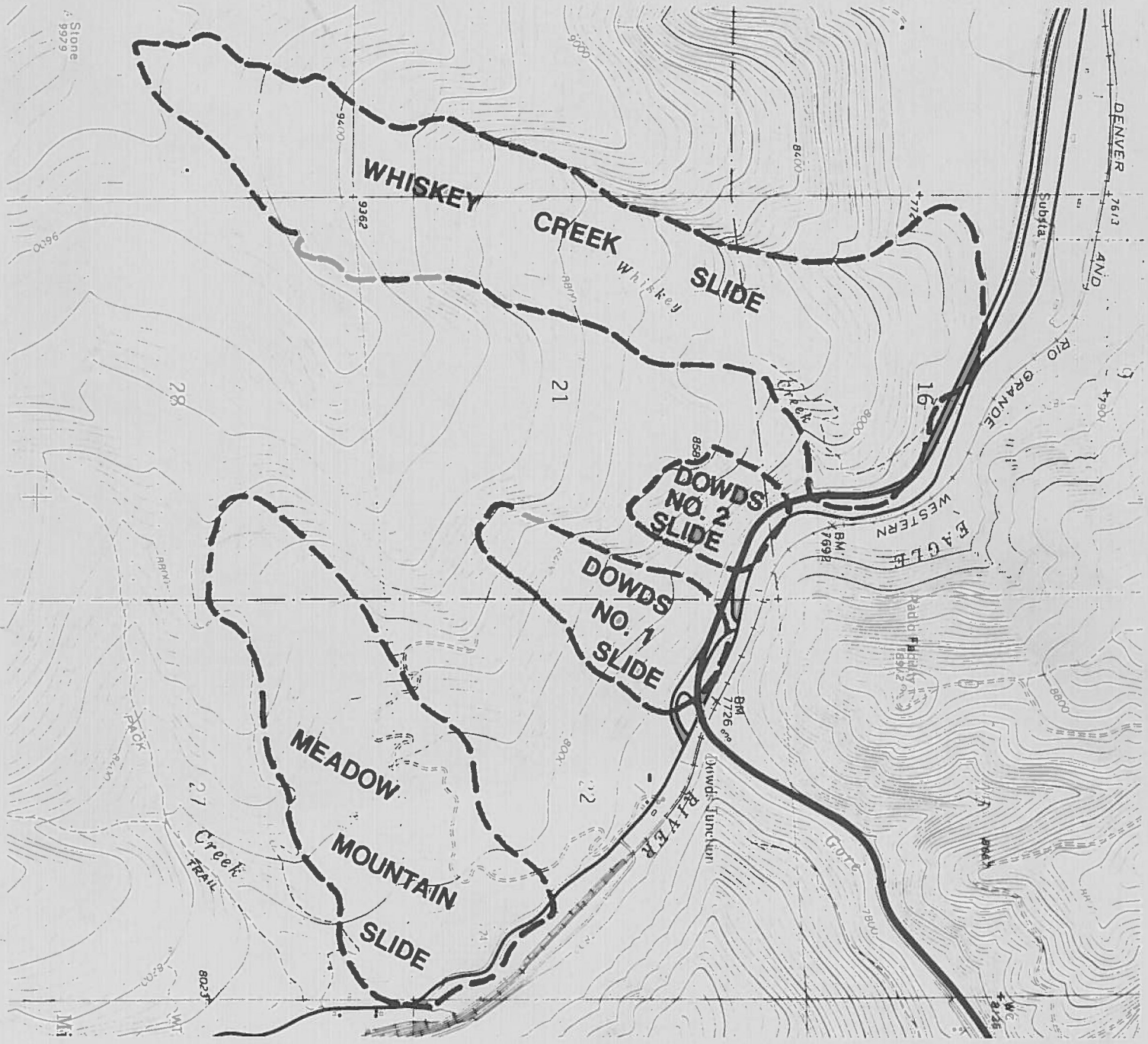
OPTIONS TO MITIGATE POTENTIAL DAMAGES FROM EARTHFLOWS NEAR DOWDS JUNCTION, COLORADO

ANALYSIS AND RECOMMENDATIONS

MINTURN EARTHFLOWS TASK FORCE

MAY 1986



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MINTURN EARTHFLOWS TASK FORCE

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May 1986

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CONCLUSIONS AND RECOMMENDATIONS

In April 1985 Governor Richard D. Lamm established the Minturn Earthflows Task Force. Its near term charge is to analyze the geology of the area and prepare emergency responses to pending earthflow problems at Dowds Junction near Minturn, Colorado. Of concern were the four slides comprising the complex: Whiskey Creek, Dowds #1, Dowds #2 and Meadow Mountain. Its long term charge is to develop recommendations for state, local and federal government to mitigate the effects of any catastrophic slides in the area. The Task Force consists of representatives of the Colorado Department of Natural Resources, the Colorado Department of Highways and the Division of Disaster Emergency Services. This report contains the results of the past 12 months of investigation and analysis by those agencies.

In the spring and summer of 1985, the primary emphasis of the Task Force was the design and installation of an electronic data monitoring system on the slide complex. This effort was funded with the $63,000 from the Governor's Emergency Fund. Weekly readings were made and distributed to appropriate government officials by the Colorado Geological Survey. The Survey also conducted a detailed analysis of the slide complex. The Highway Department had crews on-site to maintain U.S. Highway 24 which experienced several roadbed problems due to slide activity. The Division of Disaster Emergency Services conducted two emergency preparedness exercises testing the short-term and long-term response capabilities of both state and local governments for disasters of varying magnitude. The Colorado Water Conservation Board and the Division of Water Resources assisted in the design of the exercise and conducted the engineering analysis.

In the fall of 1985 and the winter of 1986, the Colorado Geological Survey and the Colorado Water Conservation Board performed detailed engineering and geological evaluations of possible options to mitigate the impacts of the slide. Over forty options are presented in response to the range of potential threats posed by the slides. The analyses are based on possible geologic and hydrologic consequences if major earthflows occur and possible river damming results. This is a big "IF" and in no way is this report intended to imply that such an event will happen or is imminent. The answers to whether any of these conditions or events is possible or probable is a question constantly before the geologists and engineers on the Task Force.

The options presented in the report fall into four general response categories: No Structural Solutions, Stop the Slide from Moving, Don't Let it Flood, and Wait Until the Last Minute. Each recommendation is examined with regard to its feasibility, timeframe for implementation, responsible party and estimated cost. A summary table of recommendations is included in this section of the report.

Collectively, the State members of the Task Force recommend over $150,000 of actions to be taken immediately in 1986-87 to address the problems posed by the threat. The Colorado Geological Survey and the Department of Highways have jointly agreed to weekly visual inspections of the slide complex, biweekly readings of water levels on the slide complex and biweekly readings of the inclinometers. The Task Force

recommends to the Governor that the monitoring system be reactivated. A request of $15,000 from the Governor's Emergency Fund has been forwarded to the Governor. This amount includes a 25 percent match from local governments. These funds would be used to repair monitoring holes damaged by slide movement over the winter and would provide biweekly readings until mid-August. Reactiviation of the system would be a joint effort of the Geological Survey and the Highway Department.

The Survey will also complete an investigation into the slide characteristics for the Highway Department this summer. The Survey will perform a preliminary analysis of the hydrogeological impacts of slide area irrigation. The Highway Department is installing drains in several areas of the slide and constructing toe anchors (rock buttress) along portions of Highway 24 this summer at a cost of $100,000.

The Division of Disaster Emergency Services (DODES) will review the status of local emergency operations plans in the area in the summer of 1986. DODES will also develop interim state emergency operation plan/action checklists, conduct a command post exercise to test communications and test the warning system in the area. DODES will encourage the development of private sector enterprise contingency plans. The Governor will request the Insurance Commission to provide information to Eagle County on additional types of insurance policies.

The Division of Water Resources will establish diversion agreements to be activitated in times of high precipitation as part of a plan for releasing and storing water from upstream reservoirs. The Water Conservation Board and the Division of Water Resources will develop area/capacity curves as part of a continuing technical analysis of potential reservoir characteristics.

The Task Force requests that the County provide flood insurance information to its residents. The Task Force also recommends that the county work with their local legislators to determine the necessity of a feasibilty study to be conducted by a private engineering firm on several pre-slide outlet works options suggested for Interstate 70 and Highway 24 in the Dowds Junction area. Permanent solutions that would preserve river, traffic and rail flow in the event of a catastrophic slide could cost millions of dollars.

The Task Force recommends that the U.S. Forest Service drain the marsh at the top of the slide complex. It also requests that the Homestake II project include landslide mitigation impacts in its planning process.

Many other options are discussed in the report. The implementation depends on the practicality based on the decline in slide movement to date this year and the availability of funds from state, local and federal coffers. While the measures outlined in this report may not solve all the earthflow movement in the area, they are intended to provide detailed information on the surface and subsurface conditions, identify actions for both the public and private sector, and heighten the awareness of the consequences of land use decisions in an area of potential geologic instability.

MINTURN EARTHFLOWS TASK FORCE RECOMMENDATIONS

OPTION 1: NO STRUCTURAL SOLUTIONS

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
Buy flood insurance in affected areas:	Immediate	Eagle County provide information to local jurisdictions and unincorporated areas. Individuals work with local insurance agents.	Average policy about $250 for $50,000 of coverage. $1.7 billior damage potential.
Creekside	Purchase immediately		-
Minturn	Investigate immediately	Individual decision	-
Downstream	Investigate immediately	Individual decision	-
Other types of insurance	Immediate	Governor request State Insur- Commission to provide information to Eagle County on insurance options.	Depends on carrier
Visual inspections	Weekly: April 1 - August 1	Joint effort of the Colorado Geological Survey, Department of Highways and Eagle County Surveyor. System and schedule to be coordinated by the Colorado Geological Survey.	General Fund
Preparation for 1986 EDM Program:			
1. Redrill Whiskey Creek Hole which has been destroyed due to movement	Immediately	Contract with CDH	$5,000 (Potential need to cost-share between CDH, Governor Emergency Fund and Eagle County)
2. Drill new hole in Meadow Mountain for depth and volume information	Immediately	Contract with CDH	$5,000 (Potential nee to cost-share between CDH, Governor's Emergency Fund and Eagle County)

OPTION 1: NO STRUCTURAL SOLUTIONS (cont'd)

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
1986 EDM Program			
Option 1: Purchase Geodetic Total Station	Read EDM's every other week: April 1-August 1 (or weekly if necessary)	Schedule for readings: April - Colorado Department of Highways May/June - Colorado Geological Survey July - Highways, GeoSurvey or County Surveyor	$10,000 to purchase Station (potential need to cost-share between CDH, Governor's Emergency Fund and Eagle County Less labor intensive than 1985 due to new equipment. Readings would be provided in-kind by indicated agencies
Option 2: Read EDM's every Purchase no new equipment - readings done manually which requires dedicated staff time	Contract with either other week: April 1-August 1 (or weekly if necessary)	$9,500 for labor GeoSurvey or Eagle County for the readings.	(potential need to cost-share between CDH, Governor's Emergency Fund and Eagle County
1987 + EDM Program	Reading cycle to be determined based on annual precipitation and interpretation of 1986 data.	Colorado Dept. of Highways Colorado Geological Survey Eagle County	Depends on actions recommended
Read water levels	Every other week: April 15-August 1	CDH to take readings CGS to interpret data	General Fund (cost approximately $250/trip)
Read inclinometer	Every other week: April 15-August 1	CDH to take readings CGS to interpret data	General Fund (cost approximately $250/trip)
Cut drain in the marsh area above the slide	Immediately for one pond	Governor request US Forest Service to dewater pond	$1,000 (?)
	Evaluate the larger area for dewatering next year.	US Forest Service	(?)

OPTION 1: NO STRUCTURAL SOLUTIONS (cont'd)

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
Monitor precipitation trends	Monthly	State Climatologist in conjunction with the National Weather Service and the US Soil Conservation Service. Information forwarded to Eagle County.	Existing agency responsibilities
Monitor snowpack trends	Monthly	US Soil Conservation Service forward data to County.	Existing agency responsibility
Monitor run-off	Frequency determined by the Colorado Water Conservation Board	County take readings as appropriate from stream gages. Data forwarded to the Colorado Water Conservation Board.	General Fund responsibility of CWCB and Eagle County
Investigate potential reservoir characteristics	Data has been collected. Curves to be developed in May.	Division of Water Resources and the Colorado Water Conservation Board prepare area-capacity curves for potential reservoirs caused by the Whiskey Creek/Meadow Mountain slides.	General Fund
Investigate slide characteristics	Drilling and photography has been completed. Analysis to be completed later as necessary. Technical report due July 1, 1986.	Colorado Geological Survey to prepare report.	$15,000 contract from CDH to GeoSurvey.
Improve Communications Network:			
Review status of local emergency operations plans for Minturn, West Vail, Avon, Eagle, Gypsum, Vail and Eagle Counties. Take appropriate action to address planning shortfalls.	May 86 - April 87	DODES with identified local governments	$1500 General Fund

OPTION 1: NO STRUCTURAL SOLUTIONS (cont'd)

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
Based on excersises run to date develop a checklist identifying State agency responsibilities and major issues to be addressed by each agency should a major incident actually occur. Encourage preplanning on the part of all agencies concerned.	May - June 86	DODES	$250 General Fund
Conduct a communications exercise to identify needed system improvements and present system shortfalls. Develop actions to be taken by whom and time frame to address each shortfall. Emphasis to be placed on ability to communicate between command elements, command and field elements of different levels of government and from different jurisdictions, as well as internal command communications.	Fall 1986	DODES-supported by State and local government agencies	$2000 General Fund
Evaluate existing warning system to disseminate warning information to governmental agencies and the general public. Identify system deficiencies and take action to address them.	Summer-Fall 1986 Implement actions to correct deficiencies ASAP once identified.	DODES-supported by State and local government agencies	$2000 General Fund
Determine need for future exercises.	January 1987	DODES-in coordination with State and local government agencies	-

OPTION 1: NO STRUCTURAL SOLUTIONS (cont'd)

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
Identify training weaknesses which surface during the planning and exercise process. Develop and conduct training to address the identified weaknesses.	Continuous process. Initial effort May 1986-Apr 1987	DODES-all state and local governmental agencies	To be identified
Upgrade status of Eagle County Emergency Preparedness Program to a full-time staff position to manage local planning and exercising.	Spring 1986	Eagle County in coordination with DODES	
Regulate development in the hazard area.	Immediately	Eagle County and local jurisdiction responsibility. Technical assistance available from GeoSurvey.	-0-
Acquire and relocate the vulnerable areas	Discussions in the near term.	Colorado Department of Local Affairs and Eagle County develop options for the State Legislature, U.S. Corps of Engineers and the Federal Emergency Management Administration.	Unknown
Re-route the transportation network	To be addressed at time of mudslide based on actual needs for both state and federal highway access.	Alternate temporary routes have been identified by responsible parties. CDH performing maintenance on bridges in event of rerouting.	Unknown but will involve state and federal highway funds.
Re-route sewers, etc	Contingency plans should be developed immediately.	DODES to advise responsible parties of potential dangers and encourage their own contingency plans.	--
Record expenditures	On-going	All parties should maintain records of costs (both special appropriations and on-going expenditures) for possible federal reimbursement in an emergency.	--
Construct landslide deflection structures	Infeasible	--	--

MINTURN EARTHFLOWS TASK FORCE
RECOMMENDATIONS

OPTION 2: STOP IT FROM MOVING

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
Cease or reduce irrigation of the slide	As requested	Division of Water Resources advise owners of situation and necessary actions. GeoSurvey to do some preliminary impact analyses in 1986.	--
Pump water out of slide	Preliminary data collection in 1986	GeoSurvey collecting preliminary data to be translated into a hydro-geological study and recommendations in 1986.	Unknown
Construct drains in slide	Work begun as needed.	CDH has installed drains under the crib wall of the Dowd's #2 slide.	General Fund
Control drainage in slide area	Preliminary data collected in 1986.	GeoSurvey collecting preliminary data to be translated into a hydro-geological study and recommendations in 1986.	General Fund
Channelize the river at the base of the slide	To be determined	This option may not be necessary; future actions will be based on the results of the buttressing currently underway by CDH.	Unknown
Install toe anchors to stabilize slide	Currently underway	CDH	$100,000 General Fund
Stabilize slide by special chemical treatment	Not practical; technology untested.	--	--
Remove unstable slide material	Inadvisable since sources of movement and inter-connection of slide mass is unknown.	--	--

MINTURN EARTHFLOWS TASK FORCE
RECOMMENDATIONS

OPTION 3: DON'T LET IT FLOOD

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
Modify weather	Not feasible; technology uncertain.	--	--
Divert water from the basin	Immediately. Collect background data and set up diversion agreements. Plan should be activated now.	Division of Water Resources collect background data. Division Engineer should work with DODES in the development of the plan.	General Fund
Release water from upstream reservoirs	Develop procedures and set up agreements immediately.	Division of Water Resources Water Planning Branch to develop plan. U.S. Army Corps of Engineers will be requested by the Governor to provide technical assistance.	--
Store water in upstream reservoirs	Develop procedures now.	Division of Water Resources Water Planning Branch to develop plan. U.S. Army Corps of Engineers will be requested by the Governor to provide technical assistance.	--
Build a new flood control dam	Investigation to be suggested immediately.	The State will formally request the proponents of the Homestake II project to include landslide mitigation impacts as part of the evaluation and design of the project. The Colorado Water Conservation Board and the Division of Water Resources will provide comments.	Unknown

OPTION 3: DON'T LET IT FLOOD (cont'd)

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
Construct pre-slide outlet works*:			
Option A. Pipeline for water only	Would require several pipes for the required capacity which would be expensive and not multifunctional	--	--
Option B. Three-box culvert for the road, river and railroad	Would be constructed at two locations: Meadow Mountain and Whiskey Creek. This would be a future action but would require construction before the slide moves.	Best option; however, high front-end cost to all parties.	--
Divert river around slide	Would require construction of a canal and trestle for Whiskey Creek and/or Meadow Mountain slides.	Innovative idea	--

*Recommendation: Feasibility Study by Engineering firm to evaluate these options as well as the cost to remove the slide. CDH would coordinate the preparation of the scope of work. The cost would be about $50,000 from an as yet unknown source.

MINTURN EARTHFLOWS TASK FORCE
RECOMMENDATIONS

OPTION 4: WAIT UNTIL THE LAST MINUTE

RECOMMENDATION	TIMEFRAME	RESPONSIBLE PARTY	ESTIMATED COST
Maintain conveyance capacity of the channel	Interim solution in in the event of movement.	County/State/U.S. Army Corps of Engineers during emergency	Unknown
Provide seepage path in slide	Not feasible due to volume involved. Dangerous piping hazards.	---	--
Siphon water over slide	Not feasible; unsuccessful at Thistle, Utah, due to slide movement and volumes involved.	---	--
Pump water over slide	Not feasible due to the number of pumps required, power needed and the availability of equipment.	---	--
Excavate overflow spillway in dam	Preliminary design concept and specifications should be developed for the file.	Division of Water Resources to develop preliminary concept and specifications.	Unknown; would require supply of polyvinyl chloride linen to construct spillway.
Blast an overflow spillway in the hillside, cut a channel and blow rock over the spillway	Not practical; blasting results may be unclear.	---	--
Cause controlled failure of slide dam	Best concept after the immediate danger has passed -- breeching may be time-consuming and not cost-effective. Negative downstream sediment impacts may occur.	---	--

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1.0 INTRODUCTION

1.1 Background

Over the past decade, Eagle County, The Colorado Department of Highways, the Department of Natural Resources, and the Division of Disaster Emergency Services have become increasingly concerned about a group of four landslides near Dowds Junction, Colorado. Dowds Junction is located in Eagle County at the intersection of U.S. Highways 6 and 24 with Interstate 70. It is approximately 2 miles west of Vail and 2 1/2 miles north of Minturn near the confluence of Gore Creek with the Eagle River. The Denver & Rio Grande Western Railroad closely follows the Eagle River corridor through Dowds Junction.

The landslide complex includes four flow areas: Whiskey Creek, Dowds #1, Dowds #2, and Meadow Mountain. The Whiskey Creek slide is larger in size than the slide that blocked the Spanish Fork River and created a lake causing extensive damage at Thistle, Utah in 1983. These slides not only pose a continuing maintenance problem for Eagle County and the Colorado Highway Department, but are a serious threat to the health and quality of life to all Coloradoans.

The period 1983/84 experienced record-breaking precipitation characterized by unusually heavy snowfall in the Fall before the ground had frozen. Snow course measurements for October and November were unusually high for the area. As this heavy snowfall melted, it soaked much more deeply into the ground than later snowfalls after the ground had frozen. Unusually large and more numerous occurrences of freezing groundwater springs issuing from normally dry cliffs, road cuts, and hill slopes have been observed in several locations along the I-70 corridor. This weather pattern and evidence of abnormally high water saturation increased concern because of the reduction in the structural strength of soil and rock and friction along failure surfaces, and the increased weight of the material. This condition was similar to the weather and precipitation events which preceded the Thistle, Utah slide in 1983.

Through the years, a great deal of highway maintenance has been required at the Dowds Junction location, related indirectly to the old landslides; the soils in the area are wet and have low strength. The slide south of Dowds Junction on Highway 24 has apparently been active since before construction of that highway in 1930. This has been the focus of a number of minor grading and leveling projects, especially during the snow melt period. Repeated patching and overlays on U.S. 24 have resulted in 8 to 10 feet of asphalt in the roadbed. The eastbound lane of I-70 and the U.S. 24 interchange were closed in the spring of 1984 by slide movement during the period of high water saturation.

Formal design studies began for Interstate Highway 70 in the Dowds Junction area in 1963. The K.R. White Company completed geologic studies in 1966 and presented their recommendations in 1967. The old landslides were recognized and methods to allow construction were presented in that report. These recommendations were incorporated into the highway design. A gravel drainage blanket was built under the I-70 embankment in anticipation of roadbed problems.

It was observed during construction on the I-70 Eagle River bridge in 1968, that some movement was taking place on the south side of the river. The Colorado Department of Highways monitored that area for approximately five years via a triangulation survey, and observed annual movements of 1/2 to 3 inches per year. Most movement occurred during the snowmelt period. No distress was recorded in the bridge structure or foundation. Formal monitoring was discontinued in about 1975; however, some movement in the roadway west of the bridge continued.

Several problems relating to soils and geology have been experienced since completion of the Interstate grading. A cut slope failure occurred prior to paving and was corrected via a large rock buttress. The bin wall that supports the Interstate fill above the frontage road west of the Dowds Interchange has shown various signs of distress. The fill slope above the bin wall eroded badly enough to require construction of a short wall to maintain the I-70 guardrail. Two mudflows occurred in that area, blocking I-70 for a few hours in 1983, and a large fill failure occurred in 1983 that closed the westbound frontage road for several days. Artesian water flowed from the pavement during the spring of 1972; this was corrected via horizontal drains.

The landslides at Dowds Junction are but one of a dozen major landslide problem areas identified in the Flood Hazard Mitigation Plan for Colorado published in 1983. In April 1985, Governor Lamm formed an interagency Earthflows Task Force to examine the potential consequences and to investigate the range of measures that might be applied to mitigate the potential damages.

1.2 Purpose

The purpose of this report is to provide a systematic technical review of the merits of the many ideas that have been suggested to mitigate potential damages from landslides at Dowds Junction, Colorado. The report is intended to provide a forum for evaluation of additional ideas and to provide a document for future reference - perhaps in an emergency - that will give planners a basic understanding of the options so that informed decisions will be possible.

1.3 Scope

The options reviewed in this report have been developed with respect to the situation at Dowds Junction, but they may also be applicable to several of the other major slide areas identified in Colorado. The level of detail is intended to be sufficient to recognize what factors (such as size, cost, availability) may be necessary to consider in evaluating the options at any site.

It should be stated that landslides, and landslide-prone areas can be very complex in nature and pose serious risks to any development placed in their vicinity. Landslides and potential slide areas should be evaluated only by competent professional engineering geologists and soil engineers. [7]

The information contained in this report is only an introduction to the options. Additional treatment of landslides can be found in the references listed at the end of the report.

1.5 Definitions

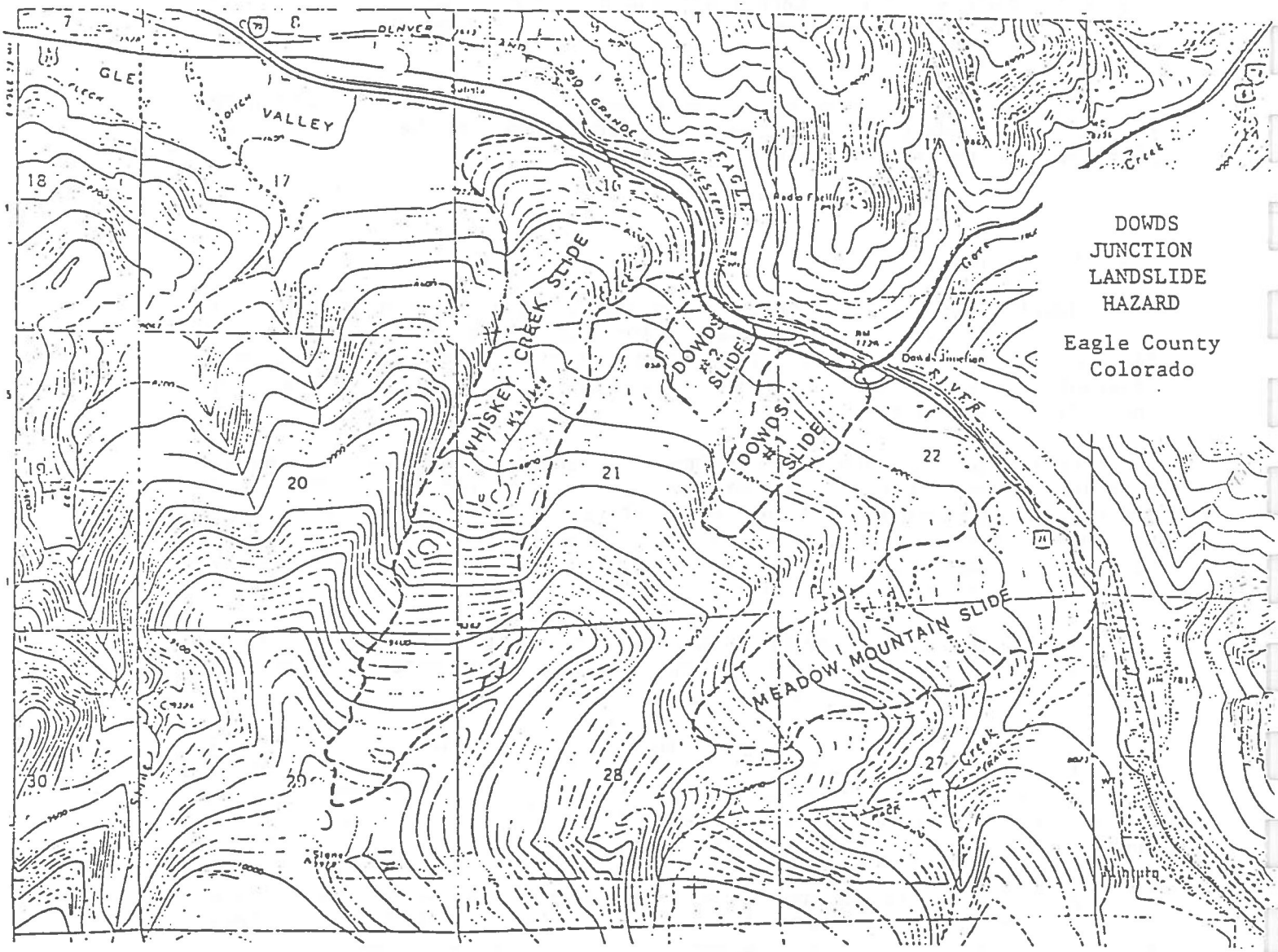
Debris flow - a mass movement involving rapid flowage of debris of wet soil, rock, and displaced vegetation; specifically, a high density flow containing abundant coarse-grained materials and resulting almost invariably from an unusually heavy rain or from a dry rock fall of unusually large volume. [7]

Earthflow - a type of slope movement and process characterized by downslope translation of soil and weathered rock over a discrete basal shear surface within well defined lateral boundaries in which the internal motions of the flowing mass approaches those of viscous fluids. Earthflows grade into mudflows through a continuous range in morophology associated with increasing fluidity. [7]

Landslide - mass movements where there is a distinct surface of rupture or zone of weakness which separates the slide material from more stable underlying material. [7]

Mudflow - a general term for a mass movement landform and a process characterized by a flowing mass of predominantly fine-grained earth material possessing a high degree of fluidity during movement. With increasing fluidity, mudflows grade into loaded and clear streams; with a decrease in fluidity, they grade into earthflows. [7]

Acre-foot - the volume of water necessary to cover an area of one acre to a depth of one foot. An acre-foot is equal to 43,560 cubic feet of water or 325,829 gallons. Water flowing at a rate of one cubic foot per second for one day will yield a volume of 86,400 cubic feet or 1.984 acre-feet.



Dowds Junction Landslide Hazard Area Map [Source: C.S. Robinson]

2.0 IMPLEMENTING A MITIGATION STRATEGY

2.1 The Range of Options

No single measure used alone is likely to solve the landslide hazard problem at Dowds Junction. An integrated approach, sensitive to the local physical and socio-economic conditions, offers the most hopeful prospect for flood damage reduction.

Over 30 specific options, organized in the following general categories, are evaluated in this report:

Do Nothing

Take a Chance

Get Ready

Get Out of the Way

Make it Go Somewhere Else

Stop it from Moving

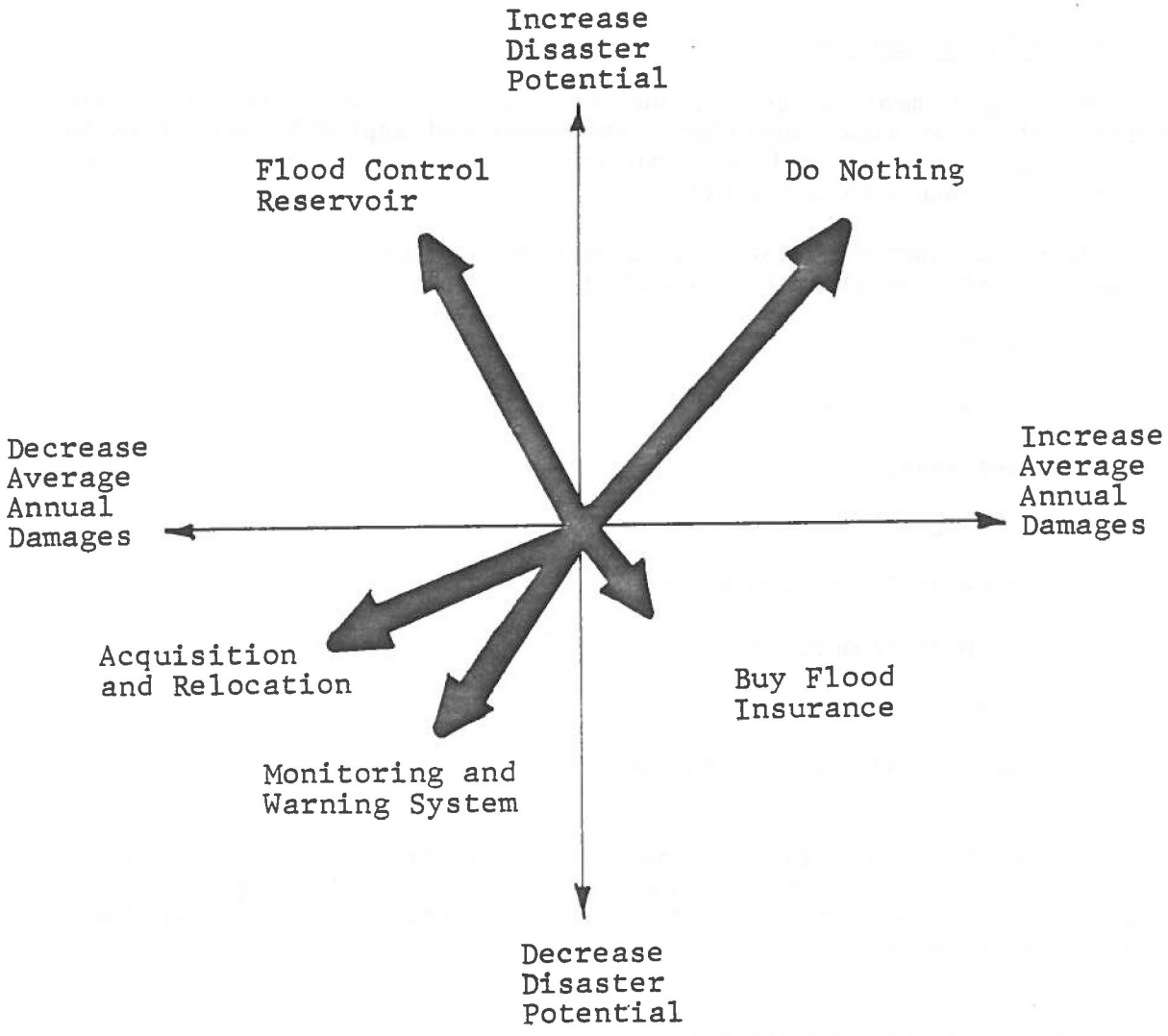
Don't Let it Flood

Wait Until the Last Minute

It was felt that this arrangement suited the intended purpose of the report better than the more traditional organizations into corrective or preventative measures, structural or non-structural measures, or short term or long term options.

2.2 A Potential for Catastrophe

Slide control can be self-defeating. Remedial public works construction may encourage development by leading the public to believe that slide problems have been eliminated, not simply reduced. Also, such construction does not prevent earthquake-related slides. Intelligent management and regulation is still needed for slide-prone areas. [4] Therefore, each of the options should be considered in terms of their potential to decrease average annual damages and their ability to decrease the potential for catastrophic disaster.



Comparison of Various Mitigation Strategies

2.3 Responsibility for Action

The problems of landslides near Dowds Junction belong to all levels of government and the private sector. The map of land ownership shows the Forest Service and the Bureau of Land Management as primary actors at the federal level. The U.S. Geological Survey and the Federal Emergency Management Agency are also interested parties.

The State of Colorado is directly involved since the State Land Board owns and is responsible for managing all of Section 16 which includes the lower end of the Whiskey Creek slide. The State Highway Department is involved because of the U.S. and Interstate highway right-of-ways that cross the base of the slides. The initial impact of slide movement will be on these state facilities.

Eagle County is directly involved because most of the damage to private property will occur within its jurisdiction. The County will be responsible for the initial response should an emergency occur.

