THE PRELIMINARY LANDSLIDE HISTORY DATABASE OF UTAH, 1850–1978

by Ashley H. Elliott and Michael J. Kirschbaum

OPEN-FILE REPORT 514
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
2007

THE PRELIMINARY LANDSLIDE HISTORY DATABASE OF UTAH, 1850–1978

by Ashley H. Elliott and Michael J. Kirschbaum

Cover Photo: Failure of cut slope with rock facing, Layton, Utah, 2006. Photo by Rich Giraud.

OPEN-FILE REPORT 514
UTAH GEOLOGICAL SURVEY
a division of
Utah Department of Natural Resources
2007

STATE OF UTAH
Jon Huntsman, Jr., Governor

DEPARTMENT OF NATURAL RESOURCES
Michael Styler, Executive Director

UTAH GEOLOGICAL SURVEY
Richard G. Allis, Director

PUBLICATIONS
contact
Natural Resources Map & Bookstore
1594 W. North Temple
Salt Lake City, UT 84116
telephone: 801-537-3320
toll-free: 1-888-UTAH MAP
Web site: http://mapstore.utah.gov
email: geostore@utah.gov

THE UTAH GEOLOGICAL SURVEY
contact
1594 W. North Temple, Suite 3110
Salt Lake City, UT 84116
telephone: 801-537-3300
fax: 801-537-3400
Web site: http://geology.utah.gov

CONTENTS

FIGURES

TABLES

THE PRELIMINARY LANDSLIDE HISTORY DATABASE OF UTAH, 1850–1978

by Ashley H. Elliott and Michael J. Kirschbaum

ABSTRACT

The *Preliminary Landslide History Database of Utah, 1850-1978* provides mostly non-technical information on landslide events that occurred from 1850 to 1978. The database was compiled from multiple sources; the most useful of these sources was the "Public PIONEER Utah's Online Library," which contains digitally archived newspapers available for search on the Web.

The database can be searched for landslide information using keyword searches such as decade, county, type, and cause (natural or human-caused) of landslides. By searching the database, it is possible to gain insight into the frequency, causes, and consequences of landsliding, as well as to identify landslide-prone areas of Utah.

Although the database is compiled from several different sources, it is not a complete record of all landslide events in Utah. The sources used to compile the database may not include all landslide reports for the years searched. The database includes limited technical information on the landslides.

INTRODUCTION

In 2005, we began compiling historical landslide data using digitally archived newspaper articles spanning 1850 to 1961. The project expanded to include flood and landslide chronologies, and some site-specific studies, which were used to verify and expand on data obtained from the newspaper articles, and we extended the database coverage to 1978. The result is a database with 488 records of 356 landslide occurrences. Ultimately, we hope to create a comprehensive historical landslide database that can be used for future research. Such a database is a useful tool for understanding the frequency, possible causes, and consequences of landsliding, and for identifying some of the landslide-prone areas in Utah.

The database is not a comprehensive compilation of all historical landslides in Utah. The initial purpose of this research was to find all reports of landslides prior to 1982 contained in digitally archived newspaper articles available through the Public PIONEER Utah's Online Library (2006) (PIONEER). Other sources were initially explored only to verify and expand on the data obtained from the PIONEER. For this reason, limited sources are represented in the current database, but we intend to update the database as more articles become available in the PIONEER and to expand the scope of the project and incorporate other landslide publications. The years and geographic coverage included in the database reflect article availability as of May 1, 2006, and are only a small part of the whole landslide history of Utah. Geographic coverage is limited to counties for which newspapers are included in the PIONEER (see figure 1 for the newspapers and their corresponding counties).

SEARCH METHODS

To create the landslide database, several different search criteria were used, including a landslide classification system as well as terminology to differentiate debris flows from floods. The Cruden and Varnes (1996) classification of landslide types was used to search all sources for landslide accounts. Although landslides of all types occur, only three types of landslides could be specifically identified (rock fall, rock slide, and debris flow) due to the limited information included in the sources. The term "landslide" is used for any mass movement that could not be further classified. Debris flows required more specific search criteria because several of the sources used to search for debris-flow events did not differentiate between floods and debris flows.

