watershed reactions to verify the studies and solutions. The reestablishment of recording gages for both precipitation and runoff is appropriate to assist in monitoring the watersheds. The National Weather Service may be able to assist in instrumenting the watersheds and in applying their watershed-runoff forecast model.

The jurisdictional agencies would be advised to adopt a program of inspection and repair of existing systems. This inspection should include drainage ways that are the responsibility of property owners. The agencies might also wish to temporarily prohibit both development on the apexes of alluvial fans and the diversion of streambeds, until the above-mentioned studies are completed. Future development should be designed around streambeds rather than rerouting streambeds to fit development.

CANYON-BY-CANYON EVALUATION OF RELATIVE POTENTIAL FOR DEBRIS FLOWS AND DEBRIS FLOODS TO REACH CANYON MOUTHS, AND MITIGATION MEASURES

(Canyons listed in sequence from south to north along Wasatch Front)

City Creek

Following a three-hour rain over Salt Lake City on September 11, 1864, a debris flow[2] "as thick as molasses" issued from City Creek (Woolley, 1946, p. 87). Based on this episode and other historic accounts of debris flood and possible debris flow (Woolley, 1946), City Creek is rated as having a high debris-flow potential (B) and high debris-flood potential (b). No specific mitigation measures are suggested for this drainage.

Mill Creek

Young alluvial-fan deposits identified beyond canyon mouth of Mill Creek (Miller, 1980) suggest a history of recurrent debris floods and a high debris-flood potential (b). Debris flows reached the main channel during the spring

---

[2]Underscoring in text and in Table 1 indicates authors' interpretation of historical accounts.

Table 1 - Evaluation of Potential for Debris Flow and Debris Flood From Canyons

Drainage (South to North)	Historic & Prehistoric Documentation of Debris Flows and Debris floods reaching canyon mouth	Volume (m^3) of Largest Single Debris Flow 1983	Largest Estimated Volume (m^3) of Single Partly-Detached Landslide	Average Main-Channel Gradient	Evaluation of Potential	
					Debris Flow	Debris Flood
City Creek	1854, 1864[5], 1874[5], 1879[5]	Minimal	---	-	B	b
Mill Creek	alluvial fan[1]	Minimal	---	-	D	b
Kenney Creek	historic, multiple prehistoric[2]	Minimal	---	-	B	b
Holbrook Canyon	None	22,000±4,000	42,000±5,000	.120	A	a
Stone Creek/ Ward Canyon	prehistoric[3], 1983[3]	15,500±1,500	2,000±500	.126	B	a
Centerville Canyon	alluvial fan[1]	2,000±200	---	.140	D	b
Parrish Canyon	1930[5], 1930[5]	1,000±200	50,000±10,000	.177	A	a
Barnard Canyon	1930[5]	6,400±1,000	10,000±2,000	.195	C	a
Ricks Creek/ Ford Canyon	1901[5], 1923[5], 1929[3], 1930[5], 1934[5]	1,040±200	4,000±500	.203	B	a
Davis Creek	1878[5], 1901[5], 1903[5], 1923[5], 1929[3], 1930[5]	Minimal	---	.305	B	b
Steed Canyon	prehistoric[3], 1901[5], 1923[5], 1930[5]	10,000±2,000	25,000±5,000	.341	A	a
Rudd Canyon	prehistoric[3], 1983[3,7]	64,000[7]	70,000-100,000	.314	A	a