2.4 Sources of Financial Assistance

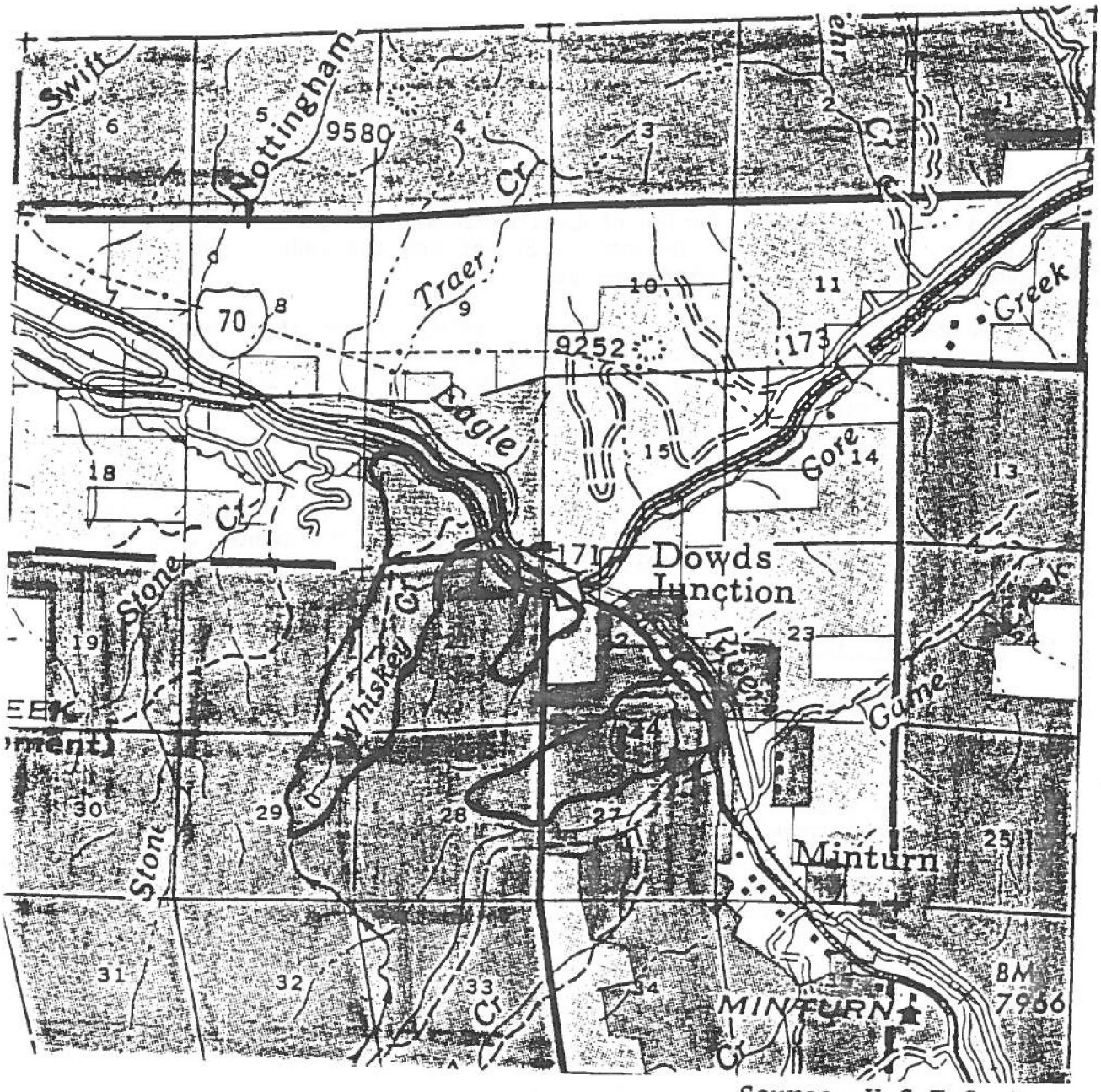
The following entities may be potentially available to provide funding and/or technical assistance to implement the various options outlined in this report:

Federal Government
- Federal Highway Administration
- Federal Emergency Management Agency
- U.S. Forest Service
- Corps of Engineers
- U.S. Geological Survey
- Soil Conservation Service

State Government
- State Land Board
- Highway User's Tax Fund
- Colorado Department of Highways
- Energy Impact Assistance
- Community Development Block Grants
- Emergency Water and Sewer Fund
- Governor's Emergency Contingency Fund
- Colorado General Assembly

Local Government
- Northwest Colorado Council of Governments
- Eagle County
- Town of Minturn

Private Sector
- Vail Associates
- Denver & Rio Grande Western Railroad
- Western Gas Supply Company (WestGas)



Source: U.S.F.S. Map

LEGEND

- Forest Service
- BLM
- State
- Private

1 inch = 1 mile

Land Ownership Map near Dowds Junction

3.0 DETAILED REVIEW OF THE OPTIONS

3.1 Do Nothing

The "do nothing," or "no action", alternative is the baseline condition to which all other action must be compared. Inaction by government bodies could be regarded as a deliberate decision to choose the do nothing alternative. The risk of a major landslide would likely remain uncertain. Fear and the potential for catastrophe would increase if further development in the area is allowed to occur.

This alternative may appear attractive due to the minimum short-term costs and the lack of effort otherwise required. This alternative could have long-term low costs if the slide moved slowly, allowing ample evacuation time. In that case, it is possible that the Eagle River would be kept open by the erosive force of the river itself, and that human effort would only be required to keep the highway clear.

Some of the consequences of this alternative under the worst case scenario include the following:

1. The potential loss of life due to being buried by a fast moving slide. Approximately 100 people are at risk.

2. The potential for losses to private property in the slide area itself estimated at over $ 10 million.

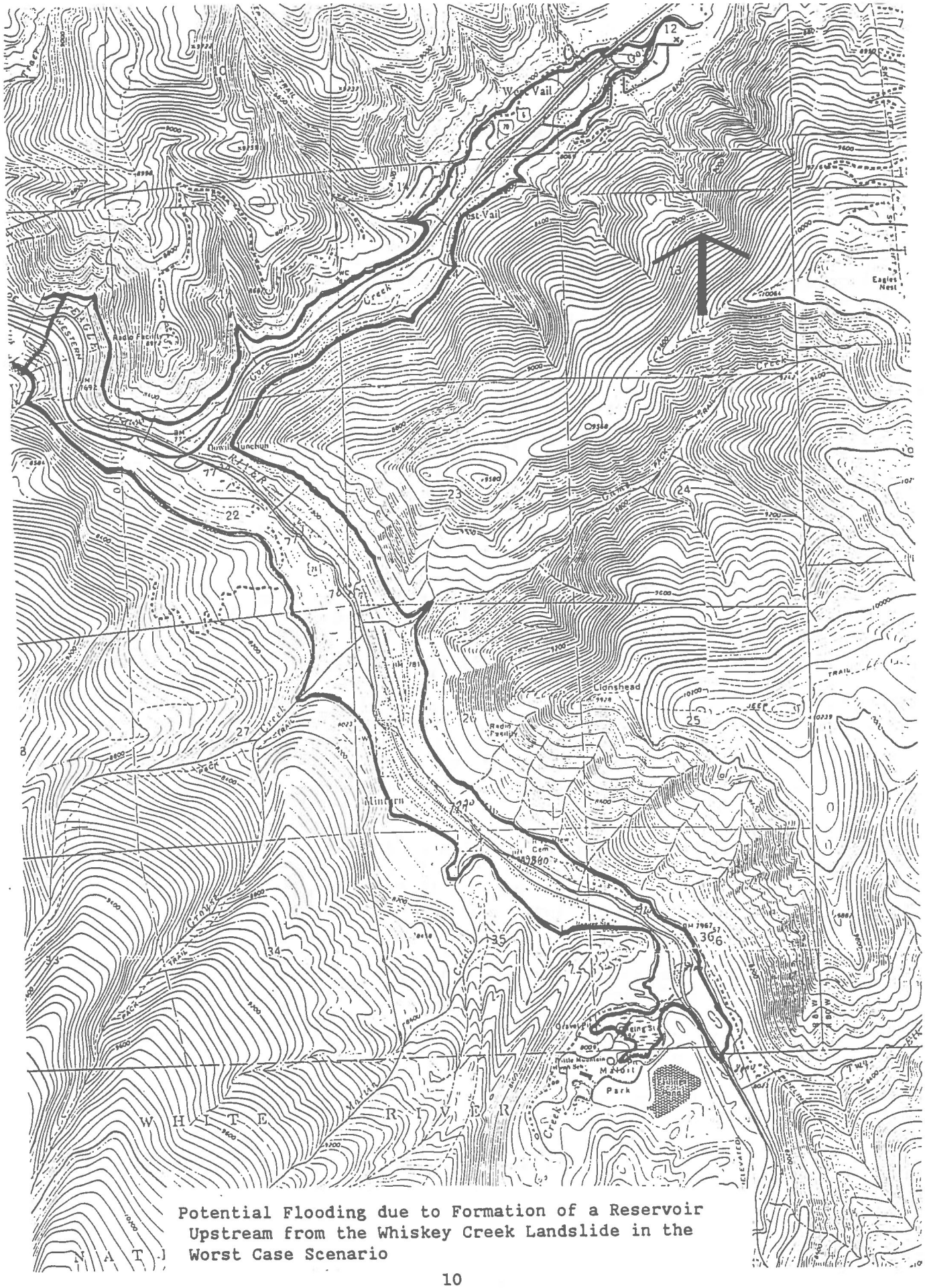
3. The potential economic loss of a significant transportation corridor including Interstate Highway 70, U.S. Highways 6 and 24, and the Denver & Rio Grande Railroad. Temporary disruption of this corridor for a 90-day period could result in a loss of about $ 600 million.

4. The potential flooding of the town of Minturn, population 1300, and perhaps a portion of West Vail if flow in the Eagle River is impeded by a Thistle-type dam. With the total submergence of about 500 structures, losses would be at least $ 50 million.

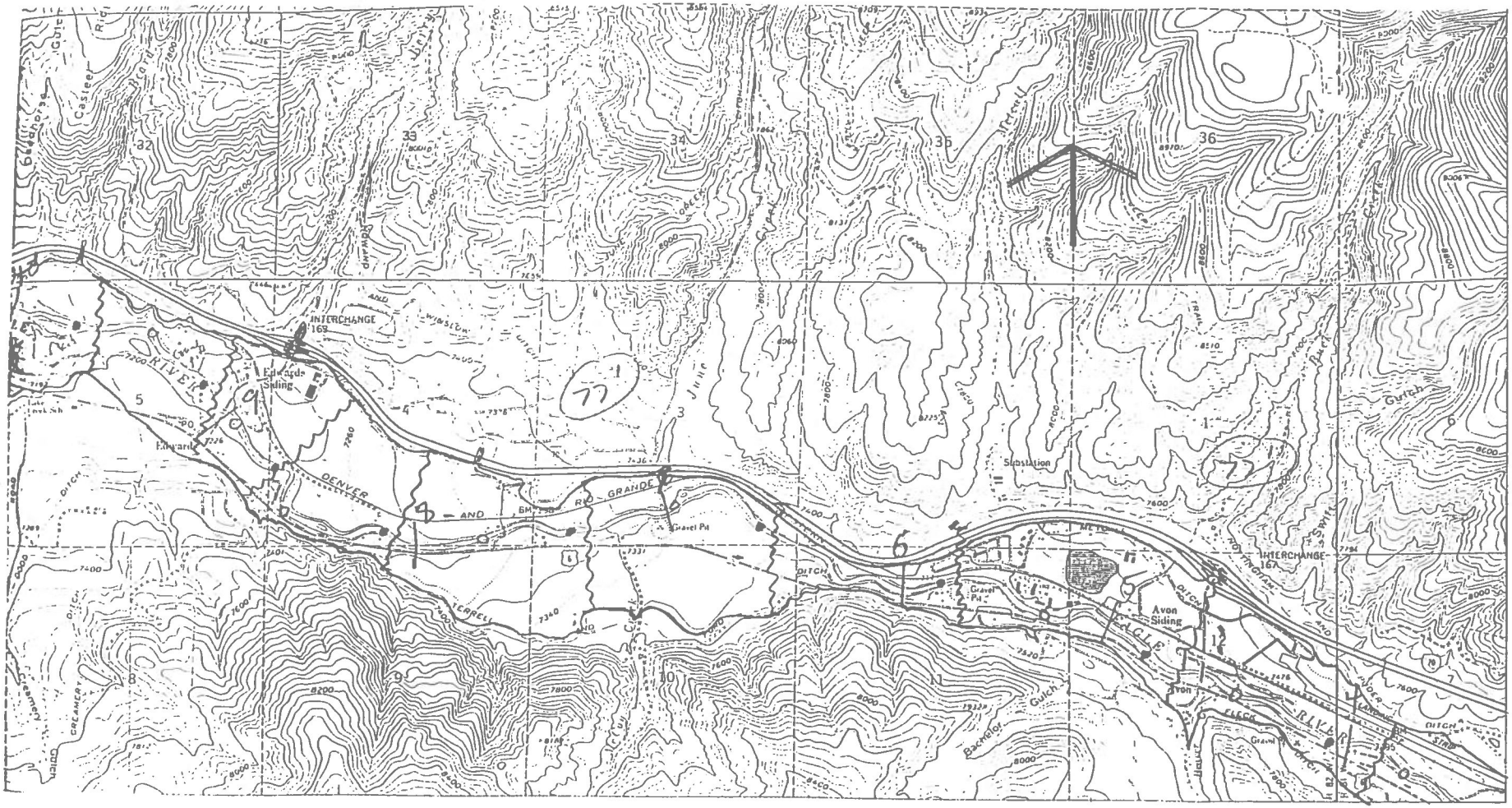
5. The potential flooding of portions of the towns and unincorporated communities of Eagle-Vail, Avon, Edwards, Wolcott, Eagle and Gypsum could occur due to a sudden or rapid failure of the dam formed by the slide. Approximately 3000 people are at risk and the damages to over 1000 structures could total over a billion dollars.

6. The cost of fighting the disaster estimated at about $ 40 million.

The total damages under the worst case scenario could be as high as $ 1.7 billion with up to 3100 fatalities.



Potential Flooding due to Formation of a Reservoir Upstream from the Whiskey Creek Landslide in the Worst Case Scenario



Potential Flood Boundaries due to a Sudden Failure of a Dam formed by a Landslide at Whiskey Creek under the Worst Case Scenario

3.2 Take a Chance

The insurance alternative for homeowners will, of course, not lessen the chance of a mudflow or landslide occurrence; however, it can protect the individual owner against major economic losses that could be caused directly by mudflows or indirectly by floods due to mudflows or landslides.

3.2.1 Buy Federally Subsidized Flood Insurance

Any property in any community that is a participant in the National Flood Insurance Program (NFIP) can be insured against flood losses. This includes properties that are shown inside or outside any floodplains identified by the Federal Emergency Management Agency (FEMA). Premiums for property shown beyond any floodplain will be less than for property shown in the floodplain if the rates are based on the degree of risk. All the communities in the Eagle River corridor in Eagle County are currently in the regular phase of the NFIP.

Mudflow damage is covered on NFIP - insured homes if the mudflow was water induced and/or contained a water consistency. Direct damage due to landslides are not covered by the NFIP. An insurance adjustor may interview local residents and community officials for verification that the mudflow was associated with water. If the adjustor denies the claim, it can be appealed directly to the Flood Insurance Claims Division in Washington, D.C. Approximately 50% of the appeals have been overturned in favor of the claimant.

The maximum amounts of flood insurance available under the regular phase of the NFIP have been established by law and are shown in the following table.

AMOUNT OF INSURANCE AVAILABLE

	Basic Insurance Limits	Additional Insurance Limits	Total Insurance Available
BUILDING COVERAGE			
Single Family Dwelling	$ 35,000	$150,000	$185,000
2-4 Family Dwelling	$ 35,000	$215,000	$250,000
Other Residential	$100,000	$150,000	$250,000
Non-Residential	$100,000	$100,000	$200,000
Small Business	$100,000	$150,000	$250,000
CONTENTS COVERAGE (per unit)			
Residential	$ 10,000	$ 50,000	$ 60,000
Non-Residential	$100,000	$100,000	$200,000
Small Business	$100,000	$200,000	$300,000

A significant number of new policies have been purchased by residents in Minturn since the Task Force has focused attention on the potential hazards at Dowds Junction. In April 1985 there were only 3 flood insurance policies in force, but by November there were 44. The Town of Avon, incorporated about 1979, joined the regular phase of the NFIP on May 22, 1985.

Status of the National Flood Insurance Program
in the Eagle River Corridor

November 25, 1985

Community	Number of Policies	Value of Policies	People *	Structures*
Minturn	44	$ 3,630,700	1300 (0)	498 (0)
Avon	0	0	1200 (45)	34 (6)
Eagle County (includes Edwards, Wilmor, and Wolcott)	60	$ 7,312,600	6728 (300)	3962 (85)
Eagle	1	$ 131,500	1150 (0)	550 (0)
Gypsum	1	$ 110,000	1000 (85)	511 (47)

* Numbers in parentheses indicate the estimated number of people or structures in any identified 100-year floodplain.

The cost of flood insurance depends on the amount of coverage, exposure to floods and the type of structure. The average annual premium in the U.S. in 1984 was $217.00 for an average policy coverage of about $58,200. Assuming about 1500 structures are at risk due to a landslide or its hydrologic consequences, the cost to the residential community for the flood insurance option is estimated at $325,000 per year.

There is a five day waiting period before a flood insurance policy becomes effective.

3.2.2 Buy Catastrophe Insurance from the Private Sector

As mentioned previously, direct damage from landslides are not covered by the NFIP. The options are to add a geologic hazard rider to one's homeowners policy or to purchase separate catastrophic insurance. Lloyds of London sold such a policy for about $260 annual premium in Utah following the Thistle disaster. However, there were some problems such as:

* the company retains the option to cancel out after 30 days notice
* the company can fail to renew the policy
* the company will control the number of policies sold in any one zip code in order to limit claims
* buy-out would not be an option following a disaster as is the case under the NFIP

Insurance is in principle a viable option for mitigating direct losses from landslides; however, to implement an effective insurance program requires a degree of specification of risk that is not generally thought to be possible for landslides (although some recent studies by the U.S. Geological Survey, the Federal Emergency Management Agency, and some private consultants suggest otherwise). The history of landslide insurance in the United States indicates that the private sector is relatively uninterested at present in offering this coverage. This reluctance to provide landslide insurance is long-standing. Several highly publicized instances of landsliding, including the Portuguese Bend landslide in Los Angeles in 1956 and the extensive coastal landslides in California during the late 1960's, have contributed to this reluctance. At present, very few companies in the United States offer landslide coverage, and then only for certain areas. [3]

Costs of landslide insurance can discourage development in slide-prone areas or encourage land uses that are less likely to experience damage. Landslide insurance from private sources is costly for areas with known slide potential because slides lack the random nature necessary for a sound insurance program. [4]

3.3 Get Ready

3.3.1 Monitor Slide Movement

The monitoring of movement of potential mudslide areas can be effective if used in conjunction with a good communications network between the people that need to be warned and evacuated. Some methods that can be used to monitor potentially unstable land movement are listed as follows:

1. Aerial or ground surveys of permanent markers.
2. Field observations including Electronic Distance Measuring devices (EDM's) and inclinometers. Inclinometers determine the depth, direction and amount of slide movement.
3. Electrical fences or trip wires.
4. Vibration meters.
5. Television observation.
6. Guided radar.
7. Laser beams.

The first two monitoring methods are at present commonly used to detect long term trends. The remaining methods are more suitable for warning and detecting rapid movement and some of them are in the testing stages. [4]

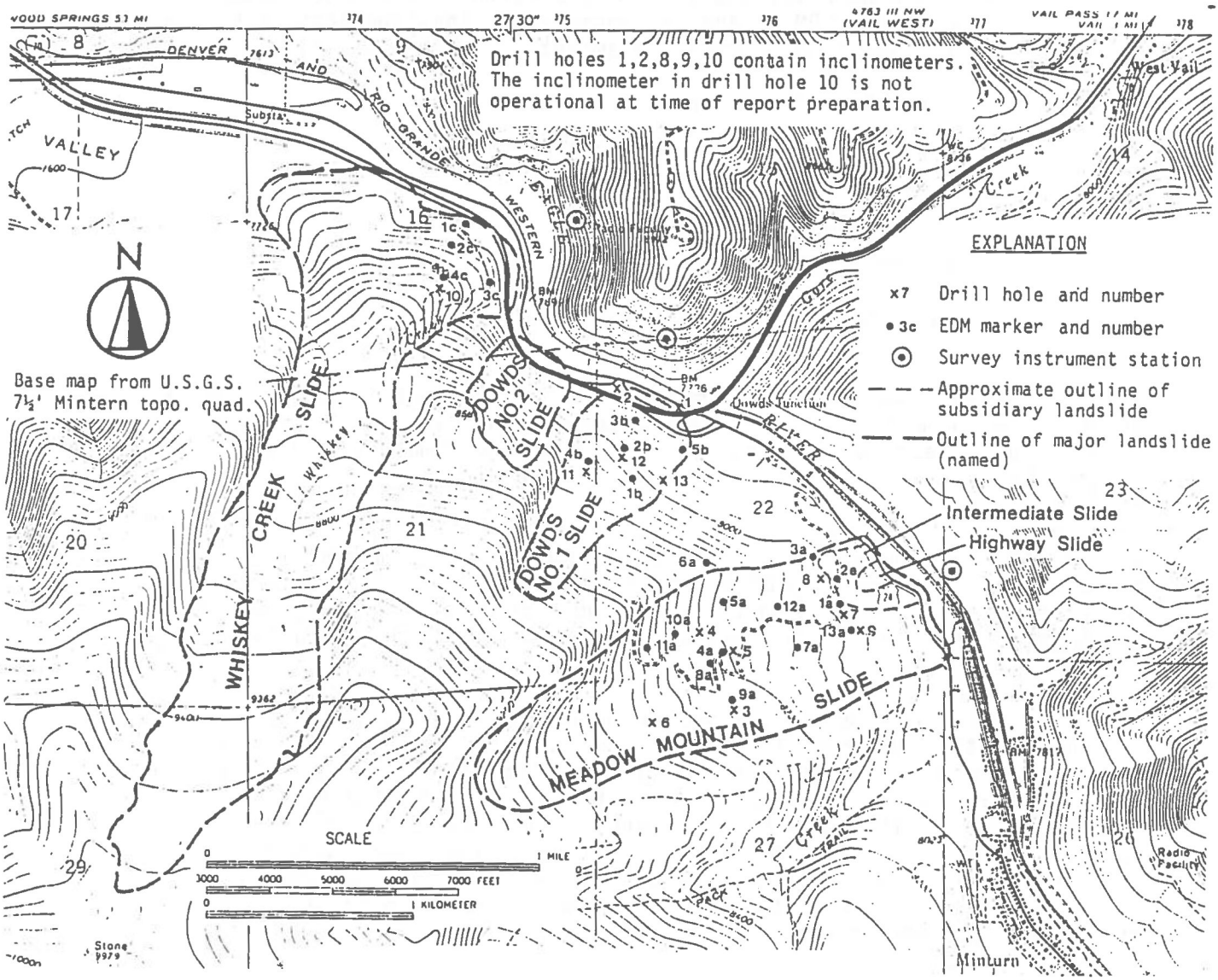
Surveys could be performed on an annual basis using aerial photographic equipment. As little as two feet of movement could be detected by the annual photographing of survey pins in the middle of white permanent survey crosses made out of heavy plastic or white aluminum. The survey pins would have to be surveyed initially on the ground.

In 1985 the Colorado Geological Survey (CGS) installed a monitoring system with $63,000 from the Governor's Emergency Fund on the advice of the task force. The CGS monitoring system includes 24 electronic distance measurement stations (in addition to 12 installed by the CDH on the Meadow Mountain highway slide) and 5 inclinometers (in addition to one installed by the CDH). Because of completion problems, the inclinometer in hole #10 on the Whiskey Creek slide is inoperative. The CDH hole on the active highway slide at Meadow Mountain has been sheared off and is no longer operative.

Simple electronic trip wire warning devices were installed on an experimental basis by the Division of Disaster Emergency Services during 1985 in several slide paths at Red Cliff.

Monitoring of the instruments and field surveillance of the slide costs approximately $1000 per reading assuming a two man crew working a 10 hour day. The monitoring program should commence about mid-April and continue at two week intervals at least through the spring and summer seasons. This effort should continue each year until a return to normal precipitation levels has been reached.

The inclinometer hole #10 at Whiskey Creek should be redrilled and one additional inclinometer hole should be drilled to monitor the intermediate slide at Meadow Mountain. The cost of this work using CDH equipment is estimated at $10,000.



Location Map for the Dowds Junction Landslide Investigation

	5-1-85	5-8-85	5-16-85	5-23-85	5-30-85	6-6-85	6-13-85	6-20-85	6-27-85	7-3-85	7-11-85	7-17-85	7-26-85	8-2-85	8-9-85	Total
1.	.05'	.01'	.01'	.01'	.04'	.04'	.03'	.01'	-.03'	.04'	-.02'	.04'	-.01'	.04'	-.06'	.20'
2.	.04'	.02'	.00'	.01	.02'	.01'	.03'	.01'	-.02'	.03'	-.01'	.00'	.01'	.02'	.05'	.22'
3.	.00'	.00'	.00'	.01	.00'	.00'	.03'	.01'	.00'	-.01'	.00'	.01'	.00'	.05'	-.05'	.05'
4.	.03'	.02'	.00'	.00'	.04'	.04'	.01'	.00'	.00'	.01'	-.01'	.03'	-.02'	.05'	.00'	.20'
5.	.41'	.33'	.24'	.24'	.18'	.16'	.04'	.24'	.11'	.05'	.01'	-.09'	.04'	.07'	.01'	2.04'
6.	.04'	.01'	.02'	.02'	?	.01'	.03'	.03'	-.01'	.01'	.00'	.04'	.00'	.03'	.01'	.24'
7.	.00'	.00'	.00'	.00'	.03'	.00'	.01'	.01'	.00'	.00'	-.01'	.05'	-.03'	.03'	.01'	.10'
8.	.34'	.29'	.21'	.21'	.14'	.15'	.01'	.12'	.09'	.05'	.04'	.03'	.05'	.03'	-.01'	1.75'
9.	.37'	.36'	.24'	.23'	.18'	.15'	.08'	.13'	.14'	.02'	.12'	.01'	.02'	.06'	-.01'	2.10
10.	.03'	.03'	.02'	.02'	.03'	.02'	.02'	.00'	.01'	.04'	-.04'	.06'	-.04'	.04'	-.03'	.21'
11.	.29'	.27'	.19'	.18'	.14'	.15'	.09'	.13'	.17'	.02'	-.09'	-.01'	.04'	.06'	-.01'	1.62'
12.	.25'	.25'	.18'	.14'	.13'	.09'	.01'	.13'	.08'	.11'	.03'	-.01'	-.02'	.06'	-.01'	1.42'
1A.				-.04'	.04'	.02'	.04'	.02'	-.04'	.06'	-.02'	-.02'	-.01'	.07'	.01'	.13'
2A.				.00'	.01'	.03'	.04'	-.01'	-.20'	.04'	-.03'	.01'	.01'	.02'	.04'	-.04'
3A.				-.03'	.00'	.05'	.02'	-.02'	-.01'	.04'	-.01'	-.01'	.02'	.03'	.03'	.11'
4A.				.04'	.03'	.10'	.09'	-.01'	-.05'	.11'	-.03'	.00'	.02'	-.01'	.00'	.29'
5A.				.00'	.01'	.08'	.09'	-.03'	-.14'	.18'	-.09'	-.02'	-.01'	.02'	.01'	.13'
6A.				.10'	-.04'	.02'	.08'	-.02'	-.05'	.09'	-.02'	-.03'	.00'	.05'	-.07'	.11'
7A.				.09'	-.02'	.02'	.06'	-.03'	-.02'	.05'	.00'	-.08'	.07'	.02'	.03'	.18'
8A.				.07'	.00'	.08'	-.02'	.00'	-.03'	.09'	?	-.06'	-.03'	.02'	-.01'	.11'
9A.				-.13'	.03'	.06'	.03'	.01'	-.10'	.14'	-.05'	-.04'	.01'	.00'	.00'	-.04'
10A.							.03'	-.06'	-.13'	.08'	.06'	-.06'	-.02'	-.03'	.02'	-.11'
11A.							.37'	-.08'	-.15'	.11'	.06'	-.11'	.00'	.10'	.00'	.30'
12A.								-.01'	.11'	-.06'	.05'	-.09'	.13'	.15'	.28'	
13A.								-.01'	.03'	.01'	.01'	-.02'	.05'	.01'	.08'	
1B.								-.06'	.06'	-.02'	.09'	-.04'	.04'	.07'	.14'	
2B.								.01'	.01'	.04'	-.03'	-.02'	.07'	.00'	.08'	
3B.								.05'	.04'	-.04'	.03'	.00'	.00'	.01'	.09'	
4B.								.01'	.03'	.01'	-.01'	-.01'	.03'	.01'	.07'	
5B.								.04'	-.08'	.06'	-.01'	-.02'	.06'	-.04'	.01'	
1C.								-.02'	.10'	-.06'	-.02'	.05'	-.05'	.08'	.08'	
2C.								-.07'	.04'	-.01'	.00'	-.01'	.06'	-.05'	-.04'	
3C.								-.04'	.03'	-.02'	.02'	-.01'	.02'	-.03'	-.03'	
4C.								-.01'	.00'	.00'	.01'	-.01'	.03'	-.01'	.01'	

East Abutment - (I-70 Bridge over the Eagle River at Dowd)

--	--	-.02'	-.02'	-.03'	-.01'	.01'	-.07'

West Abutment

--	--	-.03'	.01'	-.04'	-.03'	.01'	-.08'

DATE: August 13, 1985

AUG 1 1 1985

COLO. GEOL. SURVEY

TO: Messrs. Dolan, and Clevenger

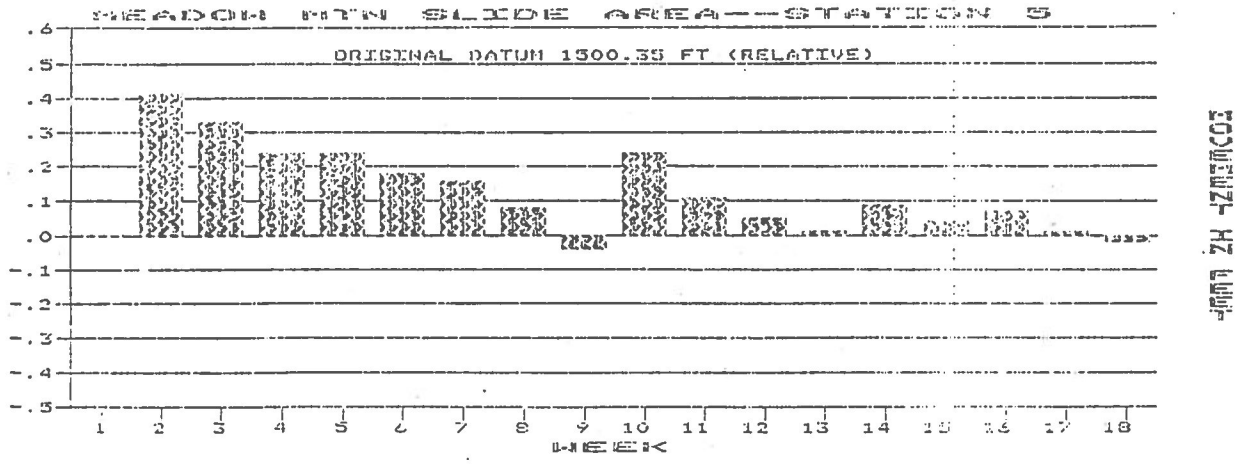
FROM: Robert K. Barrett

SUBJECT: Meadow Mountain Slide Monitoring

Following the EDM readings taken at the Meadow Mountain Slide Area, located west of State Highway 24 between Dowd Junction and Minturn. Attached is a map showing the general area and a map showing the study area and EDM point locations. Each set of readings represents a subtraction from the most recent preceding set. The format facilitates quick determination of trends.

The column on the right is cumulative movement since the initial reading for that point. Initial readings for points 1 through 12 were taken April 24, 1985. Initial readings for points 1A - 9A were taken May 15, 1985, and on June 6 for points 10A and 11A. A minus sign indicates an apparent uphill movement. This probably indicates a minor error in the mechanics of the system.

Tabulation of EDM Readings at Dowds Junction in 1985



Example of Movement at EDM Station 5

3.3.2 Investigate Slide Characteristics

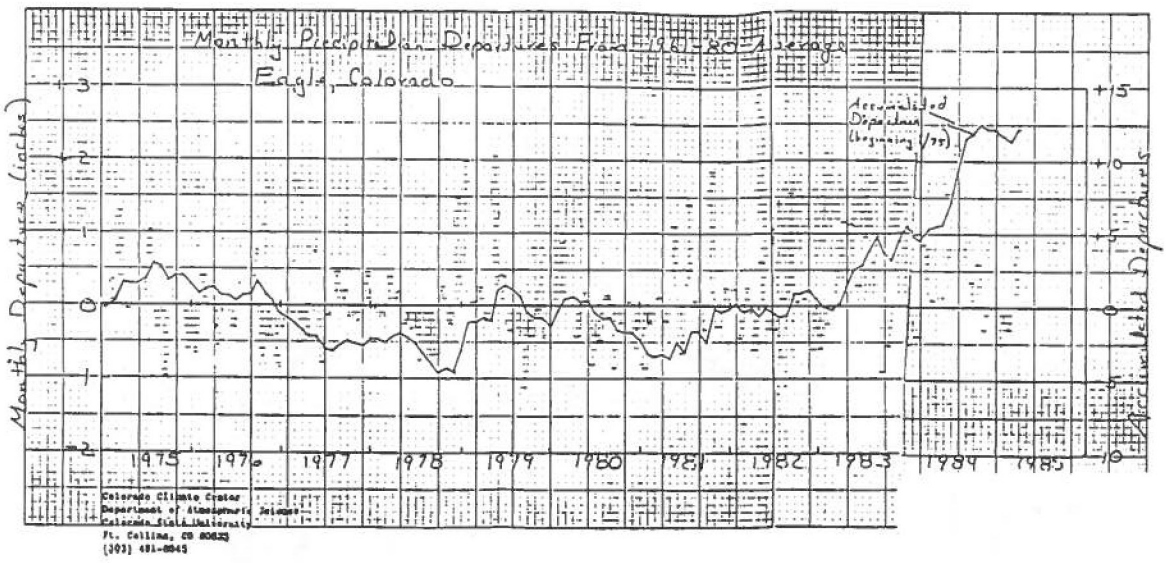
The Colorado Geological Survey (CGS), has a $15,000 contract from the Colorado Department of Highways to prepare a report and perform geologic mapping of the four slide complex. The report, due by July 1, 1986, is also supported by supplemental funding from a special appropriation from the General Assembly for mitigation of damages from the 1984 flooding on the western slope. The CGS has acquired detailed aerial color photography and detailed photogrammetric line maps at a contour interval of 10 feet and a scale of 1"= 400.' The base mapping was performed by Intrasearch Inc. of Denver under a sub-contract to the CGS. Geologic field mapping has been transferred to this base and final drafting was completed in April 1986.

In 1985, the CGS drilled 13 core holes in addition to five holes drilled previously by the Colorado Department of Highways. These holes provided lithologic data, water levels, slide plane depths and material which can be tested for engineering properties. A seismic (reflective wave) survey of the slides is another tool that could be used to gather additional data if necessary.

3.3.3 Monitor Precipitation Trends

Precipitation has been interpreted by geologists to be an indication of ground soil moisture. An unusually heavy snowfall can soak into the ground before the ground has frozen, resulting in high ground water saturation. This is a cause for concern because it reduces the structural strength of the soil, reduces the friction along failure surfaces, and increases the weight of the material thereby increasing the driving forces for a slide.

Weather stations are located at Climax and Eagle with the Eagle station believed to approximate most closely the Minturn area. The monthly precipitation departure from the 1961-1980 average is a valuable indicator of wet and dry periods. A high accumulated departure is indicative of a high carryover potential for soil moisture and super-saturated conditions. The precipitation recorded during the early fall season is a most important indicator. This data, available from the Colorado Climate Center at CSU, should be closely monitored.