Landslide Classification

We used the Cruden and Varnes (1996) classification of landslides to categorize different types of landslides in the database. According to their definition, the term "land-

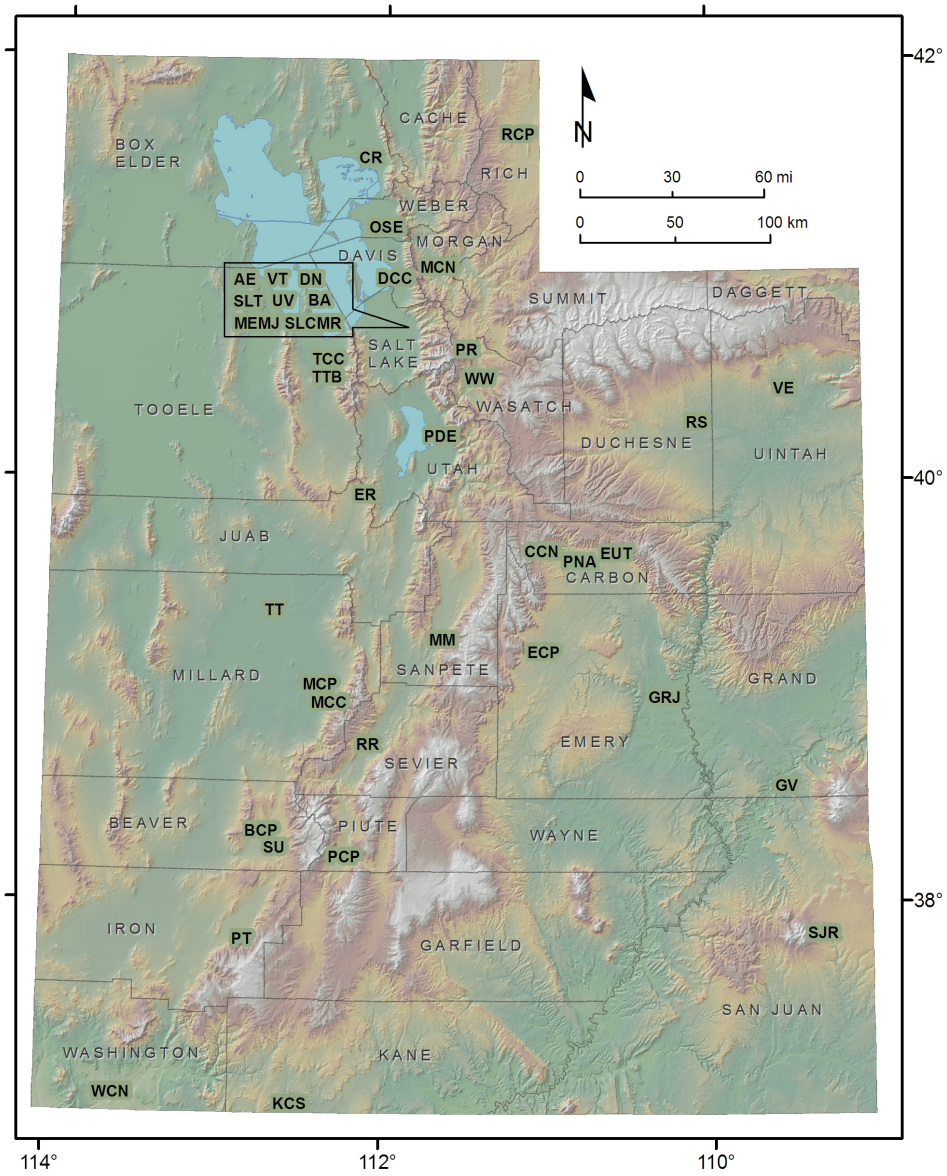

Figure 1. *Location of the county and city newspapers searched in the PIONEER. Abbreviations are shown in table 1.*

slide" is used to describe any downslope movement of rock, debris, or earth including falls, flows, and slides, and thus is not solely limited to sliding of "land." Table 2 lists the various landslide movement types and their definitions. The Cruden and Varnes (1996) landslide classification uses two words; the first word describes the type of material, and the second word describes the type of movement (table 3).