Farmington Canyon	1878[5], 1923[5], 1926[5], 1936, 1947[4]	17,000±3,000	40,000±5,000	.127	A	a
Shepard Creek	alluvial fan[1]	5,000±1,000	2,000±200	.175	D	a
Baer Creek	prehistoric[3], 1912[4], 1923[4], 1927[4], 1945[4], 1947[4]	2,400±400	20,000±5,000	.166	A	a
Holmes Creek/ Webb Canyon	alluvial fan[1], 1917[5]	Minimal	---	.209	C	b
S. Fork Kays Creek	1912[4], 1923[2], 1927[2], 1930[4], 1945[2], 1947[2]	Minimal	---	.203	B	b
M. Fork Kays Creek	prehistoric[1], 1947[2]	Minimal	---	-	C	b
Waterfall Canyon	1923[4]	Minimal	---	-	C	b
Ogden Canyon	1888[5], 1923[4,5], 1980[6]	Minimal	---	-	C	c
Coldwater Canyon	prehistoric[1], 1983[3,8]	12,000±2,000	---	.205	B	b
Willard Canyon	prehistoric[1], 1912[5], 1923[4], 1936[5]	8,000± 1,000	10,000±2,000	.195	A	a
Facer Canyon	multiple prehistoric[3], alluvial fan[1]	3,000±500	30,000±5,000	.307	A	a
Threemile Creek/ Perry Canyon	1923[4,5], alluvial fan[1]	Minimal	---	-	C	b

Sources of information:

[1]Miller (1980)
[2]Winkelaar, U.S. Forest Service, (oral commun., 1983)
[3]determined during this study
[4]Croft (1981)
[5]Woolley (1946)
[6]Thom Heller, U.S. Forest Service (oral commun., 1983) - both 1923 and 1980 events reported in tributaries to Ogden Canyon
[7]Kaliser, Utah Geologic and Mineral Survey (oral commun., 1983)
[8]Pierson, U.S. Geological Survey (oral commun., 1983)

Notes:

1) Average gradient of main stream channel was estimated from elevation difference between confluence of tributaries in headwater region and canyon mouth, divided by main channel length.
2) Volume of debris in channel could be larger than estimated if several partly-detached landslides mobilized and entered main channel simultaneously or if substantial volume of material were incorporated from channel.
3) Volumes of partly-detached landslides, estimated from aerial photos taken from helicopter and calibrated by comparison with more closely measured volumes of debris flows on Rudd, Ricks and Ward drainages.
4) Historic and prehistoric debris-flow events are underscored. Determination of whether a pre-1983 event was a debris flow or debris flood was based in part on the authors interpretation of the original citation.
5) The term "minimal" used in column 3 signifies that no landslides were observed during the spring of 1983 or that those observed were extremely small.
6) The symbol "---" in column 4 signifies that during our reconnaissance we did not observe partly-detached landslides. Such landslides may have been obscured by foliage by the time of our observation.

References Cited

Costa, J. E., and Jarrett, R. D., 1981, Debris flows in small mountain channels of Colorado and their hydrologic implication: Bulletin of the Association of Engineering Geologists, v. XVIII, n. 3, p. 309-322.

Croft, A. R., 1967, Rainstorm debris floods, a problem in public welfare: University of Arizona, Agricultural Experiment Station, Report 248, 35 p.

Croft, A. R., 1981, History of development of the Davis County Experimental Watershed: U.S. Department of Agriculture, Forest Service, Intermountain Region (Region Four), Odgen, Utah, 42 p.

Davis, F. D., 1983, Geologic map of the central Wasatch Front, Utah: Utah Geological and Mineral Survey, map 54-A, scale 1:100,000.

Daido, Atuyuki, 1971, On the occurrance of mud-debris flow: Bulletin, Disaster Prevention, Kyoto University, vol. 21, part 2, no. 187.

Gingery Associates, 1979, Hydrology report, flood insurance studies for 20 Utah communities.

Ikeya, H., 1981, A method of designation for area in danger of debris flow: International Symposium on Erosion, New Zealand.

Johnson, A. M., 1970, Physical processes in geology: Freeman, Cooper, & Co., 577 p.

Los Angeles County Flood Control District (LACFCD), 1970, Hydrology Manual.

Marsell, R. E., 1971, Cloudburst and snowmelt floods: Environmental Geology of the Wasatch Front, N1-N18.

Marston, R. B., 1958, The Davis County Experimental Watershed story: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Ogden, Utah, 37 p.

Miller, R. D., 1980, Surficial geologic map along part of the Wasatch Front, Salt Lake Valley, Utah: U.S. Geological Survey Miscellaneous Field Studies Map MF-1198, scale 1:100,000.