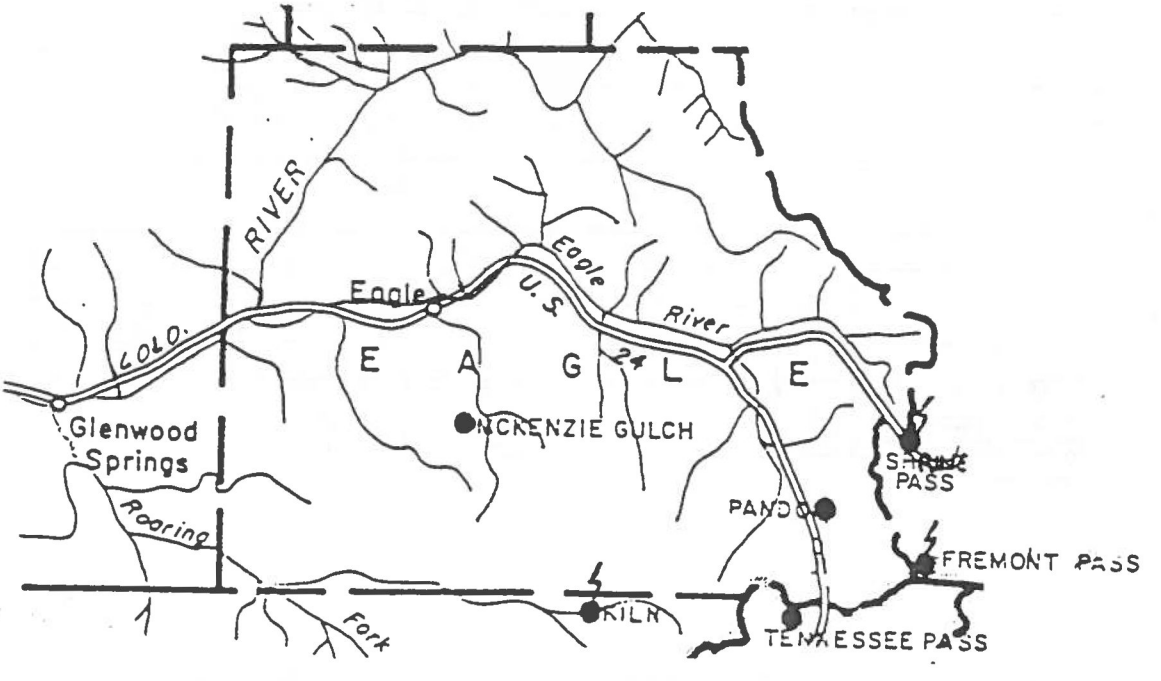
Monthly Precipitation Departure From the 1961-1980 Average at Eagle, Colorado [Colorado Climate Center]

3.3.4 Monitor Snowpack Trends

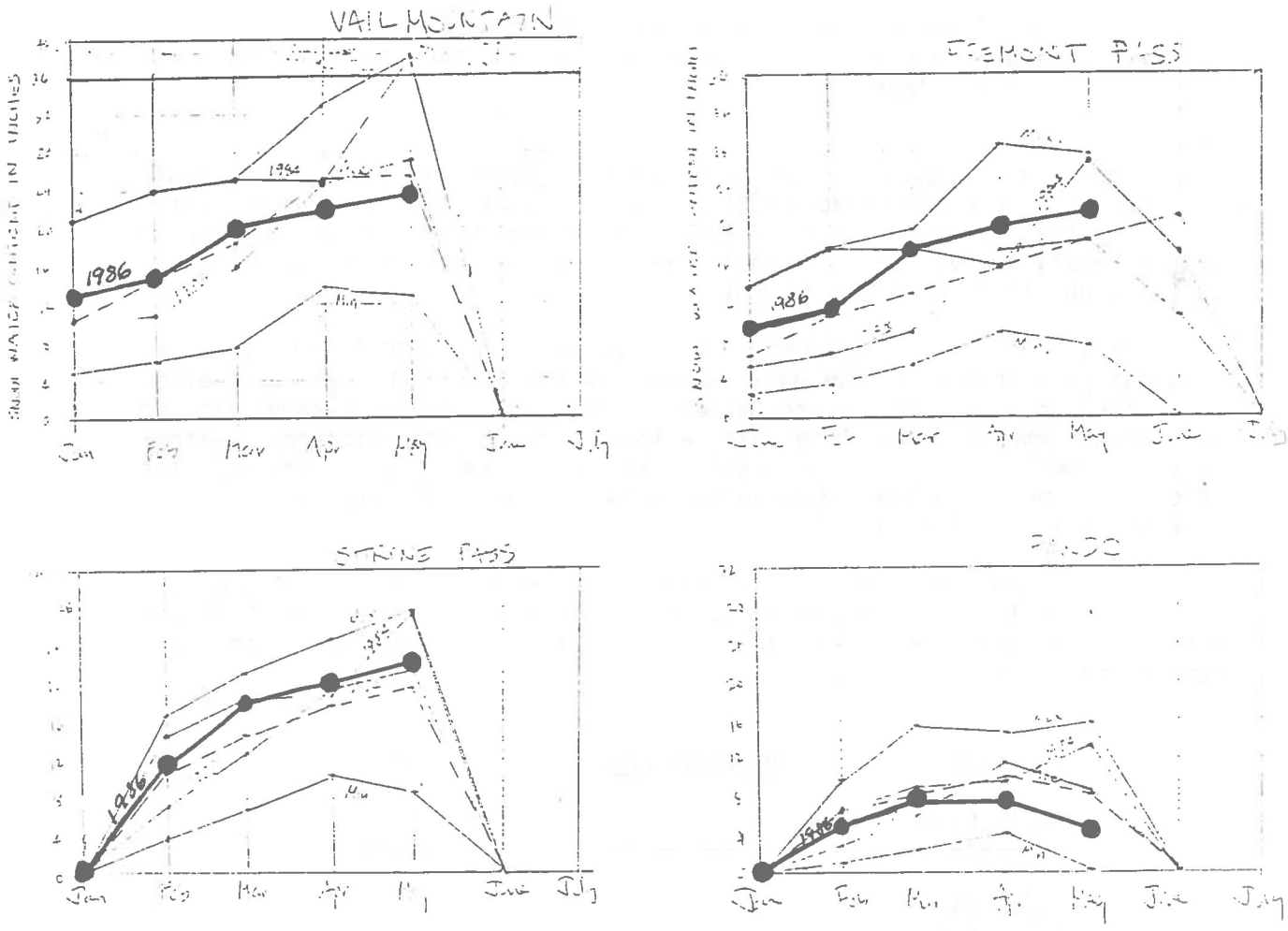
The U.S. Soil Conservation Service maintains snowcourse readings in support of their Water Supply Outlook for Colorado. Their snow survey information for the following sites should be monitored as an indication of increased soil saturation and the potential for a high spring runoff.

Snowcourse	Elevation
Vail Pass	10,200
Shrine Pass	10,700
Pando	9,500
Fremont Pass	11,400
Tennessee Pass	10,200
Kiln	9,600

The maximum, average, and minimum water content (in inches) for these stations for the first of each month is presented graphically in the following diagrams. The readings for 1983 and 1984 are also shown for each of the "envelope curves." The monthly readings from the SCS should be tracked each year.



Map of Snowcourse Sites near Dowds Junction



Snow Water Content Diagrams for four sites near Dowds Junction

3.3.5 Monitor Runoff

Streamflow in the Eagle River and Gore Creek should be monitored because this information is necessary to estimate how fast a reservoir might form behind a major slide that blocks the river.

In May 1985, engineers from the Division of Water Resources installed staff gages at the following strategic locations:

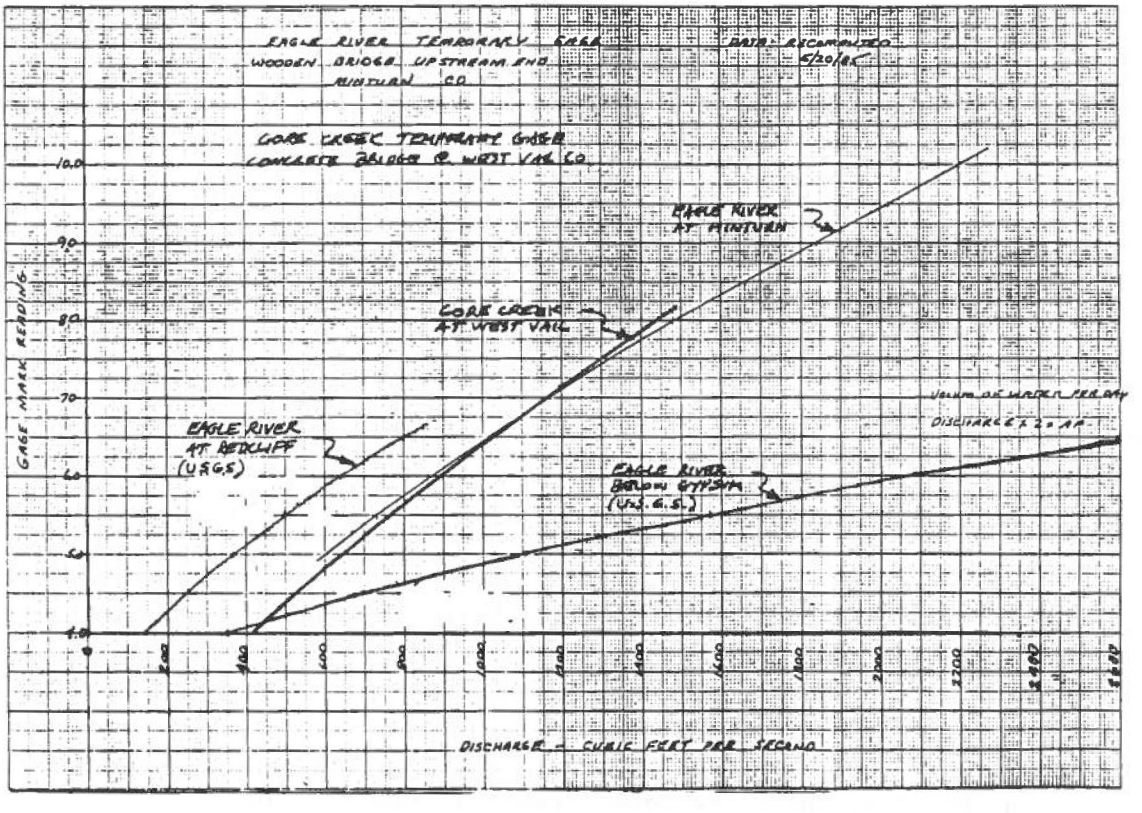
> Eagle River at the most upstream wooden bridge at Minturn. This is a vertical line with marks at 0.5 foot intervals painted on the bridge pier.
>
> Gore Creek bridge at West Vail. This is a vertical line with marks at 0.5 intervals painted on a wing wall to the bridge.

These staff gages can be read daily by local officials. The depth of flow is easily converted to discharges in cubic feet per second (cfs) by using the following chart. Runoff in cubic feet per second may be approximately converted to runoff in terms of acre-feet per day by multiplying cfs by a factor of 2.0.

Inflow to Dowds Junction can also be estimated using the flow readings at the USGS stream gage located on the Eagle River below Gypsum (drainage area = 944 square miles). The gage below Gypsum can be monitored remotely via satellite either through the National Weather Service (NWS) River Forecast Center in Salt Lake City or through the Colorado Satellite-Linked Monitoring Network. A staff gage at the site is also available for visual readings.

An approximate relationship between readings at the Gypsum gage and at Dowds Junction can be based directly on the ratio of the drainage areas. The drainage area and runoff ratio at various sites are summarized below:

Location	Drainage Area	Ratio
Eagle River at Minturn	260 sq.mi.	0.275
Eagle River below Dowds Junction	362 sq.mi.	0.383
Eagle River below Gypsum	944 sq.mi.	1.000



Rating Curves for Various Stream Gages near Dowds Junction

For example, assume the staff gage in the Eagle River below Gypsum reads about 4.25 feet. From the graph of discharge versus gage height, this converts to about 800 cfs. Then, multiplying by the drainage area ratio (800 x 0.383), approximately 306 cfs is flowing in the Eagle River below its confluence with Gore Creek at Dowds Junction.

Multiplying 306 cfs by 2.0 to convert the instantaneous rate of flow into a daily volume in acre-feet, we estimate about 612 acre-feet per day could potentially back up behind a slide at Whiskey Creek. This estimate should be checked against direct readings on the staff gages at Minturn and West Vail.

The normal monthly mean flow from 1947 through 1975 for the Eagle River below Gypsum and estimates of the normal monthly means in cfs at Dowds Junction are listed below:

Month	Eagle River below Gypsum	Eagle River u/s Dowds Jct.	Eagle River d/s Dowds Jct.
Jan	182	50	70
Feb	174	48	67
Mar	187	51	72
Apr	393	97	135
May	1341	369	512
Jun	2277	626	872
Jul	976	268	373
Aug	368	101	141
Sep	266	73	102
Oct	258	71	99
Nov	243	67	93
Dec	199	55	76

A study of flood hydrology by the CWCB in 1985 [11] determined the following relationships to estimate peak discharges at Dowds Junction based on streamflow measured at gages higher in the basin.

Eagle River at Minturn (DA=260)

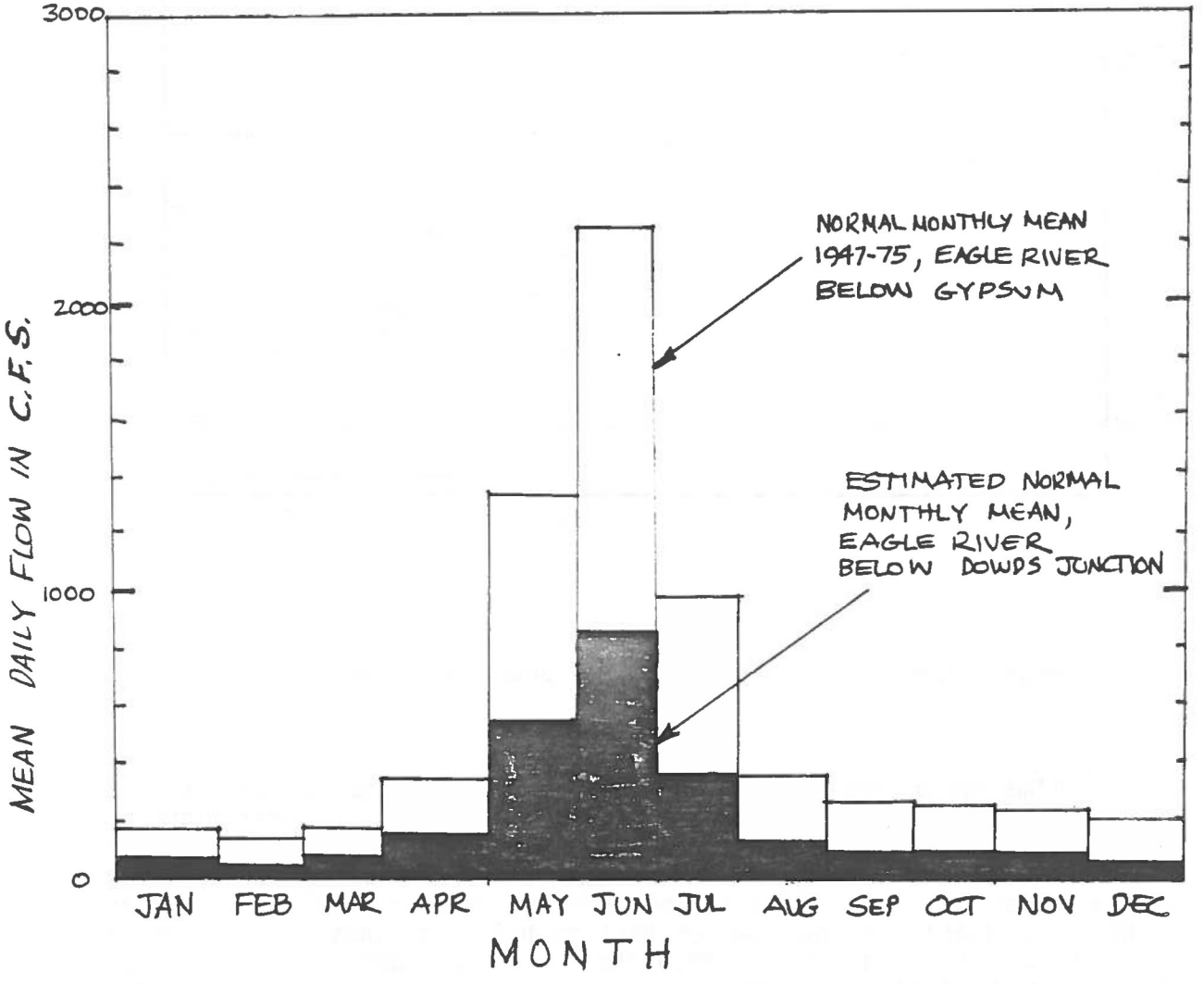
Multiply gage reading in cfs for Eagle River at Red Cliff (DA=72 sq.mi.) by (2.5) to get flow in cfs at Minturn.

Gore Creek at Mouth (DA=102)

Multiply the sum of gage readings in cfs at Gore Creek, Upper Station (DA=14.3) and Black Gore Creek near Minturn (DA=11.8) by (2.0) to get flow in cfs at the mouth.

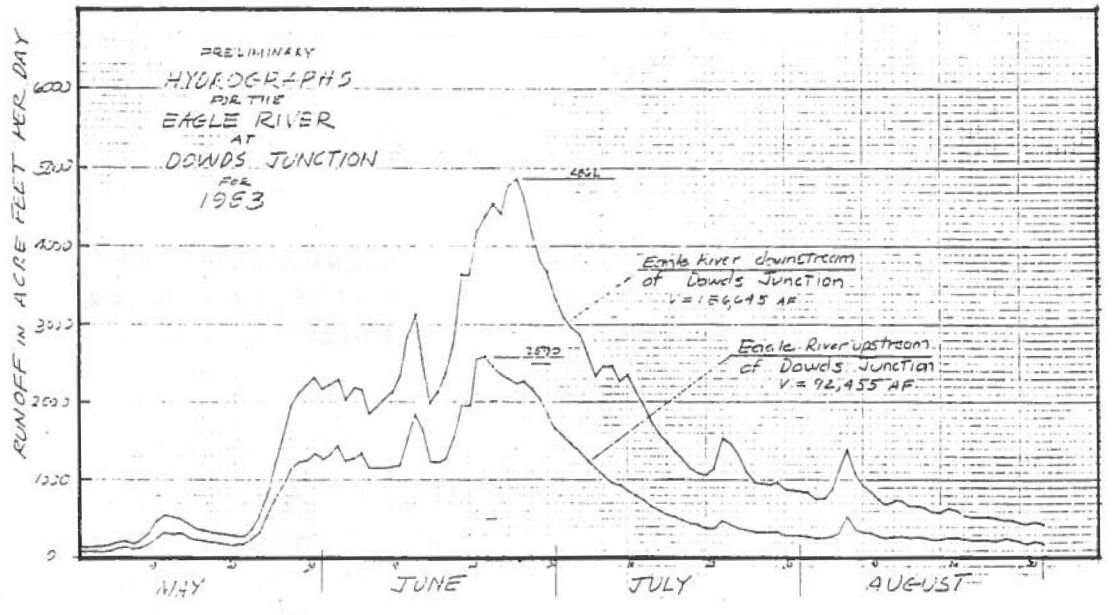
Eagle River below Dowds Junction

Sum of the above estimates.



Monthly Runoff at Dowds Junction

The following hydrographs (in acre-feet per day) for the Eagle River upstream and downstream of Dowds Junction are derived from the above relationships using 1983 runoff data. This type of calculation can be used to refine the estimates of how fast a reservoir might fill up.



Hydrographs for the Eagle River at Dowds Junction for 1983

Estimation of the available evacuation time depends on the rate of flow into the reservoir which is dependent upon when such a dam might be formed relative to the runoff season. Since this is unknown and the rate of inflow is quite variable, evacuation times are estimated assuming several rates of flow. Calculations indicate that from only 1 to 4 days might be available to the Town of Minturn before serious flooding would occur from a slide at Meadow Mountain. A flood caused by a slide at Whiskey Creek might take from 1 to 4 weeks to reach Minturn. In order for flood waters to backup as far west as West Vail, the reservoir at Whiskey creek would have to start filling at about mid-May, and it might take about 3 months. This scenario assumes that any dam that was formed would not fail or be breached through structural or non-structural methods.

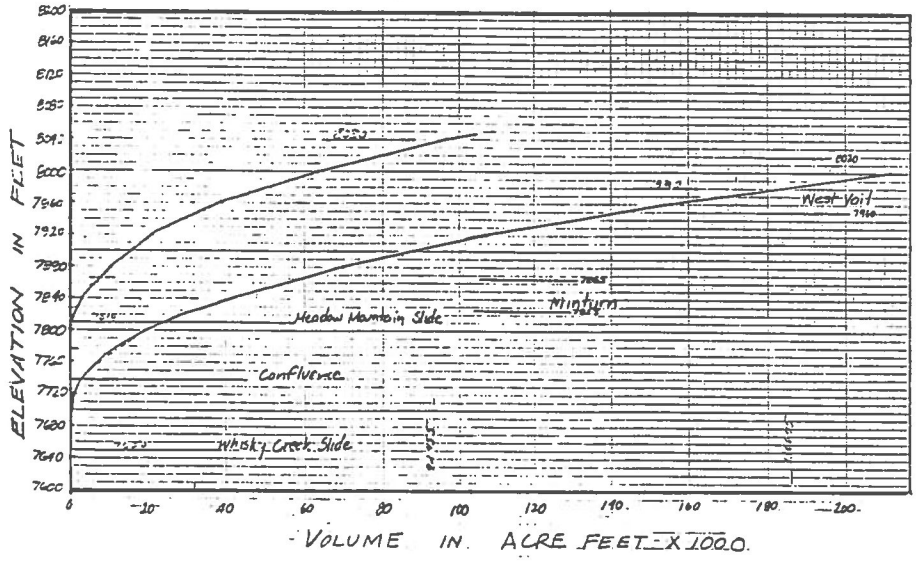
3.3.6 Investigate Potential Reservoir Characteristics

The potential for creation of a reservoir behind either the Whiskey Creek slide or the Meadow Mountain slide depends upon many factors. Determination of the maximum water surface elevation and estimates of the available evacuation time requires an analysis of the topography and knowledge of the elevation of critical facilities. Preliminary reservoir capacity curves have been developed by the CWCB from the USGS topographic maps of the Minturn quadrangle. These curves should be refined as soon as more detailed topography of the basin becomes available.

The maximum elevation of a reservoir on the Eagle River formed by the Meadow Mountain slide based on 1983 runoff (92,445 acre-feet) would be about 8030 feet. The height of the dam necessary to contain this amount of water would be 220 feet. The maximum elevation of a reservoir on the Eagle River formed by the Whiskey Creek slide based on 1983 runoff (186,645 acre-feet) would be about 7990 feet. The height of a dam necessary to contain this amount of water would be 340 feet.

A dam formed by the Meadow Mountain slide would start at about an elevation of 7810 feet. At about elevation 7825, the town of Minturn would begin to flood. At elevation 7865, Minturn would be completely inundated.

A dam caused by the Whiskey Creek slide would begin at about an elevation of 7650 feet. Flooding up the arm into Gore Creek would start at an elevation of 7740 feet. Further flooding would reach Minturn at 7825 feet, completely flooding the town by elevation 7865 feet. Continued flows into the reservoir would reach West Vail at an elevation of about 7960 feet.



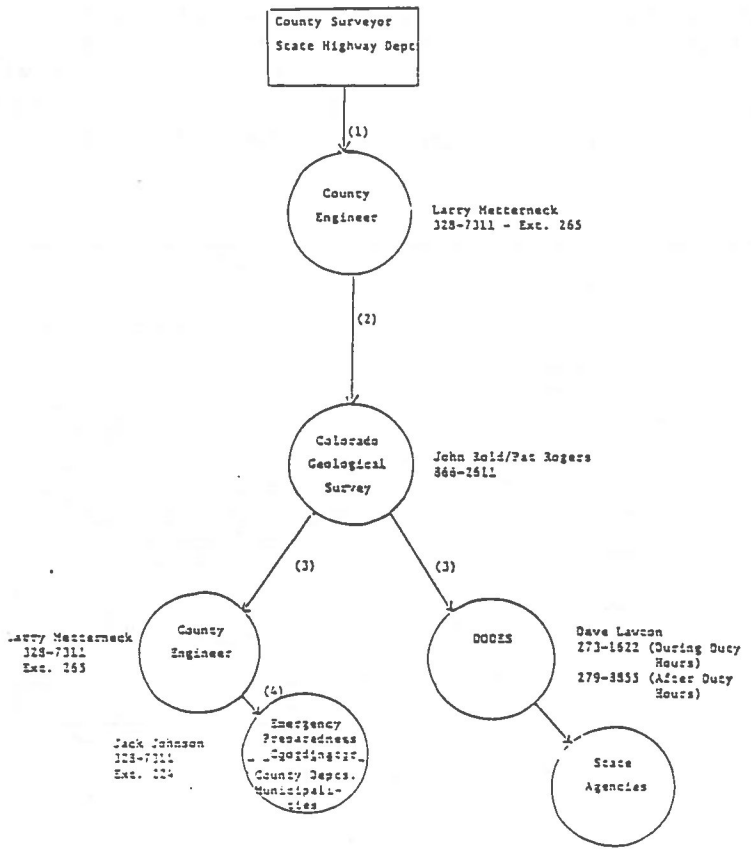
Preliminary Elevation-Capacity Curves

3.3.7 Improve Communications Network

Immediate relay of information is vital in areas where slides (such as rockfalls and debris flows) happen rapidly. Although the time, place, and magnitude of slides can be predicted only in relatively small areas in which detailed geologic and engineering studies have been conducted, susceptible areas can be identified on a larger scale. [4]

A communications network has been established in Eagle County to monitor activity in potentially threatened areas and to provide rapid notification of government agencies when significant ground movement is detected. This network should be activated and exercised on an annual basis prior to the critical threat period (March - July).

Beyond notification, there is a need to insure the communications system is adequate to support decision makers in command and control facilities between the facilities and those responsible in the field. Field units need to be able to communicate with each other over common radio frequencies. Some improvements in the communications network were made as a result of the two exercises that were conducted in 1985. However, additional exercises to identify remaining shortfalls are recommended.



Landslide Monitoring Notification System used in 1985

3.3.8 Improve Emergency Evacuation Plans

As a result of the two exercises conducted in 1985, local emergency operations plans were improved or developed by Eagle County and Minturn. The threatened populations have been identified, evacuation routes selected, and the issues involved in such an evacuation, such as transportation, traffic control, reception and care have been addressed. These plans need to be exercised on a periodic basis to insure that they remain current and that all parties are familiar with the procedures contained within them.

3.3.9 Increase Emergency Response Staff

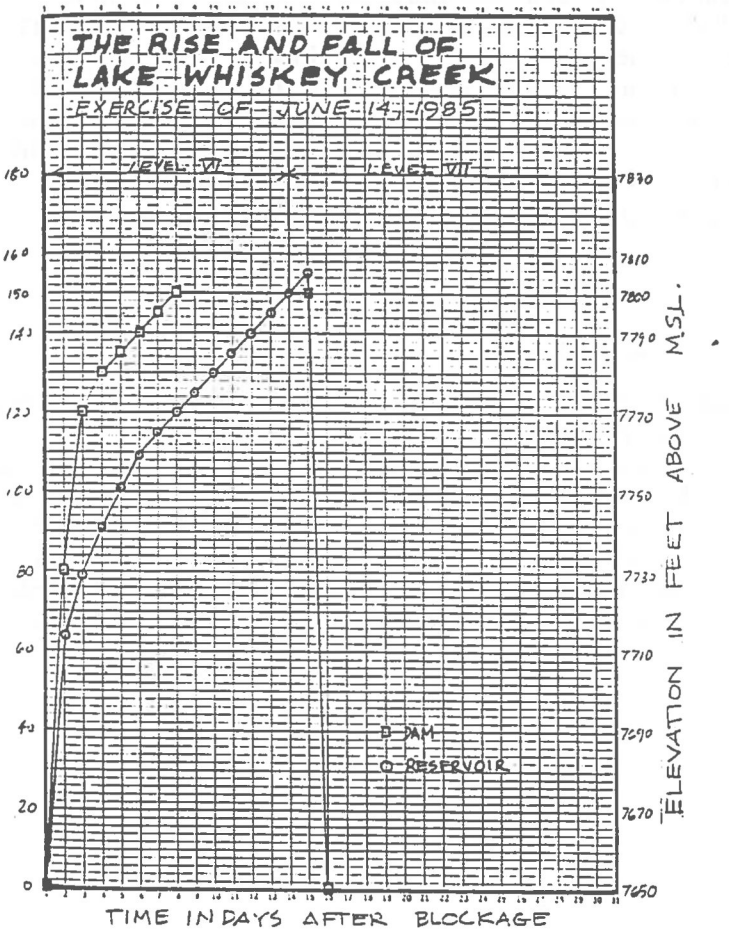
Given the complexity and serious nature of the land slides, the local government (Eagle County) emergency management organization should be staffed with full time personnel. A minimum staff for this and other emergencies would be a full time director. Further, it is essential that each level of government and their agencies address the staffing requirements to carry out assigned responsibilities. Round-the-clock operations involved in such an incident can severely impact on-going governmental activities unless they are properly planned.

3.3.10 Provide Additional Training

There is no doubt that the functions envisioned in responding to a landslide disaster require specialized expertise in activities that are not performed on a routine basis. Emergency command post operations (i.e., maintenance of operational logs, posting of maps, displaying of information, evacuation of a segment of the population and providing for their care and reception) are not functions performed on a day-in-day-out basis and therefore require specialized training. Training requirements need to be identified and programs established to address these requirements.

3.3.11 Continue Annual Exercises

Excercises are the proof of the pudding to all of the preparedness activities conducted. They provide for orientation of new personnel, updating of existing plans based on changes, and identification of deficiencies that need to be addressed. Exercises can be conducted to involve only subsystems such as communications, notification, reception and care or they can be of a nature where all systems are exercised simultaneously. The two exercises conducted in 1985 were invaluable in determining operational procedures, team building and identifying shortfalls that must be addressed. A coordinated exercise program needs to be developed that on an annual basis revisits existing plans and procedures.



Exercise of June 14, 1985

3.4 Get Out of the Way

3.4.1 Regulate Development in the Hazard Area

Regulating development in the vicinity of potential mudflows can take place by the use of design, building, and/or grading codes. All of the incorporated communities and unincorporated areas of Eagle County have adopted comprehensive floodplain management regulations. These regulations are intended to avoid future development from being exposed to 100-year flood hazards.

During the early part of 1986, the Board of County Commissioners of Eagle County was in the process of adopting geologic hazard area regulations and official maps to govern development within designated geologic hazard areas. The designation of such geologic hazard areas as a matter of state interest was granted to counties in 1974 under the authority of H.B. 1041. However, by March this approach was abandoned in favor of the development of an amendment to the existing building code or land use regulations instead of another layer of permits. The present approach is to develop an amendment which will require a developer to prepare a geologic or geotechnic report for each individual site before a building permit can be issued.

These proposed amendments, if adopted, should help keep future development from direct exposure to landslides, debris flows, and mudflows. However, neither the existing floodplain management regulations or the proposed geologic hazard regulations will be effective in discouraging development in potential reservoir basins upstream of known landslides that could block the Eagle River. Adoption of such stringent regulations for avoidance of these areas could mean economic stagnation for Minturn.

A statement which notifies potential buyers of property in a potential landslide hazard area should be made part of any real estate transaction.

3.4.2 Acquire and Relocate the Vulnerable Area

Recurrent damage from landslides may be avoided by permanently evacuating areas that have undergone slides. Structures may be removed or converted to a use less vulnerable to slide damage. The feasibility of such action depends on the value of the structures, their potential for triggering slides, whether they can be successfully reinforced, and the level of citizen concern. Techniques for removal or conversion include public acquisition, urban redevelopment, abatement of a public nuisance, nonconforming use provisions in zoning ordinances, and reconstruction of existing facilities. [4]

The federal government has a program for acquisition and relocation, known as Section 1362, but it is currently under funded and competition for the limited funds is high. If it can be established that there is a reasonable probability that a serious event is about to happen, the state may be able to assist in a relocation effort under the "imminent threat" provisions of the the Small Cities Community Development Block Grant program administered in Colorado by the Department of Local Affairs.

Relocation of private residential structures from or in the direct path of slide areas at Dowds Junction does not involve a great number of buildings. There are no such structures on the Meadow Mountain, Dowds No. 1, and Dowds No. 2 slides. Condominiums located at the base of the Whiskey Creek slide are the only significant structures which would be directly impacted.

Relocation of the Town of Minturn to avoid a potential landslide reservoir would involve moving over 1300 people and 500 structures. The cost of such an acquisition and relocation effort would be on the order of $100 million and not in proportion to the very low probability that such an event will even occur.

3.4.3 Re-route the Transportation Network

Reconstructing public facilities located in slide areas may afford an opportunity to reduce the risk of damage from landslides. Such facilities could include roads, bridges, utilities, and community facilities that are subject to rebuilding by reason of functional or structural obsolescence. This end can be achieved by reinforcing, designing to accommodate displacement, relocating in areas not subject to landslides, or bridging. Bridging refers to the construction of spans over slide areas. It is primarily used for highways; it is expensive and consequently used only as a last resort. [4]

The transportation systems in the Dowds Junction area include U.S. Highways 6 and 24, Interstate Highway 70, several gravel and unimproved dirt roads, a railroad, gas pipelines, a sewage transmission line, and an irrigation ditch. The average daily traffic level on U.S. 24 between Minturn and Redcliff was 1250 in 1980. The estimated capacity of this highway is between 3500 and 4400 ADT. The Denver and Rio Grande Western Railroad parallels the Eagle River and U.S. 24 primarily carrying freight between Salt Lake City and Pueblo. [17]

Work to repair the deck of the Nelson bridge at the north end of Minturn began in May under a grant from the Highway Department. The dirt road on the east side of the Eagle River opposite the Meadow Mountain Slide was used as a detour for two days in 1985 while the Highway Department installed a new culvert under the highway. Paving this road may be desirable should it be necessary to use it for a detour over an extended period. However, this road may not be high enough to avoid being engulfed by major slide movement and could be quickly inundated if a small dam were formed by a slide blocking the Eagle River.

The Federal Highway Administration manages the Title 23 emergency restoration fund which can pay for 90 to 100 percent of certain highway work. This agency should be kept abreast of the situation at Dowds Junction.

3.5 Make it Go Somewhere Else

3.5.1 Construct Landslide Deflection Structures

Structural debris barriers are used to divert mudflows and debris flows away from critical areas. Debris storage basins behind check dams collect landslide debris before it hits critical areas. These structures, which are major, expensive engineering works, are mostly found in parts of the western United States where debris flows are a common and hazardous form of landsliding. Landslide diversion structures, debris barriers, and debris basins have been built by governmental agencies at all levels, as well as by the private sector. [3]

Mudflows can sometimes can be diverted around development. Steps can also be taken to reduce the velocity of the flow. [4]

Deflection structures at the Dowds Junction slides do not appear to be warranted since there are no critical facilities or areas in the direct path to protect. Furthermore, the enormous magnitude of the slides at Dowds Junction and the severe space limitations in the river corridor would appear to preclude the use of this option.

3.6 Stop it from Moving

In the United States, the most commonly used physical method of landslide control is the control of ground and surface water in landslide-prone areas. The method is extensively used both by private landowners and developers and by governmental agencies. In general, surface water is diverted from landslide-prone areas by ditches, and groundwater is collected and removed by underground drainage systems and pumping wells. [3]

Many methods of mitigation can be designed for active or potentially-active landslide areas. These generally fall into four categories: 1) change of slope shape, 2) drainage management, 3) retaining structures, and 4) special treatments. Change of slope methods include excavating the entire slide, increasing the weight and resistance to movement of the lower part of the slide (loading), and a combination of excavation and loading. Drainage methods include changes of surface drainage through diversions and increasing subsurface drainage with various construction practices. Retaining structures used to control landslides include buttresses, piles, walls and anchors. [8]

Property damage from landslides often leads to a demand for public works to provide protection for existing development. This includes constructing restraining structures to prevent further sliding; taking steps to control water problems that may be contributing to instability; or excavating areas on, or near, the sliding mass to stabilize it. This type of landslide control is usually limited to small slides because of the costs involved and the necessity for careful and accurate engineering design, inspection, and maintenance. [4]

Structural measures require major action. Those structural measures that appear feasible in a reconnaisance level study should be evaluated further with a major investigation.