Landslide Types in the Database

Sources used to create the database commonly lacked information on the type of material and movement when reporting a landslide occurrence, making it difficult to determine the landslide type. For this reason, only three landslide types are identifed in the database: "rock slide," "rock fall," and "debris flow" (figures 2 through 4). "Rock slide" and "rock fall" follow the Cruden and Varnes (1996) classification; however, "debris flow" is used in a more general way, including all flows that fall within the hyperconcentrated-flow and debris-flow sediment-water concentration ranges as described by Pierson (2005). The database defaults to the term "landslide" for any mass movement that could not be further classified and may include any type of material or movement.

Debris-Flow Search Criteria

Several sources used to compile the database did not differentiate between flood and debris-flow events, making it necessary to develop criteria to use when searching for debris flows. These sources include the flood chronologies developed by Woolley (1946), Keetch (1971), Butler and Marsell (1972), and the National Weather Service (2003), as well as the debris-flow summary for Davis County by Keaton and Lowe (1998). Due to varying reporting styles of the sources, we used different criteria to search the flood chronologies and the Davis County debris-flow summary. However, by using these criteria some "floods," as described by Pierson (2005), may be included in the database as debris flows.

Flood chronologies were searched for debris flows primarily using the criteria of debris depth. Generally, any event that deposited more than six inches of debris was considered to be a debris flow. Depth estimates were not always quantified in the account but we interpreted them from information in the article.

The Keaton and Lowe (1998) report on Davis County debris-flow hazards contains a summary of historical floods in which estimated annual deposit volumes are given for different canyons. Using this information, we included any year with a reported volume greater than 1,300 cubic yards for a canyon as a single debris-flow event. However, the yearly estimated deposits might contain multiple events.

Table 1. *List of newspapers and the years searched.*

Digital Utah Newspapers Collections	Abbreviation (used in figure 1)	Years Searched (as of 5/1/06)	County of Publication
American Eagle	AE	1897-1905	Salt Lake
Beaver City Press	BCP	1908-1928	Beaver
Broad Ax	BA	1895-1899	Salt Lake
Carbon County News	CCN	1909-1915	Carbon
Corinne Reporter	CR	1871-1873	Box Elder
Davis County Clipper	DCC	1892-1924	Davis
Deseret News	DN	1850-1898	Salt Lake
Murray Eagle and Midvale Journal	MEMJ	1927-1960	Salt Lake
Eastern Utah Telegraph	EUT	1891-1915	Carbon
Emery County Progress	ECP	1900-1910	Emery
Eureka Reporter	ER	1902-1922	Juab
Grand Valley / Times Independent	GV	1896-1932	Grand
Green River Journal	GRJ	1955-1956	Emery
Kane County Standard	KCS	1929-1950	Kane
Manti Messenger	MM	1893-1922	Sanpete
Millard County Chronicle	MCC	1930-1939	Millard
Millard County Progress	MCP	1894-1939	Millard
Morgan County News	MCN	1910-1954	Morgan
Ogden Standard Examiner	OSE	1879-1908	Weber
Park Record	PR	1880-1935	Summit
Parowan Times	PT	1915-1945	Iron
Piute County Papers	PCP	1902-1949	Piute
Price News Advocate	PNA	1915-1932	Carbon
Provo Daily Enquirer	PDE	1881-1897	Utah
Rich County Papers	RCP	1896-1945	Rich
Richfield Reaper	RR	1906-1940	Sevier
Roosevelt Standard	RS	1914-1940	Duchesne
Salt Lake City Mining Review	SLCMR	1899-1929	Salt Lake
Salt Lake Tribune	SLT	1871-1899	Salt Lake
San Juan Record	SJR	1919-1953	San Juan
Southern Utonian	SU	1881-1896	Beaver
Tooele County Chronicle	TCC	1947-1948	Tooele
Tooele Transcript Bulletin	TTB	1894-1924	Tooele
Topaz Times	TT	1942-1945	Millard
Union Vedette	UV	1863-1867	Salt Lake
Valley Tan	VT	1858-1860	Salt Lake
Vernal Express	VE	1891-1936, 1948-1961	Uintah
Wasatch Wave	WW	1889-1922	Wasatch
Washington County News	WCN	1908-1923	Washington