Mizuyama, Takahisa, 1981, An intermediate phenomenon between debris flow and bed load transport: International Symposium on Erosion, New Zealand, 8 p.

National Research Council, 1982, Selecting a methodology for delineating mudslide hazard areas for the National Flood Insurance Program: National Academy Press, Washington, D.C., 35 p.

Olsen, Earl, 1981, Landslide Hazard Map (Wasatch Range): U.S. Department of Agriculture, Forest Service, Intermountain Region (Region Four) Odgen, Utah, scale 1:24,000.

U.S. Army Corps of Engineers, 1969, Flood plain information; Barton, Mill and Stone Creeks.

U.S. Army Corps of Engineers, 1974, Flood plain information; Farmington Bay Tributaries, Farmington-Centerville, Utah.

U.S. Army Corps of Engineers, 1978, Flood insurance studies, City of Bountiful, Utah.

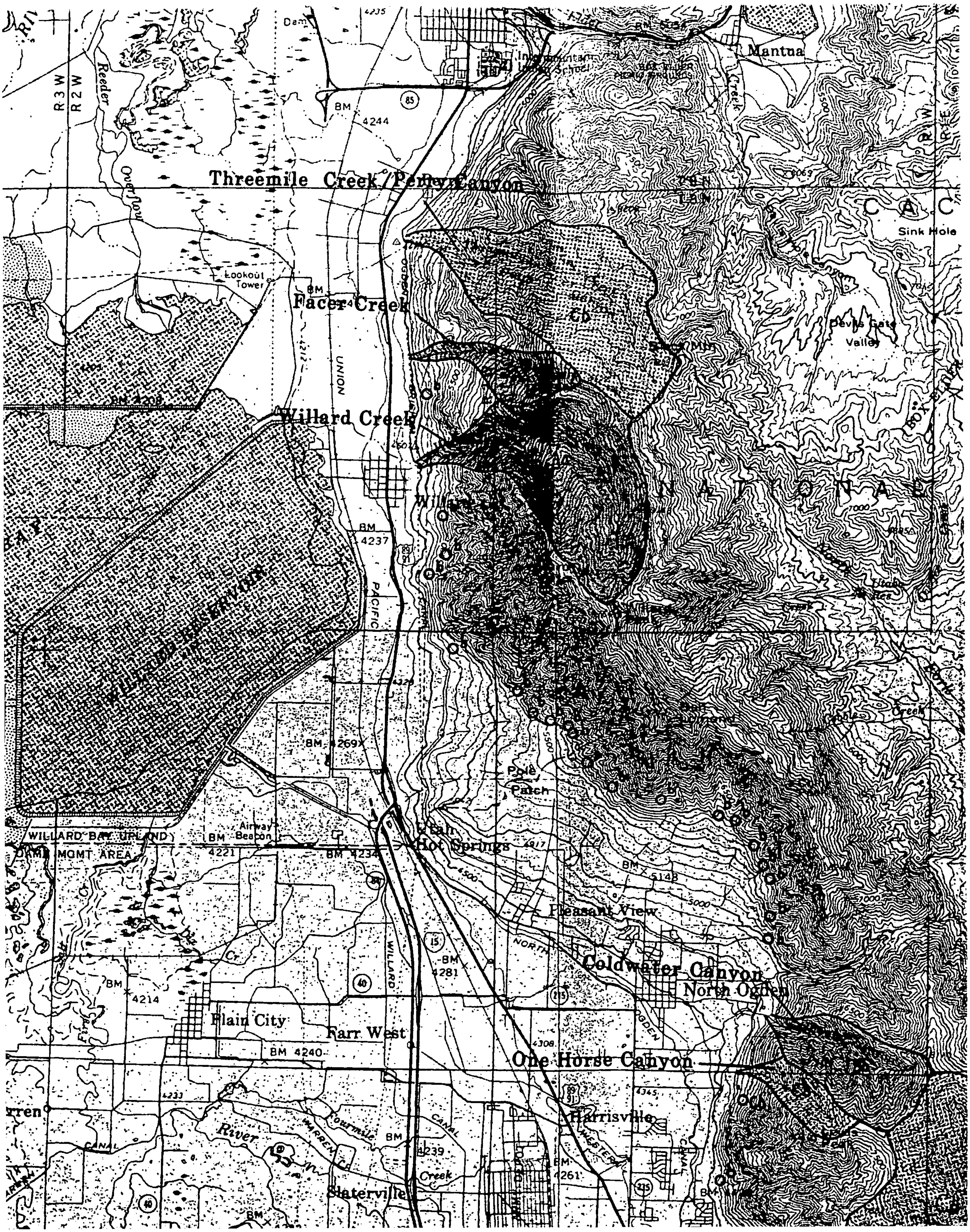
U.S. Department of Agriculture, Soil Conservation Service, 1983, Water supply outlook for Utah, Salt Lake City, June 1983.