3.6.1 Cease or Reduce Irrigation of the Slide

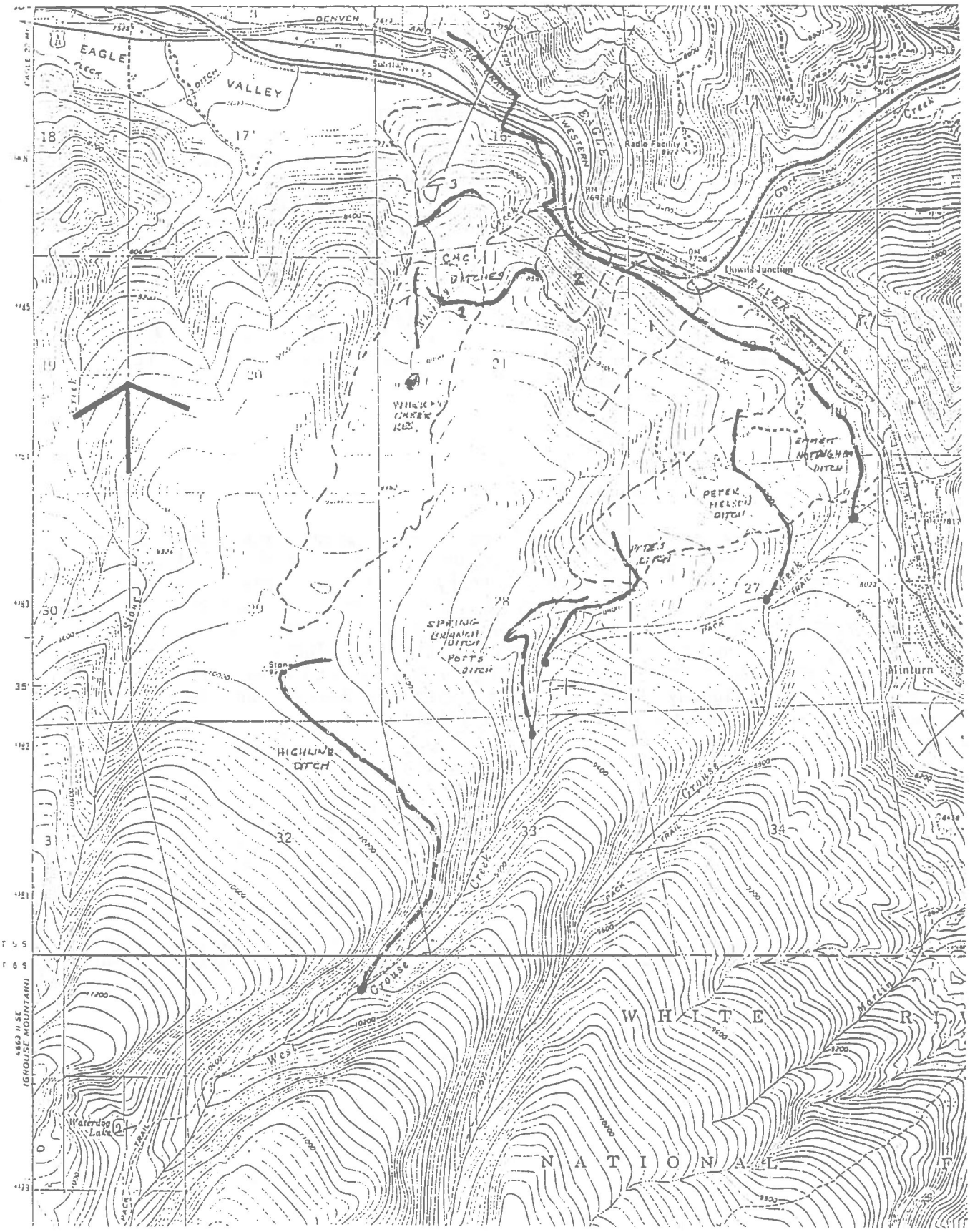
There are eight irrigation ditches and one reservoir in the four-slide area that may contribute to groundwater saturation and the risk of serious landsliding. These ditches divert water from Grouse Creek, Whiskey Creek, and Stone Creek. Their capacities and their potential to make an impact (Y=yes, N=no) on the various slides are listed below:

Diversion Structure	Total cfs	MM	D#1	D#2	WC
Highline Ditch	9.63	-	-	-	Y
Spring Branch Ditch	1.2	-	-	-	-
Pott's Ditch	2.0	Y	-	-	-
Pete's Ditch	4.4	Y	-	-	-
Peter Nelson Ditch	11.7	Y	-	-	-
Emmett Nottingham Ditch	4.0	Y	Y	Y	Y
Whiskey Creek Reservoir	55.2 AF	-	-	-	Y
LAC No. 1 Ditch	6.97	-	-	-	Y
LAC No. 2 Ditch	6.4	-	-	Y	N
LAC No. 3 Ditch	6.4	-	-	-	Y

According to the Water Commissioner for Water Division 5, District No. 37, Mr. Wayne Wells, the irrigated land and water rights were once owned by Vail and Associates, Inc. According to the manager for planning for Vail and Associates, Mr. Dean Kirkland, all of the land and ditch water rights were sold to the U.S. Forest Service in 1978. The water rights, which have considerable value due to early appropriation dates, could be sold or leased and the money used to help pay for slide mitigation.

In June 1985, the USFS District Ranger, Mr. David Stark, asked the CGS for specific recommendations for changes in drainage management on Meadow Mountain. The most prudent and conservative method of mitigating the impact of these ditches on the slides is to simply stop diverting. However, monitoring of pore water pressure in the slides would help determine whether the ditches actually contribute to significant groundwater saturation. Thus far, a hydrologic connection between ditch diversions and slide movement has not been documented. The CGS should plan to take a closer look at this aspect in 1986.

The Colorado Division of Water Resources is responsible for the administration of water rights and has the authority to require ditch owners to stop diversions should significant movement occur.



Map of Irrigation Ditches and Reservoirs that may Impact Landslides at Dowds Junction

3.6.2 Control Drainage on the Slide by Regrading

Another approach is to permanently improve and control surface and subsurface drainage in the vicinity of a potential slide area. This greatly decreases the lubricating and pore water pressure effects of water, and accompanying decrease in stability. This approach is often very effective; however, it may involve complex dewatering systems and costly long-term maintenance and monitoring problems. [7]

Regrading of the slide to control drainage may be feasible on small localized areas of the disturbed area of the "highway slide" on Meadow Mountain. However, due to the large area covered by the slide, it is felt that this is not a realistic option that would significantly prevent a catastrophic mass movement.

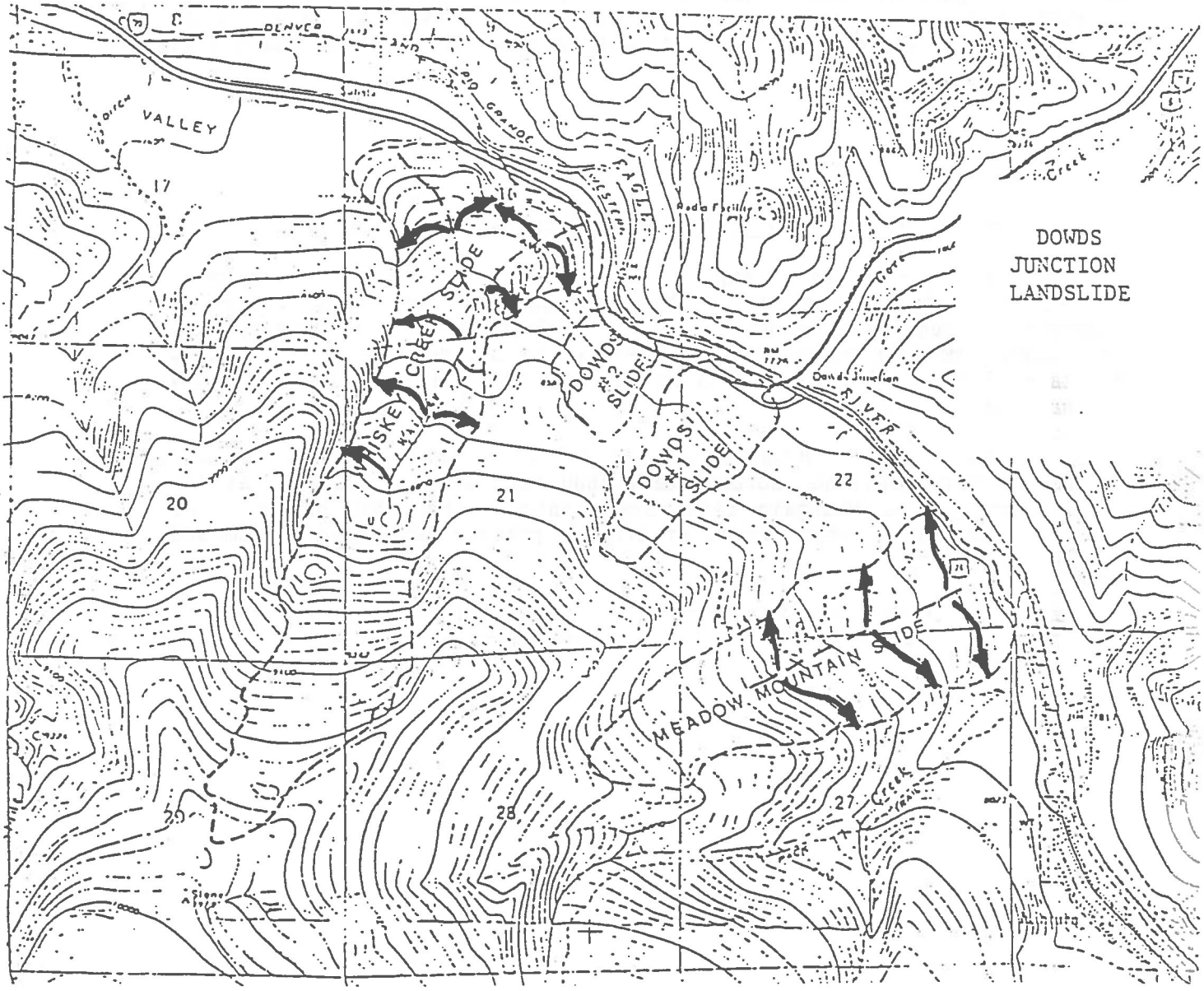
3.6.3 Construct Drains in the Slide

This measure is intended to keep surface water from percolating into the ground and would be most appropriate for the Meadow Mountain slide. However, the drains are contrary to the purpose of several existing irrigation ditches already on the slide. The Whiskey Creek slide may be too large or access too difficult for this option to be practical. The Dowds 1 and 2 slides may be too blocky. Use of this technique on Dowds 2 is probably limited to the surface area visible from the road. The Highway Department has installed drains and weep holes behind the retaining wall of the Dowds 2 slide.

A series of trenches or ridges could be cut on the face of the slide to collect surface water and divert it towards the edge of the slide. Approximately 5,000 feet of drains might be cut on the Meadow Mountain slide and about 8,000 feet might be cut on the lower half of the Whiskey Creek slide. These trenches could be made with a small bulldozer at various intervals on the slide at a cost for dozing of about $120 per hour. All disturbed areas would have to be revegetated.

A more elaborate drainage system might include installation of horizontal perforated plastic pipes imbedded in a gravel blanket. The cost of such pipe ranges between $8-10 per foot. The cost of a dewatering system should be compared to the cost of continued maintenance.

A drain should be installed by the Forest Service to remove surface water that occasionally collects and forms a small marsh on Meadow Mountain directly above the "intermediate" slide.



Map Showing Concept of Proposed Drains on
Landslides at Dowds Junction

3.6.4 Pump Water out of the Slide

Pumping water out of the slide mass can be effective provided wells are placed in the proper location and pumping operation and maintenance costs are not excessive. At the present time, not enough subsurface information has been collected to ascertain if pumping is necessary and where wells might be located. Due to the costs associated with drilling wells and pumping water out of the slide, the option should be investigated after a program of reducing surface irrigation on the slide has been set in place and its effect on pore water pressure is determined.

3.6.5 Channelize the River at the Base of the Slide

It has been suggested that a contributing factor to slide movement is the saturation of the toe of the slide and the continuous removal of sediments through erosion over time by the Eagle River. In other words, the natural meandering of the Eagle River is cutting away at the Meadow Mountain slide. This process has not been identified as a problem at any of the other slides.

The base of the Meadow Mountain slide is about 2000 feet wide. Stream reaches totalling approximately 1600 feet at two locations at the base of the Meadow Mountain slide are candidates for this option. The cost for rip-rap or other forms of erosion protection may vary from $80 to $200 per foot.

The buttress and associated rip-rap installed by the Highway Department should be considered as a test reach for the feasibility of this option.

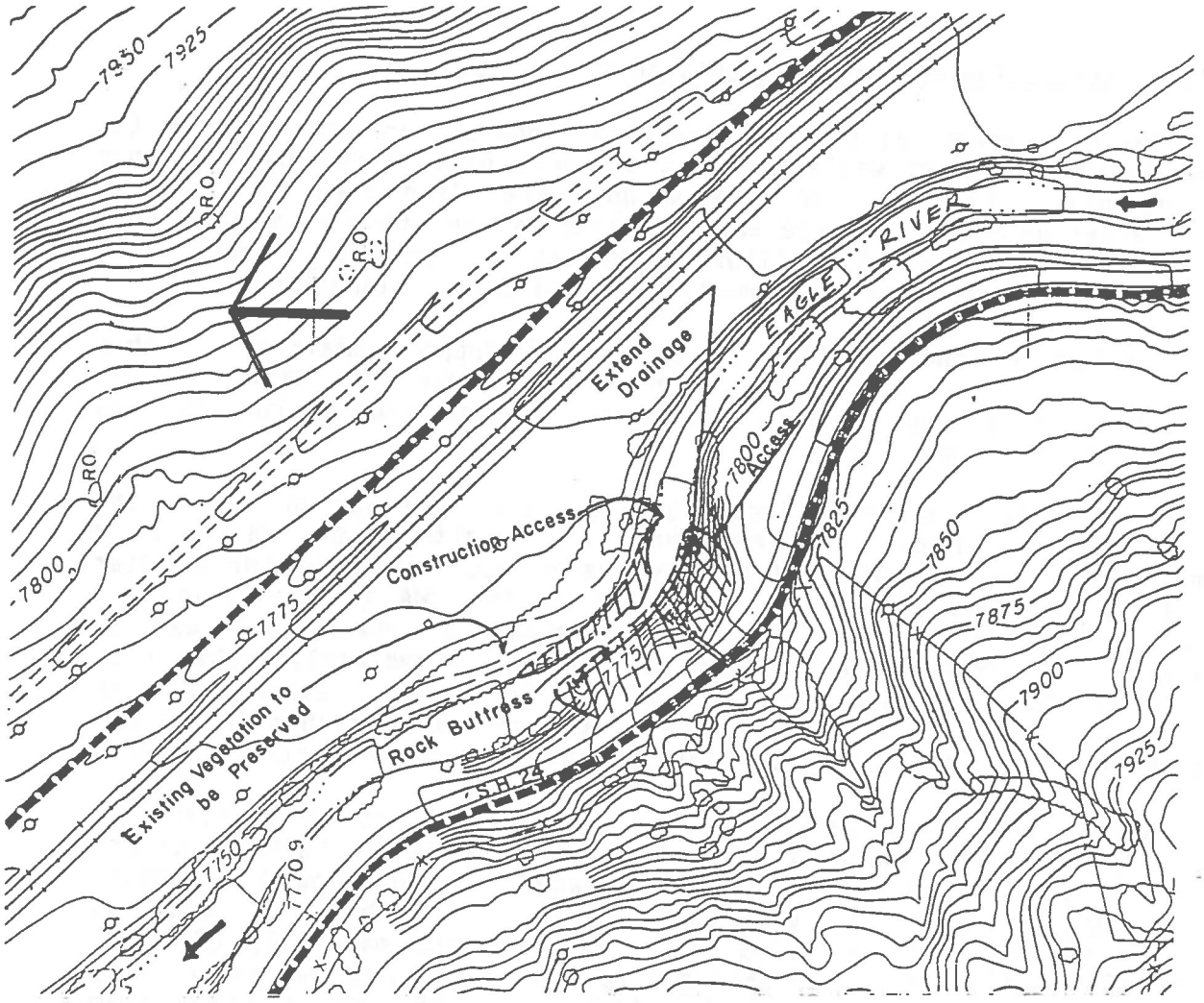
3.6.6 Install Toe Anchors to Stabilize the Slide

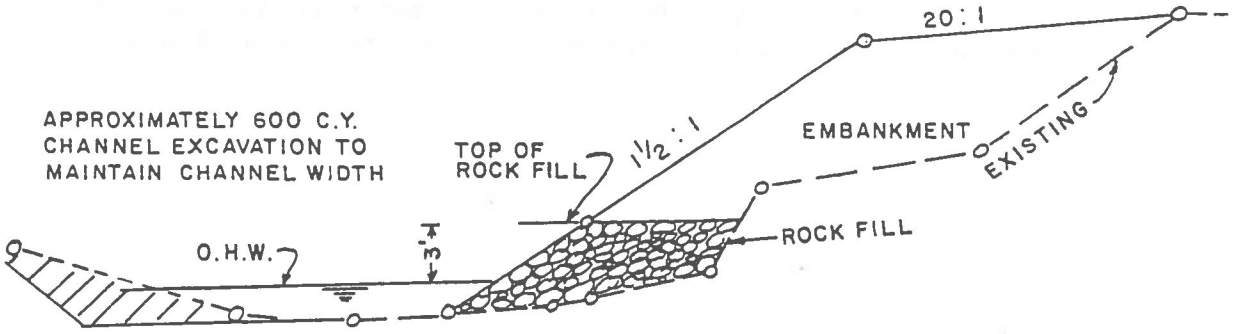
The most universal form of structural control for landslides is the retaining wall. Where walls will not suffice, other structural controls such as piles, caissons, or rock anchors are often used to stabilize earth masses on slopes. Large earth buttresses are often used to support the toe of slides, and in California this is the most common mechanical (as contrasted with hydrologic) method used to control landslides. [3]

Another is the addition of artificial support material to this area. Such support can be in the form of rock- or earth- filled buttressing, retaining walls or cribbing, concrete slurry, rock bolting and reinforced pilings. [7]

In January 1986, the Colorado Department of Highways applied to the U.S. Army Corps of Engineers and the State Department of Health for a permit under Section 404 of the Clean Water Act (CWA) and for a Water Quality Certification under Section 401 of the CWA to discharge fill material into the Eagle River. The purpose of the permit was to stabilize the existing highway slide located immediately below U.S. Highway 24 about one mile north of the Town of Minturn. Since this work was going to take place on Forest Service land, considerable effort was also necessary to obtain the necessary approvals from the District Ranger.

With a $100,000 budget, the Highway Department intends to stabilize the "highway" landslide by loading the toe with rock fill material and constructing a rock and earth buttress adjacent to and below U.S. Highway 24, being partially in the Eagle River. The buttress contains approximately 6,000 cubic yards of rock and earth material, of which approximately 350 cubic yards of large rock are placed below the ordinary high water elevation of the Eagle River. Constriction of the stream channel is mitigated by excavation and widening of the channel immediately opposite the buttress. The excavated material is used in buttress construction. The Highway Department intends to revegetate all disturbed areas.





SLIDE CONTROL EMBANKMENT
TYPICAL SECTION

Map and Cross Section showing work being done by
the Highway Department to Stabilize the Slide at Meadow Mountain

3.6.7 Stabilize the Slide by Special Treatment

Special treatments for slide control include freezing, grouting, blasting and vegetative plantings or other surface cover and erosion management. [8] Refrigerated coils were used to control a slide during the construction of Grand Coulee Dam. Chemical treatments may include the application of water absorbing compounds such as bentonite. A difficulty with chemical treatment is getting the chemicals in the right place. These measures are "stop-gap" at best and applicable to small scale slides. Little is known or written about any large scale application of this method.

3.6.8 Remove Unstable Slide Material

Modification of the ground surface by removal of all or part of the material driving the landslide is another commonly used method of preventing slope movement. [3]

However, removal of material from the toe of a landslide, such as in the construction of a road or highway, can weaken the forces of resistance and lead to an increase in slide activity. The difference between material that drives the slide and the material that holds it in place must be clearly understood. Removal of the Meadow Mountain slide material in the vicinity of U.S. Highway 24 could be a mistake.

A further concern is the problem of where to put the large volume of removed material.

3.7 Don't Let it Flood

Using hydrographs for the Eagle River at various stream gages in the upper Eagle River basin during the four month period from May 1st through August 31, 1983, the following volumes of water are estimated to have passed into Dowds Junction:

	Volume	Peak flow
Eagle River only	92,455 AF	2590 AF/day
Eagle River and Gore Creek	186,645 AF	4862 AF/day

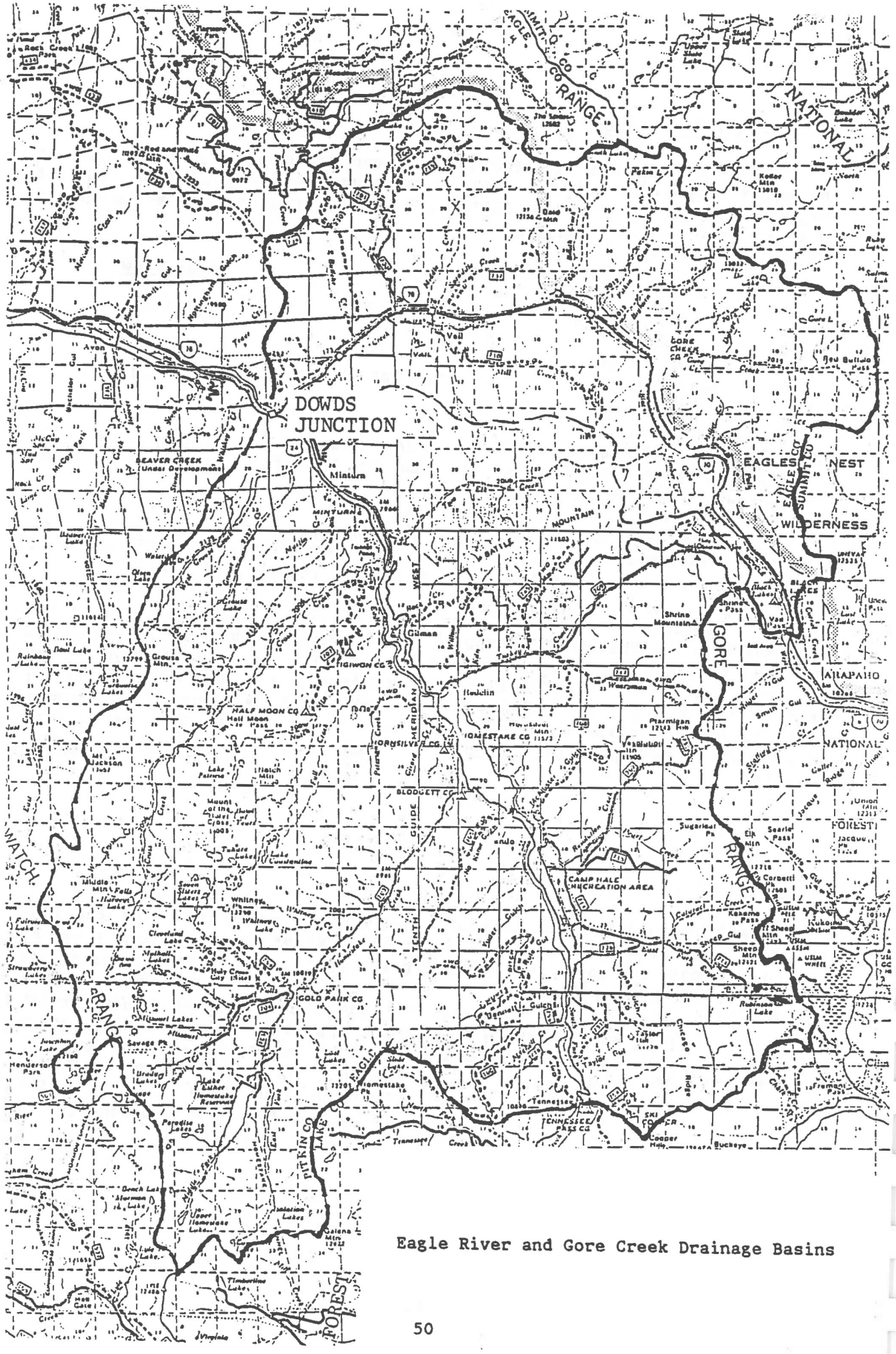
The highest normal monthly mean flow in the Eagle River was estimated to be 626 cfs (June) upstream and 872 cfs (June) downstream of the confluence with Gore Creek.

Knowledge of the mean monthly flow and the maximum volume of water that may flow into a dam site is useful in evaluating the effectiveness of various alternatives designed to reduce the impact of flooding.

The cumulative impact of operating existing irrigation facilities for emergency management purposes has been estimated by some to potentially reduce the hazard by no more than about 5 percent. The Sacramento District of the Corps of Engineers or the Water Planning Branch of the Division of Water Resources could be requested to model these options to better determine the impact of various water management strategies to mitigate the potential formation of a reservoir at Dowds Junction.

3.7.1 Modify the Weather

Weather modification, through the method known as cloud seeding, might be conducted upwind of the upper Eagle River basin in such a manner to cause rain or snow to fall before major cloud systems reach the drainage basins tributary to the landslides. However, weather modification is a tricky business and the whole concept could easily backfire. Also, this concept is in direct opposition to the ski industry economy at Vail, so there is probably little support for this option. Furthermore, it is doubtful that the impact of cloud seeding would be significant enough due to the long amount of lead time required. All weather modification proposals must first be reviewed and granted a permit through the Colorado Department of Natural Resources.



Eagle River and Gore Creek Drainage Basins

3.7.2 Divert Water from the Basin

The four and one-half mile long Homestake Tunnel diverts water from Homestake Lake on the Middle Fork of Homestake Creek to Lake Fork in the Arkansas River basin. The tunnel has a limiting maximum carrying capacity of 700 cubic feet per second (cfs). Transmountain diversions began on June 6, 1967, and the tunnel is normally operated from March through September. This tunnel could be used to lower the volume stored in Homestake Lake.

Other existing transmountain diversions occur from the East Fork of the Eagle River above Redcliff by the Columbine, Ewing and Wurts ditches. Transbasin diversion also occurs at Robinson Reservoir from the East Fork of the Eagle River to Tenmile Creek in the South Platte River basin for mining development.

Diversion Structure	Capacity cfs	Capacity AF/day
Homestake Tunnel	700	1400
Columbine Ditch	60	120
Ewing Ditch	18.5	37
Wurts Ditch	109	218
Total	887.5	1775

From 1967 to 1980, the average annual yield of the Homestake Phase I collection system was 28,000 acre-feet. During this period, annual diversions varied, primarily as a result of climatic conditions, from 9,000 acre-feet to 39,000 acre-feet. [17]

The Division of Water Resources District Engineer in Glenwood Springs is responsible for the administration of water rights in the Eagle River basin. Although these ditches will probably be running full during the time of the snowmelt runoff, it might be desirable to meet with the owners and enter into a formal agreement for the operation of these facilities during a crisis at Dowds Junction. A plan for the operation of various reservoirs and irrigation ditches in the basin during an emergency might be an important annex to the county's Emergency Response Plan. During an emergency, operation of the various diversion schemes to minimize damages could take precedence over administration of the system for water delivery purposes.

3.7.3 Release Water from Upstream Reservoirs

Water could be released from upstream reservoirs to make room for runoff if it was known far enough in advance that a slide would move. Such lowering of the water level prior to spring runoff is a normal part of most reservoir operating plans. Release of water could also be used to increase flow in the river at the toe of a moving slide. This effect may be desirable to help keep the channel open.

Homestake Reservoir is the logical impoundment to use for such purposes in the basin above Dowds Junction. However, since it is located approximately 20 miles upstream from Dowds Junction, it may take between 4 and 5 hours for such releases to reach the Junction. Any such release must be made through the owners of the reservoir, which for Homestake are the cities of Colorado Springs and Aurora, and the District Engineer.

3.7.4 Store Water in Upstream Reservoirs

The upper Eagle River basin area contains (at least) 89 natural alpine lakes with a total surface area of about 450 acres, and Homestake Reservoir has a full pool surface area of 335 acres. The natural lakes are largely located above timberline in glacial cirques in the upstream valleys. [17]

Three existing major reservoirs in the upper Eagle River basin might be used to temporarily reduce the flow in the Eagle River following a landslide at Dowds Junction. The major reservoirs and their capacities are listed below:

Reservoir	Volume in AF	Drainage Area in Sq. Miles	Percent of Total DA at Dowds Jct. (u/s Gore Ck.)
Homestake Lake	44,360	20	7.7%
Robinson Lake	3,136	2	0.8%
TOTALS	47,496	22	8.5%

Water is imported to Homestake Lake from tributaries of Homestake Creek by collection conduits that extend from the right bank of French Creek and the left bank of the East Fork of Homestake Creek and intercept intermediate tributaries.

3.7.5 Build a New Flood Control Dam

Construction of a new dam upstream of the slide in vulnerable areas could catch a majority of the runoff before a lake was formed. Because such a dam would be structurally sound, the risk of catastrophic flooding downstream would also be substantially reduced. The Homestake Water Diversion Project, Phase II, proposed by the cities of Colorado Springs and Aurora for the upper Eagle River basin could have significant positive impact on the physical ability to mitigate flooding upstream from a landslide at Dowds Junction. Four of the six alternatives described in the Final EIS proposed for this project would reduce flows at Dowds Junction. Estimated average annual depletions range from 19,600 to 38,500 acre-feet. The projected post-diversion depletions on streamflow in the Eagle River below Gore Creek for these alternatives are summarized below. [17] Note that there is a discrepancy between the CWCB estimates and the EIS estimates for mean monthly flow below Gore Creek.

PROJECTED POST-DIVERSION STREAMFLOW
EAGLE RIVER BELOW GORE CREEK

Month	Pre-Diversion Mean Monthly Discharge	Post-Diversion Mean Monthly Discharge (cfs) and Percent of Pre-Diversion Streaflow Depleted					
		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6
Jan.	29.4	29.4	29.4	29.4	29.4	29.4	29.4
Feb.	28.2	28.2	28.2	28.2	28.2	28.2	28.2
Mar.	33.5	33.5	33.5	33.5	33.5	33.5	33.5
Apr.	117.	117.	117.	117.	117.	117.	117.
May	625.	625. (-0%)	498. (-20%)	527. (-16%)	462. (-26%)	625. (-0%)	545. (-13%)
June	1330.	1330. (-0%)	1089. (-18%)	1133. (-15%)	1014. (-24%)	1330. (-0%)	1168. (-12%)
July	600	660. (-0%)	471. (-20%)	500. (-17%)	440. (-27%)	600. (-0%)	518. (-14%)
Aug.	195.	195.	195.	195.	195.	195.	195.
Sept.	97.3	97.3	97.3	97.3	97.3	97.3	97.3
Oct.	71.4	71.4	71.4	71.4	71.4	71.4	71.4
Nov.	46.9	46.9	46.9	46.9	46.9	46.9	46.9
Dec.	34.6	34.6	34.6	34.6	34.6	34.6	34.6

These diversions are shown in the EIS to have a potential to reduce inflow to Dowds Junction during the critical months of May, June and July from 12 to 27 percent under average operating conditions.

In addition, the Denver Water Department has proposals for the development of the Eagle-Piney and East Gore collection systems which would impact runoff at Dowds Junction. The East Gore Unit is estimated to yield 59,000 acre-feet from the upper Gore Creek basin. The Eagle-Piney Unit has an estimated annual yield of 64,000 acre-feet from the upper Eagle River basin. These potential projects will necessitate that facilities be constructed in the Eagle's Nest Wilderness. This activity would require a Presidential exemption or an Act of Congress prior to construction. [17]

3.7.6 Construct a Pre-slide Outlet Works

A large conduit could be placed before a slide occurs to allow immediate drainage if a "Thistle-type" dam was formed. This conduit would lay idle until used. Such a conduit could be constructed as a multipurpose concrete box culvert or as a pipeline. A pipeline could be laid as a series of pipes of various diameters or consist of pipes of various diameters laid parallel to each other to handle all or part of the flow. A pipeline could be made out of precast reinforced concrete pipe (RCP) or corrugated metal pipe (CMP).

Corrugated metal pipes have a strength limit. The cover (height of embankment over the conduit) is limited by the size (diameter) of the conduit and the gage (thickness) of the metal. If the fill limit is exceeded, the conduits could collapse. The following figures provide a quick estimate of the expected rate of discharge for various lengths of pipe under various heights.

Conduits should be located in competent material on the hill on the opposite side of the Eagle River from the landslide. If the landslide extends under the Eagle River and includes part of the opposite bank, this alternative must be carefully evaluated to avoid placing a pipeline in unstable material. The most desirable location would appear to be adjacent to the railroad tracks. Additional drain pipes could be installed at higher elevations in anticipation of the slide continuing to move. If there is rock on the hillside opposite the moving soil mass, a ledge could be excavated and a pipe installed in it.

The conduits should be carefully placed and the fill around the conduit should be of select non-permeable material and properly compacted. If the above standards are not maintained, a piping failure could result.

A large stock of several hundred or thousand feet of 24-inch, 36-inch, and 48-inch pipe and possibly 60-inch pipe would be required. Two Colorado companies that usually have a large stock of large diameter pipe on hand are:

Armco (phone 455-4080)
Thompson Pipe and Steel Company (phone 292-4080).

The approximate cost per foot of various pipe sizes are listed below for estimating purposes. Transportation, excavation, and installation charges would be additional. Pipes could be routed to the site by truck via I-70 or by train on the D&RGW Railroad.

Diameter	Cost per Foot	
	CMP	RPC
24"	$25	$40
30"	$30	$65
36"	$40	$80
48"	$45	$90
60"	$50	$100

The following provides an indication in feet of the necessary pipeline lengths, elevation differential (or head) available, and the estimated capacity of one 60-inch pipe at each of the four slides:

Slide	Approximate Maximum Required Length	Maximum Available Head in Feet*	Approximate Discharge w/ one 60" RCP
Meadow Mountain	4000	85	185 cfs
Dowds No. 1	1500	30	200 cfs
Dowds No. 2	1000	20	185 cfs
Whiskey Creek	4500	100	180 cfs

* To avoid inundation of the Town of Minturn.

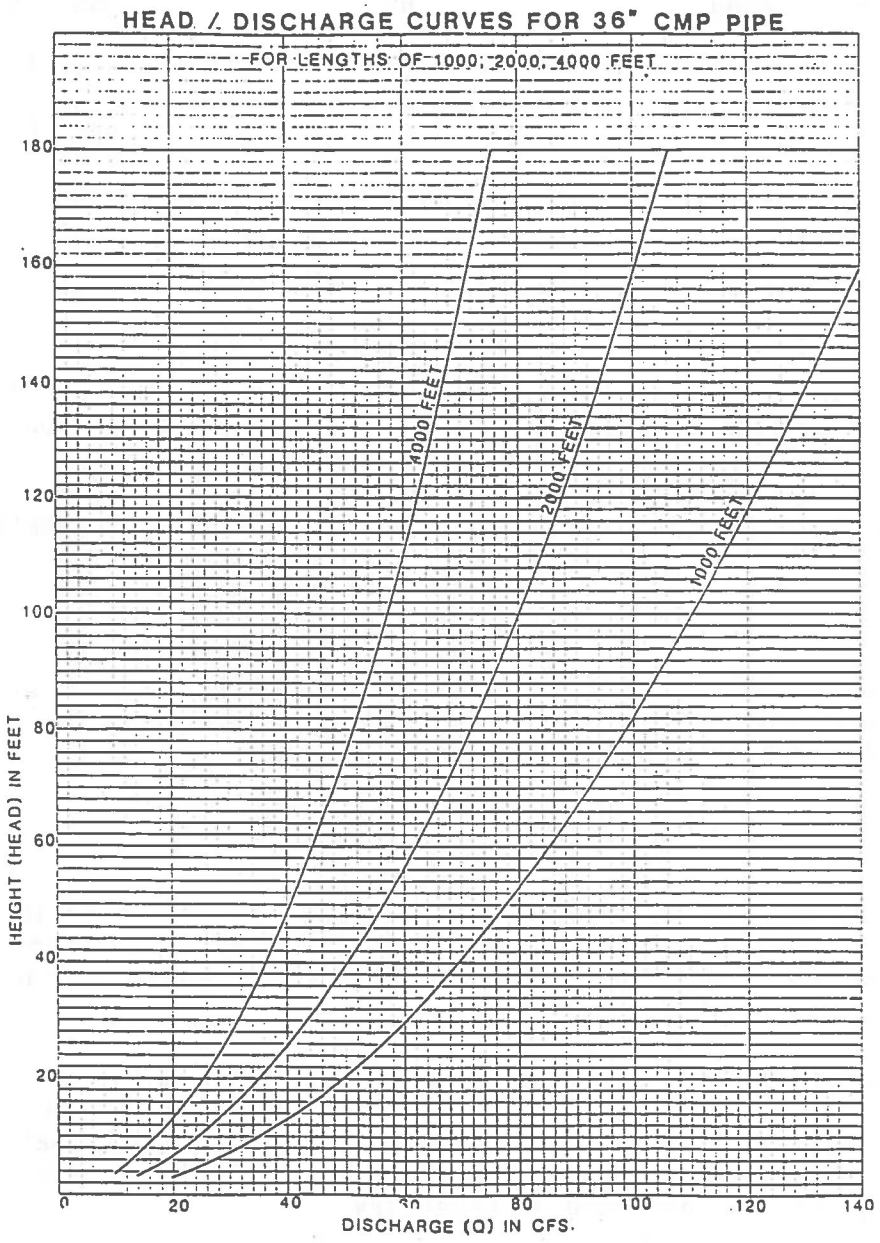
From the above table, it is apparent that four 60-inch pipelines would be necessary to pass the mean monthly flow opposite Meadow Mountain and five 60-inch pipelines would be needed for the other slides.