Table 2. *Definitions of landslide movement types simplified from Cruden and Varnes (1996).*

Type of Movement	Definition
Slide	The downslope movement of soil or rock that occurs on a rupture surface or on thin zones of intense shear strain. A continuum exists between slides and flows.
Flow	The spatially continuous movement in which the shear surfaces are closely spaced and short-lived. Often resembles a viscous liquid.
Fall	The detachment of soil or rock from a steep slope. The detached material then moves downslope by falling, bouncing, or rolling.
Spread	The extension of a cohesive mass (either rock or soil) combined with the general subsidence of that mass into softer underlying material.
Topple	The forward rotation of a mass of soil or rock about a point or axis. Topples are created by freeze-thaw actions, or are driven by gravity.

For example, the 1930 events at Parrish Creek include two debris flows, a hyperconcentrated flow, and a flood. Keaton and Lowe's (1998) estimated volume for Parrish Creek Canyon in 1930 included all four events.

The Public PIONEER Utah's Online Library

Although many sources were used to compile the database, use of the PIONEER made searching several digitally archived newspapers on the Internet possible. The PIONEER has compiled a database of scanned newspaper articles, and although the PIONEER's database is not yet a complete record of all newspapers in the state of Utah, the compilation is ongoing, and scans of new newspapers and available dates are periodically released. Table 1 shows the newspapers and the available dates searched for this project.

Articles accessed through the PIONEER are digital replicas of variable quality and this presented a few problems. The condition of some older newspapers made poor-quality scans, making it difficult for the search engine to always recognize search words correctly. To overcome