U.S. Forest Service, 1950, Survey Report, Wasatch Front, Utah

U.S. Forest Service, 1951, Survey Report, Wasatch Front, Utah

Varnes, D. J., 1978, Slope Movement Types and Processes, in Landslides: analysis and control: Transportation Research Board, National Academy of Science, Washington D.C., Special Report 1976, ch. 2.

Woolley, R. R., 1946, Cloudburst floods in Utah, 1850–1938: U.S. Geological Survey Water Supply Paper 994, 128 p.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R 3 W
R 2 W
Reeder
BM 4244
85
Threemile Creek/Perry Canyon
C A C
Sink Hole
Lookout Tower
Facer Creek
Cb
Devils Gate Valley
UNION
BM 4208
Willard Creek
N A T I O N A L
BM 4237
PACIFIC
WILLARD RESERVOIR
BM 4269
Pole Patch
Airway Beacon
WILLARD BAY UPLAND
GAME MGMT AREA
BM 4221
BM 4234
Utah Hot Springs
BM 5148
Pleasant View
WILLARD
15
BM 4281
Coldwater Canyon
North Ogden
BM 4214
Plain City
Farr West
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One Horse Canyon
Harrisville
Warren
River
WARREN
CANAL
Fourmile
Creek
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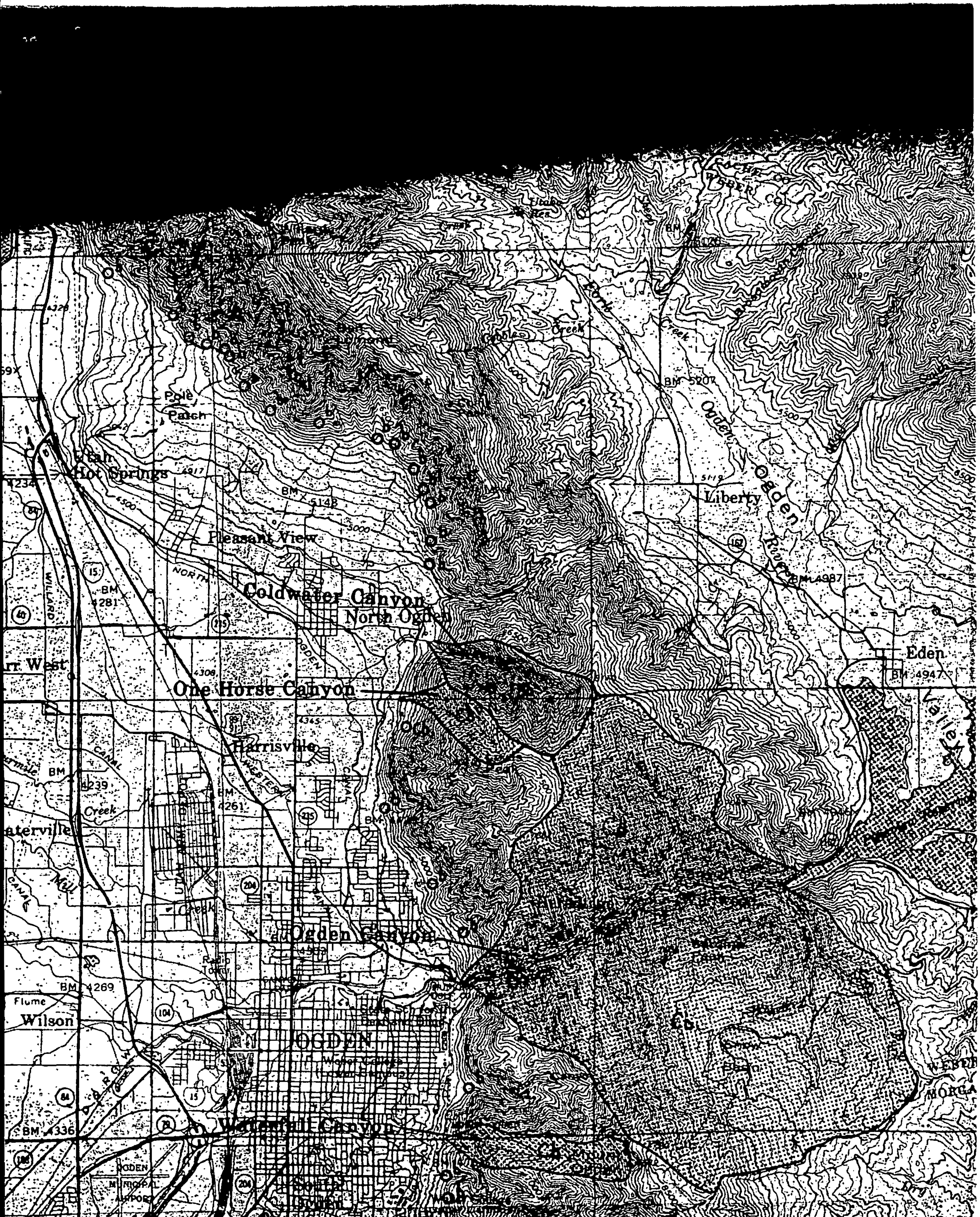
Slaterville