The cost to lay 4,000 feet of a single 60-inch RCP is approximately:

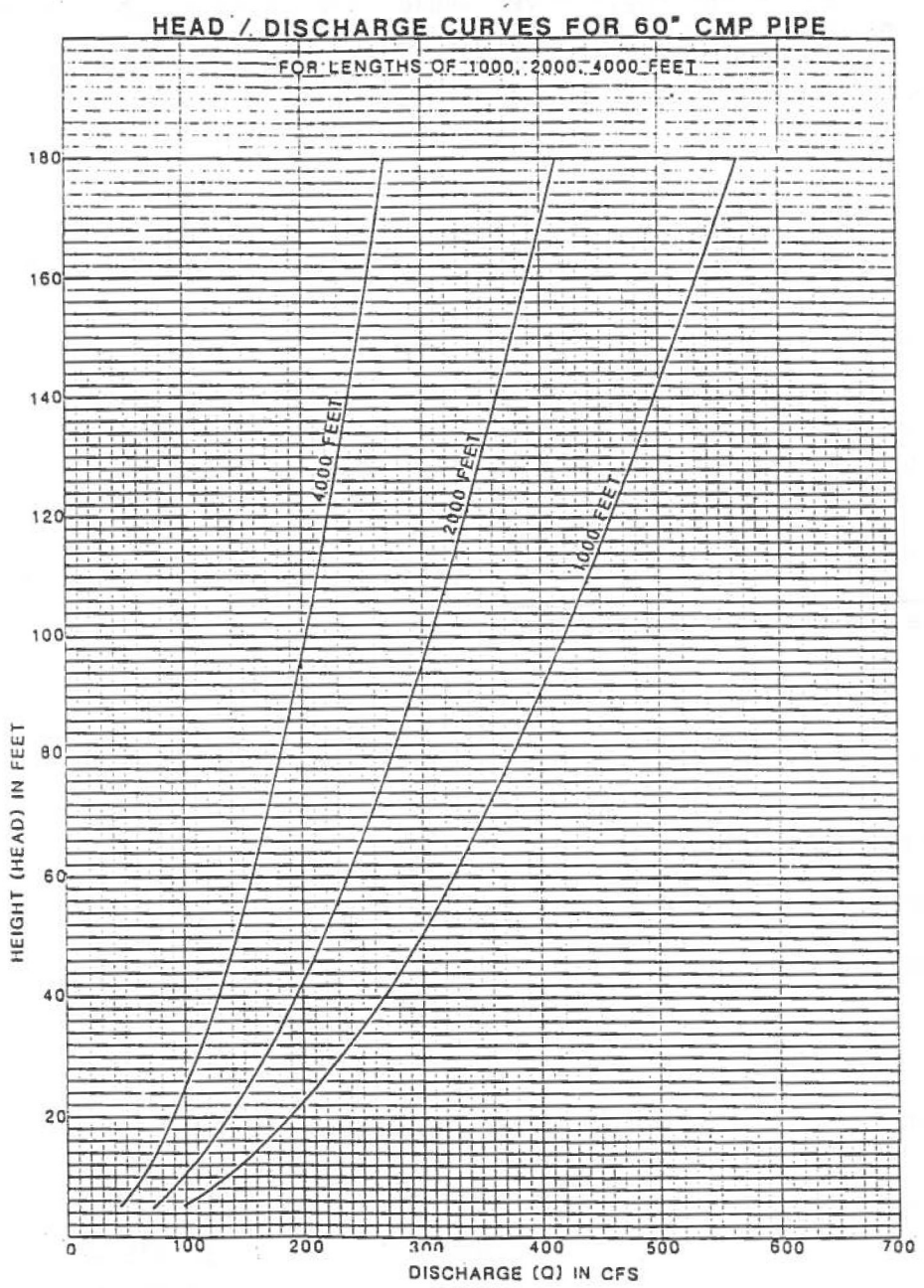
Item	Cost
Shipping	$100,000
Materials (4000 x $100) =	400,000
Labor and Equipment	800,000
Other (at 25% of Construction)	300,000
Total	$1,600,000

Due to the length of time required to lay just one pipeline of these dimensions (estimated at 40 days to lay 4,000 feet at 100 feet per day), this alternative is not considered feasible as an option during an emergency.

An oversized water main could also be constructed. Should a slide occur, the water main could be converted to a slow drain pipe. Any other conduit such as for natural gas, oil, chemicals or penstock that may exist could be converted to a drain. Other available abandoned pipelines should also be investigated and used if necessary.



Graphs of Discharge for Various Pipes of Various Lengths and Head.



Graphs of Discharge for Various Pipes of Various Lengths and Head.

3.7.7 Divert the River Around the Slide

Canals could be excavated at above elevation 8000 feet in the hillside opposite the slide to carry the Eagle River and Gore Creek around any dam that might be formed by a slide. The diversion canal must have sufficient carrying capacity and slope to carry the peak discharge without suffering damage from erosion. The canal could be natural or lined. Trestles may be necessary to cross tributary drainage paths. The point of diversion on the Eagle River would have to be about five miles above the confluence with Gore Creek. The point of diversion on Gore Creek would be about four and one-half miles above its mouth. The following table describes the general dimensions in feet of the proposed canals:

Slide	Approx. Length	Approx. Depth*	Approx. Width*	Top Width	Carrying Capacity	Stream Crossings
Meadow Mountain Slide	4.5 mi.	8	16	48	1000 cfs	1
Whiskey Creek Slide	4.5 mi.	4	13	29	500 cfs	4
	0.5 mi.	6	16	40	1000 cfs	1
	1.4 mi.	8	16	48	1500 cfs	1
TOTALS	10.9 mi.					7

* At 2:1 side slopes and V = 6ft./sec.

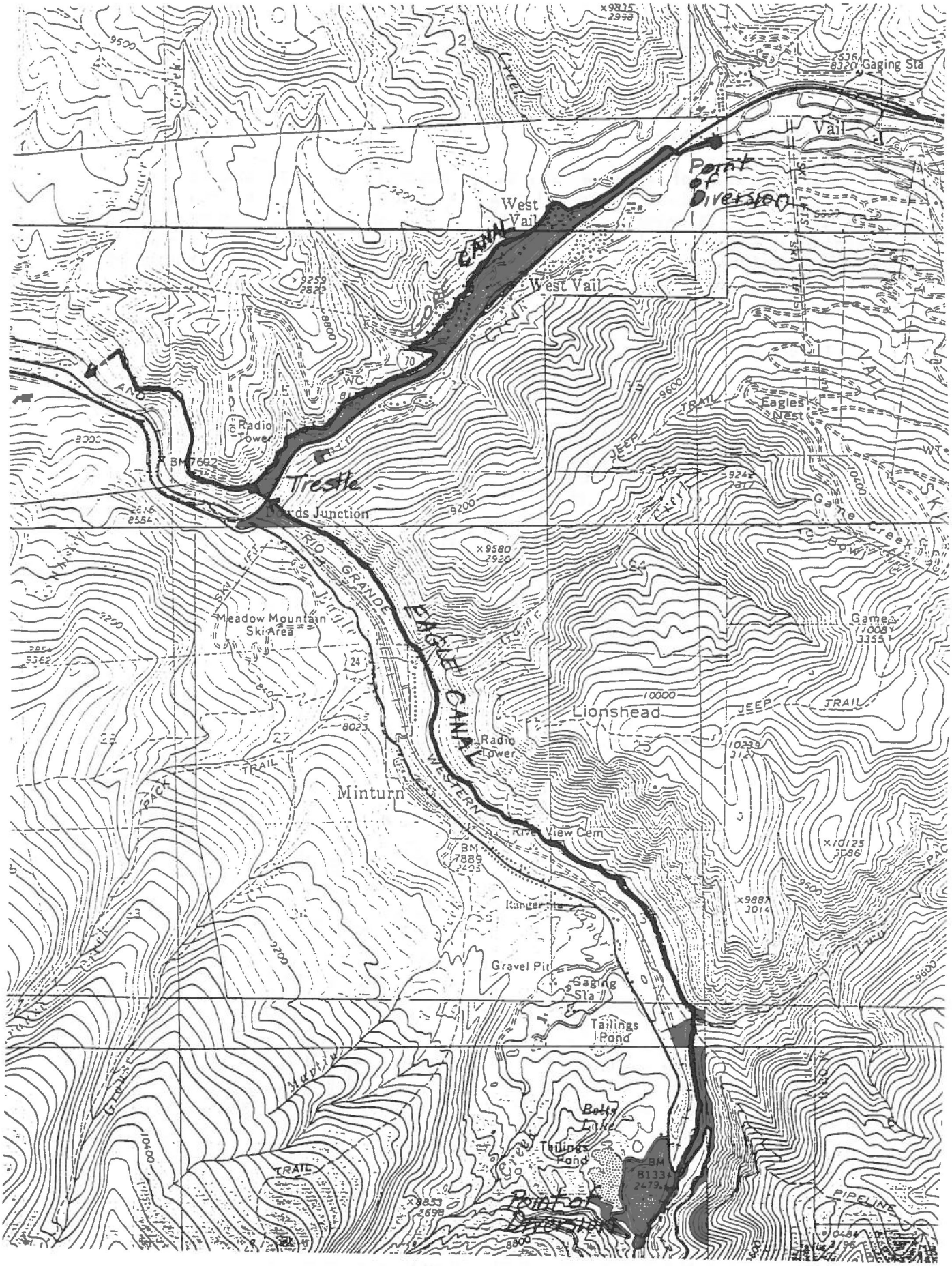
A preliminary cost estimate for the canal option is shown below:

Meadow Mountain Slide

Excavation	352,000 cu. yds. @ $3.00	=	$1,056,000
Crossings	1 @ $200,000	=	$ 200,000
Other @ 25%		=	$ 314,000
	SUBTOTAL	+	$1,570,000

Whiskey Creek Slide

Excavation	380,000 cu. yds. @ $3.00	=	$1,140,000
Crossings	5 @ $200,000	=	$1,000,000
	1 @ $400,000	=	$ 400,000
Other @ 25%		=	$ 635,000
	SUBTOTAL	=	$3,175,000
	TOTAL FOR BOTH SLIDES	=	$4,745,000



Map of proposed Diversion Canals

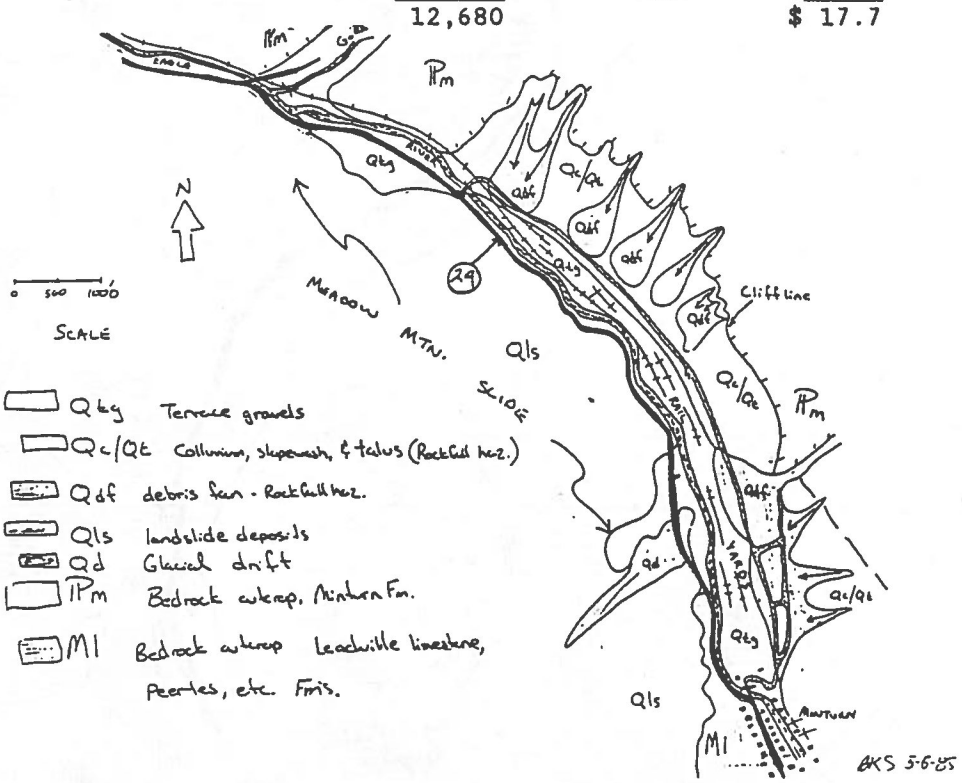
3.7.8 Excavate a Tunnel

Construction of a tunnel may be technically feasible when competent material is available. A tunnel was constructed in Utah at the Thistle Slide in 1983. However, construction of a tunnel is time consuming and expensive. A good portion of the area upstream of the slide could be inundated before the tunnel is functional. Such a tunnel should be constructed large enough to handle the flow of the river at the potential landslide.

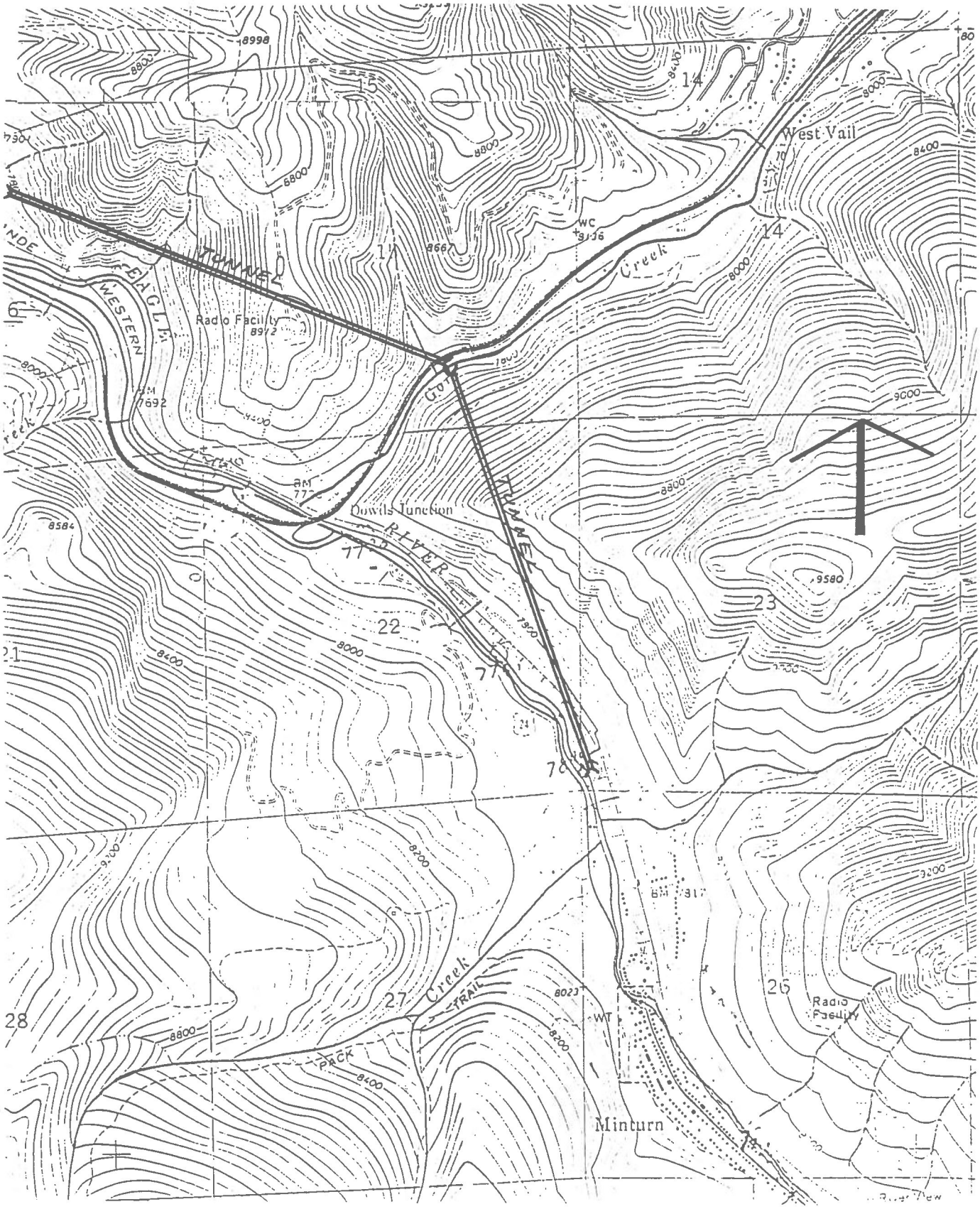
In certain cases, a multipurpose tunnel may be practable with the idea that it could also serve as a diversion structure for the river. Examples of this could include a highway, railroad, or mine tunnel.

The 1,800 foot long drainage tunnel excavated at Thistle, Utah was approximately 12 feet high and 10 feet wide. It took over 60 days to complete and cost $ 2.5 million. This is equivalent to about 30 feet per day and $ 1400 per foot. The following table summaries the time and dollar effort it would take to construct a similar tunnel at Dowds Junction assuming the same rate of progress and cost.

Tunnel	Length (feet)	Time (days)	Cost (millions)
Meadow Mountain Tunnel	5,810	194	$ 8.1
Whiskey Creek Tunnel	6,870	229	$ 9.6
	12,680		$ 17.7



Preliminary Geologic Map of the Eagle River valley near the toe of the Meadow Mountain Landslide



Preliminary Map of Proposed Tunnel Alignments

3.8 Wait Until the Last Minute

3.8.1 Maintain Conveyance Capacity of the Channel

There is essentially a very small range of soil mass flow rates during which human effort can effectively mitigate the potential damming of a river. There are basically four possible stages of a slide. They are:

1. The slide does not move. No effort is required.

2. The slide moves very slowly. The river erosive forces will keep the river channel open. Human effort is not needed, but could be helpful.

3. The slide moves faster than the river can keep the channel open. With the aid of men and machinery, it may be possible to keep the channel open. However, this possibility is dependent on the soil mass flow rate being less than the machine and water flow excavation rate. The use of dynamite to keep the channel open has been suggested. However, dynamite is more suited for solid rock than the soft, wet material that will most likely be encountered in a mudflow. Release of water from upstream storage reservoirs might help flush out slide material.

4. The slide moves faster than the river, reservoir releases, human effort and machinery can handle. A dam will be formed.

Permission to work in the river must first be obtained from the Corps of Engineers (a 404 permit) and the Forest Service if it impacts Forest Service land. The Highway Department may be able to provide the resources to fight the slide initially. The Corps of Engineers may also have authority to provide technical and financial assistance during a flood fight. Such assistance should be coordinated through the Division of Disaster Emergency Services. A list of equipment resources available to the county should be included and updated annually in the Eagle County Emergency Preparedness Plan.

3.8.2 Provide a Seepage Path in the Slide

It has been suggested that crushed gravel could be hauled in or that rock could be blasted from the opposite hillside to form a drainage or seepage path for the water to flow through the slide. However, this could be dangerous because of the potential that piping may cause the slide to fail along the rock/soil interface. The track ballast at the Thistle slide in Utah was reported to have initially flowed a significant amount of water and this weak point in the dam ultimately became a concern leading to its removal.

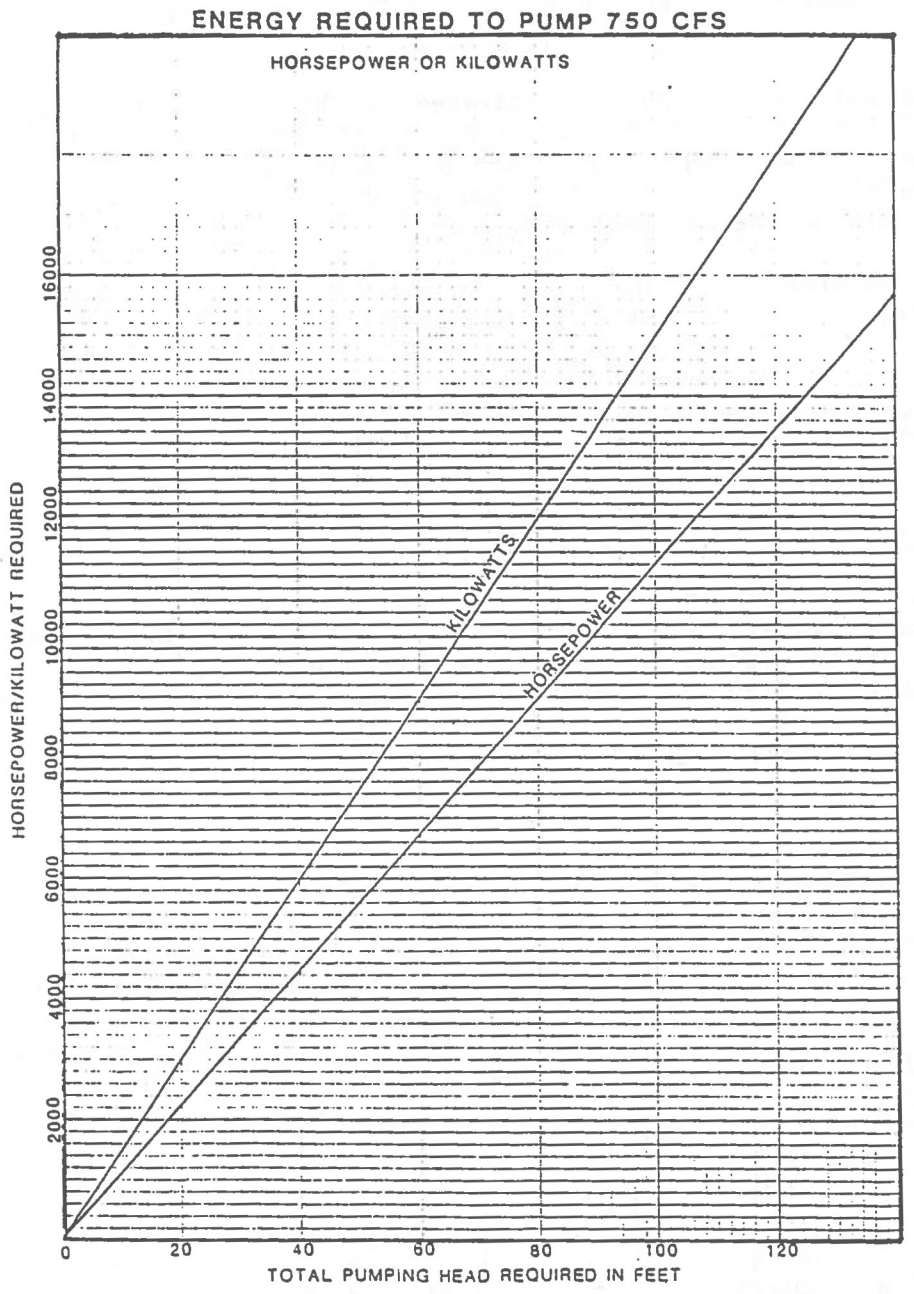
3.8.3 Siphon Water Over the Slide

Construction of a a siphon may be difficult since the slide may continue to move. Experience at the Thistle slide in Utah demonstrated that this option was not successful at that location. The siphon pipe was pulled apart as the soil mass continued to move.

3.8.4 Pump Water Over the Slide

Large capacity (30 to 50 cubic feet per second) pumps could be rented to pump water over the dam. Unfortunately, no high capacity pumps are known to be readily available in Colorado. However, such pumps may be available for rent from companies in Texas or Florida. The rental fee is approximately $1000/pump/month. Pumps from Texas could be shipped and be on the job within about 48 hours. At Thistle, Utah the pumps were placed on a barge floating in the reservoir.

About fifteen 50 cfs pumps would be needed to pass the mean monthly inflow at Dowds Junction. If this option is seriously considered, the large amount of electrical power required to run the pumps must also be evaluated. If the existing power lines at the slide are insufficient to carry the load, special measures may be necessary. Power requirements in kilowatts or horsepower for various pumping heads are shown in the following graph.



Graph of the Energy Required to Pump 750 cfs under Various Head.

3.8.5 Excavate an Overflow Spillway in the Dam

Once significant slide movement has ceased, an overflow spillway could be excavated in the slide dam to control water surface levels. A technique using a polyvinyl chloride blanket (visqueen or hyperlon) liner (30-40 mil thick) to control erosion has been found to be a reasonable approach by the Dam Safety Branch of of the Division of Water Resources (DWR).

First, a spillway channel is excavated on the crest and downstream of the face of the dam. A fuse plug is placed at the crest and the liner is laid in the spillway beginning at the bottom and working upslope with overlapping panels anchored into the dam on their upstream edge. This technique was used at the old Georgetown Dam.

Another technique that has been suggested is a material which is applied by spraying and is reported to be commercially available.

The DWR could develop specifications for this method which would allow Eagle County to stockpile the necessary supplies and include the procedure in their Emergency Plan.

3.8.6 Blast an Overflow Spillway in the Hillside

The idea behind this measure is to place the overflow spillway in competent material so erosion of the dam will not occur. The excavated rock may be used to protect or armor the downstream face of the slide dam. Some concerns raised about this suggestion have been the uncertainty of the elevation to place the spillway, the dangerous use of dynamite, and the limited access from the slide or from the hillside above.

3.8.7 Cause a Controlled Failure of the Slide Dam

It is doubtful that the Division of Water Resources, responsible for dam safety, would allow the dam formed by a mudslide to remain even if there is strong support for creation of a state recreation area in the lake formed by a dam. The concern is that such a lake could saturate the toe of landslides upstream of the dam and cause additional sliding. Such slides could displace a sufficient volume of water in the reservoir causing the dam to be overtopped. Thistle Lake in Utah was eventually drained for the same reasons.

The release of the water behind the dam might be accomplished under a controlled breaching process. This process begins with the construction of a temporary coffer dam, installation of of a pipe a few feet below the top of the dam and breaching to the level of the pipe. This process is then repeated several times. A major problem with this method is the increased sediment that will be transported down river. This sediment would impact operation of water and sewage treatment plants and harm fish and wildlife habitats.

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OPTIONS TO MITIGATE POTENTIAL DAMAGES FROM EARTHFLOWS NEAR DOWDS JUNCTION, COLORADO

TECHNICAL APPENDIX I

DESIGN OF EARTHFLOW MONITORING SYSTEM

INTRODUCTION

Concern for determining the extent and seriousness of the threat from several landslides at this location was brought to the attention of the CGS through Eagle County officials and DODES staff in March of 1985. This was triggered by slide activity affecting both U.S. Highway 24 and Interstate 70 early in the spring of 1985. At an early stage CGS met with the Colorado Department of Highways (CDOH) District Engineer and staff. During this meeting a plan for limited but immediate instrumentation and complete detailed geological field study later in 1985 was agreed upon.

Increasing levels of concern from Eagle County and DODES prompted CGS to make an office study to try and determine if more urgent action was needed. This study documented a definite trend of steadily increasing soil moisture over the past 3 or 4 years in Eagle County. Recognition of this condition plus considerable geological similarity between the Dowds slides and the situation at Thistle, Utah in 1983 gave cause for concern. (The Thistle, Utah slide had blocked the Spanish Fork River, created a lake and caused extensive damage to public and private facilities and property.) This information was presented to David Getches, Executive Director, Department of Natural Resources who felt that it would be prudent to consider an increased level of surveillance in addition to the more leisurely investigations already planned by CDOH & CGS. Discussions between Mr. Getches and the Governor's office resulted in the Governor forming a Landslide Task Force to evaluate and address the Dowds Junction situation.

The Task Force met approximately weekly under the leadership of Ron Cattany of the DNR. Through the committee various affected and contributing agencies and individuals were identified and liaison established. A more aggressive schedule of studying and monitoring the slides was devised and undertaken, emergency response plans and exercises were implemented and various contingencies were considered and discussed at length in the meetings. The Task Force also assisted DODES in planning and carrying out two emergency exercises for the Dowds Junction area.

EXPLORATION DRILLING AND INSTRUMENTATION

To better understand and monitor the slides the Task Force initiated a program consisting of four parts.

1. Exploratory core drilling was used to determine composition of the slide, the depth to the basal shear surface and water conditions within the slide masses.

2. In order to monitor changes of water level at certain key locations some drill holes were completed as hydrologic observation wells.

3. Electronic distance measurement (EDM) techniques were decided upon to provide quick and relatively inexpensive data on the rates of downslope movement on the surface of slide areas. This system consists of fixed reflector target posts at key locations on the slide. These are read for distance periodically from strategically located instrument stations on stable ground. If succeeding distance measurements decrease, downslope movement is indicated. Stable or constant distance readings indicate no significant movement at a particular monitoring station. A total of 27 EDM monitoring stations were established during the field work and observations were begun on each soon after installation. The attached table prepared by CDOH shows the monitoring history of each station during 1985 as computed by the Colorado Department of Highways, Grand Junction. CGS plotted the weekly readings on histograms showing change since previous reading. Two of the EDM charts are attached, Fig. 1 shows a history of movement, Fig. 2 at an apparently stable station, shows small variations (plus and minus) representing normal instrument and reading variations of the system.

   The advantages of this type of monitoring include: a) it is easy and fast to install and has relatively little environmental or aesthetic impact, b) if carefully selected many sites can be read from a single remote stable instrument station, c) cost of installation and monitoring is relatively low. and d) data can be analyzed and preliminarily interpreted immediately in the field when necessary. Limitations of the method include a) information on downslope movement does not give any indication of the depth of instability or movement (this is critical because greater depth implies larger volumes of material and increased potential for damage or disaster), b) line of sight is necessary between the instrument station and the monitored site, this can be a severe limitation in heavily wooded areas or where microtopography is extreme, and c) it yields no information on the composition and properties of the slide material or hydrologic conditions within the mass.

4. Inclinometer installations were selected to provide information on the location and geometry of sliding at greater depth. For this type of instrumental monitoring a drill hole is bored at a location of interest and a special casing is installed to a depth believed to be somewhat deeper than the slide material. Actual measurements are made by lowering a special instrument that is guided by grooves in the casing. The instrument is lowered twice - first in one set of grooves then along grooves at right angles to the first. From the two instrument readings any deflections (bending) can be located and measured and a vector (direction) of movement determined. With this data and an EDM reading at the site any movement can be described in three dimensions. This is very advantageous in understanding slide movement, designing engineering mitigation or anticipating the seriousness and consequences of new movement.

Figure 3 is an index map showing location of the four slides and the instrument arrays that were installed at Dowds Junction.

GEOLOGIC SITE WORK

James Soule, a senior CGS geologist, provided technical services and oversight in the drilling and instrumentation program. In addition detailed field observations were made and noted as snow cover decreased. A summary of this work is included as a subsequent section of this report.

CONCLUSIONS AND RECOMMENDATIONS

A monitoring system very close to the initial design is now in place at Dowds Junction and observations should be continued for at least two years or until prevailing high soil moisture conditions have returned to normal. Our initial evaluation from field and instrumental observations is that there continues to be a very real threat especially to the transportation corridors. Larger than historical but not catastrophic events accompanied by higher maintenance costs and lengthy highway closures seem probable unless feasible engineering mitigation measures can be devised and put in place. At least minor blockage of the adjacent streams is also possible. The upper regions of all four slides do not appear to currently be actively moving. This seems to preclude imminent major catastrophic slides, and continued surveillance of instruments in place from approximately March through July of each year will allow any major changes in stability to be observed. It should be noted that significant enlargement of currently active parts of any of the four slides (the most probable scenario) is to be expected and should be the subject of continuing planning.

The landslide alert and surveillance has in our opinion been a very valuable experience for all concerned. For the technical people from CGS and CDOH it demonstrated that even with an urgent mission considerable time is required to get a monitoring system in place and operational. This was primarily owing to the fact that it was done in difficult terrain and at a time when access was most difficult -- while a heavy snow pack was melting and running off.

Our preliminary recommendations for minimizing the damage from existing slides and decreasing the potential for future much larger slides includes:

1) A reasoned program to improve surface water management should be undertaken especially in the lower half of the Meadow Mountain slide. Some initial efforts with this have been made by CDOH near U.S. Highway 24 and some additional recommendations are contained in our attached preliminary geologic report. More comprehensive recommendations can be made based on our forthcoming detailed geologic report for CDOH that includes new and accurate topographic mapping.

2) Based on water level observations in the spring of 1986, methods for dewatering of active slide areas on Dowds No. 1, Dowds No. 2 and the east lobe of the Whiskey Creek slide should be devised. Stabilization of the currently active lower parts of all four slides is a critical factor in preventing future larger and much more serious slide activity.

3) If funding is available, the inclinometer drill hole #10 on Whiskey Creek slide should be recompleted to serve as a monitor for possible deep movement on the active east lobe. Also, one additional drill hole on the "intermediate" slide on Meadow Mountain should be drilled and instrumented to better define the depth of this slide.

4) Arrangements should be made for funding of regular monitoring of all operational EDM, inclinometer and hydrologic stations on the Dowds Junction slides in the spring and summer of 1986.

5) CDOH & CGS technical staff should evaluate this monitoring and advise other State and local governments of significant changes.

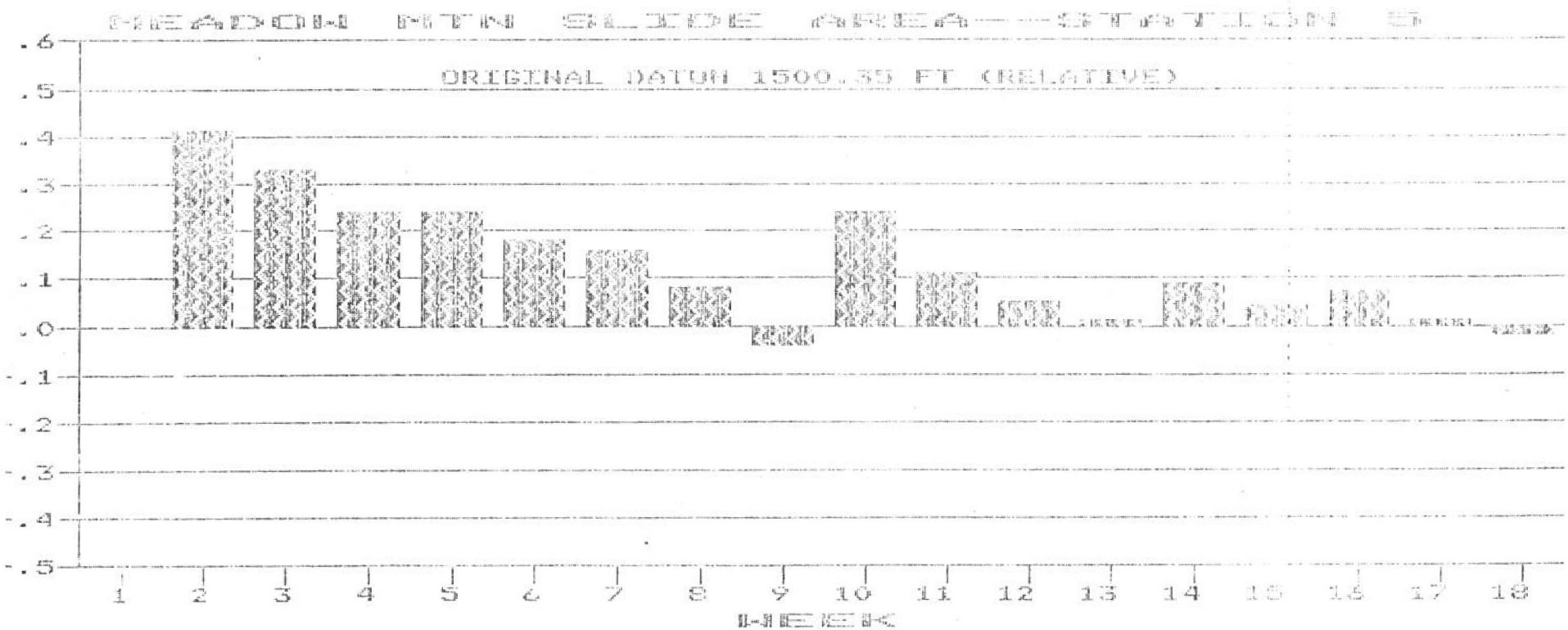


figure 1. This shows two cycles of movement followed by stability.