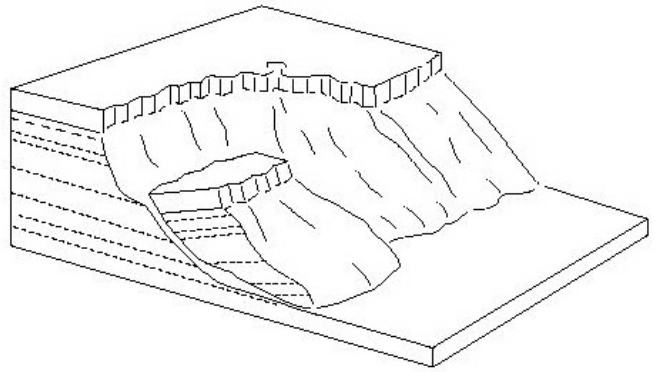

Figure 2. *Generalized depiction of a rock slide.*

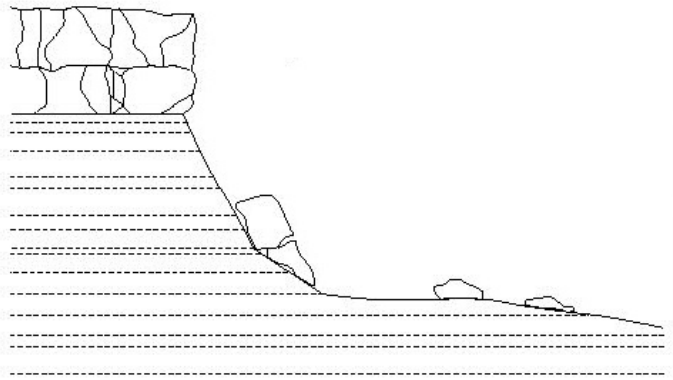

Figure 3. *Generalized depiction of a rock fall.*

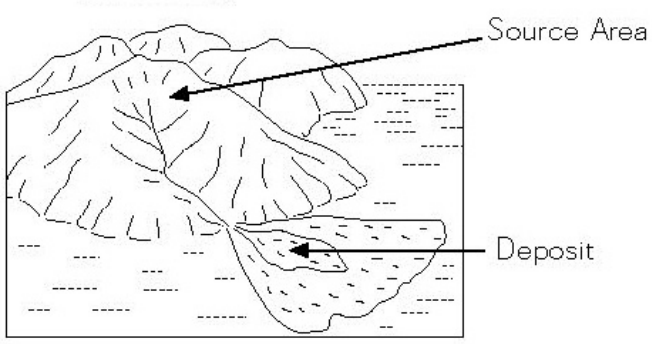

Figure 4. *Generalized depiction of a debris flow.*

Table 3. *Landslide types described by Cruden and Varnes (1996).*

Type of Movement	Type of Material		
	Bedrock	Predominantly Coarse	Predominantly Fine
Fall	**Rock fall**	Debris fall	Earth fall
Topple	Rock topple	Debris topple	Earth topple
Slide	**Rock slide**	Debris slide	Earth slide
Spread	Rock spread	Debris spread	Earth spread
Flow	Rock flow	**Debris flow**	Earth flow

Blue indicates landslide types identified in the database.

Table 4. *Usefulness of keywords used to search the PIONEER.*

Useful Keywords	Somewhat Useful Keywords	Not Useful Keywords
landslide	mudslide	rockfall
"land slide"	mud + rock	landslip
"rock slide"	debris + mud	"land slip"
cloudburst	"cloud burst"	"debris flow"
slide	slide + mud	mudflow
"mud slide"	debris + slide	"mud flow"
rockslide	debris	"mud flood"
	mud flood	"debris flood"
	"rock fall"	dirtslide
	"land slip"	"dirt slide"
	debris + rock	"dirt slump"
	rock	slump

Keywords are listed in descending order with the most useful at the top. Useful keywords are those that produced eight or more relevant articles. Somewhat useful keywords produced at least one relevant article and not useful keywords produced no relevant articles.

this recognition problem, multiple search words were used. Many of these words are variations of similar terms (such as "landslide," "land slide," and "slide"), which increased our chances of finding all relevant articles. Table 4 shows the search words used and their corresponding usefulness.

Other Sources

Other sources used to verify and expand on the data from the PIONEER include previous chronologies completed by searching newspaper records, and site-specific studies in Utah. Previous historical-flood chronologies such as Woolley (1946), Keetch (1971), Butler and Marsell (1972), and the National Weather Service (2003) have been completed for cloudburst-related floods, and were used to search for debris flows. Previous historical-landslide chronologies such as Keate (1991) and Keaton and Lowe (1998) were also used to search for debris flows. Several site-specific studies were also referenced, including studies of the North Fork of the Ogden River (Croft and Adams, 1950), the middle Wasatch Front (Goode, 1975), and the Logan Bluff landslide zone (Olsen, 2006).

DATABASE FORMAT AND USE

The database was created as a searchable document that can be used to aid in future research. Searches are conducted through the use of keywords or a combination of keywords as indicated in table 5. Once the search parameters have been set, a list of matches will be given that direct the user to the original source, which can be searched for more information.

The database listing is in reverse chronological order from youngest to oldest; events for which dates are largely unknown are listed at the beginning. Landslides are organized in the most likely chronological order based on the reported time of the event. Sources containing no time information are placed chronologically based on the newspaper article date, and those containing only the year of the landslide event are placed at the end of that year. Table 6 explains the headings used in the database. Railroad abbreviations used in the "Location" and "Notes" column are summarized in table 7. Any field (except for damage columns) left blank in the database represents information not included in the source.

LIMITATIONS

The database has several limitations inherent to the sources used to compile the database, including: available sources, years covered, geographic coverage of the newspapers, scanned articles of poor quality, and type and content of information reported in the sources. First, the available sources used to compile the database do not represent all historical landslide events. Our primary objective for this stage of the project was to compile a landslide database based on newspaper accounts available through the PIONEER. Initially, other sources were used solely to verify and expand on the data obtained through the PIONEER, but they also provided information about other landslide occurrences not discovered by searching the PIONEER. Other landslide events are likely documented by other sources that were not searched in this project. A second limitation is the incomplete record of the PIONEER newspaper articles available for search up to May 1, 2006 (table 1). Some of the newspapers included on the PIONEER were printed for more years than was available on the PIONEER. Also, not all published newspapers in Utah are currently available on the PIONEER. Third, geographic coverage of the available newspapers also limits the database to

Table 5. *List of keyword search categories that can be used to search the database.*