Pole Patch
Utah Hot Springs
BM 5148
Pleasant View
BM 4281
Coldwater Canyon
North Ogden
One Horse Canyon
Harrisville
BM 4239
BM 4261
Ogden Canyon
Radio Tower
BM 4269
Flume
Wilson
OGDEN
Waterfall Canyon
BM 4336
South Ogden
BM 5207
Liberty
Ogden River
BM 4987
Eden
BM 4947

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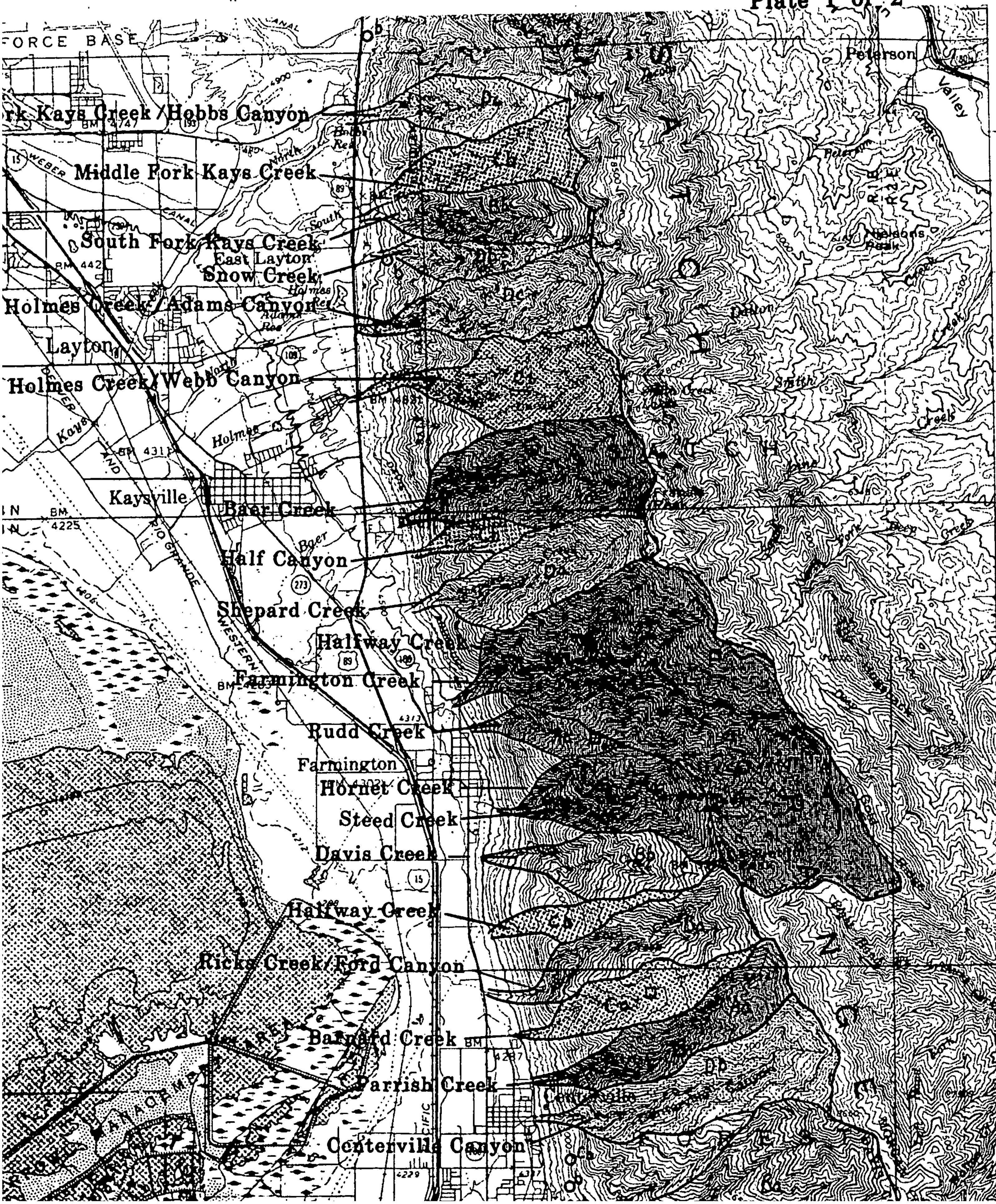
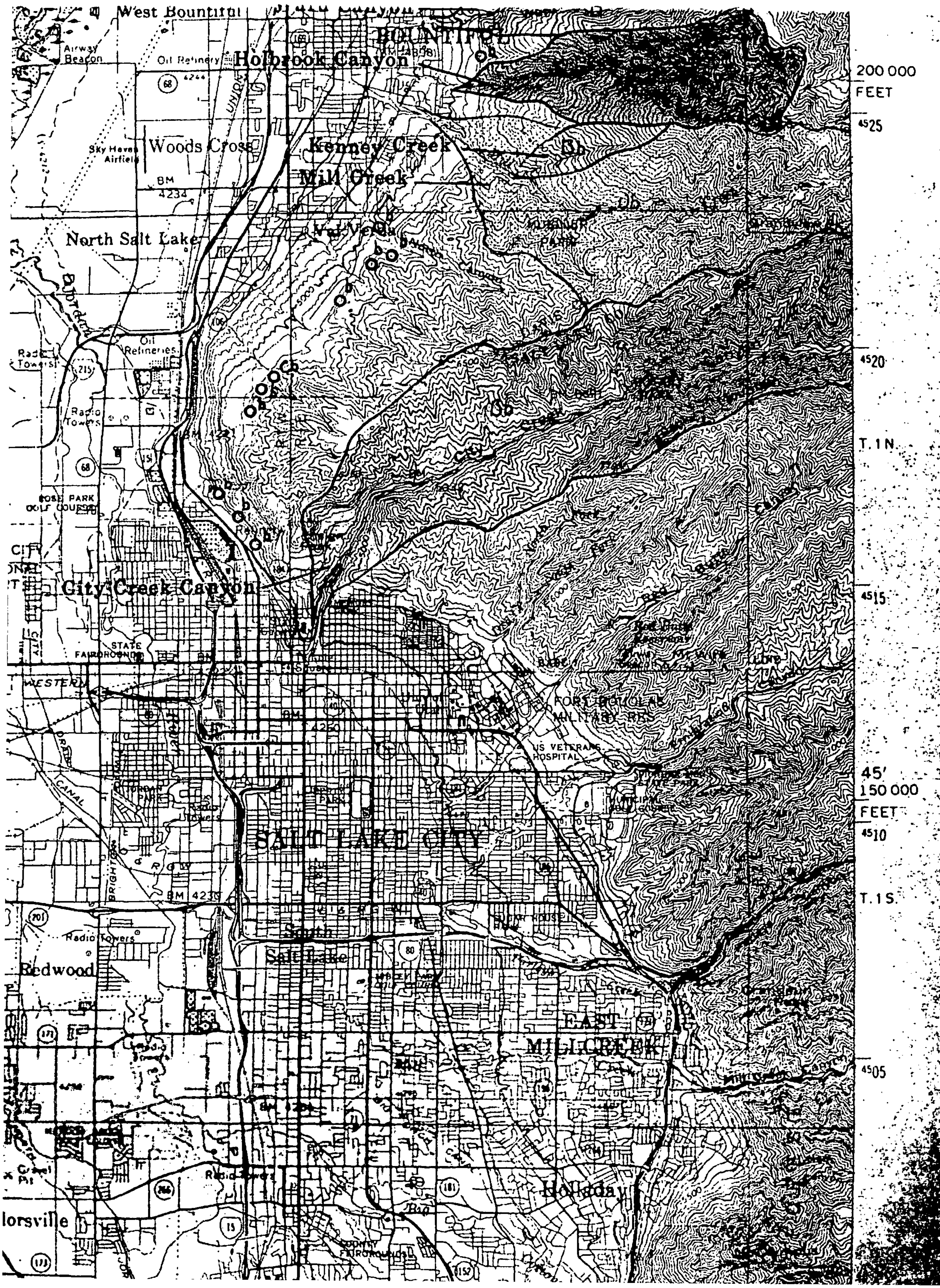
Plate 1 of 2