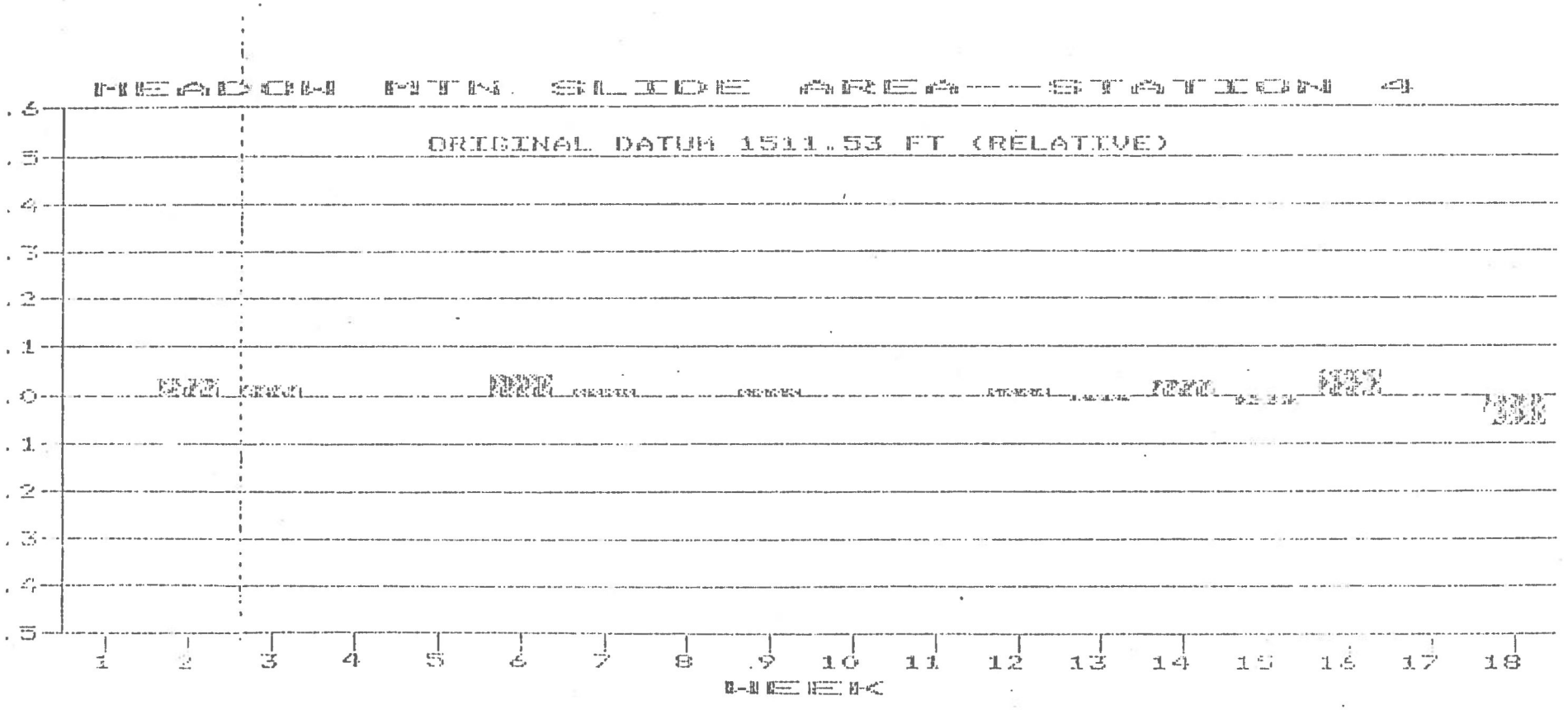
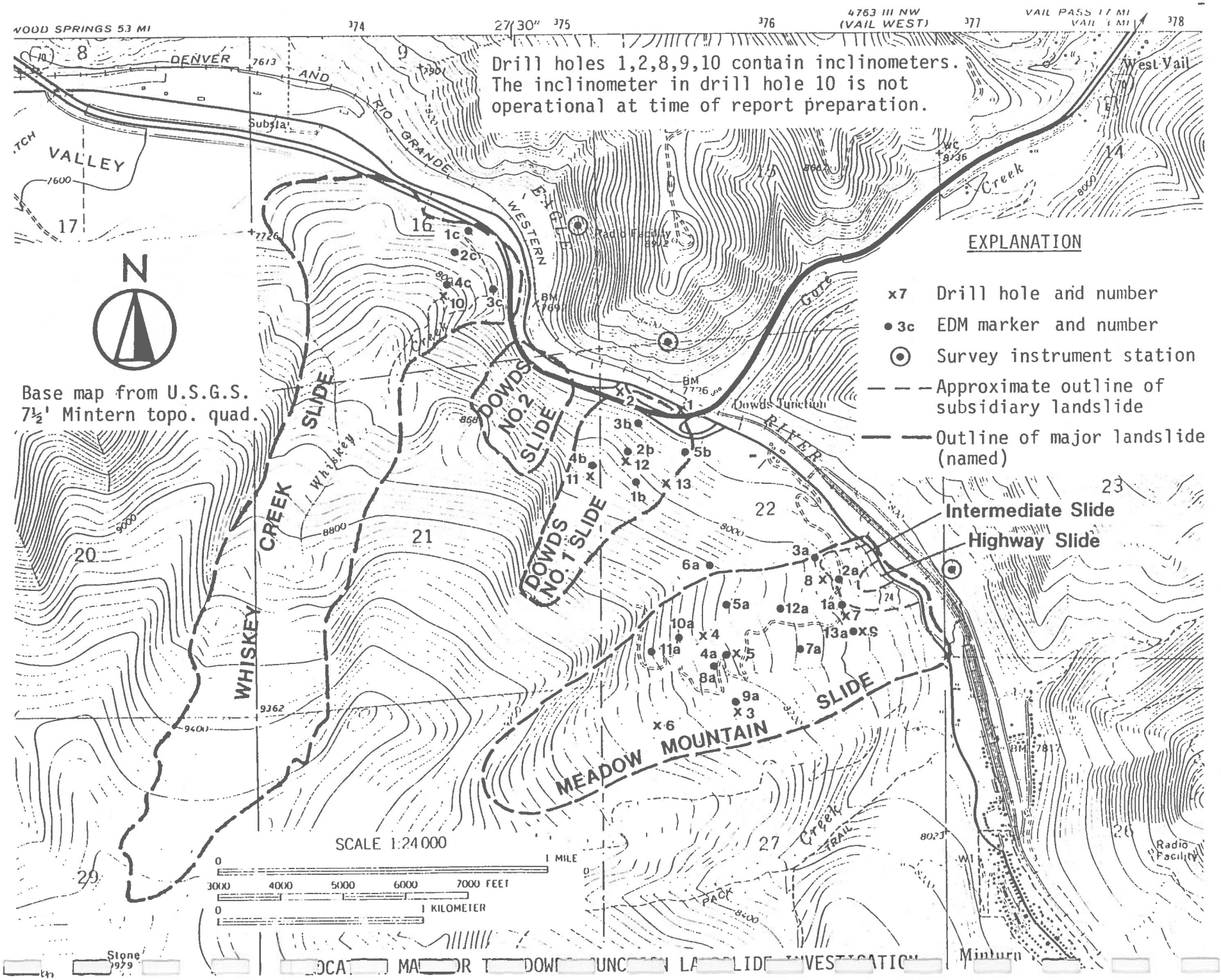


figure 2. Eighteen weekly readings show no significant movement.

figure 3


Drill holes 1,2,8,9,10 contain inclinometers.
The inclinometer in drill hole 10 is not
operational at time of report preparation.
EXPLANATION
x7 Drill hole and number
• 3c EDM marker and number
Survey instrument station
Approximate outline of subsidiary landslide
Outline of major landslide (named)
Base map from U.S.G.S.
7½' Mintern topo. quad.
N
WHISKEY CREEK SLIDE
DOWDS NO. 2 SLIDE
DOWDS NO. 1 SLIDE
MEADOW MOUNTAIN SLIDE
Intermediate Slide
Highway Slide
Dowds Junction
EAGLE RIVER
DENVER AND RIO GRANDE WESTERN
Subsla
West Vail
Radio Facility
Creek Trail
Pack
SCALE 1:24 000
1 MILE
3000 4000 5000 6000 7000 FEET
1 KILOMETER
Stone
Mintern

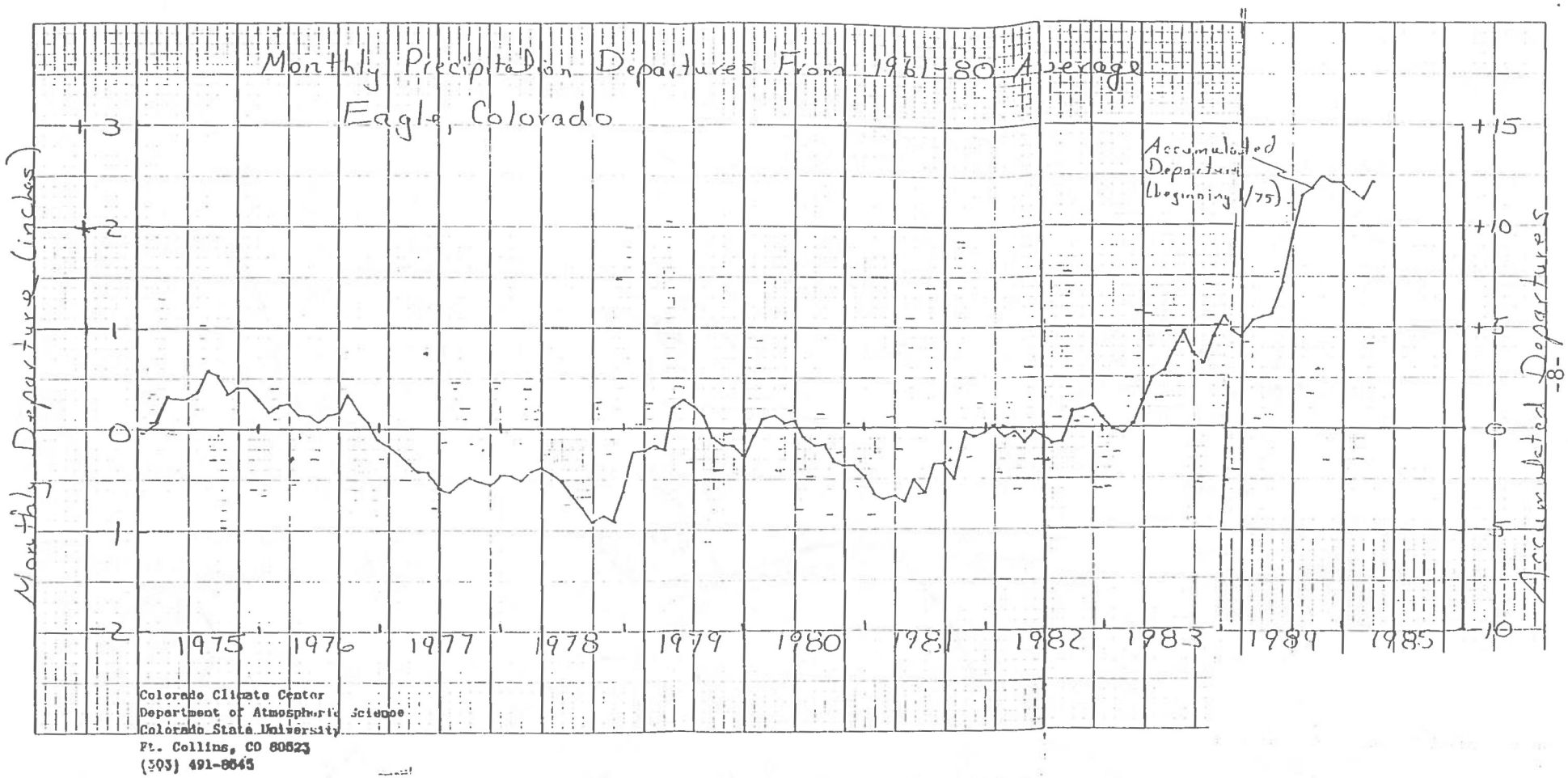


Figure 4. Graph of accummulated soil moisture plotted by the Colorado Climate Center.

TABULATION OF EDM READINGS AT DOWDS JUNCTION IN 1985

	5-1-85	5-8-85	5-16-85	5-23-85	5-30-85	6-6-85	6-13-85	6-20-85	6-27-85	7-3-85	7-11-85	7-17-85	7-26-85	8-2-85	8-9-85	Total
1.	.05'	.01'	.01'	.01'	.04'	.04'	.03'	.01'	-.03'	.04'	-.02'	.04'	-.01'	.04'	-.06'	.20'
2.	.04'	.02'	.00'	.01'	.02'	.01'	.03'	.01'	-.02'	.03'	-.01'	.00'	.01'	.02'	.05'	.22'
3.	.00'	.00'	.00'	.01'	.00'	.00'	.03'	.01'	.00'	-.01'	.00'	.01'	.00'	.05'	-.05'	.05'
4.	.03'	.02'	.00'	.00'	.04'	.04'	.01'	.00'	.00'	.01'	-.01'	.03'	-.02'	.05'	.00'	.20'
5.	.41'	.33'	.24'	.24'	.18'	.16'	.04'	.24'	.11'	.05'	.01'	-.09'	.04'	.07'	.01'	2.04'
6.	.04'	.01'	.02'	.02'	?	.01'	.03'	.03'	-.01'	.01'	.00'	.04'	.00'	.03'	.01'	.24'
7.	.00'	.00'	.00'	.00'	.03'	.00'	.01'	.01'	.00'	.00'	-.01'	.05'	-.03'	.03'	.01'	.10'
8.	.34'	.29'	.21'	.21'	.14'	.15'	.01'	.12'	.09'	.05'	.04'	.03'	.05'	.03'	-.01'	1.75'
9.	.37'	.36'	.24'	.23'	.18'	.15'	.08'	.13'	.14'	.02'	.12'	.01'	.02'	.06'	-.01'	2.10
10.	.03'	.03'	.02'	.02'	.03'	.02'	.02'	.00'	.01'	.04'	-.04'	.06'	-.04'	.04'	-.03'	.21'
11.	.29'	.27'	.19'	.18'	.14'	.15'	.09'	.13'	.17'	.02'	-.09'	-.01'	.04'	.06'	-.01'	1.62'
12.	.25'	.25'	.18'	.14'	.13'	.09'	.01'	.13'	.08'	.11'	.03'	-.01'	-.02'	.06'	-.01'	1.42'
1A.				-.04'	.04'	.02'	.04'	.02'	-.04'	.06'	-.02'	-.02'	-.01'	.07'	.01'	.13'
2A.				.00'	.01'	.03'	.04'	-.01'	-.20'	.04'	-.03'	.01'	.01'	.02'	.04'	-.04'
3A.				-.03'	.00'	.05'	.02'	-.02'	-.01'	.04'	-.01'	-.01'	.02'	.03'	.03'	.11'
4A.				.04'	.03'	.10'	.09'	-.01'	-.05'	.11'	-.03'	.00'	.02'	-.01'	.00'	.29'
5A.				.00'	.04'	.08'	.09'	-.03'	-.14'	.18'	-.09'	-.02'	-.01'	.02'	.01'	.13'
6A.				.10'	-.04'	.02'	.08'	-.02'	-.05'	.09'	-.02'	-.03'	.00'	.05'	-.07'	.11'
7A.				.09'	-.02'	.02'	.06'	-.03'	-.02'	.05'	.00'	-.08'	.07'	.02'	.03'	.18'
8A.				.07'	.00'	.08'	-.02'	.00'	-.03'	.09'	?	-.06'	-.03'	.02'	-.01'	.11'
9A.				-.13'	.03'	.06'	.03'	.01'	-.10'	.14'	-.05'	-.04'	.01'	.00'	.00'	-.04'
10A.							.03'	-.06'	-.13'	.08'	.06'	-.06'	-.02'	-.03'	.02'	-.11'
11A.							.37'	-.08'	-.15'	.11'	.06'	-.11'	.00'	.10'	.00'	.30'
12A.								-.01'	.11'	-.06'	.05'	-.09'	.13'	.15'	.28'	
13A.								-.01'	.03'	.01'	.01'	-.02'	.05'	.01'	.08'	
1B.								-.06'	.06'	-.02'	.09'	-.04'	.04'	.07'	.14'	
2B.								.01'	.01'	.04'	-.03'	-.02'	.07'	.00'	.08'	
3B.								.05'	.04'	-.04'	.03'	.00'	.00'	.01'	.09'	
4B.								.01'	.03'	.01'	-.01'	-.01'	.03'	.01'	.07'	
5B.								.04'	-.08'	.06'	-.01'	-.02'	.06'	-.04'	.01'	
1C.								-.02'	.10'	-.06'	-.02'	.05'	-.05'	.08'	.08'	
2C.								-.07'	.04'	-.01'	.00'	-.01'	.06'	-.05'	-.04'	
3C.								-.04'	.03'	-.02'	.02'	-.01'	.02'	-.03'	-.03'	
4C.								-.01'	.00'	.00'	.01'	-.01'	.03'	-.01'	.01'	
East Abutment - (I-70 Bridge over the Eagle River at Dowd)																
								--	--	-.02'	-.02'	-.03'	-.01'	.01'	-.07'	
West Abutment																
								--	--	-.03'	.01'	-.04'	-.03'	.01'	-.08'	

DATE: August 13, 1985

AUG 14 1985

COLO. GEOL. SURVEY

TO: Messrs. Dolan, and Clevenger

FROM: Robert K. Barrett

SUBJECT: Meadow Mountain Slide Monitoring

Following the EDM readings taken at the Meadow Mountain Slide Area, located west of State Highway 24 between Dowd Junction and Minturn. Attached is a map showing the general area and a map showing the study area and EDM point locations. Each set of readings represents a subtraction from the most recent preceding set. The format facilitates quick determination of trends.

The column on the right is cumulative movement since the initial reading for that point. Initial readings for points 1 through 12 were taken April 24, 1985. Initial readings for points 1A - 9A were taken May 15, 1985, and on June 6 for points 10A and 11A. A minus sign indicates an apparent uphill movement. This probably indicates a minor error in the mechanics of the system.

OPTIONS TO MITIGATE POTENTIAL DAMAGES

FROM EARTHFLOWS NEAR DOWDS JUNCTION, COLORADO

TECHNICAL APPENDIX II

RECONNAISSANCE, INSTRUMENTATION AND MONITORING OF THE MINTURN SLIDE COMPLEX

RECONNAISSANCE, INSTRUMENTATION AND MONITORING OF THE MINTURN SLIDE COMPLEX

SUMMARY

A cooperative effort between the CGH and CDOH has resulted in a preliminary determination of landsliding potential in the vicinity of Dowds Junction. It appears that massive catastrophic landsliding is not an immediate threat for any of the four large landslide areas, but continued activity of parts of these landslides can be expected to disrupt highway service and cause maintenance problems. Large scale landsliding has occurred in the past, and is still possible. The most prudent course of action as long as the current cycle of high soil moisture prevails is to continue monitoring and observation of all of these landslides. This will entail some ongoing costs and require continued coordination among the involved state and local government agencies.

The three instrumentation systems installed on the Meadow Mountain, Dowds No. 1, and Whiskey Creek landslides in 1985 were not completed and monitored early enough in the season to make definitive recommendations based on 1985 measurements. The real value of these systems will become apparent in 1986 and subsequent years when observations can be made through the entire high-risk season and technical difficulties with them are overcome.

The Meadow Mountain landslide should have surface water movement on and across it minimized as soon as possible and this should be maintained unless future study shows a lack of correlation between surface-water concentrations and active landsliding. Consideration should be given to improving the highway detour around the landslide-damaged part of U.S. Highway 24 as it probably will be needed in subsequent years. In future years if rapidly increased movement of EDM points on the Meadow Mountain landslide or other monitored slides is detected, then field personnel should be dispatched to determine if large-scale failure of any part of the landslide is imminent. Close liaison among CGS, Highway, DODES and local officials should be maintained in the reading, assessment, and distribution of monitoring data and hazard interpretations.

The Dowds No. 1 landslide consists of two parts: an upper apparently stable one and a lower one which is active, but where movement is now slow. Comparison of changes of water levels in the lower part with rates of movement will be possible in 1986 with the instrumentation installed in 1985. If these movements correlate with water levels in the slide then a dewatering plan for this landslide should be devised.

A preliminary study indicates that the major Whiskey Creek landslide/earthflow is currently stable with the exception of two local slide areas adjacent to the Interstate highway. One is on the east lobe of the major slide toe, the other is centrally located on the toe. The instrumentation on this slide is designed to determine whether small landslides immediately above the highway could be precursors to larger ones in the main Whiskey Creek feature. Such larger landslides could be sufficient to close the highway and possibly dam the Eagle River.

Introduction

At the request of several local officials and others, and after the Colorado Division of Highways (CDOH) had experienced the partial loss of an approximately 300-ft-long section of U.S. Highway 24 between Dowds Junction and Minturn, renewed investigation of the landsliding problem that caused this highway loss was initiated in late April 1985. The first on-site work was conducted by CDOH. This work consisted of drilling five boreholes, installing 12 electronic distance measuring stations (EDM points), and diverting water by ditching to keep, to the extent possible, snowmelt water out of the landslide. As will be discussed subsequently, this first work investigated a relatively small landslide (hereafter referred to as the "highway" landslide) that is in reality a small component of a much larger feature (hereafter referred to as the "intermediate" landslide) which is in turn a part of the very large older Meadow Mountain landslide shown on the location map.[1] In addition, continued instability of road cuts in three other landslides in the general vicinity of Dowds Junction (Dowds No. 1, Dowds No. 2, and Whiskey Creek landslides), which had not previously been carefully monitored and studied by CDOH or CGS, prompted the cooperative study of landslides in the area by the two agencies.

[1] The locations of the landslides, drill holes, EDM points, and other features on the location map should only be considered approximate and diagrammatic. This is because the scale of the map (1:24,000) and the generalized topography shown are too inaccurate to achieve this properly. When the high accuracy topographic maps, the compilation of which is in progress, are completed this problem will be resolved in a final report.

James M. Soule of the CGS, with the cooperation and support of Robert K. Barrett and John Post of CDOH, was given this study assignment in mid-April, 1985. Office work began immediately and field study of the Meadow Mountain landslide began on May 6, 1985.

The work plan for studying these landslides, after consultation between CDOH and CGS personnel, consisted of the following:

1. General field reconnaissance of the landslides, initially in the lower parts where the snow cover was less, and in the case of Meadow Mountain, where road damage had already occurred.

2. Selection of points where, from field observations, interpretation of aerial photographs, and as the work progressed, drill-hole data, EDM points could be most usefully installed. Sequential monitoring of EDM points could then be used to give quantitative measurement of any downslope landslide movement.

3. During and after the drilling program, interpretation of the drilling data to determine the nature of the landslide shear surface(s), their depth, and in the case of the Meadow Mountain landslide the rock unit involved from place to place. From the drill-hole data, qualitative determination of the stratigraphic level of landsliding (geologic bedrock formation), and generalized estimates of the amount of material subject to possible movement.

4. Installation of inclinometers in selected boreholes to supplement data obtained from the EDM measurements. Three of the five holes at the Dowds No. 1 landslide (the farthest upslope) were drilled and completed to permit monitoring of water levels and comparison with possible slope movements by inclinometers in the lower holes.

5. After evaluating the data obtained in 1.,2.,3., 4., and noting the locations of surface-water concentrations, areas of active earth cracking, pressure bulges and ridges, and other diagnostic landslide features, mapping of these features was to be done on high accuracy base maps compiled from aerial photography made this year. At the time of the writing of this report this part of the work has not started because the base maps have not yet been received. Intrasearch, Inc., of Denver, has been contracted to do this.

6. It was decided that the Dowds 2 slide was the least threatening and that visual observations and subsequent detailed surface mapping would suffice for evaluating its slide potential.

Methodology

At the outset of this project considerable urgency was attached to making a quick determination of the immediate potential of closure, because of massive catastrophic landsliding, of I-70, U.S. Highway 24, DRGWRR, and of possible damming the Eagle River which could result in flooding to West Vail and Minturn. Consequently we made a rapid field inspection of the apparently active parts of all the landslides. What we found out, both initially and in subsequent more detailed study is summarized below for each landslide area.

Meadow Mountain

The Meadow Mountain landslide, as generally outlined on the attached map, is a compound slope-failure feature consisting of shallow to deep (up to 40 ft) earthflows that occur on the surface of least three much deeper (90 to 160 ft) translational landslides involving bedrock. These range in size from the relatively small one affecting Highway 24, to the "intermediate" one extending several hundred feet upslope and the remainder of the major feature, which is probably made up of better stabilized older compound landslides covering more than one half square mile. The most serious immediate threat to Highway 24 and the Eagle River Valley is from the "intermediate feature". It exhibits some surficial movement as shown by the EDM measurements (see attachment and the data for EDM points 1a, 2a, 3a). It also lies immediately below a natural bog or swamp area which becomes a small ephemeral pond during each snowmelt season. Our initial assessment of the cause of landsliding in this area is that seasonal groundwater surcharge from this ephemeral lake is very likely to be a significant contributing cause for movement of this landslide. It is inconclusive whether movement of water from this landslide mass is directly affecting the more rapid movement of the smaller landslide adjacent to the highway or not. However, it should be noted that field observation of surface-water movement into earth cracks in both landslides in early May correlates with the most rapid movement of the EDM points. This suggests, of course, that removal or diversion of water would slow or stop movement of either landslide. Because of this we recommend that this pond be kept drained. Local diversion of surface water was the approach used by CDOH to attempt to slow movement of the small "highway" landslide even before our investigation began.

Because of the immediate concern for evaluating the possible loss of the highway and damming of the Eagle River, the first work of instrumentation of the Meadow Mountain landslide consisted of installation of three EDM points at the headscarp of the "intermediate" landslide. These were in addition to the twelve EDM points

that had been installed by CDOH on the smaller "highway" landslide a few weeks earlier. The remainder of the EDM points on Meadow Mountain were installed as fieldwork and the drilling program progressed, and by mid-July a total of thirteen had been installed on the larger slide feature. The first three were carefully located to ensure that if any large-scale movement of the intermediate landslide were to occur it would be immediately apparent. Later in the investigation an inclinometer was placed immediately above the headscarp of this slide near EDM point 2a at drill hole 8. Higher upslope, in the apparently less active part of the Meadow Mountain landslide, we eventually installed 10 more EDM points. Some of these were placed where localized landslide movement was suspected or where if it were to occur it might be the precursor to large scale mass movement of the entire Meadow Mountain landslide. The higher numbered ones were located simultaneously with drilling and were based on field observations obtained while drilling was in progress. From the monitoring that was subsequently done little movement in the higher area was detected and that which was seen is probably attributable to shallow earth flowage or instrument noise. However, by the time monitoring of most stations had begun, virtually all of the snowpack was gone and the ground had dried considerably. Such localized earthflowage was suspected but not demonstrated in many places on Meadow Mountain until the drilling program was well underway and considerable fieldwork had been done.

In the highest parts of the Meadow Mountain landslide, above all drill holes and EDM points, older landslide material is covered by glacial drift, mostly bouldery gravels. Even though this area has the geomorphic form of a major landslide, there is no field evidence whatsoever for deep seated modern movement and I suspect that there has been none, except for small very localized slumps. The upper part of the Meadow Mountain landslide was glaciated by valley glaciers that originated in the Grouse Creek drainage basin where such deposits are abundant. The details of the data obtained from drilling will be included in the final report, but the essentials of what was learned from this and field data can be summarized as follows:

1. The basal landslide surface of the major Meadow Mountain landslide varies in depth from approximately 90 to 160 feet below the ground surface with numerous bedrock shear zones present above the basal shear.

2. This basal shear surface occurs at different places within the Belden Shale or in the Minturn Formation; it is mostly in the Minturn Formation on the north side of the landslide. This conforms to the local structure in bedrock, as bedrock bedding has a steep component of inclination (dip) valleyward.

3. As much as 40 ft of earthflow material consisting of unconsolidated "soil" derived from bedrock units is involved in surficial slope failures that probably present no serious threat other than to the improved roads and irrigation ditches that cross the area. These earthflows account for most of the recent and obvious landslide morphology in the area.

4. Although monitoring of the most critical high runoff season has not been done as yet, water levels in drill holes probably will vary considerably seasonally and may correlate with increased rate(s) of landslide movement. Drill hole 4 had artesian flow to the surface to mid summer suggesting that in this part of the landslide near the headscarp, water pressures at or near the basal landslide surface are relatively high. It should also be noted that no irrigation ditches were being actively used in this area at this time.

5. As indicated earlier there was concern from the outset of the project about the concentrations of surface water on the old slide mass. There were observable concentrations of water in natural drainages, ponds and bogs, and in irrigation ditches. It was suspected that this water could contribute to both localized and major landsliding on Meadow Mountain. Water flows were high in several irrigation ditches, across the upper part of the area, as well as in the natural drainages during snowmelt season. With the exception of the ephemeral pond immediately upslope of the "intermediate" landslide it has been difficult as yet to establish a direct causal relationship between the surface water and specific areas of instability. This is probably because the percolation of massive amounts of water into the old slide mass is a very general phenomenon and the actual instability it produces may occur a considerable distance downslope where other conditions also promote instability. A more definitive finding on this would require additional exploration of slide plane geometry and continuing monitoring of movement over 2 or 3 more full seasons. However, the presence of artesian pressure in groundwater at borehole 4 even into mid summer demonstrates that water pressure is high at least locally in the slide mass, and based on geotechnical principles the observed rapid percolation must be considered a serious contributory factor to instability.

In mid-June, Mr. David Stark, the USFS District Ranger, Minturn, asked for specific recommendations for changes in drainage management that would decrease the risk of serious landsliding on Meadow Mountain. At that time we were still installing the monitoring system and carrying out field studies of the landslides and had not had time to evaluate the overall situation. Consequently, at that time, we were very conservative in recommending radical changes in water management. However, with still incomplete data, but a great deal more than when the project started, it seems prudent to take measures designed to reduce percolation of surface water into the slide to a minimum. This might include: A. Elimination or reduction of standing water in ponds and bogs; B. Increasing the efficiency of drainage and reducing the residence time of surface water in natural drainages and during the snowmelt season, in irrigation ditches; C. Actively draining the lower parts of the "highway" landslide and possibly the "intermediate landslide; D. In time, changing the overall irrigation scheme on Meadow Mountain to reduce water percolation during the summer months.

6. Toward the end of the drilling program on Meadow Mountain, drill holes 8 and 9 were completed in Belden Shale at 154 and 160 feet respectively. At this time and as reported to me on September 10, 1985, by Marion Welles, CDOH, an inclination measurement sonde has been run into each of these holes three times with no significant changes so far. Additionally hole 8 experienced an apparent mechanical problem with the casing flutes which makes it impossible to determine a vector of landslide motion. If this mechanical difficulty is overcome, the real value of inclinometers should become apparent next season. It should also be noted that CDOH installed an inclinometer at the base of the "highway" landslide to depth of about 75 ft below surface but the rapid movement of this landslide destroyed the installation early in the investigation.

7. One difficulty encountered near the end of the drilling program on Meadow Mountain was that it became apparent that in order to determine an approximate volume of material that might move in the "intermediate" landslide a drill hole would be needed approximately 500 ft downslope from drill hole 8. This proposed hole was not drilled because another location (drill hole 9) was drilled instead and an inclinometer installed in it. By the time of completion of this additional hole, time and budget constraints forced us to move the drilling equipment to the Whiskey Creek landslide drill site. It is recommended that this hole be drilled as early as possible in 1986.

In summary the most important accomplishments to date at Meadow Mountain are installation of a landslide movement-monitoring system in a compound landslide system whose various components exhibit differing styles of movement.

The "intermediate" landslide is the most threatening because approximate but reasonable estimate(s) of volumes of material that could move and its current movement indicate that it alone could dam the Eagle River, at least temporarily, and permanently close the present alignment of U.S. Highway 24. Such an event could be precursor to even larger scale movements in the main Meadow Mountain feature as toe support in it would be considerably reduced. Prediction of this is still impossible considering the relatively small amount of data that a limited drilling program and short-term monitoring of EDM and inclinometer stations has made available.

Dowds No. 1 Landslide

The Dowds No. 1 landslide, located south of the Eagle River at Dowds Junction, has had a recognized but poorly documented history of movement since Interstate Highway 70 was built that has dislocated and damaged the nearby highway bridge and its western approach. Prior to our field study of this feature it was not known whether large scale catastrophic failure of the landslide is possible, whether movement of it is seasonal, or whether the overall composition of the landslide varies areally or with depth.

Because of the urgency to determine if catastrophic failure of the Dowds No. 1 landslide was possible in the spring or summer of 1985 the first task assigned to the CDOH drilling crew was to drill two core holes at its base for the purpose of installing inclinometers. These drill holes were made between the on and off ramps to Interstate Highway 70 and the bridge abutment of the highway bridge and were drilled to 180.5 ft (hole 1) and 160.5 ft (hole 2) below ground level respectively (See location map.). They were drilled through ancient river gravels, which represent a former course of the ancestral Eagle River, into Minturn Formation bedrock. In hole 1 several important subsurface features were noted in the core. Several shear zones were encountered with the first occurring at about 45 ft, another at 75 ft where surprisingly a piece of non-carbonized wood was cored (This was subsequently radiocarbon dated as 8440 $\pm$ 100 years before present.) and the one that we interpreted as the basal landslide shear zone at 165 ft below the ground surface. The ancient river gravels were encountered nearly continuously in the core demonstrating that the landslide, or at least the toe or lower part of it involved and probably forced the river course to the north. Whether this movement dammed the river in the past is not known, but it appears as if this certainly might have occurred. This appears to justify concern that such an event could happen today. The second hole was virtually identical to the first except the basal shear was interpreted to be at 142 ft.

During the course of drilling the Dowds No. 1 landslide was studied using standard field methods. Prior to field study I had some preliminary ideas, based on aerial photograph analysis that proved to be partially or entirely incorrect. The most surprising discovery made is that approximately the upper one half of the landslide area shows no field evidence whatsoever for modern movement. Also notable is the fact that in this upper area, where the landslide is composed of very large blocky material consisting of Minturn Formation arkosic sandstone with individual blocks ranging to 30 ft in diameter, the snowmelt water was observed to percolate rapidly into the ground. I attribute this to the high porosity and permeability of this blocky material. The fact that the distribution of these blocks on the surface appears to be chaotic combined with their modern static condition leads me to believe that this upper part of this landslide was formed by a massive ancient rockfall collapse. The condition of the lower one half of this landslide below drill holes 11, 12, 13, appears to be entirely different however. In this area there is definite field-observable evidence for continuing but relatively slow modern movement. The morphology of the ground surface, vegetation changes and types, drilling data, and the limited known history of movement all confirm this interpretation. An apparent scarp within the landslide mass coincides with vegetation change from coniferous to deciduous forest. Water was issuing from the ground along this scarp in early May. The composition of material on this part of the landslide is similar to that in the upper part, except that the very large blocks are absent. This suggests that either the mechanism that formed the upper part is completely different from that which formed the lower part or, and perhaps a more likely reason, modern movement of the lower part can be attributed to seasonal increase of hydrostatic pressure in the lower part caused by percolation of water from the upper part and into it. The origin of material in the lower part then could be considered to be the same as that in the upper part, with the largest blocks being absent because of their disintegration by periodic movement.

With this interpretation of the field data and the budgeted drilling-program constraint of locating three water-level-monitoring holes in the Dowds No. 1 landslide, I selected the drill hole locations in the highest accessible places below the scarp. A permit had to be secured from the U.S. Forest service to construct an access road. The amount of tree damage and esthetic-degradation effects had to be considered also. Three holes were drilled to about 100 ft each as the program called for. The basal landslide shear zone was certainly not encountered in holes 11 and 12. In hole 13 we encountered sheared sandstone boulders but the diagnostic test of going through such a zone and then back into unsheared bedrock was not achieved. No free water or artesian flow occurred during or after drilling, but since these were the last holes to be drilled in the Dowds Junction investigation it was well past the snowmelt season. The entire drilling program ended on July 19th.

As was done at Meadow Mountain, EDM points were installed at the Dowds No. 1 landslide. The logic behind their location and constraints related to vegetation disturbance[2] were somewhat different however. In this case we were more concerned about correlation between changes of water levels in monitoring wells during the next spring runoff season and movement at the surface of the landslide that the EDM or inclinometers measurements might indicate. The EDM points at Dowds No. 1 are numbered 1b to 5b and the initial readings of them were made on June 20th, well past the snowmelt season, and movements from then until monitoring was terminated with the August 9th readings were slight, as expected. In short, and with respect to the immediate perceived need for determination of potential for major landsliding in 1985, the real value of the monitoring system at Dowds No. 1 will be realized only in the spring of 1986 and subsequent years.