Database Keyword Categories
Decade
County
Landslide Type
Cause
Decade and County
Decade, Landslide Type, and Cause
County, Landslide Type, and Cause

Table 6. *Headings in the database and their descriptions.*

Headings	Description
Event	Event numbers correspond to the landslide occurrence. One number is assigned per event and alphabet letters are used to separate records. Created to help organize the database in chronological order.
Newspaper Article Date	Stated only for entries obtained using the PIONEER. Corresponds to the date of the newspaper in which the article is contained.
Event Date	Date the landslide occurred based on information given in the original reference and may be complete day, month, or year.
Event Year	Year the landslide occurred. Can be used if the more specific "Date of Event" is not given.
Decade	Decade the landslide occurred. Created to search the database by decade.
Location	Location of the landslide, reported as specifically as the source information allowed. In some cases the specific location was inferred.
County	Lists the most likely county. Multiple counties listed where more specific information is not given in the source.
Time Information	Corresponds to the time the landslide occurred, including exact or general time of day, month, or season.
Source	Lists the original reference of the landslide information. List of newspapers searched using the PIONEER is listed in table 3. All other sources are listed in the reference list at the end of this report.
Newspaper Article Title	The exact title of the article from the PIONEER. Any abbreviations used in the title are not defined in this report.
Cost	Dollar value of landslide damages including direct losses, structure repair, and landslide clean up. If multiple sources report different costs, the most specific information is listed.
Public Infrastructure Damage	Divided into two categories (major and minor) based on the amount of damage incurred. Major damage includes: damage or blockage of a road or railroad that required more than a day to clean up or repair, complete destruction of a structure (such as a bridge), and any damages reported as major. Minor damage includes: damage or blockage of a road or railroad that required less than a day to clean up or repair, incomplete destruction of infrastructure, and damages reported as minor. Damage descriptions are considered first when determining the damage category. Therefore, an article that states the damage was major, but the damage description indicates otherwise, is included as a minor damage. Blanks in this column are either from no reported damage in the original source, or because the extent of the damage could not be determined.
Private Property Damage	Major and minor categories are similar to those described in "Public Infrastructure Damage" but are specific to private property damages. Major damages include: destruction or damage to houses, major landscape changes, major damage to crops, and damage reported as major. Minor damages include: fields and farms covered with sediment with little damage to crops, and damage reported as minimal or minor. Blanks in this column are either from no reported damage in the original source, or because the extent of the damage could not be determined.
Injuries	Number of persons injured by the landslide.
Fatalities	Number of fatalities caused by the landslide.
Record Number	Used when more than one source or article documents the same event. The record number indicates which record is being viewed, as well as the number of total records for the landslide event.
Notes	Used for additional information found in the article such as specific geologic data, specific damage, road and railroad closures, landslide triggering mechanisms, location information, and clean up and repair. In most cases, the information contained in the notes column was taken directly from the original reference. Includes only the most relevant information.
Landslide Type	Identifies the most likely type of landslide using Cruden and Varnes (1996) classification (rock slide, rock fall, debris flow or landslide (for all other types)).
Cause	Landslides are either reported as "natural" or "human-caused." Any slide event that occurred in road cuts, or at or near a quarry, mining operation, or canal is included in human-caused events. If a distinction between natural or human-caused could not be made, the landslide is considered to be natural.

Table 7. *List of railroad abbreviations used in the database.*

Abbreviation	Definition
RR	Railroad
UP	Union Pacific
RG	Rio Grande
RGW	Rio Grande Western
D&RG	Denver and Rio Grande

certain areas within Utah (see figure 1). Landslides not within the newspaper's coverage area or landslides not causing damage likely go unreported. Therefore, information in the database is restricted by area coverage of the newspapers as well as the "newsworthiness" of a particular landslide (whether or not it caused damage to inhabited areas). Fourth, poor image quality of scanned articles made it difficult for the search engine to always recognize the search words. As previously mentioned, several search words were used to counteract this problem (table 4).