West Bountiful
Airway Beacon
Oil Refinery
Holbrook Canyon
BOUNTIFUL
200 000 FEET
4525
Sky Haven Airfield
Woods Cross
Kenney Creek
Mill Creek
BM 4234
North Salt Lake
Oil Refineries
Radio Towers
4520
T.1N.
ROSE PARK GOLF COURSE
City Creek Canyon
4515
STATE FAIRGROUNDS
WESTERN
BM 4250
FORT DOUGLAS MILITARY RES
US VETERANS HOSPITAL
45'
150 000 FEET
4510
SALT LAKE CITY
BM 4230
T.1S.
Radio Towers
South Salt Lake
Redwood
EAST MILLCREEK
4505
Radio Towers
Gravel Pit
Holladay
COUNTY FAIRGROUNDS

Questions for McCarter:

1. what will be present in Logan?
   what visual aids are there?
   what does he need?

2. Our proposed Project:
   (1) Sen. Hatch may be able to fund
   (2) work with Utah Comprehensive Emergency Management Agency -- try to get funds channeled thru this agency to ~~USU~~ ESI/USU
   (3) write a proposal to (CEMA) with copies to Hatch
   (4) Project would consist of:
      (a) Deployment of an early warning system in, say, 10 ~~are~~ high-hazard areas
      ~~(b) manufacture of instrumentation -- improvements~~
      (b) Research aspects of slides -- how to monitor, & sensor density, critical warning signals of imminent movement
      (c) integration of a warning system into state agencies / budgets
   (5) We visualize a two-year effort
      year 1: Site Selection
         Instrument Manufacture and Deployment
         Data Collection and Analysis
      year 2: Continuation of same w/ modeling of slides & mechanisms, use of Remote Sensing, etc -- research on data collected.

Proposal -

Instrument slideareas

UURI - data

Mc Carter - consultant

Senator get line item for this state agency

- same one go folk to Utah Comprehensive

~~Emergency~~ Emergency Management Agency

- workshop to place gadgets - prioritize areas

- UU vs USU - maybe have to arrange this at -

assigned areas responsibility.

- Doug James -