If accelerated movement of the Dowds No. 1 landslide, both at depth and on the surface, is coincident with high or near surface water levels in the water-level-monitoring holes, as I fully expect it will be, then a dewatering system should be considered. I doubt that it would prove to be feasible to intercept or control percolation of snowmelt water into the upper part of the landslide because of terrain conditions, but a French drain or pumped system might prove to be feasible in the lower part, especially in view of the current actual and potential costs of maintenance and repair of the highway and bridge structure.

2 EDM points must be located such that they are in line-of-sight view of another permanent monument where a measuring instrument (electronic theodolite) is set up. Consequently vegetation (trees) cannot be in the way.

Whiskey Creek Landslide

The Whiskey Creek landslide is the largest slide in the study area. However, it is also possibly the oldest and probably the least active with exception of the east lobe of the toe where we concentrated our field and instrumentation efforts. However, major reactivation of even this relatively small active area would cause the most serious consequences for transport and commerce in the area as it is conceivable that the Interstate highway could be closed and in a worst case scenario, the Eagle River could be dammed.

Because of the limited number of EDM points (4) and drill hole(s) (1) budgeted to instrument this landslide, I carefully located them to maximize the immediately needed information. The EDM point locations were selected for the following reasons: EDM point 1c is located upslope from a relatively small slump landslide that was initiated by the Interstate highway roadcut. This roadcut is so unstable that it presents a constant maintenance problem for CDOH and complete failure of it would at least temporarily close the highway and reduce support for the potentially unstable landslide material above it. EDM point 2c is located about 500 ft upslope from 1c because of the need to monitor any large scale movement upslope from 1c if movement of 1c rapidly increases. EDM point 3c was located for the same reasons as 1c except it monitors a different slump landslide that is even more threatening. EDM point 4c is located at the same location as the only drill hole and is discussed subsequently. It should be pointed out that the most immediate problem posed by the Whiskey Creek landslide is that of increased activity of these relatively small active landslides at the lower edge (toe) of the large landslide. These originate in older metastable landslide material and could in themselves be a costly problem, and accelerated movement of these very likely could be the precursor(s) to larger scale movement of the major slide mass. Monitoring of these EDM points did not begin until June 20th and so as is the case with many of the others on the other landslides their real value will not be apparent until next spring.

The only drill hole at Whiskey Creek was drilled for two reasons: to determine the thickness and composition of the landslide at one important location and to install an inclinometer at this key location. Although the inclinometer casing was set at 295 ft in Belden Shale bedrock, the casing collapsed during cementing operations rendering it useless. The base of landslide material was found at 244 ft below ground level. The landslide material is considerably different in composition and texture than that making up the other landslides in the area. It consists predominantly of 1-to-6-in. clasts of mudstone and sandstone in a clayey matrix. Its texture indicates that the Whiskey Creek landslide initially formed as a massive earthflow or

series of earthflows. We encountered an ancient stream gravel between 210 and 215 ft below the surface which we interpreted as being associated with a distributary channel on an older landslide surface. This supports the multiple event hypothesis for formation of the Whiskey Creek earthflows.

The fourth EDM point at Whiskey Creek was installed expressly to monitor surface movement, if any, associated with basal movement indicated by inclinometer tilt. Not only does this offer the ability to measure movement both at depth and at the surface and compare them simultaneously, but enables the geologist to qualitatively predict whether large scale movement is by flowage or translational landsliding. This is important because prediction of the effects of a large-scale event depends in part on knowing the style of movement. Ancient movement probably was by earth flowage but climate and ground moisture conditions are probably different now than they were thousands of years ago when the last major Whiskey Creek landslide event occurred. The potential for reactivation will have to be evaluated as future instrumental information is obtained.

In conclusion there is only a partially operational landslide monitoring system installed at Whiskey Creek. The inclinometer hole will have to be re-drilled if the program originally planned is to be effective.

In the future it would be wise to drill more exploratory holes and possibly conduct a seismic reflection survey of the Whiskey Creek landslide, especially in its lower part. If the massive earthflow hypothesis is correct, the lower part of the Whiskey Creek landslide buries an ancient land surface topography which may include the stream bed of the ancestral Eagle River. For the purpose of determining relative stability of this landslide material it is essential to know the configuration of this surface. The west lobe of the Whiskey Creek landslide toe currently appears stable whereas the east one is not. This may simply be because the roadcuts are on the east side or perhaps for some natural geologic reasons. In addition, material properties testing should be done on the landslide material that was cored to determine physical properties, both undisturbed and remolded.

Dowds No. 2 Landslide

Although not specifically assigned for study or instrumentation during this investigation I did some field reconnaissance of the area during work on the other landslides. I had also inspected the Dowds 2 landslide on two previous occasions in the spring of 1982 and 1983. This landslide has caused damage to the Interstate highway as recently as two years ago and has been instrumented with EDM points by CDOH along the bin wall above U.S. Highway 24.

This the smallest landslide in the area is similar in some respects to the Dowds No. 1 Landslide. Large blocky material derived from the Minturn Formation predominates with a clay and sand matrix. Field work indicates that landslide material above the slump that recently temporarily closed the road is in a very unstable and precarious position. It should be expected that such slumping will continue and that road closures will happen again. However, it appears as if there is not enough highly unstable material in this landslide to form a landslide dam of the Eagle River . Nevertheless, this landslide will continue to be a threat to the Interstate. The construction work done so far to reduce this threat will probably not be very effective, and continuing problems in this area should be expected.

CONCLUSIONS AND RECOMMENDATIONS

The Dowds Junction landslide investigation is not complete. The instrumentation systems that were installed became operational too late in the season to make definitive evaluations and recommendations based on data obtained from them. In addition, the inoperative inclinometer at the Whiskey Creek landslide should be replaced before next season to complete the monitoring capability there as was originally planned.

At Meadow Mountain the most prudent and conservative course of action to reduce landslide potential will be to continue to keep as much surface water off the landslide as possible. This will entail draining of the one ephemeral pond and minimizing water flows in natural drainages and irrigation ditches. As a longer term data base from the monitoring system is developed it should become apparent which parts of the Meadow Mountain landslide are actively moving and most threatening. At that time permanent adjustments to the drainage could be made based on more complete information. This should satisfy the concerns of the U.S. Forest Service that relate both to their potential liability and to water and grazing issues. It should be anticipated that losses of highway service caused by this landslide will recur. Upgrading of the detour around the slide area should be considered by the affected government units.

The Dowds No. 1 landslide should be carefully monitored, with weekly readings as a minimum, during the 1986 snowmelt runoff season. If increased water levels in the water-monitoring holes are directly related to inclinometer deviations, and EDM point movements, then a drainage and dewatering system should be installed here. Even though, from our work, it appears as if massive large-scale landsliding is not imminent, substantial reduction in the possibility of it, combined with reduced maintenance of the highway would undoubtedly justify the expense of installing the system.

The roadcut failures in the Whiskey Creek landslide toe present an immediate threat to the Interstate highway and it will not be surprising for either or both of them to disrupt traffic and at times close the road. If either occurs, it will be absolutely critical to monitor the EDM points and inclinometers to see if this is a precursor to larger-scale movement, because this could be the initial phase of a truly catastrophic event. Slowing or stopping such an event will be virtually impossible once it is initiated.

It is expected that in our final report, following additional study funded by the Department of Highways, we will be able to make somewhat more detailed recommendations and evaluations based on detailed field and photogologic study. However, we believe that two more years of instrumental monitoring together with close attention to regional patterns of soil moisture will be need to evaluate the threat of major landsliding of these slides with a reasonable degree of confidence.

OPTIONS TO MITIGATE POTENTIAL DAMAGES FROM EARTHFLOWS NEAR DOWDS JUNCTION, COLORADO

TECHNICAL APPENDIX III

EMERGENCY PREPAREDNESS

EMERGENCY PREPAREDNESS

The exercise of emergency operations plans and procedures is essential to preparedness for any recognized hazard. Based on the Dowds Junction Landslide hazard identified by the Colorado Geological Survey, and an analysis of the four threat areas (Meadow Mountain, Dowds #1, Dowds #2, and Whiskey Creek), it was determined that two exercises should be developed i.e., one for the most immediate threat - Meadow Mountain, and one for Whiskey Creek - the largest of the slide threats.

The first scenario (Meadow Mountain) was developed in April by DODES with technical input from the Colorado Geological Survey, Colorado Water Conservation Board, and Division of Water Resources. Concurrently, Eagle County and the town of Minturn upgraded their emergency operations plans to include response procedures to meet the threat. On May 15 1985 a combined Tabletop - Communications Exercise was conducted in Eagle County with federal, state, county and town participation. The after-action report at Enclosure 1 provides detailed results of this exercise.

Immediately following the first exercise, a second scenario (Whiskey Creek) was developed. Lessons learned in the first exercise served as the basis for development of events and emphasis in the follow-on exercise conducted on June 14, 1985. Particularly noteworthy was the expanded participation from state agencies, county representatives (including Garfield County) and the potentially impacted towns. Detailed results of this exercise are in the after-action report at Enclosure 2.

Timely notification of significant movement in the hazard area, and subsequent emergency management communications is essential to response at all levels of government. The installation of measuring devices on each slide area, and a system for monitoring/reporting/analysis (now established) serves to enhance our coordinated state-county response capability. Additionally, the ability of the state to extend its emergency communications capability to an incident site on the Western Slope has been tested and proven satisfactory; some enhancement of this capability has been identified. Recognized county radio communications shortfalls have been reinforced by the exercise experience and evaluation of needs is underway.

The two exercises were recognized by all participants as beneficial in understanding the potential hazard, its implications in terms of threat to life and property, and in identifying emergency preparedness strengths and areas requiring ongoing attention. Concurrently, the experience gained in addressing this landslide hazard and the subsequent increase in preparedness will serve as the basis for similar response planning in other potential landslide hazard areas of the state. It is incumbent upon all participating jurisdictions to recognize the lessons learned as noted in the after-action reports, and initiate action to resolve issues and upgrade their emergency operations plans and procedures in anticipation of a possible incident occurring.

MEMORANDUM

DIVISION OF DISASTER
EMERGENCY SERVICES
Camp George West
Golden, Colorado 80401
(303) 273-1624

John P. Byrne
DIRECTOR

DATE: 28 MAY 1985

TO: EXERCISE PARTICIPANTS

FROM: JAMES R SEAVER, CHIEF CONTROLLER

SUBJECT: AFTER ACTION REPORT, MEADOW MOUNTAIN (DOWDS JUNCTION) LANDSLIDE EXERCISE, 15 MAY 1985

1. General On 15 May 1985 (7:30 a.m. - 2:30 p.m.), a Tabletop Exercise was conducted in Eagle County using a recognized hazard in the Dowds Junction area (intersection of U.S. 24 and I-70). The following jurisdictions/agencies participated:

   a. Town of Minturn - Command Post located in the Town Hall.

   b. County

      (a) Mobile Command Post (located at Battle Mountain High School, Eagle-Vail) - included representatives from Vail and Avon Police Departments.

      (b) Emergency Operating Center (EOC) (co-located with the CSP office in Eagle) - included representation from the town of Eagle.

   c. State

      (1) Emergency Operations Center

         (a) Division of Disaster Emergency Services
         (b) Department of Highways
         (c) Department of Natural Resources - Geological Survey, CWCB, Water Resources
         (d) Army National Guard
         (e) Department of Health
         (f) Public Utilities Commission
         (g) American Red Cross
         (h) Governor's Press Office
         (i) Federal Emergency Management Agency
         (j) Department of Social Services

      (2) Forward Command Post
         (a) Division of Disaster Emergency Services
         (b) Department of Natural Resources - Geological Survey
         (c) Colorado State Patrol
         (d) Corps of Engineers (Sacramento)
         (e) Army National Guard
         (f) U.S. Forest Service
         (g) Department of Highways

dps
COLORADO
DEPARTMENT OF
PUBLIC SAFETY

2. Objectives

   a. To exercise emergency management, and the emergency operations plans and procedures at each level of government.

   b. To test and exercise communications within and between each level of government.

3. Scenario Meadow Mountain (See Enclosure 1).

4. Exercise Play and Control

   a. Free play of emergency management action was generated by development of the seven phase scenario. Preplanned events were only inserted by the Control Group either when an area of concern was not being considered/played or to facilitate play by a jurisdiction.

   b. A four-person control group from the Division of Disaster Emergency Services was positioned as follows:

      (1) Brief Controller and assistant at Battle Mountain High School for the State EOC (relocated from Camp George West to the exercise area), State Forward Command Post, and County Mobile Command Post.

      (2) One Controller at the County EOC in Eagle.

      (3) One Controller at the Town Command Post in Minturn.

5. Observations and Analysis

   a. General Comments - See Enclosure 2.

   b. Town of Minturn - See Enclosure 3.

   c. Eagle County - See Enclosure 4.

   d. State of Colorado - See Enclosure 5.

   e. Overall Evaluation - See Enclosure 6.

6 Enclosures: a/s

(Revised, 29 Apr 85)

Enclosure 1

SCENARIO 1

(MEADOW MOUNTAIN SLIDE)

Phase I (Present): Monitoring/visual observation underway; no significant movement.

Since April, growing concern has been raised for the potential threat posed by the apparent instability of soil on Meadow Mountain located south of the intersection of Interstate 70 and U.S. Highway 24 (Dowds Junction). This concern has been heightened by the significant flow of water down the mountain, which has to be diverted under U.S. Highway 24, into the Eagle River. State Highway Department personnel have continued to work on channeling the water flow under the highway and keeping the road open; periodically the road has had to be closed for maintenance, and a detour utilized over Nelson Bridge on a county road into Minturn.

State Geologist assessments indicate that the greatest landslide threat period is 1 May through 30 June. County and State agencies have upgraded their monitoring of the area, both through instrumentation readings and visual observation. The lower region (immediately above the highway) has revealed movements in inches per day.

Intracounty emergency operations plans have been reviewed and updated in response to the potential threat. Local media have provided the public with State and County assessments of the potential threat, and citizens have been provided information on actions that should be taken in anticipation of any degree of threat.

Phase II (1-3 days): Monitoring/Visual Observation Indicate Likelihood of Movement Impacting Highway 24.

Monitoring data and increased sediment content in the stream flow under the highway have raised the concern in the Meadow Mountain area. Lower region instrument readings reveal movements now measured in feet per day; center and upper region readings also indicate increases in movement; pools of water are becoming more pronounced. More frequent readings and visual observations are being conducted.

State Highway Department crews are spending more time/effort in preventing stream flow blockages and maintaining the highway surface. Highway closures are becoming more frequent to accommodate maintenance requirements.

The frequent need to detour traffic and the increased activity in the area has made the local population (particularly in Minturn) conscious of the potential threat; response to the town's pre-emergency projects is getting more attention as evidenced by citizen calls to the town hall. Other concerns are beginning to become apparent as trucking companies query the county courthouse and Coldorado State Patrol concerning access through the Minturn area on Highway 24.

Snowmelt runoff in the Eagle River fluctuates with daily peaks estimated about 50 c.f.s. (cubic feet per second) as temperatures gradually increase from a high pressure area which has moved over western Colorado.

Phase III (1 day): Soil Movement Impacts Highway 24 resulting in Eventual Closure.

Soil movements begin to move gradually onto the highway making State Highway Department crew efforts to clear the road increasingly difficult. Concurrently, efforts to maintain unobstructed flow of water under the highway are being frustrated. Attempts to keep the highway open to traffic are becoming infrequent, with major period of traffic detour occurring.

Monitoring instrumentation readings continue to increase in the Lower Region (feet per day). In the Central and Upper Region, readings are approaching feet per day as the instability continues to increase.

Intracounty and State command posts are now in an increased readiness state.

Finally, the highway is closed at the Nelson Bridge and Main Street in Minturn.

Runoff in the Eagle River continues to fluctuate with peak discharges estimated from 100 - 200 c.f.s.

Phase IV (12-24 hours): Soil Movement Increases Threatening Expansion into Eagle River.

Soil movement has continued to flow across portions of the highway accompanied by expansion of water flow across the highway extending beyond the previously channelized stream area. Attempts to reduce the flow have proven fruitless.

Monitoring instrumentation readings in the Central and Upper Regions have increased to feet per day; aerial observation and photos are beginning to reveal cracks in the soil throughout the Meadow Mountain area.

Soil movements across the highway with increasing movement above increase the threat of expansion into the Eagle River.

Runoff in the Eagle River has taken a significant leap and a peak discharge at Minturn is estimated at abut 500 c.f.s. (extrapolated from readings at a stream gauge located at Redcliff).

Phase V (6 - 12 hours): Soil Movement Expands into Eagle River.

Soil has begun to enter the Eagle River. Slides over the highway continue to expand. Central and Upper Region instrumentation readings have increased to measurements of feet per hour.

Soil movement into the Eagle River is beginning to cause water to back up behind a small dam. However, no sooner than water is backed up to a depth of five feet, the dam is overtopped and erosion washes it away. The sequence is repeated several times, sending minor surges of water downstream.

Phase VI (2 days): Dam Build-up in Eagle River

Monitoring readings and visual observations continue to reveal increased movement throughout the slide area. Soil movement into the Eagle River continues to extend toward the far bank and expand up and downstream.

As the dam rises faster than the water can wash it away, the rapidly forming reservoir begins to expand. Inflow is estimated to be increasing, indicating the snowmelt season has begun in earnest. Water levels in the lake behind the slide are monitored hourly. The continued soil flow increases the strength of the dam, and the volume of water in the reservoir threatens the railyard and area extending south to the intersection of Highway 24 and Main Street.

Uncertainty over stability of the dam to sustain the water pressures caused by an increase in depth of water raise concern over flooding downstream should it break.

Continued dam buildup across the Eagle River and danger to the detour access via Nelson Bridge have necessitated consideration of population evacuation from the area along the county road detour, and the downtown area of Minturn.

Phase VII (6 days): Conditions Leading to Failure of the Dam

Access to the Gore Creek Valley from Minturn has been halted. Evacuation of the remaining population north of the railroad crossing and intersection of Highway 24 and Main Street has been completed.

The rise of the slide-formed dam has slowed to a maximum height of 55 feet. Backup of water continues to rise at a rapid rate.

Leakages in the dam are beginning to become increasingly evident. The dam begins to overflow and a weak area develops along the east end. The dam breaks.

ENCLOSURE 2

GENERAL COMMENTS

1. In April, the State Geological Survey identified the Dowds Junction area as a potential landslide threat location. The landslide areas were identified as Meadow Mountain, Dowds 1 and Dowds 2, and Whiskey Creek.

2. Based on analysis of the hazard, it was determined that the immediate threat was Meadow Mountain and the nearest population in Minturn. A greater, yet less immediate, threat was the Whiskey Creek landslide area, which could impact both Minturn and West Vail, then the downstream communities along the Eagle River. Accordingly, the decision was made to conduct a Tabletop Exercise using the Meadow Mountain scenario followed at a later date by the Whiskey Creek scenario.

3. A task force created at the direction of the Governor developed the scenario in coordination with Eagle County officials.

4. The full scenario was played during the exercise with timing of the phases as indicated at Tab A. An oral critique was conducted at the Avon Town Hall lasting 1 1/2 hours following termination of the exercise.

Tab A to Enclosure 2

DOWDS JUNCTION (MEADOW MOUNTAIN) LANDSLIDE EXERCISE

PHASE I - Monitoring/Visual Observation underway; no significant movement	0730 - 0830
PHASE II - Monitoring/Visual Observation Indicate Likelihood of Movement Impacting U.S. 24	0830 - 1000
PHASE III - Soil Movement Impacts U.S. 24	1000 - ~~1100~~ 1055
PHASE IV - Soil Movement Increases Threatening Expansion into Eagle River	~~1100~~ 1055 - ~~1130~~ 1145
PHASE V - Soil Movement Expands into Eagle River	~~1130~~ 1145 - ~~1200~~ 1230
PHASE VI - Dam Buildup in Eagle River	~~1200~~ 1230 - 1400
PHASE VII - Dam Break	1400 - ~~1500~~ 1425
CRITIQUE	1530 - ~~1630~~ 1700

ENCLOSURE 3

TOWN OF MINTURN

1. General

a. It has been evident since the Dowds Junction hazard was identified and an intergovernmental dialogue established that extensive response planning has been undertaken under the direction and control of the Mayor, Harold Bellm and Police Chief, Mike Gallagher.

b. During the exercise, town officials displayed a high degree of professionalism and response to the situation as it developed, sought necessary information, identified problem areas and possible solutions, and accepted input from the controller on issues to be considered and lessons learned.

2. Observations

a. The town has a "call up" (fanout) list, however the names and telephone numbers of key officials were not included.
Recommendation: That this listing be updated and maintained current with the town emergency operations plan.

b. As the hazard situation developed, it became necessary to increase the administrative staff e.g., answer phones, maintain a log of incoming and outgoing traffic.
Recommendation: That each town government employee be assigned a role, either as primary or alternate to meet the staffing requirements of the command post on a day or night shift (assume that activation of a command post extends beyond eight hours into possibly days).

c. The town command post needs sufficient dedicated telephone lines to handle emergency management traffic, when the facility is activated. Additionally known telephone lines/numbers will most likely and appropriately be busy with public inquiry type traffic.
Recommendation: Review organization of the town command post in terms of needed functional and administrative representation; then determine telephone requirements, and the most economical manner to satisfy such requirements through Mountain Bell.

d. The town charter is understood to require that all council members be present to declare a "State of Emergency."
Recommendation: Since this may pose a problem given a situation arising during the absence of one or more council members, such a requirement should be reviewed and possibly qualified in some manner.

e. Because of the extensive attention town officials must make toward addressing hazard situations and implementation of the operations plan, the assistant town manager was designated the Public Information officer. Since he had never acted in this capacity, the experience was invaluable providing he remains in that capacity and is so recognized by the town officials.
Recommendation: That a Public Information Officer be assigned with duties delineated, and the designated person seek training through the County Emergency Preparedness Coordinator, Jack Johnson. Further, given an identified hazard, consideration should be given to preparing "fill in the blank" type media releases prior to a potential emergency.

f. The town has a very active relationship with the Vail Police Department in part due to their reliance on the latter's dispatch facility. This became readily apparent as the hazard situation developed. An equally active relationship needs to be established with county counterparts if only to expedite response as an emergency situation develops. During the exercise, it was noted that often the town officials expressed concern that the county and state was making decisions on behalf of the town, even though the ultimate decision needed to be at the town level.
Recommendation: That the county, in coordination with the incorporated jurisdictions, establish as part of the countywide emergency operations plan, information/decision making and communications flow charts. This should include: flow of situational information between the municipal command posts and the county EOC both telephonically and by radio; coordination of effort on actions being developed in support of the developing hazard situation; the decision-making points (where decisions are made and how disseminated among the jurisdictions); and emergency communications frequencies/telephone numbers.

g. Whether or not a hazard situation develops to its "worst case", recovery actions (both near and long-term) need to be considered and included in emergency operations plans. Restoration of basic public utilities and other services is necessary before evacuees (if any) are permitted to return to their residences.
Recommendation: That the emergency response planning serve as, and be the basis for, the consideration of steps/actions anticipated as the emergency phase begins to diminish and the recovery phase becomes increasingly evident.

h. There is a definite need to document incoming and outgoing traffic and the basis for decisions throughout an emergency/disaster. Such a documentation becomes essential in update/revision of emergency operations plans and procedures, and against any liability claims during the post emergency/disaster period.
Recommendations: That an internal town command post standing operation procedure (SOP) be developed.

i. When evacuation became necessary, the town believed the county would assume responsibility at some point beyond the town limits; the county thought the town would retain responsibility.
Recommendation: The issue of evacuation to temporary shelters outside one jurisdiction into another should be dealt with by the county with each municipality since temporary shelter may be required in another jurisdiction. In each situation addressed, consideration should include accountability of evacuees, transportation needs, providing for health and welfare needs, town/county representation at the temporary shelter site.

3. Hazard-Specific Considerations

a. In the event of flooding, mobile homes are subject to moving creating additional hazards unless properly tied down.
Recommendation: That the town review its tie down ordinance (understand it currently includes only those in the 100-year floodplain) in consideration of this hazard analysis and others e.g., high winds. Also, attempts by owners to move trailers has the potential for interference/conflict with other emergency actions especially where road access into and out of town is limited as in Minturn.

b. Underground storage tanks containing hazardous materials create an additional threat under flood conditions.
Recommendation: The town should identify such facilities and include within their emergency operations plan actions to take in reducing this hazard as potential flood threat occurs.

c. The town should review post-flood Federal Assistance documents, and determine those pre-flood actions which would serve to expedite such assistance during the recovery phase.
Recommendation: That the town request, through the county emergency preparedness coordinator, State advice/assistance in this area.

ENCLOSURE 4

EAGLE COUNTY

1. General

   a. This exercise required wide-ranging emergency management response within the county and with municipalities and the State. While many areas surfaced requiring resolution, the professional approach and recognition of the need for analysis of numerous issues was clearly evident in the planning process and during the exercise.

   b. The need to effectively communicate regardless of where an emergency/disaster may occur in the county was visibly demonstrated and recognized. A number of the observations may be directly related to inadequacies in communications.

   c. As in most potential emergencies/disasters, initial information or situation reports will come to the dispatch center or directly to a government office. As the situation develops, it will become necessary for selected functional representatives and leadership to assemble in a location equipped to operate internally and with outside locations. In this exercise, initial situation information was provided to the County Engineer at his home and to the Emergency Preparedness Coordinator at the dispatch center. As the situation developed, county officials recognized the need to assemble in a location with other representatives to consider and make decisions on various emergency actions.

2. Observations

   a. An emergency operating center (EOC) was activated with partial representation at the CSP/County Dispatch Center. The limited space and telephone access made this area inadequate to perform needed emergency management functions.
   Recommendation: This shortfall has been recognized by the county. An area with adequate space for worst case representation needs, sufficient telephone capability, adequate materials/maps/charts, etc., and tied to the radio communications center is essential. While the area need not be reserved exclusively for EOC activities, it must be readily convertible to its emergency management functions. Telephone access requirements in the EOC should be identified and discussed with Eagle Telecommunications to determine the most economical means of accomplishment.

b. There is a need for a standing operating procedure (SOP) for activities within the EOC.
Recommendation: Many of the needs were raised by functional representatives as the exercise progressed and should be formalized, for example:

(1) Incoming and outgoing traffic (including internal EOC directives) should go through a single individual/desk. Recommendation: Consider an assistant (operations person) co-located with the Emergency Preparedness Coordinator. Alternatives resulting in significant decisions should also be documented (e.g., recorded on tape).

(2) Some clerical and administrative support must be available to meet log requirements, preparation of emergency declarations, media releases, critical activities and other actions e.g., maintaining status boards.

(3) The County Attorney should be readily available with necessary legal references to provide timely and knowledgeable counsel, as required.

(4) A county official (e.g., County Assessor) should maintain an update of damage assessment information as inputs are gathered and reported.

(5) The County Treasurer should be available to advise leadership on matters related to fiscal status.

(6) A representative (spokesman) for actually or potentially impacted incorporated areas should be present to advise/assist and participate, where appropriate, in the decision-making process.

c. The role of the Forward Command Post vis a vis the County Emergency Operations Center needs to be delineated to include function, decision-making perameters, and need for deployment. During this exercise, the county mobile command post actually functioned as an incident command post i.e., receiving and deploying resources into the incident site, making decisions (assisted by information and expertise available in the State Forward Command Post). The County Representative at the Mobile Command Post stated that resources were coming to him in a manner difficult to control; this created problems for both the County Mobile Command Post and County EOC.

Recommendation:

(1) An incident command post, under control of a designated incident commander, should direct all resources and activities within the perimeter of an incident site. Requests for additional resources should be made by the incident commander to a command post or EOC, where resource decisions are made, resources identified, and dispatched to the incident commander "packaged" for rapid deployment at the incident site. There may be more than one incident site, therefore more than one incident command post/commander dependent on extent of the emergency and jurisdictions involved.

(2) A Forward Command Post is an extension of an EOC used and deployed near the incident site, when necessary, to provide a more responsive management capability. It does not serve as a replacement for an EOC, but rather extends the visibility of the EOC nearer to the scene of the incident. It keeps in close contact with the EOC and the incident command post to insure the timely transmission of information, incident site activities and requirements, and jurisdictional direction and control.

(3) The emergency operating center is a fixed facility - fully equipped, and manned with leadership and functional authorities necessary to effective and efficient emergency management. It is the source of personnel assets and resources (internal and external to the jurisdiction), identification and analysis of short and long-term actions in response to the emergency/disaster, and financial consideration. Direction and control within and from this facility is accomplished in the name of the jurisdictions elected leadership.

d. Actions and responsibilities associated with evacuation were not clear. When Minturn officials decided evacuation of threatened populations was necessary, and such evacuation extended to temporary shelters outside its jurisdiction, it was unclear what responsibility was retained and what responsibility other jurisdictions must assume.

Recommendation: The county (in cooperation with, and assisted by each incorporated jurisdiction, adjacent county sources of temporary shelter, and appropriate State agencies e.g., Department of Social Services, Department of Health) should develop a coordinated procedure for each identified hazard, which contains as a minimum:

EAGLE COUNTY

(1) Jurisdictional responsibilities for direction and control of emergency warning and evacuation.

(2) Population accountability during evacuation and at temporary shelters.

(3) Responsibilities of authorities and support agencies at temporary shelters.

(4) Direction and control authority for return of populations to evacuated areas.

e. Given the potential hazard and its resource needs, the county needs a detailed resource listing, which identifies sources of personnel and materials with 24-hour a day contacts to insure timely access, if required.
Recommendation: That the County Emergency Preparedness Coordinator prepare a form for dispatch to all resource organizations within the county requesting information necessary for preparation of a resource listing.

f. Because an actual emergency/disaster would most likely occur over an extended period of time, depth in emergency management personnel expertise would be necessary. At emergency management facilities, at least two shift operations would be essential to the ongoing situation.
Recommendation: That the county gradually extend its depth of personnel expertise in critical areas through greater participation in exercises.

ENCLOSURE 5

STATE OF COLORADO

1. General

a. The potential emergency created by the scenario (enclosure 1) displayed the extension of State support and assistance to county government on the Western Slope. It included not only support of Eagle County, but also potential multijurisdictional coordination and assistance.

b. While the State's Forward Command Post, and possibly the communications van, would logically be deployed given a favorable assessment of other conditions statewide, the Emergency Operations Center (a fixed facility at Camp George West in Golden) was relocated to the exercise darea only to enable participants on-site observation of the threat, and attendance at the post exercise oral critique. Because telephone communications was limited within the Battle Mountain High School facility, normal access to outside agencies and jurisdictions was unrealistically limited. Accordingly, only those observations considered essential to the actual emergency management of the potential threat will be noted.

2. Observations

a. The identification of hazard development as "phases" was confusing since the county and Minturn used the same term, however each defined differently.
Recommendation: That the State (DODES), in coordination with the county, establish a clearer identification of hazard development which does not conflict with county and impacted incorporated jurisdiction response plans e.g., change "Phase" to "Stage."

b. The State Forward Command Post should be deployed forward as an extension of the State Emergency Operations Center linked to the county EOC - either co-located with a County Forward Command Post (if deployed) or in communication with the County EOC on State assistance/support. It should not be co-located with an incident command post, since such deployment risks threatening a coordinated incident command post/county EOC/State Emergency Operations Center effort.
Recommendation: That the State Emergency Operations Center obtain information from the county on the direction and control facility implementation and locations prior to State Forward Command Post deployment and site selection.

c. As a hazard develops which has the potential for State involvement (advice and/or assistance and support), functional department/agency representatives need to begin a dialogue with county counterparts e.g., what is county resource status, potential actions and needs. This will normally occur as DODES contacts State Emergency Operations Center representatives with situational information prior to or at partial/full EOC activation.
Recommendation: That departments/agencies identified for representation in the State Emergency Operations Center and Forward Command Post (if deployed) establish a dialogue now with county counterparts given the recognized hazard and lessons learned during this exercise.

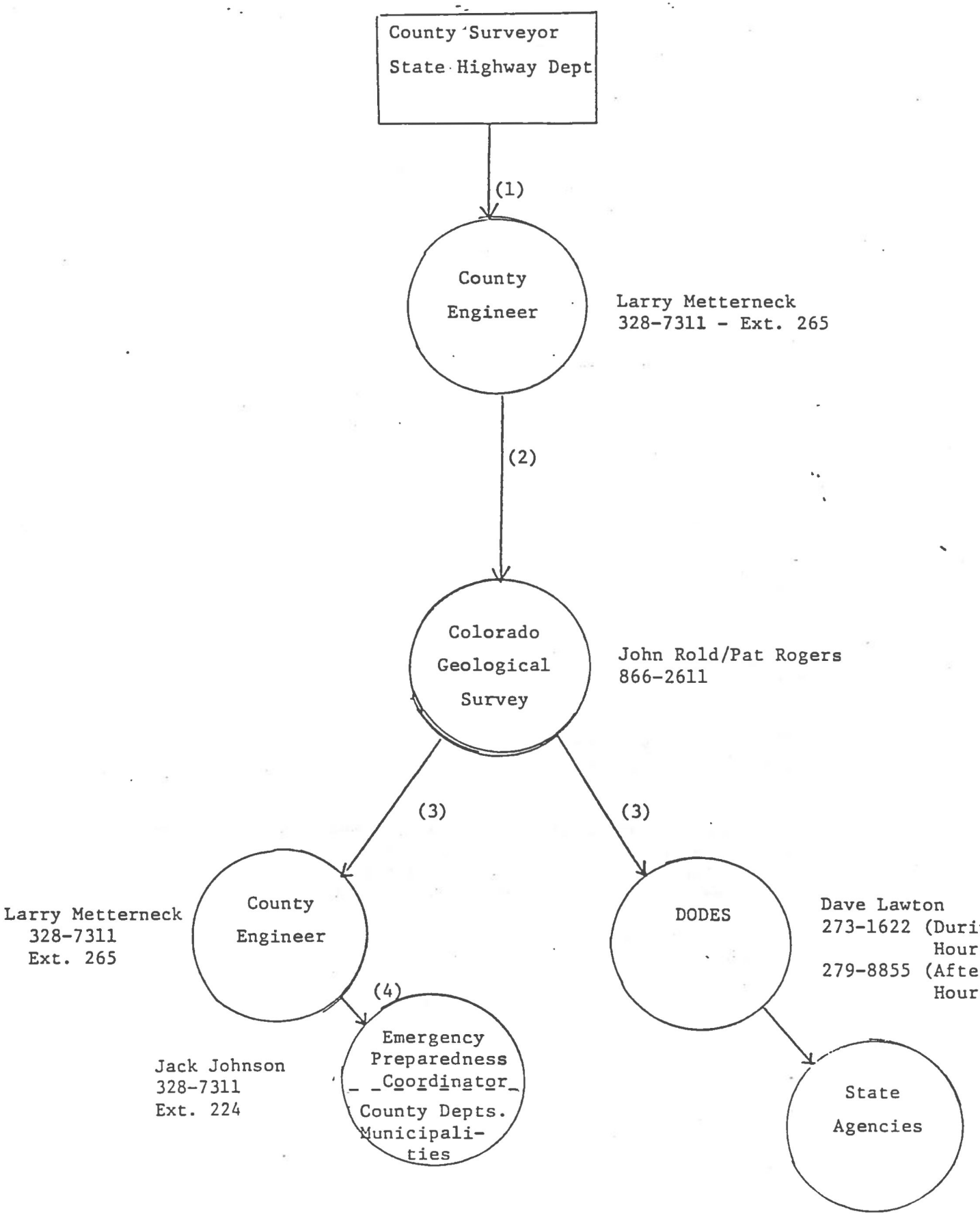
d. The need was recognized for a U.S. Forest Service and Colorado Water Conservation Board representative in both the State Emergency Operations Center and the State Forward Command Post due to the complementary nature of analysis/action response consideration.
Recommendation: That DODES request additional representation as indicated.

e. The format and wording of geological/hydrologic analysis information/data was not compatible with the needs of the user at the State and County. What does the user need as the situation develops; what can the technicians provide; to whom, in what format, how often, and how worded can the technician satisfy the user's needs?
Recommendation: That the Task Force address this issue with the County Emergency Preparedness Coordinator/County Engineer as a further development of the established procedures at Tab A.

f. Conditions (potential and actual) within the area of I-70 and U.S. 24 create traffic access considerations well beyond the immediate incident site. Road closure and detour considerations resulting in decisions were made without adequate coordination with appropriate agencies. The Department of Highways has responsibility for road closures (Federal and State highways), however, in potential emergencies needs to obtain impact input from other emergency management authorities.
Recommendation: That the Department of Highways be represented in the Task Force, and based on the implications associated with this recognized hazard prepare contingencies after an analysis of the anticipated response actions.