Finally, the database is limited by the amount of technical information contained in the original source. The database is compiled from information contained within the sources and is therefore limited to that information. If the source is inaccurate, these inaccuracies will appear in the database. Also, the amount and type of information varies for each source, particularly for the newspaper articles. Some sources have detailed information about a landslide whereas others only state the date and occurrence. These variations can be attributed to the reporting format of newspapers where technical information is not necessarily included. Probable landslide type was interpreted from the available technical information.

SUMMARY

The landslide database contains 488 records of 356 landslide occurrences from 1850 to 1978 that were compiled from multiple sources. The database can be searched for landslide information using keyword searches such as decade, county, type, and cause (natural or human-caused) of landslides. By searching the database, it is possible to gain insight into the frequency, possible causes, and possible consequences of landsliding, as well as identifying landslide-prone areas of Utah.

The most useful source used to compile the database was the Public PIONEER Utah's Online Library (PIONEER), which contains digitally archived newspapers available for search on the web. In searching the PIONEER, we used many search words to find landslide accounts. Some of the search words proved more useful than others, and some did not return any landslide accounts.

Although the database is compiled from several different sources, it is not a complete record of all landslide events in Utah. The sources used to compile the database may not include all landslide reports for the years searched. The database includes limited technical information on the landslides.

ACKNOWLEDGMENTS

We thank Elizabeth Churchill for the initial work on this project, Rich Giraud (UGS) for helping us identify debris flows in the flood chronologies, Rich Giraud and Francis Ashland (UGS) for reviewing the report and providing advice in developing the database, and William Case (UGS) for helping us develop search capabilities and formats.

REFERENCES

Butler, E., and Marsell R.E., 1972, Developing a state water plan, cloudburst floods in Utah, 1939-1969: Utah Department of Natural Resources, Division of Water Resources Cooperative-Investigations Report Number 11, 103 p., 1 plate.

Croft, A.R., and Adams, J.A., Jr., 1950, Landslides and sedimentation in the North Fork of the Ogden River, May 1949: U.S. Department of Agriculture Forest Service Research Paper 21, 4 p.

Cruden, D.M., and Varnes, D.J., 1996, Landslide types and processes, *in* Turner, A.K., and Schuster, R.L., editors, Landslides – investigation and mitigation: Washington D.C., National Research Council, Transportation Research Board Special Report 247, p. 36-75.

Goode, H.D., 1975, Environmental geology of the middle Wasatch Front, Utah: Field trip guidebook for a field trip of the annual meeting of the Geological Society of America, October 19, 1975, 22 p.

Keate, N.S., 1991, Debris flows in southern Davis County, Utah: Salt Lake City, University of Utah, M.S. thesis, 174 p.

Keaton, J.R., and Lowe, M., 1998, Evaluating debris-flow hazards in Davis County, Utah - engineering versus geological approaches, *in* Welby, C.W., and Gowan, M.E., editors, A paradox of power – voices of warning and reason in the geosciences:

Geological Society of America Reviews in Engineering Geology, Volume XII, p. 97-121.

Keetch, M.R., compiler, 1971, Sevier River basin floods 1852-1967: Salt Lake City, Utah, unpublished report by U.S. Department of Agriculture, Economic Research Service, Forest Service, and Soil Conservation Service, 113 p.

National Weather Service, 2003, Flash flood & flood deaths in Utah prior to 1950: Online, <http://www.wrh.noaa.gov/slc/projects/disasters/flood_stats/flood_deaths.php>, accessed July 14, 2003.

Olsen, S.P., 2006, History of the Logan Bluff landslide zone: Logan, Utah State University, M.S. thesis, 61 p.

Pierson, T.C., 2005, USGS Fact Sheet 2004-3142: Distinguishing between debris flows and floods from field evidence in small watersheds: Online, <http://vulcan.wr.usgs.gov/Projects/FS2004-3142/FS2004-3142.pdf>, accessed June 16, 2006.

Public PIONEER Utah's O nline Library, 2006, Utah Newspapers: Online, <http://pioneer.utah.gov/magazines_and_newspapers/utah_newspapers.html>, accessed January 1 - May 1, 2006.

Woolley, R.R., 1946, Cloudburst floods in Utah, 1850-1938: U.S. Geological Survey Water Supply Paper 994, 128 p., 23 plates.