Tab A to Enclosure 5

DOWDS JUNCTION MONITORING/NOTIFICATION SYSTEM



(1) County Surveyor measurements/observations called in to County Engineer's Office; State Highway Department notifies County Engineer when measurements/observations scheduled - then call in with measurements/observations obtained.

(2) County Engineer calls in measurements/observations received above to Colorado Geological Survey for analysis/interpretation.

(3) Colorado Geological Survey conducts analysis/interpretation of input received from the County Engineer; provides results back to County Engineer and to DODES.

(4) County Engineer passes analysis/interpretation to County Emergency Preparedness Coordinator for dissemination within county and to appropriate municipalities. State Division of Disaster Emergency Services passes analysis/interpretation to departments, as appropriate.

ENCLOSURE 6

OVERALL EVALUATION

1. The purpose of a Tabletop Exercise is to display as closely as possible conditions associated with a potential hazard as it develops, and insure as thorough and wide as possible the consideration and ultimate actions which emergency managers may be required to initiate; such actions should then be incorporated in emergency operations plans at applicable jurisdictional levels. In this exercise, the following areas did not receive sufficient attention:

   a. Health issues
   b. Emergency Evacuation from site into temporary shelter
   c. Downstream impacts.

2. While the exercise was conducted covering approximately 14 days in 7 hours with situation analysis and decision-making at a 48 to 1 pace in time, it is equally a valid comment that at times over an extended period, actions will occur at an exhaustive pace.

3. Each level of government carries with it legal responsibilities and authorities, which cannot and must not be usurped. Accordingly, it is essential that all actions in response to emergencies/disasters be made with full cognizance of jursisdictional prerogatives. In order to insure this role recognition, coordination between emergency operating/operations centers on a continuous basis is mandatory. Both decisions and sources thereof are necessary ingredients of emergency management at all levels; positions of responsibility, and positions/departments/agencies with specified authorities must be contained in emergency operations plans at all levels.

4. Effective communications begins at the center of government and must extend to an incident site regardless of its location within a jurisdiction. With a detailed analysis of hazards within a jurisdiction and exercise of emergency operations plans, communication needs can be quantified. This exercise, based on a recognized hazard raised communications shortfalls which are being addressed.

5. A number of actions took place within this exercise which when incorporated in emergency operations plans will enhance emergency preparedness. Many issues are procedural in nature, while others are dependent on funds for resolution; in both cases, they should be prioritized, based on importance and criticality, and programmed for accomplishment in a near and long term development plan.

OVERALL EVALUATION

6. Finally, the citizens of the county and municipalities, as well as those who enjoy the benefits of Eagle County can find added comfort that government officials at all levels are turning concern into action in those emergency preparedness areas that ultimately result in protection of lives and property. The next and subsequent exercises should reinforce this public awareness and satisfaciton.

MEMORANDUM

DIVISION OF DISASTER
EMERGENCY SERVICES
Camp George West
Golden, Colorado 80401
(303) 273-1624

John P. Byrne
DIRECTOR

DATE: 15 July 1985

TO: EXERCISE PARTICIPANTS

FROM: JAMES R SEAVER, CHIEF CONTROLLER

SUBJECT: AFTER ACTION REPORT, WHISKEY CREEK (DOWDS JUNCTION) LANDSLIDE EXERCISE, 14 JUNE 1985

1. General On 14 June 1985 (7:30 a.m. - 3:05 p.m.), a second* Tabletop Exercise was conducted using a recognized hazard in the Dowds Junction area (intersection of I-70 and US 6/24) in Eagle County. The following jurisdictions/agencies participated:

   a. Towns

      (1) Vail - Command Post located in the town hall.

      (2) Minturn - Command Post located in the town hall.

      (3) Avon - Command Post located in the town hall.

      (4) Gypsum - representative of the town council at the County Emergency Operations Center (EOC).

      *See DODES Memorandum, subject: After Action Report, Meadow Mountain (Dowds Junction) Landslide Exercise, 15 May 1985, dated 28 May 1985, for description/results of the first exercise.

   b. Counties

      (1) Eagle County

         (a) Emergency Operating Center - located at the joint County-CSP Communications Center in the town of Eagle.

         (b) Forward Command Post - located in vicinity of the Avon Town Hall.

      (2) Garfield County - Chairman, Board of County Commissioners and County Emergency Management Coordinator located in the Eagle County Emergency Operating Center.

c. State

(1) Emergency Operations Center

(a) Division of Disaster Emergency Services
(b) Governor's Press Office
(c) Department of Health
(d) Department of Natural Resources - Geological Survey, Water Conservation Board, Water Resources
(e) Department of Highways
(f) Colorado State Patrol
(g) Colorado Army National Guard
(h) Public Utilities Commission
(i) Department of Social Services
(j) Department of Law
(k) Federal Emergency Management Agency (Region VIII)
(l) US Forest Service
(m) American Red Cross

(2) Forward Command Post

(a) Division of Disaster Emergency Services
(b) Department of Highways
(c) Department of Natural Resources - Geological Survey, Water Conservation Board.
(d) Colorado State Patrol
(e) Colorado Army National Guard
(f) U.S. Forest Service

2. Objectives

a. To exercise emergency management, and the emergency operations plans and procedures at each level of government.

b. To test and exercise communications within and between each level of government.

3. Scenario Whiskey Creek (See Enclosure 1)

4. Exercise Play and Control

a. Free play of emergency management actions was generated by development of the seven (7) level scenario. Preplanned events were only inserted by the Control Group either when an area of concern was not being considered/played, or to facilitate play by a jurisdiction/agency.

b. A five-person Control Group from the Division of Disaster Emergency Services was positioned (with dedicated communications provided by the Colorado Army National Guard) as follows:

(1) Chief Controller and assistant at the Eagle County EOC to control overall exercise play and to observe actions of EOC participants, the town of Eagle and Gypsum, and Garfield County representatives.

(2) One controller at the towns of Vail and Minturn to observe actions at the respective command posts.

(3) One controller at Avon to observe actions of the town; also the county and State Forward Command Posts.

(4) One controller at the State Emergency Operations Center at Camp George West in Golden to observe actions.

5. Observations and Analysis

a. General Comments - See Enclosure 2.

b. Towns of Vail, Minturn, Avon and Gypsum - See Enclosure 3.

c. Eagle County. See Enclosure 4.

d. Garfield County - See Enclosure 5.

e. State of Colorado - See Enclosure 6.

f. Overall Evaluation - See Enclosure 7.

JRS:bl
7 Enclosures: a/s

ENCLOSURE 1

SCENARIO 2

WHISKEY CREEK SLIDE

Level I (Present): Monitoring/visual observation underway; no significant movement.

Since April, growing concern has been raised for the potential threat posed by the apparent instability of old landslide mass in the Whiskey Creek area west of the intersection of Interstate 70 and U.S. 6/24 (Dowds Junction).

State Geologists' assessments indicate that among the four potential slide areas at Dowds Junction, the Whiskey Creek slide has the greatest potential threat due to its size. Accordingly, county and state agencies have upgraded their monitoring of the area, both through instrumentation readings and visual observation. The lower region (immediately above Interstate 70 eastbound lanes) shows evidence of tension cracks, and incipient tension cracks have been seen further back.

Snowmelt runoff in the Eagle River (measured near Gypsum) fluctuates with daily peaks estimated about 3,000 c.f.s.(cubic feet per second) as temperatures gradually increase.

Intracounty emergency operations plans continue to be reviewed and updated as a result of lessons learned in a May 15 (Meadow Mountain scenario) exercise, and response to the potential threat.

Level II (1 - 3 days): Monitoring/visual observations indicate likelihood of movement impacting Interstate 70 and possibly U.S. 6/24.

Monitoring data, especially in the lower region has raised increased concern in the Whiskey Creek slide area. Lower region instrument (electronic distance measurements - EDM) readings have now increased from inches to feet per day. Tension cracks in the lower region are more noticeable, and cracks are beginning to increase in the second tier. More frequent readings and visual observations are being conducted.

State Highway Department crews are spending more time/effort in clearing debris/mud from the eastbound lanes of I-70. Periodic one-lane eastbound closures are becoming more frequent to accommodate maintenance requirements.

With increasing public awareness of the potential Dowds Junction landslide threat (particulary in Minturn, West Vail, Eagle-Vail and Avon), the county sheriff's department and town halls are getting more queries from citizens concerning government response plans, and particularly warning and evacuation procedures. Commercial and transportation companies are beginning to query the Colorado State Patrol concerning access through the Dowds Junction area on Interstate 70 and U.S. Hwy 6/24.

Runoff into Dowds Junction is monitored at staff gauges recently installed on bridges over the Eagle River at Minturn and over Gore Creek at West Vail. Daily peaks are observed at 400 c.f.s. in the Eagle River (Minturn) and 150 c.f.s. in Gore Creek (West Vail).

Level III (1 - 2 days): Soil movement impacts interstate 70 resulting in eventual closure.

Soil movements begin encroaching onto the eastbound lanes of the highway making State Highway Department crew efforts to clear the road increasingly difficult. Frequent detours are followed by a major period of interstate closure, traffic being rerouted around the incident site on U.S. 6/24 from Avon (Exit 167) to Dowds Junction intersection (Exit 171).

Monitoring instrumentation readings continue to increase in the lower region (feet per day) above the interstate. In the second tier, tension cracks are becoming increasingly greater in number and length; definite movement of EDM markers is now evident in daily readings.

Town, county and state emergency management facilities are now in an increased readiness state.

Finally, the interstate is closed from Exit 167 to Exit 171 as mud blocks westbound lanes; State Highway Department crews continue to attempt to reduce the width of the wet soil movement over the interstate, while shifting attention to U.S. 6/24. Traffic on U.S. 6/24 continues with priority to emergency vehicles and local communities support services.

Runoff in the Eagle River at Minturn and Gore Creek (West Vail) is estimated by local officials to measure 500 c.f.s. and 200 c.f.s. respectively.

Level IV (1 day): Soil Movement increases onto U.S. 6/24 threatening expansion into Eagle River.

Soil movement has continued across the interstate and down now onto U.S. 6/24 despite State Highway Department attempts to reduce impacts beyond the interstate.

Monitoring readings in the lower region are becoming increasingly more difficult to obtain due to disruption of instrument placements. Soil movement is expanding in breadth along the lower region. Second tier measurements have now increased to several feet per day; aerial observations and photos are revealing larger fractures/tension cracks throughout the area from the throat of the original old slide area north to the interstate.

As this level progresses, U.S. 6/24 becomes impassable despite efforts to limit the overflow of soil, has extended across the D&RGW Railroad tracks, and is now moving toward the river.

Runoff in the Eagle River at Minturn and Gore Creek in West Vail has continued to show measurements of 500 c.f.s. and 200 c.f.s. respectively. Combined flow of the Eagle River and Gore Creek at Dowds Junction is 1400 acre-feet per day.

Level V (1 day): Soil Movement expands into Eagle River

Soil has moved throughout the area between U.S. 6/24 and the Eagle River, and has now begun to enter the river. Slides over the interstate and U.S. 6/24 continue to expand. The limited instrumentation readings in the lower region and second tier have increased now measuring in feet per hour. The geologist on-site urgently informs the State EOC and County Engineer that a large and continuing event is underway. Soil movement into the Eagle River has begun to restrict water flow to a depth of 5 feet; then the soil mass is overtopped and erosion washes it away. The sequence continues several times, sending minor surges of water downstream.

Level VI (13 days): Dam Build-up in Eagle River.

Monitoring readings and visual observations continue to reveal increased movement throughout the slide area. Soil movement into the Eagle River continues to extend toward the far (north) bank and expand up and downstream.

As the slide-dam rises faster than the water can wash it away, the rapidly forming reservoir begins to expand. Inflow is estimated to have peaked at 1500 acre feet per day, indicating the snowmelt season is at its height. Water levels in the lake behind the slide are monitored hourly. The continued soil flow increases the strength of the dam backing up water on both the Eagle River and Gore Creek. The D&RGW Railroad is now inaccessible with partial inundation beginning near the confluence of Gore Creek and Eagle River.

Uncertainty over stability of the slide-dam to sustain water pressures caused by an increase in depth of water raises concern for potential flood threats downstream should it break.

Continued buildup of water back of the dam has caused total inundation of the intersection of U.S. 6/24 and Interstate 70 off-ramps (Exit 171), and continued flooding causes concern for the threat to low-lying residences in West Vail and Minturn. The other slide areas (especially Meadow Mountain and Dowds 1) continue to show less than significant movement, however monitoring and visual observation continues on a daily basis.

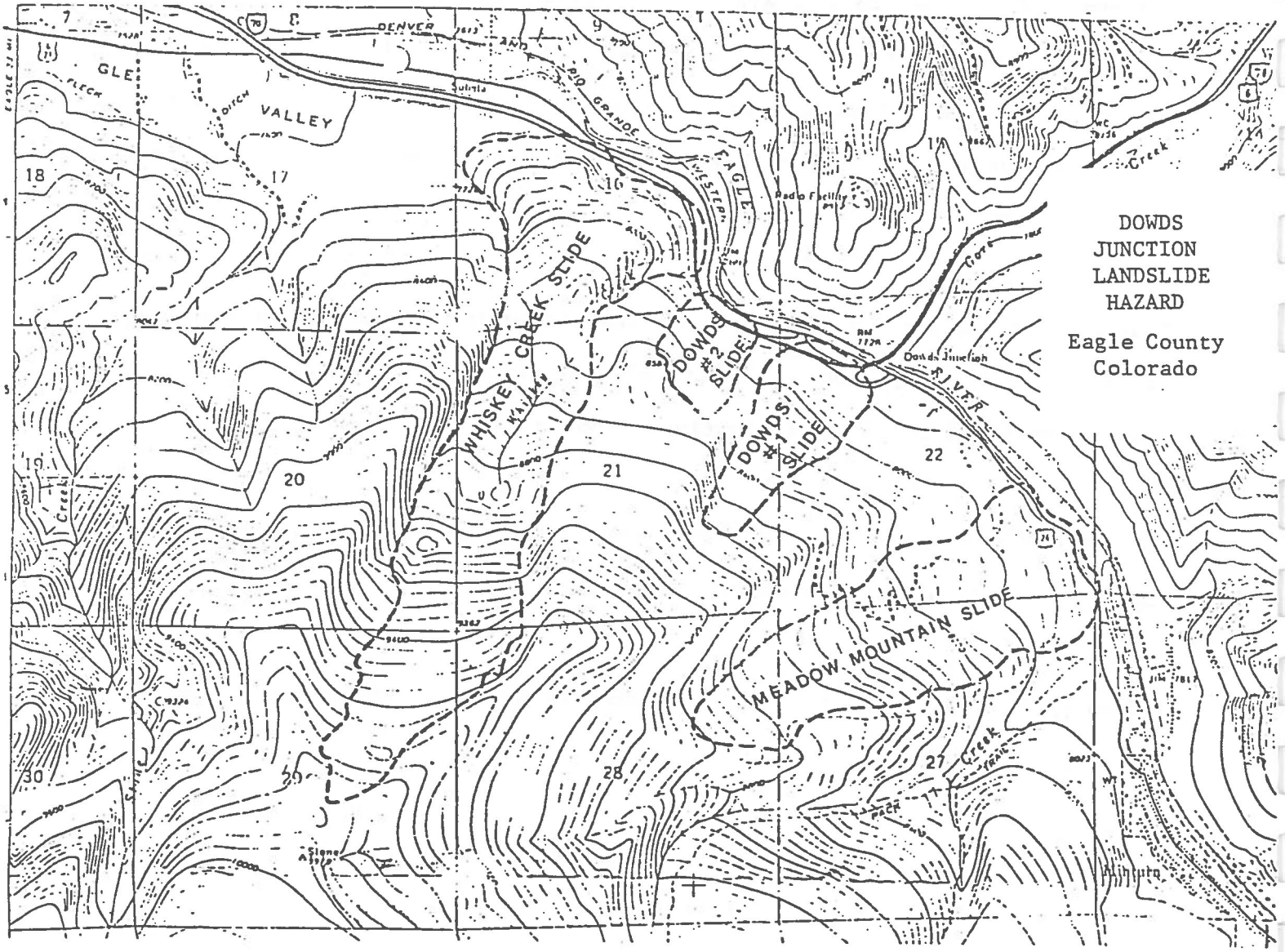
Level VII (1 day): Conditions leading to and failure of the dam.

The dam continues to rise with the buildup of soil despite efforts to curtail movement and attempts to maintain spillway flow. The rise of the slide-formed dam has stopped at a height of approximately 150 feet (7800 ft. above sea level). Backup of water is rising at about 5 feet per day and will soon result in inundation of the rail yard north of Minturn and up Gore Creek over the interstate.

Leakages through the dam face are becoming increasingly evident. A weak area is developing visibly along the north edge of the slide dam. Shifting of the heavily saturated soil mass is continuing to be observed.

As the water rises and tops the slide-dam, breaks at selected points on the top occur and channels are created.

Suddenly, the saturated soil mass slumps as a loose mudflow releasing the water behind the dam.


DOWDS
JUNCTION
LANDSLIDE
HAZARD
Eagle County
Colorado
WHISKEY CREEK SLIDE
DOWDS #2 SLIDE
DOWDS #1 SLIDE
MEADOW MOUNTAIN SLIDE
DENVER AND RIO GRANDE
EAGLE RIVER
VALLEY
Dowds Junction
Minturn

ENCLOSURE 2

GENERAL COMMENTS

1. This exercise was a follow-up to the initial exercise of the Dowds Junction landslide hazard conducted on 15 May 1985, and used a scenario depicting the Whiskey Creek threat area - the largest of the four potential threat areas in the Dowds Junction area. The potential inundation impacts include a portion of both Minturn and West Vail upstream, and areas along the Eagle River/Colorado River extending downstream into Garfield County (approximately Parachute).

2. Since timely notification of significant hazard area movements is essential to effective response, measuring devices have been installed in all four threat areas, a monitoring schedule/data reporting procedure established and implemented, and analysis begun as an ongoing process. It is important that all jurisdictions/agencies requiring the results of the analysis now and in the future have access to the periodic information. Accordingly, anyone needing this monitoring information, and not now on the distribution list, make their requirements known to either the county (Jack Johnson, Emergency Preparedness Coordinator) or the State Division of Disaster Emergency Services (Dave Lawton, Chief of Operations).

3. Priority of scenario play during this exercise was to Levels III, IV, V and VI as indicated at Tab A. Upon termination of the exercise, oral critiques were conducted concurrently at the Avon Town Hall and at the State Emergency Operations Center in Golden.

4. The observations and evaluation comments contained herein should be reviewed in conjunction with those made in the after action report for the first exercise. Where lessons learned remain unresolved, particular note should be made for subsequent action. Equally important, lessons learned in one jurisdiction may apply equally to others at the same level of government or at another level, yet not be specifically identified/reiterated.

TAB A

Dowds Junction (Whiskey Creek) Landslide Exercise

Level I (Present):	Mointoring/Visual Observation Underway; no significant movement.	0730–0800
Level II (1–3 days):	Monitoring/Visual Observations indicate likelihood of movement impacting Interstate 70 and possibly US6/24.	
Level III (1–2 days):	Soil movement impacts Interstate 70 resulting in eventual closure.	0800–~~0900~~ 0945
Level IV (1 day):	Soil movements increases onto US6/24 threatening expansion into Eagle River.	~~0900–0930~~ 0945–1100
Level V (1 day):	Soil movement expands into Eagle River.	~~0930–1030~~ 1100–1145
Level VI (13 days):	Dam Build-up in Eagle River.	~~1030–1230~~ 1145–1400
Level VII (1 day):	Conditions leading to and failure of the dam.	~~1230–1500~~ 1400–1505
Critique		~~1530~~ 1545

ENCLOSURE 3

TOWNS OF VAIL, MINTURN, AVON, EAGLE AND GYPSUM

1. General

a. Wider jurisdictional participation and involvement was noted during this exercise. With the exception of the town of Eagle, which did not participate, all towns with potential inundation in Eagle County were represented either in operation of a Command Post or at the County EOC.

b. It was observed once again, that those actively participating in each town displayed a high degree of professionalism and dedication in response to conditions as the scenario developed.

2. Observations

a. Town of Vail

(1) Emergency management operations were conducted from the communications center and an adjacent office in the town hall. The controller was advised that in an actual emergency, the council chambers would be used with a message center system between communications and the EOC. Recommendation: That in future exercises, the actual area be used in order to test and evaluate internal operating procedures, equipment and materials requirements, adequacy of telephone communications and responsiveness of the message center system, etc.

(2) The communications center supports not only Vail, but also Minturn and Avon areas. The personnel operating this facility performed in a commendable manner - the results were an informed operation in each jurisdiction served. It was felt that an internal plan for each potential hazard needs to be developed to include specific call-up listings. Recommendation: That the town, in coordination with the county, develop a response plan consistent with the county emergency operations plan now being upgraded, and in the communications area the towns also serviced by the Vail Communications Center.

(3) A water gauge has been placed on a bridge over Gore Creek in West Vail. This gauge is designed to provide data on water volume moving into the Eagle River at any given time, and was intended to provide needed data should a landslide at Dowds Junction develop a dam backing up water into and threatening West Vail. No one has been assigned to read this gauge if a requirement develops. Recommendation: That the town, in coordination with the county, designate an individual to read

the gauge, when required. The town should also have located in the Communications Center, or other suitable area, a picture of the gauge, its location, instructions on its use, and a map of the potential inundation area along Gore Creek.

b. Town of Minturn

(1) It was noted with pleasure that the town is taking action, based on lessons learned in the first exercise, to amend current resolutions to provide authority to the mayor or mayor pro tem to declare an emergency rather than the full town council as previously required.

(2) A water gauge has been placed on the Broadway bridge on the Eagle River in Minturn. This gauge is designed (like the one in West Vail) to provide data on water volume in the river at any given time, and especially if a landslide at Dowds Junction creates a dam downstream, resulting in a potential inundation problem in Minturn (and if Dowds 1 or Whiskey Creek, a threat to West Vail). Recommendation: That the town, in coordination with the county, designate an individual to read the gauge, when required. The town should also have located in the town hall a picture of the gauge, its location, instructions on its use, and a map of the potential inundation area along the Eagle River.

c. Town of Avon

(1) While response to the developing scenario by town officials was excellent, it became apparent that an emergency operations plan was needed, which identified department responsibilities, community interfaces, and technical/resource requirements and sources thereof. Recommendation: That the town, in close coordination with the County Emergency Preparedness Coordinator to insure compatability with the County LEOP, develop an emergency operations plan to meet response needs of this identified hazard.

(2) The presence and active participation of elected leadership is essential to ultimate decision-making in an exercise or actual emergency e.g., emergency declarations. Mayor Alan Nottingham's presence was indicative of the dedication of members of the Avon town government. Recommendation: That the town continue to include leadership and expand participation to other officials in the planning process and during future exercises.

(3) Since Avon is the first incorporated area downstream which would be impacted should a dam form and then break, it is essential that the town consider the inundation threat and need for possible "precautionary evacuation" as a dam forms. Recommendation: That the town evaluate the potential inundation threat to life and, in coordination with the county, establish warning and evacuation plans and procedures.

d. Town of Eagle

While there was no representation during this exercise, it is evident given the threat, that lessons learned in other incorporated areas could apply equally to Eagle. Recommendation: That the town of Eagle review the two after action reports, identify applicable actions for emergency preparedness, and participate actively in county planning and future exercises, as appropriate.

e. Town of Gypsum

(1) A member of the Town Council was present in the County EOC during the exercise to provide liaison between the two jurisdictions. Such a presence provides not only necessary representation in county decision-making, but also insures a coordinated effort as situations develop impacting the incorporated areas either directly (e.g., resources identification) or indirectly (e.g., county, State and Federal disaster declarations). Recommendation: That the town incorporate in its emergency planning designation of a representative to be dispatched to the county EOC, when potential or actual emergencies arise, and such a request is made by the county.

(2) The town did not place requirements on the county for situational information, nor was situational information on the town apparent in the county EOC. This would have been necessary as level VI and VII of the scenario developed. Recommendation: That both the county and town incorporate in their emergency plans, information needs which then serve as the basis for assessing strengths and shortfalls in response capabilities - one aspect of decision-making prior to and during an emergency.

ENCLOSURE 4

EAGLE COUNTY

1. General

a. As a result of lessons learned in the first exercise, county preparations were more extensive e.g., the EOC arrangement was organized to include status boards, tables/chairs, and six dedicated telephones; wider functional representation.

b. Initial notification began at 7:30 a.m. with monitoring analysis from the State Geologist to the County Engineer at his home. When the County Engineer was not immediately available for follow-on information, the County Emergency Preparedness Coordinator was notified.

c. The County EOC was intentionally activated earlier than would normally occur in order to brief personnel on internal EOC procedures. It brought together essential functional representatives and leadership in one location to manage in a coordinated manner response actions.

2. Observations

a. The dialogue among functional representatives in the EOC, while initially minimal, was strengthened as the exercise continued. When the Sheriff indicated he did not have sufficient information on the overall situation, periodic briefings were instituted. The results were beneficial to all functional representatives. Recommendation: That such a technique for situational update became an SOP item in the EOC. Additionally, the county should consider expanding the emphasis on coordination by including:

(1) Status board for each functional area.

(2) A "coordination line" in the message form to provide greater exposure to such a need in response actions.

(3) Designated release authorities (e.g., commissioners, sheriff, emergency preparedness coordinator) for county-originated traffic to insure coordination is affected prior to release, and the action is appropriate/clear/concise/accurate.

b. Telephonic communications were severed (simulated) during a portion of the exercise, and in fact occurred to the State Emergency Operations Center (273 prefix switching problem) early in the exercise. While it logically increased the burden/workload on radio communications until the problems were resolved, the re-

sponse by the EOC dispatchers and the Eagle Telecommunications was excellent. Recommendations:

(1) That the county establish a "precedence system" (e.g., routine, priority, emergency) in the EOC SOP for message traffic (radio), so during periods of increased traffic priorities of transmission can be used by communicators.

(2) That Mountain Bell/Eagle Telecommunication representatives be brought into the emergency preparedness/planning process now to insure an ongoing understanding of telephone communication needs when a potential or actual emergency necessitates activation of an EOC.

c. While Levels I through VI were played with intensive interest and energy, Level VII (i.e., impacts resulting from a dam failure) did not get the same attention. Recommendation: That the county conduct a session (tabletop exercise or discussion) at a later date to go over actions necessary in response to downstream inundation.

d. Unincorporated areas need to be brought into the situation early to insure activation of internal response mechanisms (including those in an indirect role e.g., Basalt could possibly provide resources even though not directly impacted). Recommendation: That the county, if not already accomplished or known, request a point of contact from each incorporated area for initial emergency notification and situational information.

e. Warning and timely evacuation of impacted populations is an essential decision point in any response to a potential hazard. In order to reduce congestion on roads and facilitate orderly reception at temporary shelters, such activities may take place in stages with the most endangered population moved first. Recommendations:

(1) That the county and impacted towns assess the population warning needs, determine warning means available, identify shortfalls and possible means of resolving them.

(2) That the county, in coordination with the towns, consider in planning the "precautionary evacuation" of the most endangered populations as the potential threat develops. In each case, estimated population figures (including breakout of handicapped/others needing assistance) need to be determined.

f. Location of a temporary morgue was discussed and found in conflict with an identified temporary shelter; the problem did not appear to have been resolved as the exercise ended. Recommendation: That the county resurface this issue and establish a site for inclusion in the emergency operations plan. Location consideration should include size, ingress and egress away from possible evacuation routes, etc.

g. The potential inundation areas need to be portrayed on more detailed town/county maps so that the user can more effectively depict functional information. Recommendation: That the county, in coordination with the Colorado Water Conservation Board, develop inundation maps meeting the needs of the user.

h. With access from Vail to Avon severed as the landslide dam formed, consideration of other routing for emergency equipment resulted. Such access would be necessary if a route was feasible. Recommendation: That the county, in coordination with the U.S. Forest Service, determine the feasibility of using a road from Wolcott to Vail, which was discussed during the exercise.

ENCLOSURE 5

GARFIELD COUNTY

1. General

   a. The presence of the Chairman, Board of County Commissioners, and the Emergency Management Coordinator at the Eagle County EOC throughout the exercise provided the opportunity to gain first-hand information on the landslide threat and actions taken in response as the scenario developed.

   b. Unfortunately, time was not available to extend Level VII of the scenario into Garfield County, however some impacts were noted e.g., traffic rerouting, potential inundation areas from the county line to New Castle.

2. Observations

   a. If this landslide threat were to occur, a representative/liaison from Garfield County would be a valuable asset in the Eagle County EOC. He/she would be able to provide timely situational information to emergency managers in Garfield County, and assess potential impacts as the threat develops at the incident site. Recommendation: That a liaison be identified for dispatch to the Eagle County EOC should it become activated in response to this landslide threat.

   b. Many lessons have been learned from the two exercises conducted in response to the Dowds Junction landslide hazard, which logically may be applicable to Garfield County and its unincorporated areas. Recommendation: That the county review the two after action reports, and incorporate applicable lessons learned in a threat response annex to the County Emergency Operations Plan.

   c. Based on the potential worst case downstream inundation impacts, public utilities may be disrupted. Recommendation: That the county assess potential impacts, and determine with assistance of the applicable utilities alternatives in meeting emergency needs during the response and recovery phases.

ENCLOSURE 6

STATE OF COLORADO

1. General

   a. The State Emergency Operations Center was activated in Golden, and the Forward Command Post (FCP) with communications van deployed to Avon. Operations within each facility were enhanced by more extensive staffing and the experience gained during the first exercise. Internal and external dialogue increased, participants had a greater grasp of the developing situation, and emergency management actions necessary. Greater focus was placed on anticipation of needs, rather than reaction to the developing situation.

   b. In this scenario, State actions rather than county response were the initial concern as impacts on Interstate 70 and U.S. 6/24 occurred. The result was a decision to declare a State Disaster Emergency (10:00 a.m.) prior to a county declaration (11:42 a.m.) followed by a Federal Disaster Declaration.

2. Observations

   a. The telephone system at Camp George West needs to be evaluated in terms of EOC requirements when activated. All trunk lines were not taken over, and confusion remains over clearing telephones in the dimension system. The county EOC personnel expressed concern with the excessive number of rings before anyone answered at the State EOC. Would the problem become even more difficult if more than one county EOC is activated, and placing demands on the State EOC? Recommendations: That DODES analyze the telephone system, procedural or equipment changes be made as deemed necessary, and a communications exercise be developed with county participation to insure acceptable telephonic access into and out of the State EOC in the event of an emergency/disaster.

   b. There appears to be no county level Red Cross representative in Eagle County. As a result, Red Cross interface with the Social Services representative in the County EOC was lacking as evacuation planning and implementation occurred. Recommendation: That the Department of Social Services, in coordination with the American Red Cross and the county, identify a local Red Cross representative to interface with the county prior to and during an emergency/disaster.

c. Traffic rerouting decisions appeared to be made in a timely manner, however the lack of effective dissemination of information to county level law enforcement agencies created confusion. At the State level, the decision was made that traffic on I-70 be diverted around the incident site at Rifle and Silverthorne. However, local Department of Highways personnel indicated that traffic from the west on I-70 would be rerouted over the bridge at Glenwood Springs, then to Aspen and Tennessee Pass; Garfield County representatives strongly objected to this congestion in the Glenwood Springs area at a time when county preparedness actions would be underway. Recommendation: That the Department of Highways, in coordination with appropriate county representatives, review the rerouting requirements and dissemination procedures to insure compatibility with emergency preparedness needs of the jurisdictions impacted.

d. Evacuation decisions - who orders, under what condition - is a concern at the State/County/Town levels of government. What role each level of government should play, unilaterally or in concert, needs to be considered. Recommendation: That DODES, in coordination with the Governor's office, Department of Law, and the impacted counties, establish a procedure for evacuation decision-making, given the Dowds Junction hazard.

e. The Public Information operation needs to be reviewed and a plan established to meet media/government needs. A State/local public information presence would probably be needed (1) on both sides of the incident site preferably co-located with direction and control facilities e.g., county and/or State Forward Command Posts, and (2) supported by the State EOC, in communications with the Governor's office, to coordinate information on official State actions, and provide a lifeline for responses/PIO's in the field. Recommendation: That DODES, in coordination with the Governor's Press office and the county PIO, establish a plan for public information in support of the Dowds Junction landslide hazard.

f. The downstream inundation map identifing the worst case threat if a 200 foot dam were to form and then break included areas along the Eagle and Colorado Rivers to New Castle, even though charts indicate a threat extending further west to Parachute. Recommendation: That the Division of Water Resources complete preparation of inundation maps to Parachute, and provide to DODES for distribution to the impacted county.

g. Requests for assistance were often duplicated as they arrived at the State EOC i.e., coming from the County EOC and State FCP. Recommendation: That DODES develop a standard procedure for receiving and processing requests for assistance generated at county level during emergencies/disasters.

h. This exercise covered in excess of 14 days in a 7 1/2 hour period, thereby not requiring resort to shifts in the direction and control facilities. In a real situation, depth in representative participation would be essential. Recommendation: That departments/agencies represented in the EOC and FCP establish plans for such depth in representation should this or another similar emergency/disaster situation occur.

i. The Eagle County Communication Center was heavily taxed due to the large amount of traffic that logically flowed in from radio-dependent agencies. Concurrently, when the telephones went out, traffic volume increased significantly. The State EOC reduced the burden by using the CCIC terminal; the State FCP does not at this time have that capability. Intra-county and some State traffic had to be received in written form, then retransmitted over the CCIC terminal by County Communication personnel often creating a backlog. Recommendation: That DODES evaluate the benefits in equipping the FCP/Communications Van with a CCIC terminal, which would assist in reducing processing workloads in communications centers.

j. Health issues received wider play and the scope of concerns was extensive involving interjurisdictional assistance and support. Recommendation: That the Department of Health, in coordination with the County Environmental Health officer, document actions identified and interjurisdictional assistance/support arrangements for implementation if needed.

ENCLOSURE 7

OVERALL EVALUATION

1. The objectives of this exercise were:

   a. To exercise emergency management, and the emergency plans and procedures at each level of government, and

   b. To test and exercise communications within and between each level of government.

2. This second exercise using an expanded scenario in the same general hazard area was beneficial in correcting shortfalls noted in the first exercise, and expanding on the lessons learned. In this respect, the following is considered essential:

   a. Each jurisdiction/agency/department needs to review the observations in both this and the previous after action report, identify actions outstanding in each report, and initiate a program to resolve issues, and establish plans and procedures to resolve shortfalls. (Note: Since this threat will continue to exist into the fall, then become a potential next spring once again, it is essential that effort to complete outstanding actions be accomplished in the near term.).

   b. Emergency operations plans at each level of government need to be revised/refined to incorporate lessons learned. State Planner assistance effort from DODES to the county is scheduled to continue, in a dedicated manner through September, 1985; timely assistance solicited from other agencies will be most appreciated.

   c. Intra-county radio communications continue to be an identified shortfall warranting study and resolution in the near term. State communications shortfalls identified in the first exercise appear to have been corrected with the exception of the need for computer upgrade; this needs to be addressed in the near term also.

3. It is essential that jurisdictions legal advisors continue to be active participants in the ongoing emergency operations plan development, and that they insure consistency of opinions through a dialogue between each level of government.

4. It has been noted with satisfaction that participants at each level of government, while recognizing ongoing needs and requirements for refinement of plans/procedures, have expressed a greater confidence in the coordinated response demanded should this threat become an actual incident. Continued attention to shortfalls and lessons learned should serve to not only enhance emergency management response to this hazard, but also contribute favorably in response to other identified hazards.

5. Appreciation is extended to the following persons, who in the last three months have provided special support and assistance in development of the exercise program for the Dowds Junction Landslide Threat area:

   a. Jack Johnson - Emergency Preparedness Coordinator, Eagle County

   b. A. J. Johnson - Sheriff, Eagle County

   c. Mike Gallagher - Police Chief, Minturn

   d. Bill Stanton - Colorado Water Conservation Board

   e. Pat Rogers - Colorado Geological Survey